

Terrestrial Attributes of the

Shark Bay

World Heritage Property

that give rise to its *Outstanding Universal Value*.

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Chapter One: Introduction

1.1 Nomination of Shark Bay to the World Heritage List

Shark Bay was nominated in October 1990 and inscribed on the World Heritage List in December 1991 on the basis of its natural heritage values. When listed, it was one of only 11 properties on the World Heritage List to satisfy all four natural heritage criteria.

Shark Bay World Heritage Property (see Attachment 1) covers a total area of approximately 2.2 million hectares, of which about 71% is marine waters and 630,000ha terrestrial (CALM 1996). The existing terrestrial reserves comprise about 6% of the World Heritage Property, or 20% of the terrestrial component, and their management is described in the recently released Shark Bay Terrestrial Reserves Management Plan 2000-2009 (Hancock et al. 2000). The terrestrial component of the Property is made up from areas of the mainland, peninsulas and islands. They include:

Mainland

- The mainland from the Zuytdorp Cliffs in the west, Tamala-Hamelin Station Homesteads in the north and the eastern and southern boundary of the property. This dry and isolated section of the Property includes the boundary between the Southwest and Eremaean Botanical Provinces.
- ‘Carnarvon Coast’ is a sliver of mangrove and beach along the eastern coastline of the Property between Hamelin Station and south of Carnarvon.

Peninsulas

- Peron Peninsula (105,000ha) is 150km long with Nanga Station (75,000ha) at its base. Its red and white dunes contrast with spectacular coastal scenery including the unique Shell Beach. Low arid vegetation and fauna mix with species at the northern end of their range. The Crown now owns Peron and Nanga Stations.
- A 2-4 km wide strait separates Edel Land on the western most point of the Australian mainland from Dirk Hartog Island. It protects spectacular cliffs, diverse heathlands, the unique Sand-hill Frog, the tranquil bays and limestone islets.

Islands

- Dirk Hartog Island is quite large at about 80 km long and up to 15 km wide. Although it has been a pastoral lease for 100 years, it still retains a diversity of flora and fauna, with many species of special interest.
- Bernier and Dorre are two long thin island nature reserves covering 9,720ha which lie some 50 km west of Carnarvon in the north-western part of the Property. Their habitat and isolation has protected five species of threatened mammals.
- Faure Island and Pelican Island are the only two islands in the eastern gulf of Shark Bay. Pelican Island is a 6 ha sand spit supporting a large Pelican and seabird nesting colony. Faure Island has been a pastoral lease for 100 years. It has been extensively cleared and impacted by grazing but retains extensive mangroves.
- The over forty small islets in Freycinet Reach and Denham Sound range in size from small limestone outcrops to islands with beaches, rocky points and vegetated white dunes. They are used by breeding seabirds and contain endemic reptiles.

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The Agreement between the State of Western Australia and the Commonwealth of Australia on Administrative Arrangement for Shark Bay World Heritage Property signed on 12 September 1997 established the SBWHP Ministerial Council. In addition, it established the Community Consultative Committee (CCC) and Scientific Advisory Committee (SAC) to advise the Ministerial Council. The agreement also commits to the development of a strategic plan for the entire World Heritage Property, in order to provide an overall framework to ensure the protection, conservation and preservation of the Property's 'outstanding universal value'. The strategic plan has not yet been completed.

1.2 What are World Heritage Value and Values?

Discussions of World Heritage properties are often in terms of World Heritage 'values' and a property's 'outstanding universal value'. A property is said to have 'outstanding universal value' if the World Heritage Committee is satisfied the property meets the specified criteria and conditions of integrity for a natural site. The four criteria are discussed in Chapter 3. 'Values' for a natural site typically refer to those biophysical attributes that are seen as the reason why the property is of 'outstanding universal value'. This paper attempts to document the **terrestrial** attributes that give rise to Shark Bay's 'outstanding universal value'. The identification of research, monitoring and management actions is consistent with Australia's obligations under the World Heritage Convention, in particular, ensuring the protection, conservation, preservation and transmission to future generations of the property's 'outstanding universal values'.

However, it is not each attribute or 'value' in isolation nor discrete locations where a group of attributes occur that is important, "*it is the holistic nature of the area which is critical*" (Lucas et al.1998, p12). Thus it is the totality of the interrelated natural attributes of an area that give rise to the areas 'outstanding universal value'. Indeed at the operational heart of the World Heritage Convention is the notion that prospective properties be assessed in sum, not part. Therefore, it is the sum of the terrestrial and marine 'values' that gives the Shark Bay World Heritage Property its 'outstanding universal value'.

1.3 Abbreviations

CALM	Department of Conservation and Land Management, WA
WA	Western Australia
IUCN	the World Conservation Union
SB	Shark Bay
SBWHP	Shark Bay World Heritage Property
UNESCO	United Nations Educational Scientific and Cultural Organisation

Chapter Two: Methods

2.1 Approach adopted for the Consultancy

The methods used are based upon those used by Lucas *et al.* (1998) to re-describe the natural heritage values of the Great Barrier Reef World Heritage Area. The methodology adopted for the identification and description of the outstanding universal value of the Shark Bay World Heritage Property consisted of four steps:

Step 1. Identification of natural heritage attributes

An analysis of the 1990 nomination document (Department of Arts 1990) for the Shark Bay World Heritage Property was carried out to locate the natural heritage attributes contained within that document. The terrestrial natural heritage attributes were taken from this list and circulated to the scientific, technical and research staff in Western Australia to confirm adequacy of the original list. The consolidated list of **terrestrial** natural heritage attributes is contained in Appendix 3. It is recognised that the final terrestrial attribute list is not exhaustive, but was compiled within the constraints of resources, time and available expertise.

Step 2. Identification and contact with appropriate experts

Coincident with the identification of natural heritage attributes, individuals considered to be experts for each attribute were identified. Attempts were made to locate Western Australian based experts. Experts were initially contacted by e-mail and the aims of the project were detailed, and its methodology outlined. The majority of experts were willing participants in the project and face to face meetings were arranged. In most cases, expert involvement consisted of about a 30-minute discussion and written feedback via e-mail on each summary document. Experts were not paid for their time.

I have consulted widely with experts to gain the requisite information and evaluations in order to expand and clarify the justification for World Heritage listing of Shark Bay. For this component of the consultancy twenty experts were consulted, and they are listed in Appendix 4.

Step 3. Drafting of attribute summary.

A draft summary of information was written by the consultant based upon the available literature, in particular the recent work on the southern Carnarvon Basin (Burbidge, Harvey and McKenzie 2000). The consultant also used his extensive knowledge of the Shark Bay site gained as Site Manager for the Department of Conservation and Land Management over a four year period (1996-2000). Each summary was reviewed by the relevant expert(s) and additional comments incorporated. Due to the limited budget for this project, summaries should be viewed as an adequate draft that will require review within 1-2 years. The summary documents are contained in Appendix 1.

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The attribute summary documents attempted to articulate the following information where appropriate and where available:

a) Description of the Attribute:

Taxa: estimates of abundance and diversity, estimate of endemism, identification of rare, restricted, threatened or relict taxa.

Habitat: location, estimate of extent, importance to species diversity.

b) Importance of attribute to ecological processes

c) Identification of locations that are important examples for the attributes.

d) Importance of the Shark Bay World Heritage Property to the scientific understanding of the attribute.

e) Any other unique or important aspects about the attribute.

f) The location of literature to support the comments made.

g) The identification of significant information gaps.

Step 4. Linking of attribute to the World Heritage criterion.

The links were made to the original nomination document for Shark Bay, which was quite inclusive but not well organised. There was no attempt made to identify new attributes but some updating of examples of terrestrial flora, fauna, ecological communities, landscapes and geology was attempted. The approach adopted was to define each criterion in turn and describe from the nomination document how the **terrestrial** attributes of the Shark Bay World Heritage Property met each criterion (see Chapter 3).

Chapter Three: Justification for Listing the Shark Bay World Heritage Property

The World Heritage Committee assesses which properties are of ‘outstanding universal value’ for the purposes of the World Heritage List. The definitions of cultural and natural heritage are interpreted through the use of two separate sets of criteria, one for each type of heritage. For a property, like Shark Bay, to be inscribed upon the World Heritage List by virtue of its natural heritage, the Committee must be satisfied that it meets at least one or more of the natural heritage criteria *and* the associated conditions of integrity. The evaluation of natural heritage nominations will assess the natural heritage attributes of the property against the established criteria, and assess the management regime and long term viability of protection of the property against the conditions of integrity.

Shark Bay was nominated in October 1990 and accepted by the World Heritage Committee in December 1991 as having ‘outstanding universal value’ for all four natural heritage criteria. At the time of nomination Shark Bay was only the eleventh property to be accepted for all four natural heritage criteria. However, only three of these criteria have included **terrestrial** natural heritage attributes or ‘values’ – (ii), (iii) and (iv).

The current World Heritage nomination criteria for natural sites differ to some extent from those at the time of nomination of Shark Bay as a World Heritage Area. However, the changes made in 1996 of the criterion first proposed in 1981 do not dramatically change the situation but rather have clarified it and removed some overlap. The approach adopted below is to define each criterion in turn and describe from the nomination document how the **terrestrial** attributes of the Shark Bay World Heritage Property meet each criterion. For each, the 1996 criterion is preceded by the 1981 criterion in place at the time of Shark Bay nomination - following a similar review by Lucas *et al.* (1998) of the natural attributes of the Great Barrier Reef World Heritage Area. Only the 1996 ‘Conditions of Integrity’ (and not the 1981 Conditions) are provided at the end of the three criteria with terrestrial ‘values’.

I have followed the normal practice of setting out the justification in broad terms and without references, supported by the greater detail shown in the summaries of attributes that are contained in Appendix 1 of this report. They can be compared and contrasted with the original nomination document (Department of Arts, p26-39).

NOTE: The following justification is NOT to be used as a replacement or update for the Nomination document. The original 1990 Nomination document is legally binding. In addition, the natural heritage attribute summary sheets collated in this paper were done with a \$7,500 World Heritage grant where resource allocation was limited. It should, however, assist in more clearly articulating the terrestrial natural heritage attributes used for each of the criteria. Plus it is a sound basis for a review of the nomination document if this is required in the next 2-3 years.

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4.5.1 Natural Attributes which match Criterion (i)

Criterion (i) 1981 *'...be outstanding examples representing major changes of earth's history. This category would include sites which represent the major 'era' of geological history such as 'the age of reptiles' where the development of the planet's natural diversity can be demonstrated and such changes as the 'ice age' where early man and his environment underwent major changes...'*

Criterion (i) 1996 *'...be outstanding examples representing major changes of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features...'*

In the nomination document for Shark Bay there were no terrestrial values nominated under this Criterion (Department of Arts 1990, page 26-27). The natural heritage values for Criterion (i) was based upon the marine values of the benthic microbial communities, microbial mats and stromatolitic microbialite structures and adjacent Holocene deposits in Hamelin Pool and L'haridon Bight.

4.5.2 Natural Attributes which match Criterion (ii)

Criterion (ii) 1981 *'... be outstanding examples representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment. As distinct from the periods of the earth's development, this focuses upon ongoing processes in the development of communities of plants and animals, landforms and marine and freshwater bodies. This category would include, for example (a) as geological processes, glaciation and volcanism (b) as biological evolution, examples of biomes such as rainforests, deserts and tundra, (c) as interaction between man and his natural environment, terraced agricultural landscapes.'*

Criterion (ii) 1996 *'...be outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals...'*

In the nomination document, the marine and terrestrial attributes for this Criterion were clearly separated in the text (Department of Arts 1990, pages 28-36).

The Shark Bay World Heritage Property is of major botanical and zoological significance primarily as the habitat for a rich flora and fauna species and subspecies:

- At the northern or southern limits of their range;
- Protected on refugia as a result of the isolation of habitats on peninsulas and islands from the disturbance that has occurred elsewhere on the mainland;
- Endemic to the Property;
- Characteristic of the arid lands; and
- Transitional elements between the south west and arid land (Eremaean).

Flora and Vegetation

Shark Bay represents a meeting point of three major climatic regions and forms a transition zone between two major botanical provinces – the complex and species rich heathlands and woodlands of South-West Province to the less diverse *Acacia* shrublands of the Eremaean Province. Shark Bay has over 855 indigenous plant taxa. A major feature of Shark Bay's flora

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is that 33% of species reach the end of their range, representing 229 species at their northern limit and 56 species at their southern limit.

The sharp overlap between botanical provinces is most pronounced in the southern part of the World Heritage Property. A pronounced overlap between major botanical provinces is of great scientific value in determining the adaptation of species to their environment and the factors which limit distribution and abundance. It is clearly related to the decreasing quality and reliability of rainfall to the north and east. The southern section of the proposed extension to the Zuytdorp Nature Reserve corresponds to this boundary and together with Kalbarri National Park (south of the World Heritage Property) are important reserves north and south respectively of the boundary of these two major floristic provinces.

The area south of Freycinet Estuary contains the unique type of vegetation known as 'tree heath'. The reasons for the "gigantism" of these shrubs are not fully understood. The nominated area contains almost all of this vegetation type.

There are also at least 53 species of vascular plants endemic to the Shark Bay region. Shark Bay has a rich history of scientific collection resulting in it being the type locality, place where the first specimens of species were collected and site of collections of specimens at the limits of their distribution. The completion of the analysis of the floristic quadrant based surveys of the Property will continue to expand or clarify the ranges of flora species, identify new flora species and clarify floristic communities from the Property.

Mammals

Of the 11 Australian rodent and 53 Australian marsupial taxa classified as *critical*, *endangered* or *vulnerable*, six are found on Bernier and Dorre Islands. They are the Djoongari or Shark Bay Mouse (*Pseudomys fieldi*), Western Barred Bandicoot (*Perameles bougainville bougainville*), Rufous Hare-wallaby (*Lagorchestes hirsutus* subspecies *bernieri* and *dorreae*), Banded Hare-wallaby (*Lagostrophus fasciatus fasciatus*) and Boodie (*Bettongia lesueur lesueur*).

These six mammal taxa are extremely useful in the study of evolution, as it is known that the populations on Bernier and Dorre Islands became separated from the mainland some 7,000 years ago. One of the best known examples to science in the study of island biogeography is the Rufous Hare Wallaby or Mala that has three extant populations or subspecies from the mainland, Bernier Island and Dorre Island.

The Banded Hare-wallaby (*Lagostrophus fasciatus*) formally occurred on the Australian mainland and is now only found on Bernier and Dorre Islands. Research into the Banded Hare-wallaby has indicated that the species may be a relict from the Post-Pleistocene macropod sub-family Sthenurinae and therefore represent the most primitive Sthenurinae known. Thus the most primitive Sthenurinae species is arid-adapted. In all other macropodid sub-families, the most primitive known forms are rainforest or wet sclerophyll forest dwellers. The Sthenurines may represent the first group of macropodoids to take advantage of the growing arid areas of Australia, joined later by potoroines and macropodines.

There are five south-western mammal species that reach their northern limit in the Shark Bay World Heritage Property – Dibbler, Heath Rat, Southern Brown Bandicoot, Ash-grey Mouse and Banded Hare-wallaby.

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Birds

The Shark Bay World Heritage Property has a rich avifauna with over 230 species or 35% of Australia's bird species being recorded, included 135 land birds and 26 terrestrial waterbirds.

Some of this diversity is due to its straddling the South-west and Eremaean Botanical Provinces, with several southern land birds attaining their usual northern limit at or near this boundary in the southern section of the Property, e.g. Regent Parrot, Blue-breasted Fairy-wren, Brown-headed Honeyeater, Tawny-crowned Honeyeater, Red Wattlebird, Golden Whistler, Grey Currawong and Australian Raven. In addition, the Rock Parrot, Western Yellow Robin, Southern Scrub-robin and Chestnut Quail-thrush are at their northern limit on the islands and peninsulas of Shark Bay.

Shark Bay is the southern limit of significant stands of mangroves in Western Australia. Consequently seven northern birds wholly or largely dependent on mangroves have their southern limit in the Property, (a) three from the mangroves along the mainland coast from south of Carnarvon to Gladstone: Brahminy Kite, White-breasted Whistler, Dusky Gerygone; and (b) four from the mainland coast plus the mangrove patches on the peninsulas and islands of Shark Bay: Striated Heron, Mangrove Grey Fantail, White-breasted Woodswallow, Yellow White-eye (Storr 1990; Johnstone et al. 2000).

In addition, Shark Bay is an important seabird breeding area, with some 38 small islands providing nesting sites for 16 species including the Eastern Reef Egret, Osprey, Pacific Gull, Silver Gull, Caspian Tern, Crested Tern, Roseate Tern, Fairy Tern and Bridled Tern. The Pacific Gull is a temperate species at the northern end of its range in Shark Bay and the Property is the southern most recorded breeding site for the Lesser Crested Tern in Western Australia.

The islands, peninsulas and gulfs of Shark Bay provide refuge for six relict or endemic species and subspecies of birds. The high level of endemism results from the long-term isolation of these islands and the limited opportunities for recolonisation from the mainland. A sub-species of the *Near Threatened* Thick Billed Grasswren (*Amytornis textilis textilis*) has a major stronghold on Peron Peninsula and just to the east of the Property on Hamelin and Woodley Stations. Five other endemic wren taxa are listed from the Shark Bay islands as *Vulnerable*:

- Variegated Fairy-wren (Bernier and Dorre Islands) *Malurus lamberti bernieri*
- White-winged Fairy-wren (Dirk Hartog Island) *Malurus leucopterus leucopterus*
- Southern Emu-wren (Dirk Hartog Island) *Stipiturus malachurus hartogi*
- Rufous Fieldwren (Dirk Hartog Island) *Calamanthus campestris hartogi*
- Rufous Fieldwren (Dorre Island) *Calamanthus campestris dorrie*

Reptiles and Amphibians

The Shark Bay World Heritage Property is noted for its diversity of terrestrial reptile taxa and supports atleast one hundred four species. The fauna consists of 15 geckos, 13 pygopodids, 12 dragons, 4 goannas, 42 skinks and 18 snakes (Appendix 7). The Property contains 12 of the 30 dragon species found in Australia. This richness is in part due to the location of Shark Bay at the meeting point of two of the State's three main natural regions.

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However, the frog fauna is depauperate with only four frog species of the 15 species recorded from the southern Carnarvon Basin have been recorded from Shark Bay which is generally dry except for shallow claypans following significant rainfall and scattered open bore overflow areas. The Sandhill Frog (*Arenophryne rotunda*) is endemic to the Property, from Dirk Hartog Island, Edel Land and along the coast south to the Murchison River. It needs no free water to breed or survive (Roberts 1985, 1990). *Pseudophryne guentheri* and *Neobatrachus pelobatooides* are a south-west species that has their northern limit in the very south of the Property. None of these frog species are on National or State threatened lists.

Many southern species are at their northern limit at Shark Bay include the frog *Pseudophryne guentheri* and *Neobatrachus pelobatooides*, the geckos *Phyllodactylus marmoratus* and *Strophurus spinigerus spinigerus*, the pygopodid *Aclys concinna major*, *Aprasia smithi*, *Delma australis*, *Delma fraseri*, *Pletholax gracilis edelensis* and *Pygopus lepidopodus lepidopodus*, the agamid *Tympanocryptis butleri*, the skinks *Ctenotus australis*, *Ctenotus fallens*, *Ctenotus lesueurii*, *Ctenotus pantherinus pantherinus*, *Egernia kingii*, *Egernia multiscutata bos*, *Egernia stokesii aethiops*, *Egernia stokesii badia*, *Morethia obscura* and *Tiliqua rugosa rugosa*, the blind snakes *Ramphotyphlops australis* and *Ramphotyphlops leptosoma*, the python *Aspidites ramsayi*, and the elapid snakes *Neelaps bimaculata* and *Vermicella fasciolata fasciolata*.

Northern species at their southern limit in Shark Bay include the frog *Neobatrachus wilsmorei*, the geckos *Strophurus rankini* and *Diplodactylus klugei*, the pygopodid *Delma nasuta*, the agamid *Ctenophorus rubens*, the skinks *Lerista connivens*, *Lerista uniduo*, *Lerista varia* and *Menetia surda cresswelli*, and the elapid *Demansia calodera*.

Several species characteristic of the arid interior reach the coast at Shark Bay, eg. the leptodactylid frog *Neobatrachus wilsmorei*, the geckos *Diplodactylus squarrosus* and *Strophurus strophurus*, the skinks *Egernia inornata*, *Lerista aff. muelleri* B, *Lerista nichollsi* and *Morethia butleri*, and the monitors *Varanus brevicauda* and *Varanus eremius*. These Eremaean elements have their main ranges to the east of the Property and five other species listed in the nomination document (page 16 and 34) are in fact not found in the Property itself.

The islands, peninsulas and gulfs of Shark Bay provide a refuge for nine relict or endemic species and subspecies: the pygopodids *Aclys concinna major*, *Aprasia haroldi* and *Pletholax gracilis edelensis*, the skinks *Ctenotus youngsoni*, *Ctenotus zasticus*, *Egernia stokesii aethiops* and *Menetia 'amaura'*.

The Property is rich in old Australian elements, eg. 12 species of diplodactyline geckos and 13 pygopodid lizards. The gecko sub-family Diplodactylinae is confined to Australia, New Zealand, New Caledonia and the Loyalty Islands (Storr, Smith and Johnstone 1990, p7). They lay eggs that have an elastic, parchment-like shell, always number two to a clutch and the eggs are prone to desiccation. Pygopods are confined to Australia and New Guinea (Storr, Smith and Johnstone 1990, p103).

Shark Bay is remarkable for its wealth of fossorial (living below ground) reptile species including three species of the pygopodid genus *Aprasia* (two endemic), 15 species of the skink genus *Lerista*, five blind snakes (*Ramphotyphlops*) and five species of elapid snakes (*Vermicella*, *Neelaps*, *Simoselaps*).

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Conditions of Integrity (ii) 1996 – *should have sufficient size and contain the necessary elements to demonstrate the key aspects of processes that are essential for the long-term conservation of the ecosystems and biological diversity they contain; for example, an area of tropical rainforest should include a certain amount of variation in elevation above sea level, changes in topography and soil types, patch systems and naturally regenerating patches; similarly a coral reef should include, for example, seagrass, mangroves or other adjacent ecosystems that regulate nutrient and sediment inputs into the reef.*

The conditions of integrity are met by the great size, the range in environments and the generally unmodified nature of the nominated Property. Shark Bay World Heritage Property covers a total area of approximately 2.2 million hectares, of which about 29% or 630,000ha is terrestrial lands (Attachment 2). The Property contains significant areas of mainland, peninsulas and islands where the influence of the extensive coastline coupled with the arid landforms provides exceptional biodiversity. The range of habitat and vegetation types varies greatly from the woodlands and coastal heaths of the South-west to the spinifex grasslands and Acacia shrublands of the Eremaean Botanical Province.

These factors combined with the adequate planning and management arrangements will justify the prediction that the ecological and evolutionary processes in the Property will continue unimpeded and that the diversity and complexity of the present terrestrial ecosystems will be perpetuated. The existing terrestrial reserves comprise about 6% of the World Heritage Property, or 20% of the terrestrial component, and their management is described in the recently released Shark Bay Terrestrial Reserves Management Plan 2000-2009 (Hancock et al. 2000). A number of new conservation reserves have been created since the nomination of the Property (François Peron National Park and Shell Beach Conservation Park in January 1993; Zuytdorp Nature Reserve in December 1991). Other proposed additions have been identified in the Shark Bay Region Plan (Dirk Hartog Island; western Edel Land; South Peron; extensions to Zuytdorp).

4.5.3 Natural Attributes which match Criterion (iii)

Criterion (iii) 1981 '*...contain unique, rare or superlative natural phenomena, formations or features or areas of exceptional natural beauty, such as superlative examples of the most important ecosystems to man, natural features, (for instance, rivers, mountains, waterfalls), spectacles presented by great concentrations of animals, sweeping vistas covered by natural vegetation and exceptional combinations of natural and cultural elements.'*

Criterion (iii) 1996 '*...contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance...'*

Shark Bay's great diversity of landscapes and deeply contrasting colours are built on the regions unique visual elements – the seascapes of its shallow embayments, the exceptional coastal scenery, the contrasting arid landscape, and the many peninsulas, islands and bays. This combination of elements is particularly notable in the following areas of Shark Bay:

- along the Zuytdorp Cliffs,
- on Dirk Hartog Island,
- on Peron Peninsula, and
- on Heirisson and Bellefin Prongs.

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Other special features of exceptional natural beauty in Shark Bay include:

- The unique sweeping beaches of white shells at Shell Beach;
- The strongly contrasting colours of the dunes and cliffs of Peron Peninsula;
- The inundated birridas, such as Big and Little Lagoon; and
- The richness of the flora contributing to extensive wildflower displays each spring

Conditions of Integrity (iii) 1996 – *should be of outstanding aesthetic value and include areas that are essential for maintaining the beauty of the site; for example, a site whose scenic values depend on a waterfall, should include adjacent catchment and downstream areas that are integrally linked to the maintenance of the aesthetic qualities of the site.*

The conditions of integrity are met by the size of the Property, which includes all the superlative natural phenomena of Shark Bay within the boundaries. Careful management of existing and foreseeable pressures on the Property will ensure that each of these superlative natural phenomena will be conserved. Arrangements for the planning and management of the Property are already in place or are proposed.

4.5.3 Natural Attributes which match Criterion (iv)

Criterion (iv) 1981 '*...be habitats where populations of rare and endangered plants and animals still survive. This category would include those ecosystems in which concentrations of plants and animals of universal interest and significance are found.*'

Criterion (iv) 1996 '*...contain the most important and significant natural habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.*'

Historical and Scientific Collections

Shark Bay is the type locality, place where the first specimens of species were collected and site of collections of specimens at the limits of their distribution. Dirk Hartog Island is the site of the first Australian plants collected by European explorers with William Dampier in the *Roebuck* collecting a number of plant specimens in August 1699 that are now at Oxford University, England (George 1999). The largely scientific French expeditions commanded by Thomas Nicolas Baudin in 1801 and 1803 were perhaps the most significant to visit the Shark Bay area. Scientific personnel on the expedition were more numerous than on any other European voyage to Australia. Their collections from the Shark Bay landings are extensive. The French explorer Louis Desaules de Freycinet visited Shark Bay in September 1818. The main collection is housed at the Muséum Nationale d'Histoire Naturelle in Paris and Shark Bay is the type locality for many flowering plants and seaweeds.

Shark Bay is the habitat for many species of plants and animals that are recorded as threatened (*critical*, *threatened* or *vulnerable* under the IUCN criteria). Importantly, these habitats occur in the biogeographically significant transition zone between Australia's south-west and the arid zones.

Mammals

Of the 11 rodent and 53 marsupial taxa classified as *critical*, *endangered* or *vulnerable* in the Australian Action Plans, six are found on Bernier and Dorre Islands. Many threatened

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Australian mammal species, like these extant Shark Bay mammals, were distributed widely across the mainland and their contemporary distribution has reduced significantly. They are the Djoongari or Shark Bay Mouse (*Pseudomys fieldi*), Western Barred Bandicoot (*Perameles bougainville bougainville*), Rufous Hare-wallaby (*Lagorchestes hirsutus* subspecies *bernieri* and *dorreae*), Banded Hare-wallaby (*Lagostrophus fasciatus fasciatus*) and Boodie (*Bettongia lesueur lesueur*).

Bernier and Dorre Islands contain the only remaining wild populations of four of these species, with three being entirely extinct elsewhere and the Mala having only a small captive population of the mainland sub-species in the Tanami Desert. The Boodie is extinct on the mainland with populations on Bernier and Dorre Island in Shark Bay and on Barrow and Boodie Islands some 600 km further north off the Pilbara coast.

There are no endemic mammal species in Shark Bay, although there are local sub-species.

A total of 33 indigenous mammal species (plus 8 bats) have been recorded as extant in Shark Bay since European visits began (Appendix 8), although most of the medium-sized mammals have disappeared from the mainland and Dirk Hartog Island over the last 100 years. The Property mainland has one monotreme, one honey possum, four dasyurid, three large macropod, four rodent, six bat and ten introduced species recorded as extant (Appendix 8). In addition one bandicoot, three medium-sized macropod and two rodent species are extant only on Bernier and Dorre Islands. Four nationally important mammal reconstruction projects are currently being undertaken in Shark Bay. If successful they will reintroduce an additional 6-10 locally extinct mammal species back to the Property, many of which are on State and National threatened species lists.

Frogs and Reptiles

The Sandhill Frog (*Arenophryne rotunda*) is endemic to Shark Bay. There are a number of endemic terrestrial reptiles species concentrated in two groups - the pygopodids *Aclys concinna major*, *Aprasia haroldi* and *Pletholax gracilis edelensis* and the skinks *Ctenotus zastictus*, *Ctenotus youngsoni*, *Egernia inornata*, *Egernia multiscutata bos*, *Egernia stockesii aethiops*, *Lerista connivens*, *Lerista humphriesi*, *Lerista kendrici* and *Metetia 'amaura'*.

The Property has populations of two taxa classified as *Endangered* the south-western WA population of the Woma (*Aspidites ramsayi*) and Western Spiny-tailed Skink (*Egernia stockesii badia*); and two *Vulnerable* taxa the Baudin Island Spiny-tailed Skink (*Egernia stockesii aethiops*) and Hamelin Ctenotus (*Ctenotus zastictus*). In addition four species are listed as 'Rare or insufficiently known' whose status can not be determined without more information, but are thought to be threatened - the legless lizards *Aclys concinna major*, *Aprasia haroldi*, *Pletholax gracilis edelensis* and the skink *Lerista humphriesi*. However, the taxonomy of many terrestrial reptile groups in Shark Bay are currently under major review and there will be new taxa described that may be threatened.

Birds

There are six sub-species of wren from Shark Bay which are considered threatened. The *Near Threatened* western sub-species of the Thick Billed Grasswren (*Amytornis textilis textilis*) is currently restricted to the Shark Bay region, with a major stronghold on Peron Peninsula and another local population just to the east of the Property on Woodleigh Station and the north-eastern corner of Hamelin Station. It is locally extinct on Dirk Hartog Island (Garnett and

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Crowley 2000). Five other endemic wren taxa are listed from the Shark Bay islands as *Vulnerable*:

- Variegated Fairy-wren (Bernier and Dorre Islands) *Malurus lamberti bernieri*
- White-winged Fairy-wren (Dirk Hartog Island) *Malurus leucopterus leucopterus*
- Southern Emu-wren (Dirk Hartog Island) *Stipiturus malachurus hartogi*
- Rufous Fieldwren (Dirk Hartog Island) *Calamanthus campestris hartogi*
- Rufous Fieldwren (Dorre Island) *Calamanthus campestris dorrie*

Small populations of the *Vulnerable* Malleefowl, *Near Threatened* Australian Bustard and *Near Threatened* Bush Stone-curlew occur on the Property. They have dramatically reduced in numbers and maintain patchy distribution across the southern half of their extensive ranges, due to habitat destruction and predation of nests or ground dwelling sub-adults by foxes.

The *Near Threatened* Star Finch (*Neochmia ruficauda clarescens*) was listed in the original nomination document, however, its southern limit is just to the east of the Property and it has not been located in Shark Bay.

Flora and Vegetation

Shark Bay has over 850 indigenous taxa, of which 53 are endemic to the Property, 229 are at their northern limit and 56 at their southern limit.

Conditions of Integrity (iv) 1996 – *should contain habitats for maintaining the most diverse fauna and flora characteristic of the biographic province and ecosystem under consideration; for example, a tropical savannah should include a complete assemblage of coevolved herbivores and plants; an island ecosystem should include habitats for maintaining endemic biota; a site containing wide ranging species should be large enough to include the most critical habitats essential to ensure the populations of those species; for an area containing migratory species, seasonal breeding and nesting sites, and migratory routes, wherever they are located, should be adequately protected; international conventions, eg. The Convention of Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention), for ensuring the protection of habitats of migratory species of waterfowl, and other multi- and bilateral agreements could provide this assurance.*

The conditions of integrity are based on the quality of the natural attributes, the near pristine condition of the habitat and size of the Property. It contains habitats of sufficient size to provide the greatest opportunity for the survival of plant and animal species described above. A distinguishing feature of Shark Bay compared to mainland Australia is the opportunity to maintain refuges on islands and potentially a number of peninsulas for native mammals threatened or made extinct elsewhere due to the effects of predators and habitat destruction. Bernier and Dorre Islands are nature reserves managed for conservation and their significance is further recognised by restrictions on public access.

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Appendix 1: Natural Heritage Attribute Summary Papers

Natural Heritage Attribute 1.5: Historical and Scientific Collections

Alex S. George and Roberta A. Cowan

SOURCE:

Alex S. George
Contract Botanist and Editor

Roberta A. Cowan
School of Biological Sciences, Murdoch University

CONCLUSIONS:

- Dirk Hartog Island is the site of the first Australian plants collected by European explorers with William Dampier in the *Roebuck* collecting a number of plant specimens in August 1699 that are now at Oxford University, England (George 1999).
- The largely scientific French expeditions commanded by Thomas Nicolas Baudin in 1801 and 1803 were perhaps the most significant to visit the Shark Bay area. Scientific personnel on the expedition were more numerous than on any other European voyage to Australia. Their collections from the Shark Bay landings are extensive.
- The French explorer Louis Desaulles de Freycinet visited Shark Bay in September 1818. The main collection is housed at the Muséum Nationale d'Histoire Naturelle in Paris and Shark Bay is the type locality for many flowering plants and seaweeds.
- Shark Bay is the type locality, place where the first specimens of species were collected and site of collections of specimens at the limits of their distribution.

MOST RELEVANT CRITERIA: (ii) and (iv)

Reference to this Attribute was made in the Nomination Document: page (paragraph); European explorers: p3par2-6; p14par2-3; p18par2; p33par5; Plate 1.

SEE ALSO:

Terrestrial Flora and Vegetation, Mammals, Reptiles and Frogs, Terrestrial Birds.

DISCUSSION:

Shark Bay and the vicinity have been a focus of scientific effort since the early days of European exploration. One reason may be its secure anchorage for sailing ships, the coast to the south and north offering no protected anchorage for some distance. A number of expeditions carried botanical collectors, and many new species were named from their specimens, some by collectors themselves but most by other botanists.

Dampier August 1699

Dirk Hartog Island is the site of the first Australian plants collected by European explorers. From 17 to 21 August 1699, William Dampier in the *Roebuck* was at anchor near Cape Levillain and landed several times on the island. He collected a number of plants (George 1999), one of which was named *Dampiera* in his honour, the species *Dampiera incana* being based on his collection. On 23 August some of his crew landed on Bernier Island, but it is uncertain whether they collected plants. It is likely that a seaweed, *Cystoseira trinodis*, was scooped up in Shark Bay, or in the open sea off this part of the coast. Dampier's specimens are now at Oxford University, England.

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Baudin 1801 and 1803

The Baudin expedition was perhaps the most significant to visit the Shark Bay area (Baudin 1974). It left Le Havre, France, on 19 October 1800, in two ships, the *Géographe* commanded by Thomas Nicolas Baudin (1754-1803) and the *Naturaliste* commanded by Jacques Félix Enimane Hamelin. Their aims were largely scientific, although at the time the British suspected political motives. Sailing via Tenerife and Mauritius, they made landfall in Australia at Cape Leeuwin on 27 May 1801. After spending some 8 days in Geographe Bay they left to sail north but became separated. Baudin reached Shark Bay first, staying there from 26 June to 11 July 1801. From 27-29 June, they landed on Bernier Island (where Péron became lost overnight), then from 30 June to 4 July explored parts of Shark Bay but did not land, and on 5-11 July landed again on Bernier Island. Baudin then sailed to Timor.

Hamelin in the *Naturaliste* was at Shark Bay from 16 July to 4 September. From 17 July to 2 August he was anchored off Cape Levillain, Dirk Hartog Island, where several landings were made. They visited Cape Inscription, removed Vlamingh's 1697 plate and left one of their own. From 2 August to 4 September, they were anchored in Dampier Road, off the north-west tip of Peron Peninsula. They landed a number of times on the Peninsula, probably north of where Denham is now, and explored extensively in the area.

Hamelin sailed on to Timor and there rejoined Baudin. They then sailed around the western coast of Australia (without landing) to Tasmania, surveyed Bass Strait and the mainland coast for some distance westward until they met Flinders in Encounter Bay. Then they sailed to Sydney to refit and recuperate. There, Baudin bought the locally-built *Casuarina* to continue his survey and placed it under the command of Henri Desaulles de Freycinet. Hamelin returned to France in the *Naturaliste*, taking the collections gathered to that time.

Baudin visited Shark Bay again in 1803, on this part of the voyage keeping his two ships together. They had one anchorage, from 16 to 23 March, in Dampier Road off the north-west tip of Peron Peninsula. Again, landings were made a number of times on the Peninsula, probably near the north end.

From there the expedition sailed again for Timor, made an excursion along the north coast of Australia as far as Melville Island, then to Mauritius, where Baudin died. The return to France was made in the *Géographe*, reaching France on 25 March 1804.

Scientific personnel on the expedition were more numerous than on any other European voyage to Australia. Because of dissension on the outward voyage, some were left at Mauritius. Those who visited Shark Bay were Joseph Bailly (mineralogist), Pierre François Bernier (astronomer), Charles Pierre Boullanger (geographer), Louis Depuch (mineralogist), Pierre Ange François Xavier-Fauré (geographer), Antoine Guichenot (gardener's boy), Jean-Baptiste Louis Claude Leschenault de la Tour (botanist), Charles Alexander Lesueur (artist), Stanislas Levillain (zoologist), François Péron (zoologist) and Anselm Riedlé (head gardener).

Their collections from the Shark Bay landings are extensive, but no list has ever been compiled. The major set of plants is housed at the Muséum Nationale d'Histoire Naturelle in Paris, and duplicates may be found in several other herbaria. The specimens were not studied by expedition members but by other scientists in France such as Alphonse de

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Candolle, René Louiche Desfontaines, Jacques Etienne Gay and Jacques J.H. de Labillardière. Because field records were minimal, it is not always possible to determine the precise locality and commonly the collector of a collection, with Baudin himself sometimes cited as the collector. Localities and the collector were recorded for some collections however, Shark Bay being 'Baie des Chiens Marins', and Bernier and Dorre Islands the 'Isles Stériles'; and at that period Australia was still commonly known as New Holland. Many of the plants and animals proved to be new species and were described at various times during the following decades. Among those for which the Shark Bay area is the type locality are:

Abutilon geranioides, *Acacia coriacea*, *Clematis microphylla*, *Diplolaena grandiflora*, *Frankenia pauciflora*, *Guichenotia ledifolia*, *Gyrostemon ramulosus*, *Alectryon oleifolius*, *Pileanthus limacis*, *Pittosporum phylliraeoides*, *Sida calyxhymenia*, *Solanum lasiophyllum*, *Solanum orbiculatum* and possibly *Stylobasium spathulatum*.

Plants named after expedition members include:

Guichenotia, *Lechenaultia*, *Beyeria leschenaultii*, *Calytrix leschenaultii*, *Eucalyptus baudiniana*, *Synaphea lesueurensis* (named indirectly from the hill named after him), *Quoya cuneata*, *Pityrodia cuneata* and *Macrozamia riedlei*.

Besides flowering plants, a number of seaweeds were collected during the expedition including many from Shark Bay, but only one that probably came from there was a new species, viz. *Sargassum peronii* C. Agardh (and its heterotypic synonym *Sargassum boryi* C. Agardh).

Freycinet 1818

As one of several expeditions sent to search for the lost French explorer La Pérouse, Louis Desaules de Freycinet (who had sailed with Baudin) left Toulon on 17 September 1817 in *L'Uranie* and sailed via Rio de Janeiro, Cape Town and Mauritius (Marchant 1998). Surgeons Jean René Constant Quoy and Joseph Paul Gaimard, an officer Louis Isidore Duperrey and the pharmacist Charles Gaudichaud-Beaupré were all naturalists. They reached Shark Bay on 11 September 1818 and next day anchored off Dirk Hartog Island. Several landed on the island. Freycinet then moved the *L'Uranie* to Peron Peninsula and anchored there from 13 to 26 September, while Duperrey explored Hamelin Pool. They sailed for Timor on 26 September. On the return voyage they were wrecked on the Falkland Islands and lost many collections. Following rescue they reached France on 13 November 1820.

As with the Baudin collections, only general data accompany those surviving from this voyage, those most commonly seen, again being 'Baie des Chiens Marins' and 'Isles Stériles'. The main set is housed at the Muséum Nationale d'Histoire Naturelle in Paris. Gaudichaud studied the collections and named a number of new species from the area including: *Alyogyne pinonianus*, *Calogyne berardiana*, *Cassia chatelainiana*, *Enneapogon caerulescens*, *Halgania littoralis*, *Rhodanthe humboldtianum*, *Porana sericea*, *Ptilotus divaricatus*, *Scaevola tomentosa* and *Waitzia podolepis*. Named after Gaudichaud are *Rhagodia gaudichaudiana*, *Commersonia gaudichauditi* and *Ptilotus gaudichaudii*.

Species named by other botanists included: *Beyeria cyanescens* and *Keraudrenia hermanniaefolia*.

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The Freycinet voyage resulted in many collections of seaweed from Shark Bay, including a number of type specimens:

Green seaweed

Acetabularia calyculus Lamouroux (type from Shark Bay, collectors Quoy and Gaimard);

Brown seaweed

Encoelium clathratum C. Agardh = *Hydroclathrus clathratus* (C. Agardh) Howe (original material included Gaudichaud collections from Shark Bay);

Zonaria furcellata C. Agardh = *Dictyota furcellata* (C. Agardh) Geville (type from Shark Bay, Gaudichaud);

Sargassum uvifera C. Agardh = *Caulocystis uvifera* (C. Agardh) Areschoug was also collected by the French in Shark Bay but the expedition is unknown;

Red seaweed

Hutchinsia glomerata C. Agardh = *Tolypocladia glomerulata* (C. Agardh) Schmitz (type from Shark Bay, Gaudichaud);

Sphaerococcus revolutus C. Agardh = *Dicranema revolutum* (C. Agardh) J.G. Agardh (type from Shark Bay, Gaudichaud);

Amphiroa crassa Lamouroux (type from Shark Bay, collectors Quoy and Gaimard).

King and Cunningham, 1822

Phillip Parker King and Allan Cunningham, with John Septimus Roe, who became Western Australia's first surveyor-general, visited Shark Bay in the *Bathurst* and landed on Dirk Hartog Island from 21 to 25 January 1822, visiting Cape Inscription, Turtle Bay and Cape Levillain. Although it was midsummer, Cunningham collected a few plants (King 1827, pp 185-188), some of which he named himself, e.g. *Acacia idiomorpha*, *Acacia ligulata*, *Calytrix stigosa*, *Euphorbia eremophila*. Among other plants, *Angianthus cunninghamii* commemorates him. Cunningham's main set of specimens is at the Royal Botanic Gardens, Kew.

Later Visitors

The survey ship HMS *Herald*, commanded by Henry Mangles Denham, spent almost four months in Shark Bay, from March to June 1858, surveying deep into the various embayments. Aboard was the botanist William Grant Milne who collected at various sites including Dirk Island. Among his specimens was the type of *Angianthus mietnei*.

The explorer, botanist and magistrate Maitland Brown visited Shark Bay, Dirk Hartog Island and the Gascoyne River briefly in 1863 and made a small collection, including the types of *Eremophila maitlandii*, *Eremophila platycalyx* and *Pityrodia paniculata*. These specimens are now at the National Herbarium of Victoria.

In 1874, the German government despatched the *Gazelle*, commanded by G.E.G. Freiherr von Schleinitz, on a marine scientific voyage which called at Shark Bay in 1875. Fredrich Naumann was the botanical collector, his specimens being studied by Adolf Engler and others and later housed in the Botanischer Garten, Berlin. A number of seaweeds were collected, two of which proved new species - *Anadyomene reticulata* and *Caulerpa delicatula*, named by Eugene Ashkenazy.

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In October-November 1877, the Government Botanist of Victoria, Ferdinand Mueller travelled overland from Geraldton to Freycinet Harbour, Shark Bay. Among the new species discovered by Mueller near Shark Bay were *Brachycome latisquamea* and *Tetragonia diptera*. In his account of the botany of Shark Bay, Mueller (1883) included collections made by John Forr and Josef Polak in the region of the Gascoyne and Lyons Rivers from May to October 1882. Several new species were named from these, including *Velleia macroplactra*, *Podotheca polackiii* [sic] and *Ptilotus polakii*. The collections are also at the National Herbarium of Victoria.

In the 20th century, prior to the recent surveys by the Department of Conservation and Land Management, several major expeditions have visited the region. In 1959, a joint Western Australian Museum, State Herbarium, Fisheries Department, University of Western Australia party spent 14 to 26 July on Bernier and Dorre Islands (Ride et al. 1962). From the plants collected by Robert Royce the new species *Triodia plurinervata* was named. In September 1972, Andrew Burbidge and Alex George collected on Dirk Hartog Island. George collected some 250 species in a year of above average rainfall (Burbidge and George 1978). The species *Olearia occidentissima* was named from these collections.

The first sets of all recent collections are housed at the Western Australian Herbarium.

CONSERVATION MANAGEMENT, RESEARCH AND MONITORING PRIORITIES

- The description provided in this paper focuses on early collections of flowering plants and seaweed. A systematic review of all plants collected from Shark Bay, where they are housed and their scientific significance is warranted.
- Similar reviews of other flora and fauna groups is urgently required – mammals, reptiles, amphibians, birds, non-flowering plants, invertebrates.
- The collections of Baudin and Freycinet from the Shark Bay landings are housed at the Muséum Nationale d'Histoire Naturelle in Paris, and duplicates may be found in several other herbaria. As there is no list yet compiled of these extensive collections, further study of these specimens may be warranted.
- The linking of Shark Bay's extensive maritime history and the significance of its early scientific collections presents many opportunities for education and interpretation of the World Heritage values of the Property.
- The celebration of anniversaries for many of the early scientific expeditions may also present opportunities to fund complementary scientific survey or analysis of collections.

Comments received from:

Greg Keighery and Neil Gibson.

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Appendix 1: Natural Heritage Attribute Summary Papers

Natural Heritage Attribute 1.6: Flora and Plant Communities

Paul Hepburn Brown (Ed.)

SOURCE:

Greg Keighery, Neil Gibson, Alan Burbidge and Mike Lyons
Department of Conservation and Land Management

CONCLUSIONS:

- The boundary between two of the major floristic provinces in Australia – the South Western and Eremaean Botanical Provinces - runs through the southern part of the World Heritage Property. The proposed extension to the Zuytdorp Nature Reserve will protect the transition vegetation on and to the north of this major phytogeographic boundary.
- Shark Bay has over 850 indigenous taxa, of which 53 are endemic to the Property, 229 are at their northern limit and 56 at their southern limit. Large numbers of flora species have their type localities in Shark Bay (see Historical Collections).
- The completion of the systematic flora survey of Dirk Hartog Island, analysis of floristic quadrat data for the Shark Bay World Heritage Property and mapping of vegetation types remain outstanding tasks that will greatly assist management.
- Pre-planning for catastrophic disturbance events (broad scale fires, invasive weeds, over-grazing) on the islands and peninsulas of Shark Bay are essential.

MOST RELEVANT CRITERIA: (ii), (iii), (iv)

Reference to this Attribute was made in the Nomination Document: page (paragraph);

Flora and Vegetation: p3par2; p10par6; p11par2-3; p12par2-3; p13par1-5; p14par2; p33par2-4; p34par3; p37par3; Plates 1, 6, 7, 10, 25, 28. Appendix 6.

Botanical Province: p10par5-6; p11par1-3, p12par1-3; p13par5; p33par1; p33par1-3; p34par3

SEE ALSO:

Historical Collections. Wetlands and Wetland Flora and Fauna.

DISCUSSION:

Despite Shark Bay being the site of very early visitation and floristic study by several European expeditions (see 'Historical Collections'), the area was until recently still poorly known botanically. Keighery *et al.* (2000) reports on the first detailed study of the vascular flora of the southern Carnarvon Basin, including the whole of the Shark Bay World Heritage Property. Localised floristic surveys have been undertaken in the World Heritage Property by Trudgen and Keighery (1995), Bernier and Dorre Islands by Royce (1962), Dirk Hartog Island by Burbidge and George (1978), wetland flora survey (Gibson *et al.* 2000a), and temperate to arid transition through the Zuytdorp area by Gibson *et al.* (2000b).

Shark Bay has over 855 indigenous taxa, of which 53 are endemic to the Property, 229 are at their northern limit and 56 at their southern limit (Trudgen and Keighery 1995).

Botanical Province Boundary and Transition Zone

The boundary between two of the major floristic provinces in Western Australia – the South Western and Eremaean Botanical Provinces - runs through the southern part of the World Heritage Property (Beard 1976a, 1976b, 1980). A pronounced overlap between major botanical provinces is of great scientific value in determining how species adapt to different environments, and factors that limit distribution and abundance. This boundary represents the transition from the complex and species rich heathlands and woodlands of south-western Australia to the less diverse *Acacia* shrublands of the Eremaean Province. It is clearly related to the decreasing quality and reliability of rainfall to the north and east.

Gibson *et al.* (2000b) established 100 quadrants across this boundary from Peron Peninsula to south of the Murchison River to accurately determine this major phytogeographic boundary based on floristic composition, soils and climatic parameters. Gibson *et al.* (2000b) suggested that the boundary of the South Western Botanical Province determined by Beard (1976b) should move west 25 km and south 50 km to exclude the unique tree heaths in the Tamala area and the *Acacia-Casuarina* thicket on red sandplain to the east (Figure 1).

The southern section of the proposed Zuytdorp Nature Reserve corresponds to this boundary and together with Kalbarri National Park (south of the World Heritage Property) are important reserves north and south respectively of the boundary of these two major floristic provinces. Kalbarri National Park has 1,071 taxa recorded within its boundaries of which 223 are at their northern limit. A long standing recommendation to increase substantially the Zuytdorp Nature Reserve by acquiring parts of Nanga, Tamala and Murchison House Station will protect the transition vegetation to the north of this major phytogeographic boundary (and WHP value). Mineral prospecting, mining, feral goats, wildfire, *Phytophthora* dieback and proposals for upgraded access can adversely impact the area's environmental values.

Island Flora

A preliminary report by Claymore and Markey (1999) outlines a World Heritage funded project to systematically survey the vascular flora of Edel Land and Peron Peninsula (90 quadrats), Bernier Island (21 quadrats) and Dorre Island (16 quadrats) at a scale useful to management. Of the 123 recorded taxa on Dorre Island, 9 were weeds. The Dorre Island flora included two WHP endemic species, four priority flora, two south-west species at their northern limit and five tropical species at their southern limit. On Bernier Island 130 taxa have been recorded with 9 weeds. Bernier Island contained 10 species at their northern limit and two priority flora.

Keighery (1990) records 282 flora species from Dirk Hartog Island with 31 being weeds. Keighery *et al.* (2000) recorded from Dirk Hartog Island one endemic species, 35 species at their northern limit and five species at their southern limit. However, a detailed flora survey of Dirk Hartog Island is urgently required to upgrade species lists, complete data collection and quadrant establishment throughout the World Heritage Property, and allow Property wide vegetation mapping.

A recent flora survey established 10 quadrates on Faure Island where a May (Autumn) 2000 survey was completed and a Spring survey is still required (G. Keighery, personal communication). There are flora lists for the majority of small islets in Freycinet Inlet, near Dirk Hartog Island and for Pelican Island (Abbott 1980; Keighery, Alford, Keighrey, Burbidge and Fuller, unpublished observations).

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Vegetation

Beard (1976a) published a single map-sheet of the dominant vegetation of the Carnarvon District at a scale of 1:1,000,000. The Shark Bay Region was mapped and documented separately at a scale of 1:250,000 (Beard 1976b). Payne et al. (1980) mapped the Carnarvon Basin at a scale of 1:250,000 for rangeland management purposes based on both vegetation and geomorphology. Burbidge and George (1978) listed five major structural formations in their description of Dirk Hartog Island. Royce (1962) published species lists with vegetation descriptions for Bernier and Dorre Islands.

There is a requirement for specific mapping of vegetation types based upon floristic presence/absence across the Shark Bay World Heritage Property. The floristic, soil and vegetation data from the 227 floristic quadrants established by Claymore and Markey (1999) and Gibson *et al.* (2000b) has been collected and stored in a way that could be used in the first stage of this project. Following completion of the last area to be surveyed, Dirk Hartog Island, floristic analysis by Gibson *et al.* (1994) will be used to define community types. It is hoped these community types can then be identified from aerial photography with limited ground truthing and therefore the whole World Heritage Property can be mapped at a scale of 1:25,000 and/or 1:10,000 from orthophotographs. The identification of vegetation types and their mapping will (a) allow assessment of their conservation status within the Property; (b) provide the basic terrestrial management unit for threats (fire, weeds, habitat destruction, recreational impact) and species; and (c) stimulate further work on information gaps and ecological questions.

Weeds

The management of the introduction and spread of new or existing environmental weeds in the World Heritage Property is a major challenge in protecting the areas floristic and fauna habitat values. To date there have not been systematic or focused weed surveys in the Property, although other floristic surveys provide preliminary weed species lists. A rolling environmental weed monitoring and control plan is urgently required. Of the major weeds already present in Shark Bay, three at least require immediate attention:

- Buffel Grass (*Cenchrus ciliaris*) is a tussocking perennial native to Africa and India. It was widely planted in pastoral regions for stock and it has become a widespread weed of roadsides, creeklines, river edges and spinifex vegetation types from Shark Bay to the Pilbara. The small patches on the coast of Bernier and Dorre Islands must be eradicated. Further work on the role of fire in Buffel Grass invasion of spinifex communities in Shark Bay is required.
- South African Boxthorn (*Lycium ferocissimum*) is a serious and invasive shrub that is common to the south of the Property along the Geraldton coast and offshore islands. The Zuytdorp coast and Shark Bay islands should be periodically monitored and Boxthorn controlled when detected. It has been recently noted on one island in Freycinet Inlet and on Faure Island (G. Keighery, pers. comm.).
- Ruby Dock (*Rumex vesicarius*) is native to North Africa, the Middle East through to India. It is found in disturbed situations, particularly spreading along roadsides and water courses, in the arid zone from where it can then spread through adjoining vegetation. Requires control along road corridors throughout the Property.

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Other Threats

The majority of the World Heritage Property has been grazed by stock (sheep and cattle) and feral goats for over 100 years. Physical impact has been widespread, but most intense around water points and on Birridas (salt lake areas). Grazing animals have also spread many rangeland weeds and facilitated localised plantings of Buffel Grass. The proposal to purchase many of the pastoral leases within the property will allow destocking and goat control.

Human disturbance from increased access for recreation and construction of roads remains a major concern in this very fragile environment. Increased 4WD numbers are allowing visitors to access areas previously protected by their sheer isolation, particularly along the coast. The Zuytdorp area has been inaccessible for many years and recent proposals for a major road and/or extensive mining operations will open the area up to off-road driving, potential weed introduction, disease spread and increasing fire incidence.

Trials by CALM on Peron Peninsula have indicated that many of the intact *Acacia* shrublands of the Eremaean Province will not burn under normal conditions. However, following destocking and above average rainfall/plant growth conditions, wildfire may actively burn through these shrublands. Fire does pose a threat on the islands (Dirk Hartog, Bernier and Dorre) where the conservation values are extremely high, even if the probability of fire is low. The thicker vegetation types in the Zuytdorp area, and in areas where spinifex (and/or Buffel Grass) dominates, can carry intense, large and regular wildfires that may adversely effect their biodiversity values and encourage further weed invasion.

Disease and active clearing do not pose significant threats at this time.

Non-Vascular Plants

Non-vascular plants are perhaps the least documented. A list of Lichen species can be obtained from Sammy (1985), but no information is available on mosses or fungi (Keighery 1990).

CONSERVATION MANAGEMENT, RESEARCH AND MONITORING PRIORITIES

Environmental Weeds

- Immediately search for and physically remove all Buffel Grass (*Cenchrus ciliaris*) from Bernier and Dorre Islands Nature Reserves.
- Collate environmental weed list for the Property and rank them in terms of potential environmental damage to World Heritage values.
- Prepare a weed management plan for control/eradication of priority invasive environmental weeds, determine their distribution and implement a weed strategy.
- Western Australian Main Road Department and Shire of Shark Bay to prepare a combined environmental weed plan for access tracks and road corridors under their control.

Stock, Goats and Fire

- Once any pastoral lands are purchased by Government, all stock should be removed. A feral goat control program should be carried out on all conservation lands in the Property. This should be done in conjunction with the systematic closure of artesian bores.
- Operational plans and strategies need to be prepared well in advance of a potential wildfire on the islands (Dirk Hartog, Bernier, Dorre, Salutation) and along the Zuytdorp Coast to guide management on time-effective approaches to combating such fires.

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Complete Systematic Flora Survey

- Complete a systematic survey of extant flora on Dirk Hartog Island (following its purchase by government) and Faure Island. Establish photo points on disturbed sites.
- Analyse the full set of data from permanent plots collected on Kalbarri and Zuytdorp (Gibson *et al.* 2000); Edel Land, Peron Peninsula, Bernier - Dorre Island Nature Reserve (Claymore and Markey 1999), Faure Island and proposed survey on Dirk Hartog Island.
- Finally, determine vegetation types for the Property and map these vegetation types at a scale useful to management.

Encourage further Research

- Encourage research organisations and tertiary students to carry out projects on flora and ecological communities in Shark Bay.
- CALM to prepare an outline for 2-6 tertiary student flora projects for annual SAC endorsement.

Comments received from:

Greg Keighery and Neil Gibson.

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Appendix 1: Natural Heritage Attribute Summary Papers

Natural Heritage Attribute 1.7: Terrestrial Reptiles and Frogs

Paul Hepburn Brown (Ed.)

PRINCIPLE SOURCE:

Norm McKenzie¹ and Ken Aplin²

¹Department of Conservation and Land Management

²Western Australian Museum

CONCLUSIONS:

- The Shark Bay World Heritage Property has a depaupate frog fauna (four species) and an exceptional richness in terrestrial reptile fauna (104 taxa) consisting of 15 geckos, 13 pygopodids, 12 dragons, 4 goannas, 42 skinks and 18 snakes.
- The Property has many terrestrial herpetofauna species at their northern (26 taxa) and southern (10 taxa) limit of their distribution. In addition, eight species characteristic of the arid interior reach the coast at Shark Bay.
- The Property has populations of two taxa classified as *Endangered* the south-western WA population of the Woma (*Aspidites ramsayi*) and Western Spiny-tailed Skink (*Egernia stockesii badia*); two *Vulnerable* taxa the Baudin Island Spiny-tailed Skink (*Egernia stockesii aethiops*) and Hamelin Ctenotus (*Ctenotus zasticus*); plus four species listed as 'Rare or insufficiently known' whose status can not be determined without more information, but are thought to be threatened.
- Shark Bay is remarkable for its wealth of fossorial (living below ground) reptile species including three species of the pygopodid genus *Aprasia* (two endemic), 15 species of the skink genus *Lerista*, five blind snakes (*Ramphotyphlops*) and five species of elapid snakes (*Vermicella*, *Neelaps*, *Simoselaps*).

MOST RELEVANT CRITERIA: (ii) and (iv)

Reference to this Attribute was made in the Nomination Document: page (paragraph); Frogs and Reptiles: p15par7; p16par2-6; p34par2-6; p35par1; p38par3; Plates 11, 26; Appendix 7.

SEE ALSO:

DISCUSSION:

Early Collections

The earliest reptile records from the study area were made during visits by the French navigators Baudin (1801 & 1803) and Freycinet (1818) and the naturalists who accompanied them, notably Peron, Quoy and Gaimard (Storr and Harold 1978). However, their collections were small and poorly localised. Next to visit Shark Bay were the German zoologists W. Michaelsen and R. Hartmeyer in 1905. Although their specimens were accurately localised, well annotated and carefully studied by F. Werner, the leading German herpetologist of the day, such was the backward state of reptile taxonomy that his work is difficult to follow (Storr and Harold 1978).

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Localised collections initially concentrated on the Shark Bay islands: Bernier and Dorre Islands (Douglas and Ride 1962); Faure Island in 1959 (W.H. Butler, unpublished), Dirk Hartog Island (Wells and Wells 1975; Burbidge and George 1978) and on Peron Peninsula (K. Morris, Pers. Comm.). The first comprehensive inventories of the mainland, carried out between 1976 and 1980 by Harold, Peterson and Winton, allowed Storr and Harold (1978, 1980a, 1980b, 1990) to review the ecology of frogs and reptiles known from the Zuytdorp and Shark Bay areas. The composition of reptile and amphibian communities in non-aquatic environments of the southern Carnarvon Basin was described by McKenzie *et al.* (2000b).

The reptile and frog lists provided in Appendix 7 of the nomination document for Shark Bay World Heritage Property (Department of Arts 1990) was based upon Storr and Harold (1978, 1990). The 'Eastern Zone' was the area from Hamelin Pool Station in the south to the Gascoyne River (Carnarvon) in the north and east to the Northwest Coastal Highway. This area was not included within the Property and species noted only for the eastern zone have not been included in this paper unless subsequent collecting has found them within the Property.

Frogs

It is not surprising that only four frog species of the 15 species recorded from the southern Carnarvon Basin (McKenzie *et al.* 2000b) have been recorded from Shark Bay (<4% of the herpetofauna in Appendix 7), as the Property contains no rivers and is generally dry except for shallow claypans following significant rainfall and scattered open bore overflow areas. The Sandhill Frog (*Arenophryne rotunda*) is endemic to the Property, from Dirk Hartog Island, Edel Land and along the coast south to the Murchison River. It needs no free water to breed or survive (Roberts 1985, 1990). *Pseudophryne guentheri* and *Neobatrachus pelobatooides* are a south-west species that has their northern limit in the very south of the Property. None of these frog species are on National or State threatened lists.

Terrestrial Reptiles

One hundred four terrestrial reptile taxa are now known from the Shark Bay World Heritage Property, consisting of 15 geckos, 13 pygopodids, 12 dragons, 4 goannas, 42 skinks and 18 snakes (Appendix 7). The Property contains 12 of the 30 dragon species found in Australia.

McKenzie *et al.* (2000b) found the herpetofaunal assemblages were influenced by environmental processes operating at two geographical scales: (1) a biogeographical scale related to the differences between Eremaean and South-western faunas, and correlating to the study area's arid-to-mesic and tropical-to-temperate climatic gradients, but mitigated by coastal effects in the northern part of the study area, and (2) a local scale related to topographic and soil attributes. As McKenzie *et al.* (2000b, p356) concluded for the southern Carnarvon Basin, the areas total herpetofauna species richness comes from four sources:

1. The Property straddles the biogeographic transition from the South-western to Eremaean Phytogeographic Province, and includes components of the reptile fauna of both regions.
2. The sandy environments that dominate the Eremaean (Australia's red centre) are well represented in the Property, as are a variety of the semi-arid woodlands, sand heaths and coastal habitats of the South-west.
3. Rich *Lerista* assemblages were recorded by McKenzie *et al.* (2000b) in most non-saline habitats and earlier Kendrick (1991) found that there has been a significant radiation of *Lerista* taxa in the region.
4. The arid adapted genera *Diplodactylus*, *Strophurus*, *Ctenophorus*, *Ctenotus* and *Lerista* are very diverse within the Property (5, 6, 8 and 14 species respectively).

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Many southern species are at their northern limit at Shark Bay include the frog *Pseudophryne guentheri* and *Neobatrachus pelobatoides*, the geckos *Phyllodactylus marmoratus* and *Strophurus spinigerus spinigerus*, the pygopodid *Aclys concinna major*, *Aprasia smithi*, *Delma australis*, *Delma fraseri*, *Pletholax gracilis edelensis* and *Pygopus lepidopodus lepidopodus*, the agamid *Tympanocryptis butleri*, the skinks *Ctenotus australis*, *Ctenotus fallens*, *Ctenotus lesueurii*, *Ctenotus pantherinus pantherinus*, *Egernia kingii*, *Egernia multiscutata bos*, *Egernia stokesii aethiops*, *Egernia stokesii badia*, *Morethia obscura* and *Tiliqua rugosa rugosa*, the blind snakes *Ramphotyphlops australis* and *Ramphotyphlops leptosoma*, the python *Aspidites ramsayi*, and the elapid snakes *Neelaps bimaculata* and *Vermicella fasciolata fasciolata*.

Northern species at their southern limit in Shark Bay include the frog *Neobatrachus wilsmorei*, the geckos *Strophurus rankini* and *Diplodactylus klugei*, the pygopodid *Delma nasuta*, the agamid *Ctenophorus rubens*, the skinks *Lerista connivens*, *Lerista uniduo*, *Lerista varia* and *Menetia surda cresswelli*, and the elapid *Demansia calodera*.

Several species characteristic of the arid interior reach the coast at Shark Bay, eg. the leptodactylid frog *Neobatrachus wilsmorei*, the geckos *Diplodactylus squarrosus* and *Strophurus strophurus*, the skinks *Egernia inornata*, *Lerista aff. muelleri* B, *Lerista nichollsi* and *Morethia butleri*, and the monitors *Varanus brevicauda* and *Varanus eremius*. These Eremaean elements have their main ranges to the east of the Property and five other species listed in the nomination document (page 16 and 34) are in fact not found in the Property itself.

The islands, peninsulas and gulfs of Shark Bay provide a refuge for nine relict or endemic species and subspecies: the pygopodids *Aclys concinna major*, *Aprasia haroldi* and *Pletholax gracilis edelensis*, the skinks *Ctenotus youngsoni*, *Ctenotus zasticus*, *Egernia stokesii aethiops* and *Menetia 'amaura'*.

The Property is rich in old Australian elements, e.g. 12 species of diplodactyline geckos and 13 pygopodid lizards. The gecko sub-family Diplodactylinae is confined to Australia, New Zealand, New Caledonia and the Loyalty Islands (Storr, Smith and Johnstone 1990, p7). They lay eggs that have an elastic, parchment-like shell, always number two to a clutch and the eggs are prone to desiccation. Pygopods are confined to Australia and New Guinea (Storr, Smith and Johnstone 1990, p103).

Shark Bay is remarkable for its wealth of fossorial (living below ground) reptile species including three species of the pygopodid genus *Aprasia* (two endemic), 15 species of the skink genus *Lerista*, five blind snakes (*Ramphotyphlops*) and five species of elapid snakes (*Vermicella*, *Neelaps*, *Simoselaps*).

McKenzie et al (2000b) found no evidence of introduced reptile or amphibian species in the southern Carnarvon Basin. There is no reason to suppose that any frog or reptile species has become extinct in Shark Bay during the last 200 years, despite much disturbance. Quadrants visibly degraded by goats, stock and/or rabbits were not significantly poorer in species than those elsewhere in the study area. Other studies have indicated that grazing significantly reduces the abundance of reptiles, but not their species richness.

Threatened Species

The *Endangered* south-western WA population of the Woma (*Aspidites ramsayi*) appears to be close to extinction over most of its range through habitat destruction and predation on

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young snakes. The northern limit to this population is on Peron Peninsula where a significant population appears to still survive. Survey of geographical range, habitat preferences and assessment of threatening processes required within the Property.

The *Endangered* Western Spiny-tailed Skink (*Egernia stockesii badia*) occurs on Peron Peninsula (McKenzie et al. 2000b), Dirk Hartog Island and the semi-arid zone of WA extending from the Gascoyne River south-east to the north-eastern wheatbelt around Kununoppin. Its current distribution has declined in the northern wheatbelt and further survey within the Property is urgently required (Cogger et al. 1993). The *Vulnerable* Baudin Island Spiny-tailed Skink (*Egernia stockesii aethiops*) occurs only on Baudin Island, a small islet nature reserve in Freycinet Estuary, Shark Bay (Storr and Harold 1990). Ecological research is required to determine habitat usage on the island and specific management actions. Baudin Island needs to be protected from fire, introduced predators and damage by tourists.

The *Vulnerable* Hamelin Ctenotus (*Ctenotus zasticus*) is known from a single patch of mallee on two adjacent pastoral properties south-east of Hamelin Homestead (Storr 1984). Further surveys and ecological research is required to determine its current conservation status and to formulate appropriate management strategies (Cogger et al. 1993).

Cogger et al. (1993) in 'The action plan for Australian reptiles' list four other reptiles from Shark Bay as 'Rare or insufficiently known' whose status can not be determined without more information, but are thought to be threatened - the legless lizards *Aclys concinna major* (Edel Land, Nanga), *Aprasia haroldi* (Edel Land), *Pletholax gracilis edelensis* (Edel Land, Zuytdorp) and the skink *Lerista humphriesi* (Zuytdorp).

Type specimens of a number of reptile species were collected in Shark Bay including four by Storr (1978) the legless lizards *Aprasia haroldi* and *Pletholax gracilis edelensis* and skinks *Lerista planiventralis decora* and *Menetia amaura*.

CONSERVATION MANAGEMENT, RESEARCH AND MONITORING PRIORITIES

- Support the consolidation of taxonomic work on specimen collections from Shark Bay and the Carnarvon Basin resulting in the formal publication of new forms or taxa.
- Further broadscale surveys for terrestrial reptiles within the Property should not be supported until taxonomy of local reptiles is consolidated, except for Dirk Hartog Island.
- Complete a systematic survey of herpetofauna on Dirk Hartog Island to collect material useful for molecular genetic analysis (following its purchase by government).
- Communicate results of surveys and research on herpetofauna of Shark Bay to the broader community.

Management systems for the *Endangered*, *Vulnerable* and 'insufficiently known' reptile species within the Property can only be developed following research into species ecology, threatening processes and detailed surveys to determine distribution. These include:

- Protect Baudin Island and its habitat from destructive human use until further information on the Baudin Island Spiny-tailed Skink's (*Egernia stockesii aethiops*) biology, ecology, taxonomic status and distribution are collected.
- Urgent survey work is required to determine the full geographic range of the Hamelin Ctenotus (*Ctenotus zasticus* Storr, 1984) and its single known location should be fenced to exclude stock, feral goats and rabbits.

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Comments received from:

Norm McKenzie.

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Appendix 1: Natural Heritage Attribute Summary Papers

Natural Heritage Attribute 1.8: Terrestrial Mammals

Paul H. Brown (Ed.)

SOURCE:

Norm McKenzie, Bill Muir and Nich Hall
Department of Conservation and Land Management

CONCLUSIONS:

- Fourteen of the original 33 ground-dwelling indigenous species are now extinct from Shark Bay and a further six species are only found on Bernier and Dorre Islands, although some species have recently been reintroduced. The rate of medium-sized mammal extinction from mainland Shark Bay (57%, 19/33) and Dirk Hartog Island (77%, 10/13) is extreme.
- Bernier and Dorre Islands Nature Reserve remains a refuge for 5 species (6 taxa) of medium-sized mammals extinct until recently on mainland Australia and which are Endangered or Vulnerable under the IUCN Red List category for Australia.
- Shark Bay is a transitional zone for Australian mammal fauna. The original mammal fauna has both south-western elements at their northern limit, southern desert species at their north-east limit and central desert species at their east limit. There are no endemic species in Shark Bay, although there are local sub-species.
- Four nationally important mammal reconstruction projects are currently being undertaken in Shark Bay. If successful they will provide valuable information for other species reintroduction projects in semi-arid and arid Australia.
- There have been no extinctions of bat species from Shark Bay.

MOST RELEVANT CRITERIA: (ii) and (iv)

Reference to this Attribute was made in the Nomination Document: page (paragraph);
Terrestrial mammals: p15par3-6; p33par6; p34par1; p35par5-6; p37par8; p38par1;
Plates 9, 10, 27, 30, 31, 32; Appendix 8.

Feral animals: p15par4-5; p23par4&7; p24par4-6.

SEE ALSO:

DISCUSSION:

Mammals (non-bat)

There are useful mammal records prior to 1900 from the Shark Bay Islands and Peron Peninsula (see review by Ride *et al.* 1962). The earliest island records were made in 1699 by William Dampier of HMS Roebuck, whereas the first mainland records were collected on Peron Peninsula in 1801 by scientists and crew of the *Geographe*. Modern mammal surveys were conducted on Bernier and Dorre Islands (Ride and Tyndale-Biscoe 1962), Dirk Hartog Island (Burbidge and George 1978), Heirison Prong (Risbey *et al.* 2000), Peron Peninsula (Keith Morris, personal communication) and the southern Carvarvon Basin, including Shark Bay (McKenzie *et al.* 2000).

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McKenzie et al (2000) reconstructed the original fauna of the southern Carnarvon Basin (including Shark Bay) from lists extracted from the literature, the Western Australian Museum collection, Late Holocene sub-fossil records and their own survey. We have used a subset of their data to reconstruct the World Heritage Property mammal fauna. A total of 33 indigenous species (excluding bats) have been recorded as extant in Shark Bay since European visits began (Appendix 8), although most of the medium-sized mammals have disappeared from the mainland and Dirk Hartog Island over the last 100 years.

The World Heritage Property mainland has one monotreme, one honey possum, four dasyurid, three large macropod, four rodent, six bat and ten introduced species recorded as extant (Appendix 8). In addition one bandicoot, three medium-sized macropod and two rodent species are extant only on Bernier and Dorre Islands.

The mammal list from Appendix 8 in the nomination document (Department of Arts 1990) listed four marsupials (Kultarr, Stripe-faced Dunnart, Pig-footed Bandicoot, Golden Bandicoot) and two bats (Black Flying Fox, Greater Long-eared Bat) recorded east of the Property and these have been excluded from this paper. Mammal species added to the list for the Property in the past 10 years include Fat-tailed Dunnart, White-tailed Dunnart, Hairy-footed Dunnart, Western Grey Kangaroo and the Water Rat.

World Heritage Values

Of the 11 Australian rodent and 53 Australian marsupial taxa classified as *critical*, *endangered* or *vulnerable* (Maxwell *et al.* 1996; Lee 1995), six are found on Bernier and Dorre Islands. They are the Djoongari or Shark Bay Mouse (*Pseudomys fieldi*), Western Barred Bandicoot (*Perameles bougainville bougainville*), Rufous Hare-wallaby (*Lagorchestes hirsutus* subspecies *bernieri* and *dorreae*), Banded Hare-wallaby (*Lagostrophus fasciatus fasciatus*) and Boodie (*Bettongia lesueur lesueur*).

These six mammal taxa are extremely useful in the study of evolution, as it is known that the populations on Bernier and Dorre Islands became separated from the mainland some 7,000 years ago. One of the best known examples to science in the study of island biogeography is the Rufous Hare Wallaby on Bernier and Dorre Island, compared to the Mala or mainland sub-species from the Tanami Desert population.

Bernier and Dorre Islands supports 9 extant species including populations of five medium-sized mammal species extinct on mainland Australia (Burrowing Bettong, Rufous Hare Wallaby, Banded Hare Wallaby, Western Barred Bandicoot, Shark Bay Mouse) as well as the only extant population of Water Rat in the southern Carnarvon Basin. Bernier and Dorre Islands contain the only remaining wild populations of four of these species (although there is a captive population of mainland Mala in the Tanami Desert). The Boodie is only found on these two islands in Shark Bay and on Barrow and Boodie Islands some 600 km further north off the Pilbara coast. These two islands are outstanding features of the World Heritage Property and are of international importance for the protection and conservation of the World's mammal biodiversity. They must be protected from introduced predators, introduced grazers, weeds and human disturbance.

The Banded Hare-wallaby (*Lagostrophus fasciatus*) formally occurred on the Australian mainland and is now only found on Bernier and Dorre Islands. Research into the Banded Hare-wallaby has indicated that the species may be a relict from the Post-Pleistocene

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macropod sub-family Sthenurinae and therefore represent the most primitive Sthenurine known. Thus the most primitive Sthenurine species is arid-adapted. In all other macropodid sub-families, the most primitive known forms are rainforest or wet sclerophyll forest dwellers. The Sthenurines may represent the first group of macropodoids to take advantage of the growing arid areas of Australia, joined later by potoroines and macropodines.

There are five south-western mammal species that reach their northern limit at Shark Bay – Dibbler, Southern Brown Bandicoot, Banded Hare-wallaby, Ash-grey Mouse and the Heath Rat (Baynes 1990).

Extinction Rate

Combined live and sub-fossil records indicate that 19 mammal species have become extinct in the Shark Bay mainland since the time of settlement (Woylie, Crested Nailtail Wallaby, Bilby, Southern Brown Bandicoot, Mulgara, Chuditch, Southern Dibbler, Red-tailed Phascogale, Long-tailed Hopping Mouse, Desert Mouse, Western Chestnut Mouse, Heath Rat, Lesser and Greater Stick-nest Rats, as well as the five Shark Bay Island species). The Pale Field-rat now persists only as isolated populations on Edel Land. Only 15 species remain extant, a 57% (19/33) loss of species since European settlement.

Dirk Hartog Island has had 13 species of indigenous mammal recorded, with only three small ground dwelling species remaining extant (Little long-tailed Dunnart, Ash Grey Mouse, Sandy Inland Mouse). Dirk Hartog has had a long history of grazing by sheep and goats. It has never had foxes or rabbits, but supports a healthy feral cat population.

Bats

McKenzie and Muir (2000) completed the first systematic field survey of bats in the southern Carnarvon Basin and Shark Bay. Their data indicate that the mainland part of the World Heritage Property contains 6 extant bat species, all microbats. They did not sample the Shark Bay islands or Edel Land. The bat fauna represent two temperate species characteristic of the South-west (*Scotorepens balstoni* and *Mormopterus planiceps*) and four widespread species (*Tadarida australis*, *Chalinolobus gouldii*, *Nyctophilus geoffroyi* and *Vespadalus finaysoni*). A single specimen of the Little Red Flying-fox is held at the WA Museum from the homestead garden at Tamala Station. It is a rare seasonal visitor to Shark Bay. *Macroderma gigas* is the only sub-fossil species of bat found in Shark Bay (three exposed coastal deposits at Useless Loop) that is not known in modern collections (McKenzie and Muir 2000). Diversity of bats with a habitat is directly correlated to the complexity in the vegetation structure thus the number of available niches. Peron has only simple shrubland thus two bats.

Table 1: Bats known from the Shark Bay World Heritage Property (from Table 6 in McKenzie and Muir 2000). ‘e’ subfossil deposit. EL - Edel Land not surveyed.

		ZU	NE	NA	PE	EL
White-striped Freetail Bat	<i>Nyctinomus/Tadarida australis</i>	*	*	*	*	-
Lesser Long-eared Bat	<i>Nyctophilus geoffroyi</i>	*	*	*	*	-
Gould’s Wattled Bat	<i>Chalinolobus gouldii</i>	*	*	*		-
Finlayson’s Cave Bat	<i>Vespadalus finaysoni</i>	*	*			-
Southern Freetail Bat	<i>Mormopterus planiceps</i>	*	*	*		-
Inland Broad-nosed Bat	<i>Scotorepens balstoni</i>		*			-
Ghost Bat	<i>Macroderma gigas</i>					e
Little Red Flying-fox	<i>Pteropus scapulatus</i>			*		-

SHARK BAY WORLD HERITAGE PROPERTY

McKenzie and Muir (2000) found a comparison of sub-fossil, historical and contemporary bat records reveal no evidence of the range contractions and extinctions that are overt among other mammal groups (see below). They suggest that bats have persisted because they are less exposed to introduced predators (foxes and feral cats), do not compete with introduced herbivores (rabbits, cattle, sheep, goats, camels) and granivores (house mouse) and can use flight to avoid these threatening processes.

Mammal Reintroductions

Shark Bay has a number of successful indigenous mammal reintroduction sites and mammal reconstruction sites of national/international importance:

- ❑ In 1990 a number of Greater Stick-nest Rats were reintroduced from South Australia to the 162 ha Salutation Island in Freycinet Harbour where they have successfully established. CALM monitors the population at least bi-annually. In 1998 CSIRO and CALM moved some of these animals to Heirisson Prong.
- ❑ Heirisson Prong is a 1,200 ha area on Edel Land managed, since 1992, as an endangered mammal reconstruction site, conservation area and research site by the mining community of Useless Loop and CSIRO Division of Wildlife and Ecology (Short *et al* 1994). The Burrowing Bettong, Western Barred Bandicoot and Greater Stick-nest Rat have been successfully introduced to Heirisson Prong from the Shark Bay islands. The Shark Bay mouse was unsuccessfully reintroduced in 1994. Extensive research has been undertaken on species ecology, extant flora/fauna, the threats from introduced predators (foxes and feral cats) and competition with rabbits.
- ❑ Project Eden was initiated in 1995 by CALM to return ten locally extinct mammal species to the 105,400 ha Peron Peninsula. Control programs for introduced pests (foxes, feral cats, stock and feral goats) and captive breeding programs for threatened species (Bilby, Western Barred Bandicoot, Mala, Banded Hare-wallaby) have been established. The Woylie, Bilby, Mala and Banded Hare-wallaby have been reintroduced to Peron.
- ❑ Faure Island was purchased privately in 1999 for mammal reconstruction.

Introduced Mammals

There are ten species of introduced mammals recorded from Shark Bay, including the dingo. The feral cat (*Felus catus*) and house mouse (*Mus musculus*) were probably introduced pre-European settlement (Burbidge et al 1988), although there appears little evidence of introduction of cats to Western Australia from early Macassan or European vessels (Gaynor 2000). The pastoral industry has operated in Shark Bay since before 1870 (Cooper 1997; Edwards 1999). Sheep, cattle, horses, feral goats, wild dogs and camels have been introduced to the Property in association with the pastoral industry and remain extant. The first fox (*Vulpes vulpes*) was trapped in the late 1920s about 20 km south of Coburn House (Harold Crawford, personal communication) and rabbits (*Oryctolagus cuniculus*) are estimated to have arrived in about 1910 (McKenzie et al 2000). Feral Goats were eradicated from Bernier Island in the mid-1970s (Anon. 1971).

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CONSERVATION MANAGEMENT, RESEARCH AND MONITORING PRIORITIES

Bernier and Dorre Island Nature Reserve

- A single detailed Recovery Plan is required to manage the five threatened mammals (and the Water Rat) on Bernier and Dorre Islands for their long term conservation and their use as a renewable source of breeding stock for mainland reintroductions.

Introduced Species

- Monitor introduced species distribution and numbers. Use best practice techniques to control each introduced species where control will assist threatened species or ecological communities. Remove stock and feral goats from pastoral leases when the State Government purchases them.
- Prepare an 'Action Plan' to set in motion management actions to assess, confirm and combat a reported introduction of exotic pest species to Bernier, Dorre or Salutation Islands.

Threatened Species

- Periodically monitor threatened mammal species populations (at least once every 5 years).

Mammal Recovery Projects

- Support, integrate and distribute information from the four Shark Bay mammal recovery sites – Heirisson Prong, Peron Peninsula, Faure Island and Salutation Island.

Dirk Hartog Island

- Purchase Dirk Hartog Island as a proposed National Park.
- Complete a systematic survey of extant flora and fauna on Dirk Hartog Island (following its purchase by government).
- Investigate program to eradicate stock, feral goats, and feral cats from the island and the re-introduction of its locally extinct mammal fauna (following its purchase by government).

Bats

- Survey bat species on Edel Land and Dirk Hartog.

Comments received from:

Dr Andrew Burbidge, Dr Keith Morris and Dr Norm McKenzie.

SHARK BAY WORLD HERITAGE PROPERTY

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Appendix 1: Natural Heritage Attribute Summary Papers

Natural Heritage Attribute 1.9: Breeding Seabirds

Paul Hepburn Brown (Ed.)

SOURCE:

Dr Andrew Burbidge and Phillip Fuller,
Department of Conservation and Land Management

CONCLUSIONS:

- Shark Bay World Heritage Property is an important area for ‘seabirds’, including 16 species recorded breeding on 42 islands and islets in Shark Bay.
- Shark Bay World Heritage Property is an important seabird breeding area, with some 38 small islands providing excellent nesting sites for species such as the Eastern Reef Egret, Osprey, Pacific Gull, Silver Gull, Caspian Tern, Crested Tern, Roseate Tern, Fairy Tern and Bridled Tern.
- Shark Bay World Heritage Property is at the extremity of distribution for the Pacific Gull, which is a temperate species at the northern end of its range, and the southern most recorded breeding site for the Lesser Crested Tern in WA.
- The Pied Cormorant breeding colonies at Quoin Bluff South on Dirk Hartog Island, Freycinet Island and Pelican Island are the three largest reported in WA.
- The Australian Pelican rookery recorded on Pelican Island is the only colony in Shark Bay and on the Gascoyne Coast.

MOST RELEVANT CRITERIA: (ii) and (iv)

Reference to this Attribute was made in the Nomination Document: page (paragraph); Breeding Seabirds: p17par2; p35par3. Plate 23. Appendix 9.

SEE ALSO:

Appendix 1.10: Terrestrial Birds.

DISCUSSION:

The nomination document for Shark Bay (Department of Arts 1990) states that the rich avifauna of the area includes “over 230 species or 35% of Australia’s bird species”. This paper is the first of a group dealing with breeding ‘seabirds’ of the Shark Bay World Heritage Property. Subsequent papers will address terrestrial water birds and land birds of the Property. This discussion of ‘seabirds’ that depend on the ocean for food and use the islands or mainland of the Shark Bay World Heritage Property for breeding or roosting does not include waders using the tidal flats nor seabirds that do not use land within the Property for breeding. These latter groups are outside the scope of this review of terrestrial ‘values’ of the Property and should be dealt with within a marine priority framework.

SHARK BAY WORLD HERITAGE PROPERTY

Seabirds:

The seabirds of Shark Bay are relatively poorly known. Burbidge *et al.* (1996), when reviewing the seabirds of Western Australia, highlighted the Archipelago of the Recherche, Shark Bay islands and islands of the Kimberley coast, in that order, as the most poorly surveyed for seabird breeding. Burbidge and Fuller (2000) carried out, with World Heritage funding support, a survey of seabirds breeding on the smaller Shark Bay islands in autumn and spring 1997. They also collated all published data, as well as unpublished data from the CALM Seabird Breeding Islands Database (SBID) and from a recent visit to some islands by R.E. Johnstone (Museum of Natural Science, WA Museum) and others.

The traditional definition of seabird includes groups such as shearwaters, gulls and terns (Ross *et al.* 1995). Eleven species have been recorded breeding on 42 islands and islets in Shark Bay that are considered to be true seabirds: Wedge-tailed Shearwater, Australian Pelican, Pied Cormorant, Silver Gull, Pacific Gull, Caspian Tern, Crested Tern, Lesser Crested Tern, Roseate Tern, Bridled Tern and Fairy Tern (Attachment 9A). This compares with the Great Barrier Reef World Heritage Area that supports breeding colonies of 22 species of seabirds on at least 54 'significant' island sites (Lucas *et al.* 1998, p112-117). All the true seabirds have tropical or subtropical affinities except the Pacific Gull, which is a temperate species and is at the northern end of its range at Shark Bay. Shark Bay is at the southern edge of the breeding distribution of the Lesser Crested Tern. The other species have widespread distributions and are found along most of the Australian coastline.

Table 1 provides a summary of the breeding data collected by Burbidge and Fuller (2000) in 1997. Some of the estimates of minimum numbers of breeding pairs are clearly underestimates, as the author's visits did not coincide with peaks of breeding. At the Houtman Abrolhos, Roseate Terns breed in both early summer and autumn, with numbers breeding in summer being much higher (Fuller *et al.* 1994). Autumn breeding at Shark Bay was recorded, but any summer breeding would have been missed. Crested Terns also probably have their peak of breeding in the early summer, again something that was missed. Caspian Terns have a long breeding season along the Western Australian coast and some winter and summer breeding would probably have been missed. Counts for Wedge-tailed Shearwater, Pied Cormorant and Australian Pelican are probably near complete.

With only a few hundred breeding pairs, Wedge-tailed Shearwaters are not common in Shark Bay, but the existence of 'white-breasted phase' birds, reported by Serventy (1972) needs further investigation.

Pied Cormorants are particularly numerous at Shark Bay (Table 1). The breeding colonies at Quoin Bluff South on Dirk Hartog Island, Freycinet Island and Pelican Island are the three largest reported in WA (CALM SBID; Fowler 1947). The large numbers of this species reflect both the large area of protected water within the embayment and the relative abundance of suitable food fish.

The western subspecies of the Pacific Gull *Larus pacificus georgii* is found from Shark Bay to Lancelin on the west coast and, on the south coast, from Cape Leeuwin westwards into South Australia. It is a comparatively rare bird, numbering in the thousands (Burbidge *et al.* 1996).

Seabirds breed on most of the smaller islands in Shark Bay, with a few species, such as Caspian Terns, Ospreys and White-bellied Sea-Eagles breeding in low numbers on the larger (Faure, Dirk Hartog, Dorre, Bemier) islands.

SHARK BAY WORLD HERITAGE PROPERTY

Other 'Oceanbirds' using the Islands

The other breeding species that depend on the ocean for their food and breed mainly on islands are Eastern Reef Egret, Osprey, White-bellied Sea-Eagle, Pied Oystercatcher and Sooty Oystercatcher (Attachment 9A). All five species have widespread distributions and are found along most of the Australian coastline. Further survey on the larger islands (Dirk Hartog, Faure, Bemier and Dorre) will add records, particularly of White-bellied Sea-Eagles, Ospreys and oystercatchers.

Table 1. Summary of breeding seabirds recorded in Shark Bay, May and September 1997 from Burbidge and Fuller (2000).

SPECIES	ESTIMATED MINIMUM TOTAL NUMBER OF BREEDING PAIRS	MINIMUM NUMBER OF BREEDING ISLANDS/ISLETS
Wedge-tailed Shearwater, <i>Puffinus pacificus</i>	580	5
Pied Cormorant, <i>Phalacrocorax varius</i>	3430	7
Australian Pelican, <i>Pelicanus conspicillatus</i>	95	1
Osprey, <i>Pandion haliaetus</i>	20	16
White-bellied Sea-Eagle, <i>Haliaeetus leucogaster</i>	1	1
Pied Oystercatcher, <i>Haematopus longirostris</i>	14	7
Pacific Gull, <i>Larus pacificus</i>	16	7
Silver Gull, <i>Larus novaehollandiae</i>	1000	26
Caspian tern, <i>Stema caspia</i>	11	11
Crested Tern, <i>Stema bergii</i>	441	5
Roseate Tern, <i>Stema dougallii</i>	230	2
Fairy Tern, <i>Stema nereis</i>	3	1

CONSERVATION MANAGEMENT, RESEARCH AND MONITORING PRIORITIES

- Further early summer and autumn seabird surveys on the islands of Shark Bay are required to determine breeding numbers and locations for many of the terns, including Roseate Terns, Crested Terns and Caspian Terns. Adverse weather will be an issue.
- The 'white-breasted phase' Wedge-tailed Shearwaters reported by Serventy (1972) needs further investigation.
- Visits to the larger islands (Dirk Hartog, Faure, Bemier and Dorre) in winter by local CALM staff and volunteers will add records, particularly of White-bellied Sea-Eagles, Ospreys and oystercatchers.
- Continued protection of Shark Bay small islands from human disturbance during seabird breeding will include vesting all as nature reserves, education of boat users, patrols and some restriction of access to small islets, as per Shark Bay Terrestrial Reserves Management Plan (Hancock et al. 2000).

Comments received from:

Dr Andrew Burbidge and Dr Allan Burbidge.

SHARK BAY WORLD HERITAGE PROPERTY

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Appendix 1: Natural Heritage Attribute Summary Papers

Natural Heritage Attribute 1.10: Terrestrial Birds

Paul Hepburn Brown (Ed.)

PRIMARY SOURCE:

R Johnstone, Allan Burbidge, P Stone (2000)
Department of Conservation and Land Management

CONCLUSIONS:

- Shark Bay World Heritage Property has a fauna of 135 species of land bird and 26 terrestrial waterbirds. Considering its dry climate, physiographic uniformity and scarcity of fresh water and woodlands, the Property has a moderately rich land bird avifauna.
- Garnett and Crowley (2000) list five endemic wren sub-species restricted to Dirk Hartog, Bernier and Dorre Islands as *Vulnerable*. Shark Bay remains the stronghold of the *Near Threatened* Thick-billed Grasswren (western form). Small populations of the *vulnerable* Malleefowl, *Near Threatened* Australian Bustard and *Near Threatened* Bush Stone-curlew occur on the Property.
- Southern land birds at their usual northern limit within the Property include the Blue-breasted Fairy-wren, Golden Whistler, Brown-headed Honeyeater, Tawny-crowned Honeyeater, Red Wattlebird, Grey Currawong, Australian Raven, Rock Parrot, Western Yellow Robin, Southern Scrub-robin and Chestnut Quail-thrush.
- Seven northern birds wholly or largely dependent on mangroves have their southern limit in the Property.
- The relatively low number of waterbirds (26 species) reflects the lack of surface water, except after major rains, and low wetland diversity throughout the Property.

MOST RELEVANT CRITERIA: (ii) and (iv)

Reference to this Attribute was made in the Nomination Document [page and paragraph]:
Terrestrial Birds: p17par1-2; p35par2-3; p38par4-6. Plate 12. Appendix 9.

SEE ALSO:

Appendix 1.9: Breeding Seabirds.

DISCUSSION:

The nomination document for Shark Bay (Department of Arts 1990) states that the rich avifauna of the area includes “over 230 species or 35% of Australia’s bird species”. This second natural heritage attribute paper on birds of the Shark Bay World Heritage Property addresses terrestrial water birds and land birds. We have listed in Appendix 9B 135 species of land bird and in Appendix 9C 26 terrestrial waterbirds from the Property.

SHARK BAY WORLD HERITAGE PROPERTY

Early Observations

Carter (1917) and Serventy and Whittell (1967) gave brief accounts of early exploration of Shark Bay by the French at the beginning of the nineteenth century. The earliest records from the study area were made early last century with the visits of the French navigators Baudin and Freycinet and the naturalists who accompanied them, notably Peron, Quoy and Gaimard (Storr and Harold 1978). However, their collections were small and poorly localised.

Next to visit Shark Bay was Thomas Carter, a competent field bird observer resident in the area from 1887, who published a range of his field notes (Carter 1917, 1923). Lawson Whitlock was another field naturalist who provided early bird observations from around Denham and on Dirk Hartog Island (White 1920; Whitlock 1920, 1921). Since then, there were very few detailed sets of observations from Shark Bay until the last few decades (Johnstone et al. 2000).

Localised observations and bird lists for the Shark Bay islands and Peron Peninsula included: Bernier and Dorre Islands (Mees 1962); Dirk Hartog Island (Howard 1978; Sedgwick 1968; Burbidge and George 1978); Peron Peninsula (Brooker 1988) and Shark Bay broadly (Davies and Chapman 1974; Abbott 1977). The occurrence and geographic distribution of the species present has been summarised by Storr (1985) for the Shark Bay region, by Storr (1990) for the Gascoyne Region and by Johnstone et al. (2000) for the southern Carnarvon Basin. All three papers encompass the Property plus a considerable area to the east and north-east.

A comprehensive bird list for Shark Bay was also collated by the RAOU (1996). The bird list included in Appendix 9 of the nomination document (Department of Arts 1990) for Shark Bay World Heritage Property was based upon Storr (1990). A list of land birds for this paper is provided in Appendix 9B and terrestrial water birds in Appendix 9C.

LAND BIRDS

In Appendix 9B, 135 species of land bird from the Property are listed. Considering its dry climate, physiographic uniformity and scarcity of fresh water and woodlands, the Shark Bay World Heritage Property has a moderately rich land bird avifauna (Storr 1990).

Some of this diversity is due to its straddling the South-west and Eremaean Botanical Provinces, which marks the boundary between the acacia-dominated vegetation to the north and the eucalypt-dominated vegetation to the south (see Attribute 1.6: Flora and Vegetation). Several southern land birds attain their northern limit at or near this boundary in the southern section of the Property, e.g. Regent Parrot, Blue-breasted Fairy-wren, Brown-headed Honeyeater, Tawny-crowned Honeyeater, Red Wattlebird, Golden Whistler, Grey Carrawong and Australian Raven. In addition, the Rock Parrot, Western Yellow Robin, Southern Scrub-robin and Chestnut Quail-thrush are at their northern limit on the islands and peninsulas of Shark Bay.

Shark Bay is the southern limit of significant stands of mangroves in Western Australia. Consequently seven northern birds wholly or largely dependent on mangroves have their southern limit in the Property, (a) three from the mangroves along the mainland coast from south of Carnarvon to Gladstone: Brahminy Kite, White-breasted Whistler, Dusky Gerygone; and (b) four from the mainland coast plus the mangrove patches on the peninsulas and islands of Shark Bay: Striated Heron, Mangrove Grey Fantail, White-breasted Woodswallow, Yellow White-eye (Storr 1990; Johnstone et al. 2000).

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Threatened Species

The western sub-species of the *Near Threatened* Thick-billed Grasswren (*Amytornis textilis textilis*) once extended over much of southern Western Australia (Brooker 1999, 2000). Since the early 1900s it has declined markedly in its distribution and is currently restricted to the Shark Bay Region, with a major stronghold on Peron Peninsula and another local population just to the east of the Property on Woodleigh Station and the north-eastern corner of Hamelin Station. It is locally extinct on Dirk Hartog Island (Garnett and Crowley 2000). The Thick-billed Grasswren is an icon bird species for the Shark Bay World Heritage Property.

Garnett and Crowley (2000), in the Action Plan for Australian Birds, lists the five endemic wren taxa from the Shark Bay Islands as *vulnerable* and recommend a number of actions to protect them: • prevent establishment of rats on the islands, • restrict the spread of wildfires, • monitor populations every 3 years, • secure Dirk Hartog Island for the protection of wren habitat. The high level of endemism results from the long term isolation of these islands and the limited opportunities for recolonisation from the mainland. The islands, peninsulas and gulfs of Shark Bay provide refuge for the following taxa of wrens:

- White-winged Fairy-wren (Dirk Hartog Island) *Malurus leucopterus leucopterus*
- Southern Emu-wren (Dirk Hartog Island) *Stipiturus malachurus hartogi*
- Rufous Fieldwren (Dirk Hartog Island) *Calamanthus campestris hartogi*
- Rufous Fieldwren (Dorre Island) *Calamanthus campestris dorrie*
- Variegated Fairy-wren (Bernier and Dorre Islands) *Malurus lamberti bernieri*

The *Near Threatened* Star Finch (*Neochmia ruficauda clarescens*) was listed in the nomination document (Department of Arts 1990), however, its southern limit is just to the east of the Property and it has not been located in Shark Bay (Johnstone et al. 2000, p399).

The *Vulnerable* Malleefowl, *Near Threatened* Australian Bustard and *Near Threatened* Bush Stone-curlew have dramatically reduced in numbers and maintain patchy distribution across the southern half of their extensive ranges. This is thought to be from habitat destruction and predation of nests or ground dwelling sub-adults by foxes. The Malleefowl's north-western limit was historically up to Cape Range-Exmouth, but this has contracted southwards to Tamala Station and along the Zuytdorp coast in Shark Bay. Captive raised Malleefowl were recently reintroduced to Peron Peninsula in 1996-1997 by CALM under the wildlife program 'Project Eden'. The Australian Bustard is a nomadic visitor to the Property.

TERRESTRIAL WATERBIRDS

There are 26 terrestrial waterbirds listed in Appendix 9C (this does not include seabirds eg gulls, cormorants and terns; nor shorebirds or waders). The relatively low number of waterbirds reflects the lack of surface water, except after major rains, and low wetland diversity throughout the Property. There are no naturally permanent freshwater swamps, springs, claypans or river pools. There are no river systems in the Property, although the Wooramel and Gascoyne Rivers reach the sea on the eastern boundary of the Property. The Murchison River is well south of the Property. Along the exposed limestone cliffs of the west coast of Dirk Hartog Island and the Zuytdorp area, small ponds and short, deeply incised streams form after major rainfall events. However, they do not form useful waterbird habitat.

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Birridas (evaporite pans) occur in interdunal depressions across most of the Property, except for the dry south-western section of the Zuytdorp area. Most of the birridas contain gypsum and, although they may be dry for long periods, anecdotal information suggests their water levels show subdued response to oceanic tides (Halse et al. 2000). They have a low diversity of terrestrial waterbirds, but provide periodic wader habitat.

There are a few uncapped artesian bores, which flow constantly, and have formed small artificial swamps. The bores feeding the swamp near Hamelin Station homestead and Peron homestead are examples of this wetland type. However, many of the free-flowing bores on the Property are being capped or permanently closed and the artificial swamps are drying out. The overflow at Hamelin Homestead and Hamelin store account for many of the waterbird records for the Property.

CONSERVATION MANAGEMENT, RESEARCH AND MONITORING PRIORITIES

- General surveys for land or waterbirds of the Property are a low priority. Collation of species lists for conservation reserves and/or sections of the Property from current data sets would be useful. A verification of the bird list in Appendix 9 is also needed.
- Periodic monitoring of the Thick-billed Grass-wren (*Amytornis textilis textilis*) every 5 years following the methodology of Brooker (1999). Significant reduction in abundance and/or distribution will require immediate review of actions and National priorities for the species Interim Recovery Plan (Brooker 2000).
- A survey of the Southern Emu-wren (*Stipiturus malachurus hartogi*) on Dirk Hartog Island is urgently required by a competent ornithologist to determine distribution, habitat preference and relative abundance. During the survey, the opportunity should be taken to survey the other Dirk Hartog wren species (White-winged Fairy-wren, Rufous Fieldwren, Thick-billed Grass-wren). Subsequent monitoring every 5 years should detect changes.
- Birds nesting on the ground (e.g. Malleefowl, Bush Stone-curlew, Banded Lapwing) and close to the ground in dense shrubs (e.g. wren species, Southern Scrub-robin, Samphire Thornbill) would greatly benefit from the control of stock (sheep and cattle) and feral goats. Control programs should be a priority for conservation reserves within the Property and Dirk Hartog Island. Subsequent control of feral cats and/or foxes may also assist.
- Large wildfires that impact significant areas of the Zuytdorp, Peron or Edel Land Peninsulas and the large islands of Shark Bay would be very damaging for bird populations. There should be fire management plans prepared, and resources made available, to limit the adverse impacts of fires within the Property.
- Secure Dirk Hartog Island as a National Park.
- Minor Projects:
 - Study the habitat utilisation and seasonal distribution of the seven mangrove dependent bird species within the Property: Brahminy Kite, White-breasted Whistler, Dusky Gerygone, Striated Heron, Mangrove Grey Fantail, White-breasted Woodswallow, Yellow White-eye. What importance do the mangroves south of Carnarvon and in Shark Bay serve for each species and individuals of the species?
 - Study the use of bore overflows within the Property for waterbirds (and other aquatic flora and fauna) to assist in determining targeted closure and capping of bores.

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- The patches of exotic plantings of Tamarisk and other tree species are being intensively used for nest sites by raptors, owls, butcherbirds, crows and a range of smaller birds. A study of the extent of this usage and behavioural-spatial partitioning of this artificial habitat would be of interest.

Comments received from:

Dr Allan Burbidge.

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Appendix 3: Terrestrial Natural Heritage Attribute List

Collated from Nomination Document (Department of Arts 1990)

PLACE NAMES

Baudin Island	p38par3
Bellefin Prong	p9par8, p12par2, p36par8
Bemier Island	p4par3, p4par5, p6par2, p8par1, p9par7, p13par4-5, p15par3-6, p24par4, p33par6, p34par1, p35par5-6, p38par1, p39par2&6, plate 9-10, 22, 27, 30-34
Big Lagoon	p10par4, p37par1, plate 29
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Carnarvon	p4par10, p8par4
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Edel Land	p4par6, p8par1, p9par7, p10par1, p11par1, p12par2, p13par2-3, p23par5
Faure Island	p9par6, p17par2, plate 23
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Dirk Hartog (Dutch Explorer)	p3par2
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Gaimard (French naturalist)	p3par5
Hamelin (French explorer)	p3par6
Francois Peron (French naturalist)	p3par4, p14par3, p18par2
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<i>Naturaliste</i> (French ship)	p3par4
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<i>Acacia tetragonophylla</i>	p11par3
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<i>Adenanthus acanthophyllus</i> (endemic)	p11par2
<i>Alyogyne huegelii</i> var <i>huegelii</i> (northern limit)	p12par2
<i>Amphipogon turbinatus</i> (northern limit)	Appendix 6
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<i>Atriplex</i>	p12par2
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<i>Baeckea</i> spp. 1 (northern limit)	p11par2
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<i>Beaufortia dampieri</i> (endemic)	p13par4
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<i>Calothamnus</i> spp.1 (northern limit)	p11par2
<i>Calothamnus</i> spp.2 (northern limit)	p11par2
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<i>Delma fraseri</i> (northern limit)	p16par2, p34par3
<i>Delma nasuta</i> (southern limit)	p16par3, p34par4
<i>Pletholax gracilis</i> (northern limit)	p16par2, p34par3
<i>Pletholax gracilis edelensis</i> (endemic, threatened)	p16par5, p34par6, p38par3
<i>Pygopus lepidopodus</i> (northern limit)	p16par2, p34par3

Skinks

<i>Ctenotus fallens</i> (northern limit)	p16par2, p34par3
<i>Ctenotus lesuerii</i> (northern limit)	p16par2, p34par3
<i>Ctenotus youngsoni</i> (endemic, threatened)	p16par5, p34par6, p38par3
<i>Ctenotus zastictus</i> (endemic, threatened)	p16par5, p34par6, p38par3
<i>Egernia badia</i> (northern limit)	p16par2, p34par3
<i>Egernia bos</i> (northern limit)	p16par2, p34par3
<i>Egernia kingii</i> (northern limit)	p16par2, p34par3
<i>Egernia stokesii aethiops</i> (endemic, threatened)	p16par2&5, p34par3&6, p38par3
<i>Egernia depressa</i> (arid)	p16par4, p34par5
<i>Egernia formosa</i> (arid)	p16par4, p34par5
<i>Egernia inornata</i> (arid)	p16par4, p34par5
<i>Lerista</i> – Genera	p16par6, p35par1
<i>Lerista connivens</i>	p38par3
<i>Lerista humphliesi</i>	p38par3
<i>Lerista muelleri</i> (arid)	p16par4, p34par5
<i>Lerista maculosa</i> (relict)	p16par5, p34par6
<i>Lerista petersoni</i> (threatened)	p38par3
<i>Menetia amaura</i> (endemic, threatened)	p16par5, p34par6, p38par3
<i>Morethia obscura</i> (northern limit)	p16par2, p34par3
<i>Morethia butleri</i> (arid)	p16par4, p34par5
<i>Tiliqua rugosa</i> (northern limit)	p16par2, p34par3

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Monitors

<i>Varanus brevicauda</i> (arid)	p16par4, p34par5
<i>Varanus caudolineatus</i> (arid)	p16par4, p34par5
<i>Varanus eremius</i> (arid)	p16par4, p34par5
<i>Varanus giganteus</i> (arid)	p16par4, p34par5

Blind Snakes

Ramphotyphlops leptosoma (northern limit)	p16par6, p35par1 p16par2, p34par3
Ramphotyphlops grypus (southern limit)	p16par2, p34par4

Pythons and Elapid Snakes

<i>Aspidites ramsayi</i> (northern limit, threatened)	p16par2, p34par3, p38par3
<i>Demansia calodera</i> (southern limit)	p16par3, p34par3
<i>Vermicella</i> – Genus	p16par6, p35par1
<i>Vermicella bimaculata</i> (northern limit)	p16par2, p34par3
<i>Vermicella fasciolata</i> (northern limit)	p16par2, p34par3

MAMMALS

	p37par8, p38par1-2
Burrowing Bettong (threatened)	p15par3-6, p33par6, p38par1, plate 27&32
Rufous Hare-wallaby (threatened)	p15par3-6, p33par6, p35par5, p38par1, plates 27&30
Banded Hare-wallaby (threatened)	p15par3-6, p33par6, p35par6, p38par1, plate 27
Shark Bay Mouse (threatened)	p15par3-6, p33par6, p38par1, plate 10, plate 27, 31
Western Barred Bandicoot (threatened)	p15par3-6, p33par6, p38par1, plate 9&27
Greater Stick-nest Rat (threatened)	p 15par5
Ash-grey Mouse (northern limit, threatened)	p15par6, p34par1, p38par1
Little Bat (<i>Eptesicus finslaysoni</i>)	p38par1
Reintroduction of native species	p15par4-5, p24par5
Feral animals	p23par4, p23par7, p24par4-6
Feral Cat	p23par7
Feral Goat	p23par7, p24par4
Fox	p23par7, p24par6
Rabbit	p23par7, p24par6

BIRDS

	p17par1, p35par2, p38par4-5, plate 12
Breeding marine birds	p17par2, p35par3, plate 23
Thick-billed Grasswren (threatened)	p17par2, p35par3, p38par6, plate 12
B&W Winged Fairy-wren (threatened, endemic)	p38par6
Southern Emu-wren (threatened)	p38par6
Regent Parrot (northern limit)	p17par1, p35par2
Western Yellow Robin (northern limit)	p17par1, p35par2
Blue Breasted Fairy Wren (threatened)	p35par2
Striated Heron (southern limit)	p17par1, p35par2
Brahminy Kite (southern limit)	p17par1, p35par2
Dusky Gerygone (southern limit)	p17par1, p35par2
Osprey	p17par2, p35par3
Caspian Tern	p17par2, p35par3
Wedge-tailed Shearwater	p17par2, p35par3

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APPENDIX 7: AMPHIBIAN AND REPTILE SPECIES RECORDED FROM THE SHARK BAY WORLD HERITAGE PROPERTY

Terrestrial reptile and frog species known from the Shark Bay World Heritage Property.

IUCN Red List category: 'Aust' Cogger et al. (1993) for Australian reptiles and Tyler (1997) for Australian frogs. 'WA' WA Wildlife Conservation Act (Specially Protected Fauna) Notice and Ranking 2001. [EX extinct; EN endangered; VU vulnerable; CD conservation dependent; LR low risk]. Other values – N (northern limit), S (southern limit), En (endemic), Ty (type locality) and Is (Islands only). Survey areas – ZU (Zuytdorp), TH (Tamala-Hamelin) EL (Edel Land), Di (Dirk Hartog Island), BD (Bernier-Dorre Is), PE (Peron).

		Aust	WA	ZU	TH	EL	Di/BD	PE
Frogs								
Sandhill Frog	<i>Arenophryne rotunda</i>		En	*		*	*/-	
Humming Frog	<i>Neobatrachus pelobatooides</i>		N	*				
Goldfields Bullfrog	<i>Neobatrachus wilsmorei</i>		S	*				
Guenther's Toadlet	<i>Pseudophryne guentheri</i>		N	*				
Geckos								
Clawless Gecko	<i>Crenadactylus aff. ocellatus horni</i>			*	*	*	*/*	*
	<i>Diplodactylus alboguttatus</i>			*	*	*		*
	<i>Diplodactylus klugei</i>		S					*
	<i>Diplodactylus ornatus</i>			*	*	*	*/*	*
	<i>Diplodactylus pulcher</i>			*	*		-/*	*
	<i>Diplodactylus squarrosusi</i>		Is				* Faure Is	
Tree Dtella	<i>Gehyra variegata</i>			*	*	*	*/*	*
Bynoe's Gecko	<i>Heteronotia binoei</i>			*	*	*	*/*	*
Nob-tailed Gecko	<i>Nephrurus levis occidentalis</i>			*	*	*	*/*	*
Marbled Gecko	<i>Phyllodactylus marmoratus</i>		N			*		
	<i>Strophurus michaelsoni</i>			*				*
	<i>Strophurus rankini</i>		S				-/*	
Western Spiny-tailed Gecko	<i>Strophurus spinigerus spinigerus</i>		N	*	*	*	*/*	
	<i>Strophurus strophurus</i>			*	*		-/*	*
Barking or Thick-tailed Gecko	<i>Underwoodisaurus milii</i>			*		*	*/*	
Pygopodids								
Burton's Snake-lizard	<i>Aclys concinna major</i>		N En			*		*
	<i>Aprasia sp. aff. fusra</i>				*			
	<i>Aprasia haroldi</i>		En Ty			*		
	<i>Aprasia smithi</i>		N Ty	*	*			
	<i>Delma australis</i>		N	*	*			
	<i>Delma butleri</i>			*	*		*/-	*
	<i>Delma fraseri fraseri</i>		N	*	*			
	<i>Delma nasuta</i>		S			*		*
	<i>Delma tincta</i>					*		
	<i>Lialis burtonis</i>			*	*	*	*/*	*
Common Scaly-foot	<i>Pletholax gracilis edelensis</i>		TyEn	*		*		*
	<i>Pygopus lepidopodus lepidopodus</i>		N	*	*	*	*/-	*
Hooded Scaly-foot	<i>Pygopus nigriceps nigriceps</i>				*	*	*	*
Dragons – Agamid Lizards								
Common Scaly-foot	<i>Amphibolurus longirostris</i>				*			*
	<i>Ctenophorus inermis</i>			*	*	*		*
	<i>Ctenophorus maculatus maculatus</i>			*	*	*	*/*	*
	<i>Ctenophorus nuchalis</i>			*				
	<i>Ctenophorus reticulatus</i>			*	*	*	*/*	*
	<i>Ctenophorus rubens</i>		S		*			
	<i>Ctenophorus scutulatus</i>			*	*			*

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		Aust	WA	ZU	TH	EL	Di/BD	PE
Thorny Devil, Mountain Devil	<i>Moloch horridus</i>			*	*			*
	<i>Pogona minor minor</i>			*	*	*	*/-	*
	<i>Tympanocryptis adelaidensis adelaidensis</i>			*	*	*	*/-	
	<i>Tympanocryptis butleri</i>		N	*	*	*	*/-	
	<i>Tympanocryptis parviceps parviceps</i>			*		*	*/-	*
Goannas								
	<i>Varanus brevicauda</i>				*			*
Desert Goanna	<i>Varanus eremius</i>			*	*	*		*
Gould's Goanna	<i>Varanus gouldii</i>			*	*	*	*/-	*
	<i>Varanus tristis tristis</i>			*	*	*		*
Skinks								
	<i>Cryptoblepharus carnabyi</i>			*	*	*	*/-	*
	<i>Cryptoblepharus plagiocephalus</i>			*	*		*/-	
	<i>Ctenotus alleni</i>				*			*
	<i>Ctenotus australis</i>		N	*				
	<i>Ctenotus fallens</i>		N	*	*	*	*/-	*
	<i>Ctenotus lesueurii</i>		N	*		*	*/-	*
	<i>Ctenotus maculatus maculatus</i>			*	*			
	<i>Ctenotus pantherinus pantherinus</i>		N	*	*			*
	<i>Ctenotus schomburgkii</i>			*		*		*
	<i>Ctenotus youngsoni</i>		En		*	*	*/-	
	<i>Ctenotus zasticus</i>		En		*			
	<i>Cyclodomorphus branchialis</i>			*	*	*	*/-	*
	<i>Cyclodomorphus celatus</i>			*	*	*	*/-	*
	<i>Egernia inornata</i>		En Ty		*			
Three Bays Island	<i>Egernia kingii</i>		N Is		*			
Bernier Island	<i>Egernia multiscutata bos</i>		En Is				*/-	
	<i>Egernia stokesii badia</i>		N				*/-	*
Baudin Island Skink	<i>Egernia stokesii aethiops</i>		En Is		*			
	<i>Eremiascincus richardsonii</i>							*
	<i>Lerista connivens</i>		S En		*	*		*
	<i>Lerista elegans</i>			*	*	*	*/-	*
	<i>Lerista humphriesi</i>		En	*				
	<i>Lerista kendricki</i>		En Ty	*	*			
	<i>Lerista lineopunctulata</i>			*	*	*	*/-	*
	<i>Lerista macropisthopus fusciceps</i>				*			*
	<i>Lerista maculosa</i>				*			
	<i>Lerista aff. muelleri B</i>			*				*
	<i>Lerista nichollsi</i>			*				
	<i>Lerista planiventralis decora</i>			*	*			*
	<i>Lerista planiventralis planiventralis</i>					*	*/-	
	<i>Lerista aff. praepedita A</i>			*	*		*/-	
	<i>Lerista aff. praepedita B</i>				*	*	*/-	*
	<i>Lerista uniduo</i>		S		*			*
	<i>Lerista varia</i>		S			*		*
	<i>Menetia 'amaura'</i>		En Ty	*		*		*
	<i>Menetia aff. greyii A</i>			*	*			*
	<i>Menetia surda cresswelli</i>		S	*	*	*	*/-	*

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		Aust	WA	ZU	TH	EL	Di/BD	PE
	<i>Morethia butleri</i>		Ty		*			
	<i>Morethia lineocellata</i>			*	*	*	*/*	*
	<i>Morethia obscura</i>		N	*	*	*		*
Western Blue-tongued Lizard	<i>Tiliqua occipitalis</i>				*	*		*
Bobtail	<i>Tiliqua rugosa rugosa</i>		N	*	*	*	*/*	*
Blind Snakes								
Southern Blind Snake	<i>Ramphotyphlops australis</i>		N		*	*	-/*	
	<i>Ramphotyphlops grypus A</i>							*
	<i>Ramphotyphlops hamatus</i>			*	*	*		*
	<i>Ramphotyphlops leptosoma</i>		N	*				
	<i>Ramphotyphlops waitii</i>			*	*			
Pythons								
Woma or Ramsay's Python	<i>Aspidites ramsayi</i>		N					*
Stimson's Python	<i>Morelia stimsoni stimsoni</i>						*/*	*
Elapid Snakes								
Black-necked Whip Snake	<i>Demansia calodera</i>		S		*	*	*/*	*
Yellow-faced Whipsnake	<i>Demansia psammophis reticulata</i>			*	*	*	*/-	*
Moon or Orange-naped Snake	<i>Furina ornata</i>					*		*
Western Black-naped Snake	<i>Neelaps bimaculata</i>		N		*	*		
Mulga or King Brown Snake	<i>Pseudechis australis</i>			*	*	*	*/*	*
Ringed Brown Snake	<i>Pseudonaja modesta</i>			*	*	*	*/*	*
Gwardar	<i>Pseudonaja nuchalis</i>			*	*	*	*/-	*
Monk or Hooded Snake	<i>Rhinoplocephalus monachus</i>			*	*	*		*
Jan's or Desert Banded Snake	<i>Simoselaps bertholdi</i>				*			*
West Coast Banded Snake	<i>Simoselaps littoralis</i>			*	*		*/*	*
Narrow-banded Snake	<i>Vermicella fasciolata fasciolata</i>		N	*	*	*	*/-	*

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APPENDIX 8: TERRESTRIAL MAMMAL SPECIES RECORDED FROM THE SHARK BAY WORLD HERITAGE PROPERTY

Indigenous mammal species known from the Shark Bay World Heritage Property based on Table 6 in McKenzie *et al* 2000. Bats not listed below, but in attribute paper on mammals in Table 1.

IUCN Red List category: 'Aust' Maxwell *et al* (1996, Table 1) for Australian marsupials and Lee (1995) for Australian rodents. 'WA' WA Wildlife Conservation Act (Specially Protected Fauna) Notice 2001. [EX extinct; EN endangered; VU vulnerable; CD conservation dependent; LR low risk]

'Local' extant presence within World Heritage Property [ex locally extinct; Is Bernier/Dorre only; re remaining] Survey areas – ZU (Zuytdorp), EL (Edel Land), DHI (Dirk Hartog Island), BD (Bernier-Dorre Is), PE (Peron) Species records from – 'a' captures by McKenzie *et al* 2000; 'b' WA Museum specimens; 'c' published literature; 'e' sub-fossil records.

		Aust	WA	Local	ZU	EL	DHI/BD	PE
Dasyurids								
Mulgara	<i>Dasyercus cristicauda</i>	VU	VU	ex	e	e	e/-	e
Chuditch; Western Quoll	<i>Dasyurus geoffroi</i>	VU	VU	ex	-	e	e/-	c
Southern Dibbler	<i>Parantechinus apicalis</i>	EN	EN	ex	e	e	e/-	-
Red-tailed Phascogale	<i>Phascogale calura</i>	EN	EN	ex	-	e	-	e
Fat-tailed Dunnart	<i>Sminthopsis crassicaudata</i>	VU		re	b	-	-	a
Little long-tailed Dunnart	<i>Sminthopsis dolichura</i>	LR(lc)		re	a	a	b/-	a
White-tailed Dunnart	<i>Sminthopsis granulipes</i>	LR(lc)		re	a	-	-	-
Hairy-footed Dunnart	<i>Sminthopsis hirtipes</i>	LR(lc)		re	a	-	-	b
Bandicoots								
Bilby	<i>Macrotis lagotis</i>	VU	VU	ex	-	-	-	-
Western Barred Bandicoot	<i>Perameles bougainville</i>	EN	EN	Is	e	e	e/c	c
Southern Brown Bandicoot	<i>Isodon obesulus</i>	LR(nt)	CD	ex	e	e	-	-
Macropods								
Boobie/Burrowing Bettong	<i>Bettongia lesueur</i>	VU	VU	Is	-	e	c/c	-
Woylie; Brush-tailed Bettong	<i>Bettongia penicillata</i>	LR(cd)	CD	ex	-	e	e/-	c
Rufous Hare-Wallaby	<i>Lagorchestes hirsutus</i>	VU	VU	Is	-	-	-/c	e
Banded Hare Wallaby	<i>Lagostrophus fasciatus</i>	VU	VU	Is	-	-	c/c	e
Western Grey Kangaroo	<i>Macropus fuliginosus</i>	LR(lc)		re	a	-	-	-
Euro; Common Wallaroo	<i>Macropus robustus</i>	LR(lc)		re	b	b	-	a
Red Kangaroo	<i>Macropus rufus</i>	LR(lc)		re	b	-	-	-
Crested Nailtail Wallaby	<i>Onychogalea lunata</i>	EX	EX	ex	-	-	-	e
Native Rodents								
Water Rat	<i>Hydromys chrysogaster</i>	LR		Is	-	-	-/c	-
Spinifex Hopping Mouse	<i>Notomys alexis</i>	LR		re	a	e	-	a
Long-tailed Hopping Mouse	<i>Notomys longicaudatus</i>	EX	EX	ex	-	e	-	-
Ash-grey Mouse	<i>Psuedomys albocinereus</i>	LR		re	a	a	b/b	b
Desert Mouse	<i>Psuedomys desertor</i>	K		ex	-	e	e/c	-
Shark Bay Mouse	<i>Psuedomys fieldi</i>	EN	VU	Is	e	e	e/c	c
Sandy Inland Mouse	<i>Psuedomys hermannsburgensis</i>			re	a	a	b/-	a
Western Chestnut Mouse	<i>Psuedomys nanus</i>	LR		ex	e	e	-	-
Heath Rat	<i>Psuedomys shortridgei</i>	EN	VU	ex	e	e	e/-	-
Pale Field Rat	<i>Rattus tunneyi</i>	LR		re	e	c	-	e
Lesser Stick-nest Rat	<i>Leporillus apicalis</i>	EX	EX	ex	-	e	-	e
Greater Stick-nest Rats	<i>Leporillus conditor</i>	VU	VU	ex	e	e	e/-	e
Other Mammals								
Honey Possum	<i>Tarsipes rostratus</i>	LR(lc)		re	a	-	-	-
Echidna	<i>Tachyglossus aculeatus</i>	LR(lc)		re	a	e	-	a

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**APPENDIX 9: BIRD SPECIES RECORDED FROM THE SHARK BAY
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LIST 9A: SEABIRDS BREEDING ON SHARK BAY ISLANDS

Data based on Burbidge and Fuller (2000). Breeding sites in Shark Bay: ZU (coastline Zuytdorp Cliffs); Fr (Freycinet Inlet); Di (Dirk Hartog Island); BD (Bernier and Dorre Islands); EG (eastern gulf, including Peron and islands). No non-breeding 'seabirds' were noted by Burbidge and Fuller (2000) on the islands of Shark Bay and none are listed below as they do not appear to be using the terrestrial part of the Property.

		Status	Breed	ZU	Fr/Di	BD	EG
TRUE SEABIRDS							
Procellariidae							
Wedge-tailed Shearwater	<i>Puffinus pacificus</i>		B		*/-		
Phalacrocoracidae							
Pied Cormorant	<i>Phalacrocorax varius</i>		B	*	*/*	*	*
Pelecanidae							
Australian Pelican	<i>Pelicanus conspicillatus</i>		B				*
Laridae							
Pacific Gull	<i>Larus pacificus</i>	N	B		*/-	*	*
Silver Gull	<i>Larus novaehollandiae</i>		B	*	*/*	*	*
Caspian Tern	<i>Sterna caspia</i>		B		*/*	*	*
Crested Tern	<i>Sterna bergii</i>		B		*/-	*	
Lesser Crested Tern	<i>Sterna bengalensis</i>	S			*/-		
Roseate Tern	<i>Sterna dougallii</i>		B		*/-		
Fairy Tern	<i>Sterna nereis nereis</i>		B		*/*	*	
Bridled Tern	<i>Sterna anaethetus anaethetus</i>		B		*/*		
BIRDS DEPENDENT ON THE OCEAN FOR FOOD							
Ardeidae							
Eastern Reef Egret	<i>Egretta sacra</i>		B	*	*/*	*	*
Accipitridae							
Osprey	<i>Pandion haliaetus</i>		B	*	*/*	*	*
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>		B	*	*/*	*	*
Haematopodidae							
Pied Oystercatcher	<i>Haematopus longirostris</i>		B		*/*	*	*
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>		B			*	

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**APPENDIX 9: BIRD SPECIES RECORDED FROM THE SHARK BAY
WORLD HERITAGE PROPERTY**

LIST 9B LAND BIRDS

Bird species known from the Shark Bay World Heritage Property based on Johnstone *et al* 2000. The list has been divided into A) 'seabirds' breeding in Shark Bay, B) land birds and C) terrestrial water birds to reflect papers in document. Shorebirds have not been listed as they are principally associated with the marine environment.

IUCN Red List category under 'Status': Garnet and Crowley (2000) for Australian birds. [EX extinct; EN endangered; VU vulnerable; CD conservation dependent]. Species at their northern (N) or southern (S) limit of their range in Western Australia.

Survey areas – ZU (Zuytdorp), h (Hamelin Pool only), EL (Edel Land), DHI (Dirk Hartog Island), BD (Bernier-Dorre Is), PE (Peron and Nanga), (c) (mangroves between Carnarvon and Gladstone).

		Status	Breeding	ZU	EL	DHI/BD	PE
Casuariidae							
Emu	<i>Dromaius novaehollandiae</i>		B	*	*		*
Megapodiidae							
Malleefowl	<i>Leipoa ocellata</i>	VU/N	B	*			*
Phasianidae							
Stubble Quail	<i>Coturnix pectoralis</i>		B	*	*	*/-	*
Accipitridae							
Black-shouldered Kite	<i>Elanus caeruleus axillaris</i>						*
Letter-winged Kite	<i>Elanus scriptus</i>			*	*		*
Square-tailed Kite	<i>Hamirostra isura</i>			*			
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>			*			
Whistling Kite	<i>Haliastur sphenurus</i>			h		*/-	*
Brahminy Kite	<i>Haliastur indus girrenera</i>	S					*(c)
Brown Goshawk	<i>Accipiter fasciatus fasciatus</i>		B	*		*/-	*
Collared Sparrowhawk	<i>Accipiter cirrhocephalus cirrhocephalus</i>		B	*		*/-	*
Little Eagle	<i>Aquila morphnoides morphnoides</i>				*	*/-	*
Wedge-tailed Eagle	<i>Aquila audax</i>		B	*	*	*/*	*
Spotted Harrier	<i>Circus assimilis</i>		B	*		*/-	*
Falconidae							
Brown Falcon	<i>Falco berigora berigora</i>		B	*	*	*/-	*
Australian or Nankeen Kestrel	<i>Falco cenchroides cenchroides</i>		B	*	*	*/*	*
Australian Hobby	<i>Falco longipennis longipennis</i>		B	*	*	*/*	*
Peregrine Falcon	<i>Falco peregrinus macropus</i>			*	*		*
Otididae							
Australian Bustard	<i>Ardeotis australis</i>	Near Th	B	*		*/-	*
Turnicidae							
Little Button-quail	<i>Turnix velox</i>						*
Burhinidae							
Bush Stone-curlew	<i>Burhinus grallarius</i>	Near Th	B			*/-	*
Charadriidae							
Banded Lapwing	<i>Vanellus tricolor</i>		B	*	*	*/-	*
Inland Dotterel	<i>Peltohyas australis</i>		B			*/-	

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			Status	Breeding	ZU	EL	DHI/BD	PE
Columbidae								
* Domestic Pigeon	<i>Columba livia</i>			B	*		*/-	*
Rock Dove								*
* Laughing Turtle-dove	<i>Streptopelia senegalensis senegalensis</i>			B	*		*/-	*
Common Bronzewing	<i>Phaps chalcoptera</i>			B	*	*	*/-	*
Crested Pigeon	<i>Ocyphaps lophotes</i>				*	*	-/-	*
Diamond Dove	<i>Geopelia cuneata</i>			B	*	*	*/-	
Peaceful Dove	<i>Geopelia striata placida</i>				h			
Psittacidae								
Red-tailed Black Cockatoo	<i>Calyptorhynchus banksii samueli</i>			B	*			
Galah	<i>Cacatua roseicapilla roseicapilla</i>			B	*	*	*/-	*
Little Corella	<i>Cacatua sanguinea westralensis</i>					*	*/-	*
Major Mitchell's Cockatoo	<i>Cacatua leadbeateri</i>				*			
Cockatiel	<i>Nymphicus hollandicus</i>				h		*/-	*
Regent Parrot	<i>Polytelis anthopeplus anthopeplus</i>	N			*			*
Australian Ringneck	<i>Platycercus zonarius zonarius</i>			B	*			
Mulga Parrot	<i>Platycercus varius</i>				*			*
Elegant Parrot	<i>Neophema elegans</i>				*			
Rock Parrot	<i>Neophema petrophila</i>	N		B		*	*/-	*
Budgerigar	<i>Melopsittacus undulatus</i>						*/-	*
Cuculidae								
Pallid Cuckoo	<i>Cuculus pallidus</i>				*	*	*/*	*
?Fan-tailed Cuckoo	<i>Cacomantis flabelliformis flabelliformis</i>				*			*
Black-eared Cuckoo	<i>Chrysococcyx osculans</i>				h			*
Horsfield's Bronze Cuckoo	<i>Chrysococcyx basalis</i>			B	*	*	*/*	*
Shining Bronze Cuckoo	<i>Chrysococcyx lucidus plagosus</i>							*
Strigidae								
Boobook Owl	<i>Ninox novaeseelandiae boobook</i>						*/	
Tytonidae								
Barn Owl	<i>Tyto alba delicatula</i>			B		*	-/*	*
Podargidae								
Tawny Frogmouth	<i>Podargus strigoides brachypterus</i>			B	*			*
Caprimulgidae								
Spotted Nightjar	<i>Eurostopodus argus</i>			B	*		*/*	*
Aegothelidae								
Australian Owlet-nightjars	<i>Aegotheles cristatus cristatus</i>				*			*
Apodidae								
Fork-tailed Swift	<i>Apus pacificus pacificus</i>							*
Halcyonidae								
Sacred Kingfisher	<i>Todiramphus sanctus sanctus</i>							*
Meropidae								
Rainbow Bee-eater	<i>Merops ornatus</i>				*	*		*
Maluridae								
Splendid Fairy-wren	<i>Malurus splendens splendens</i>			B	*	*	*/-	*
Variiegated Fairy-wren	<i>Malurus lamberti assimilis</i>			B	*	*	*/-	*
Variiegated Fairy-wren	<i>Malurus lamberti bernieri</i>	VU		B			-/*	
Blue-breasted Fairy-wren	<i>Malurus pulcherrimus</i>	N		B	*			*
White-winged Fairy-wren	<i>Malurus leucopterus leuconotus</i>			B	*	*	-/-	*

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		Status	Breeding	ZU	EL	DHI/BD	PE
White-winged Fairy-wren	<i>Malurus leucopterus leucopterus</i>	VU	B			*/-	
Southern Emu-wren	<i>Stipiturus malachurus hartogi</i>	VU	B			*/-	
Rufous Field-wren	<i>Calamanthus campestris hartogi</i>	VU	B			*/-	
Rufous Field-wren	<i>Calamanthus campestris dorrie</i>	VU	B			-/*	
Rufous Field-wren	<i>Calamanthus campestris</i>		B		*		*
Thick-billed Grass-wren	<i>Amytornis textilis textilis</i>	NearTh	B			*/-	*
Pardalotidae							
Striated Pardalote	<i>Pardalotus striatus westraliensis</i>		B	*	*		
Acanthizidae							
White-browed Scub-wren	<i>Sericornis frontalis balstoni</i>	N	B	*	*	*/*	*
Rufous Fieldwren	<i>Calamanthus campestris</i>		B	*	*	*/*	*
Redthroat	<i>Pyrrholaemus brunneus</i>		B		*		*
Weebill	<i>Smicronis brevirostris</i>			*			
Western Gerygone or Warbler	<i>Gerygone fusca fusca</i>			*			*
Dusky Gerygone	<i>Gerygone tenebrosa</i>	S	B				(c)
Broad-tailed Thornbill	<i>Acanthiza apicalis</i>		B		*		*
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>		B				*
Samphire Thornbill	<i>Acanthiza iredaleri iredaleri</i>		B		*		*
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>		B	*			*
Southern Whiteface	<i>Aphelocephala leucopsis castaneiventris</i>			h			
Maliphagidae							
Brown Honeyeater	<i>Lichmera indistincta indistincta</i>		B	*	*	*/-	*
Black Honeyeater	<i>Certhionyx niger</i>			h			*
Pied Honeyeater	<i>Certhionyx variegatus</i>		B	*	*		*
Singing Honeyeater	<i>Lichenostomus virescens</i>		B	*	*	*/*	*
Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>			t			*
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>			*	*		*
Brown-headed Honeyeater	<i>Melithreptus brevirostris leucogenys</i>	N	B	*			*
White-fronted Honeyeater	<i>Phylidonyris albifrons</i>			*	*		*
Tawny-crowned Honeyeater	<i>Phylidonyris melanops</i>	N	B	*			
Yellow-throated Miner	<i>Manorina flavigula</i>			*			
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>		B	*	*	*/-	*
Red Wattlebird	<i>Anthochaera carunculata</i>	N		*			
White-fronted Chat	<i>Ephthianura albifrons</i>		B	h		*/-	*
Orange Chat	<i>Ephthianura aurifrons</i>		B	h			*
Crimson Chat	<i>Ephthianura tricolor</i>		B	h	*	*/-	*
Petroicidae							
Red-capped Robin	<i>Petroica goodenovii</i>		B	h	*	*/-	*
Hooded Robin	<i>Petroica cucullata</i>		B			*/-	*
Western Yellow Robin	<i>Eopsaltria australis griseogularis</i>	N	B	*	*		*
Southern Scrub-robin	<i>Drymodes brunneopygia</i>	N	B	*		*/-	*
Pomatostomidae							
White-browed Babbler	<i>Pomatostomus superciliosus</i>		B	*	*	*/-	*
Cinclosomatidae							
Western or Chiming Wedgebill	<i>Psophodes occidentalis</i>		B	t	*	*/-	*
Chestnut Quail-thrush	<i>Cinclosoma castanotus</i>	N	B	*	*		*
Neosittidae							
Varied Sittella	<i>Daphoenositta chrysoptera pileata</i>			*			

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			Status	Breeding	ZU	EL	DHI/BD	PE
Pachycephalidae								
Crested Bellbird	<i>Oreoica gutturalis</i>			B	*	*	*/-	*
Golden Whistler	<i>Pachycephala pectoralis fuliginosa</i>	N			*			
Rufous Whistler	<i>Pachycephala rufiventris rufiventris</i>			B	*	*		*
White-breasted Whistler	<i>Pachycephala lanioides</i>	S						(c)
Grey Shrike-thrush	<i>Colluricincla harmonica rufiventris</i>			B	*	*		*
Dicruridae								
Mangrove Grey Fantail	<i>Rhipidura phasiana</i>	S		B				*(c)
Grey Fantail	<i>Rhipidura fuliginosa preissi</i>			B	*			*
Willie Wagtail	<i>Rhipidura leucophrys leucophrys</i>			B	*	*	*/-	*
Magpie Lark	<i>Grallina cyanoleuca</i>						*/-	*
Campephagidae								
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae novaehollandiae</i>			B	*		*/-	*
White-winged Triller	<i>Lalage tricolor</i>			B	*			*
Artamidae								
White-breasted Woodswallow	<i>Artamus leucorhynchus leocopygialis</i>	S						*(c)
Masked Woodswallow	<i>Artamus personatus</i>			B		*		*
Black-faced Woodswallow	<i>Artamus cinereus melanops</i>			B	*		*/-	*
Dusky Woodswallow	<i>Artamus cyanopterus</i>	N			*			*
Little Woodswallow	<i>Artamus minor</i>				*		*/-	*
Cracticidae								
Grey Butcherbird	<i>Cracticus torquatus torquatus</i>			B	*	*	*/-	*
Pied Butcherbird	<i>Cracticus nigrogularis</i>				*			
Australian Magpie	<i>Cracticus tibicen tibicen</i>				*			
Grey Currawong	<i>Strepera versicolor plumbea</i>	N			*			
Little Crow	<i>Corvus bennetti</i>			B	*	*	*/*	*
Australian Raven	<i>Corvus coronoides perplexus</i>	N		B	*			
Hirundinidae								
White-backed Swallow	<i>Cheramoeca leucosternum</i>			B		*	*/-	*
Welcome Swallow	<i>Hirundo neoxena</i>			B	*	*	*/*	*
Tree Martin	<i>Hirundo nigricans nigricans</i>			B	*	*	*/-	*
Fairy Martin	<i>Hirundo ariel</i>							*
Zosteropidae								
Yellow White-eye	<i>Zosterops luteus</i>	S		B				*(c)
Western Silver-eye	<i>Zosterops lateralis gouldii</i>			B		*	*/*	*
Sylviidae								
Australian Reed Warbler	<i>Acrocephalus australia gouldi</i>					h		
Little Grassbird	<i>Megalurus gramineus gramineus</i>					h		
Brown Songlark	<i>Cinloramphus cruralis</i>					*	*	*/*
Alaudidae								
Singing Bushlark	<i>Mirafrja javanica horsfieldi</i>					h		
Dicaeidae								
Mistletoebird	<i>Dicaeum hirundinaceum hirundinaceum</i>						*	*/-
Passeridae								
Zebra Finch	<i>Taeniopygia guttata castanotis</i>			B	*	*	*/-	*
Motacillidae								
Australian Pipit	<i>Anthus australis australis</i>			B	*	*	*/*	*

SHARK BAY WORLD HERITAGE PROPERTY

LIST 9C: TERRESTRIAL WATER BIRDS

Bird species known from the Shark Bay World Heritage Property based on Johnstone *et al* 2000. The list has been divided into A) 'seabirds' breeding in Shark Bay, B) land birds and C) terrestrial water birds to reflect papers in document. Shorebirds have not been listed as they are principally associated with the marine environment.

IUCN Red List category under 'Status': Garnet and Crowley (2000) for Australian birds. [EX extinct; EN endangered; VU vulnerable; CD conservation dependent]. Species at their northern (N) or southern (S) limit of their range in Western Australia.

Survey areas – ZU (Zuytdorp), h (bore overflow wetlands at Hamelin Pool only), EL (Edel Land), DHI (Dirk Hartog Island), BD (Bernier-Dorre Is), PE (Peron and Nanga).

		Status	Breeding	ZU	EL	DHI/BD	PE
Anatidae							
Black Swan	<i>Cygnus atratus</i>			h			
Australian Shelduck	<i>Todorna tadornoides</i>	N		h		*/-	
Australian Wood Duck	<i>Chenonetta jubata</i>			h			
Grey Teal	<i>Anas gibberifrons</i>		B	*	*	*/-	*
Pacific Black Duck	<i>Anas superciliosa</i>			h			
Australian Shoveler	<i>Anas rhynchotis rhynchotis</i>			h			
Australasian							
Podicipedidae							
Australasian Grebe	<i>Tachybaptus novaehollandiaenovaehollandiae</i>			h			
Hoary-headed Grebe	<i>Poliocrphalus poliocephalus</i>			h			
Ardeidae							
White-necked Heron	<i>Ardea pacifica</i>			h			
White-faced Heron	<i>Ardea novaehollandiae</i>		B	*	*	*/*	*
Intermediate Egret	<i>Ardea intermedia</i>				*		
Little Egret	<i>Ardea garzetta nigripes</i>			h			*
Eastern Reef Heron	<i>Ardea sacra sacra</i>		B	*	*	*/*	*
Nankeen Night Heron	<i>Nycticorax caledonicus</i>						*
Striated Heron	<i>Butorides striatus stagnatilis</i>	S	B				*
Threskiornithidae							
Glossy Ibis	<i>Plegadis falcinellus</i>			h			
Straw-necked Ibis	<i>Threskiornis spinicolis</i>			h			
Yellow-billed Spoonbill	<i>Platalea flavipes</i>			h			
Rallidae							
Buff-banded Rail	<i>Gallirallus philippensis</i>			h		*/-	
Baillon's Crake	<i>Porzana pusilla palustris</i>			h			
Australian Spotted Crake	<i>Porzana fluminea</i>		B	h			
Spotless Crake	<i>Porzana tabuensis</i>			h			
Black-tailed Native Hen	<i>Gallinula ventralis</i>			h			
Eurasian Coot	<i>Fulica atra australis</i>		B	h			
Recurvirostridae							
Black-winged Stilt	<i>Himantopus himantopus leucocephalus</i>			h		*/-	
Sylviidae							
Australian Reed Warbler	<i>Acrocephalus australis gouldi</i>			h			