Donato Environmental Services
ABN: 68083 254 015
Mobile: 0417 819 196
Int'l mobile: +61 417 819 196
Email: ddonato@rbe.net.au

Lipson Island baseline flora and fauna report and assessment of risk

Final report to:
Golder Associates
November 2011

FINAL REPORT

DES
DONATO
ENVIRONMENTAL SERVICES

Disclaimer

This report has been prepared and produced by Donato Environmental Services (ABN 68083 254 015) in good faith and in line with the Terms of Engagement between Golder Associates Pty Ltd and Donato Environmental Services.

Citation

Madden-Hallett, D. M., Hammer, M., Gursansky, W. and Donato, D. B., 2011. Lipson Island baseline flora and fauna report and assessment of risk. For Golder Associates, Donato Environmental Services, Darwin.

Table 1. Distribution

Receivers	Copies	Date Issued	Contact name
Golder Associates	Draft report (electronic)	11 July 2011	Rebecca Powlett
DES	Draft report (electronic)	31 August 2011	Danielle Madden-Hallett
Golder Associates	Final report (electronic)	16 September 2011	Rebecca Powlett
DES	Electronic comment	26 October 2011	David Donato
Golder Associates	Final report (electronic)	30 October 2011	Jennifer Boniface
DES	Electronic comment	1 November 2011	David Donato
Golder Associates	Final report (electronic)	7 November 2011	Jennifer Boniface

Executive summary

Golder Associates Pty Ltd approached Donato Environmental Services (DES) for a qualitative and quantitative assessment of flora and fauna within the Lipson Island Conservation Park, including the intertidal environments. Centrex Metals Ltd (Centrex) has extensive tenement holdings over iron ore resources and exploration targets on Eyre Peninsula in the southern Gawler Craton. The lack of Infrastructure to export resources from proposed Centrex operations has lead to Centrex proposing a marine port facility at Sheep Hill, Eyre Peninsula, South Australia. The development was formally gazetted as a major project on 6 January 2011, including the Port road access corridor and slurry pipelines of Swaffers road.

The DES work includes a baseline assessment of the ecology and the potential impacts to the Lipson Island Conservation Park as a result of the proposed port construction and operation. Lipson Island Conservation Park is situated 150 m offshore from the lower eastern Eyre Peninsula, South Australia, 20 km north of Tumby Bay and approximately 1.5 km south from the Port proposed by Centrex. It is designated a conservation reserve and managed under the *National Parks and Wildlife Act* 1972 (NPW Act). No management plan has been adopted for the reserve.

Formal biological surveys have not been undertaken at Lipson Island Conservation Park, a low-lying intertidal island with a total area of 6 ha and consisting of a granite platform with limestone capping. The dominant vegetation at the centre of the island is *Nitraria billardera*. The outer rim of the island has little or no vegetation and consists of exposed rocky outcrops, sand and grit. The tidal swing can be up to 1.6 m [3].

The objectives of this baseline study, assessment and subsequent report are to:

- characterise the existing flora and fauna species and habitat types of the project's potential area of impact, with particular focus on species and communities of conservation significance (local, regional, state or national);
- identify potential project constraints associated with flora and fauna; and
- identify, interpret and mitigate the potential impacts.

A search of published literature and relevant databases was carried out prior to the field survey to determine the potential presence of conservation-significant flora and fauna species. Terrestrial and intertidal surveys were conducted on 29 and 30 May 2011.

Lipson Island is a significant rookery and roost for bird species including those listed under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and relevant state legislation. The marine intertidal environment, although not diverse, is free of invasive species. Potential risks have been identified and managed with relevant management plans to maintain the ecological integrity of the island. These include:

- seabird rookery noise disturbance impact mitigation plan;
- seabird rookery light disturbance impact mitigation plan;
- soil erosion and siltation management plan;
- weed management plan;
- siltation and turbidity management plan;

- dust abatement plan;
- integrated feral animal management plan;
- industry standard ballast water management plan;
- uncontrolled spill management plan;
- uncontrolled spill contingency emergency plans;
- uncontrolled release of hard waste (of entrapment and entanglement with hazards) management plan;
- wildlife entanglement contingency emergency plans;
- a staff access and activity policy; and
- invasive species (Silver Gull) management plan.

This assessment has also identified some site-specific impacts that require specific monitoring or further investigation. These include but are not necessarily limited to:

- Little Penguin monitoring plan; and
- seabird and shorebird (including migratory waders) rookery and roosting monitoring plan.

The risk assessment tool used in this report has identified the residual impacts greater than low (this assumes successful implementation of all mitigation measures and management procedures). The residual impacts greater than low were:

- release of invasive marine species from ballast water; and
- increase in habitat and resources for terrestrial invasive species (e.g. Silver Gull).

These residual impacts may be further managed and assessed once the detailed project design and further study are completed.

If the potential impacts are managed as identified then they are not likely to be significant from the proposed development. Management, mitigation and monitoring should be incorporated into an Environmental Management System.

There is no recognised requirement to refer this proposed development to the EPBC Act or the Department of Sustainability, Environment, Water, Population and Communities.

Contents

Executive summary iii

Introduction 2

- Background 2
- Project description 2
- Description of Lipson Island 3
- Study objectives 4
- Legislation 4

Methodology 9

- Survey methods 9
- Desktop survey 9
- Literature survey 9
- Field survey 9
- Conservation significant species 14
- Risk assessment methodology 15

Survey results 18

- Desktop survey results 18
- Field survey results 23
- Marine fauna results 27
- Impact identification and risk management 31
- Risk assessment results 32

Discussion 37

- General ecology 37
- Flora ecology 37
- Fauna ecology 37
- Conservation significance species 38
- Introduced species 39
- Impact identification and management 39
- Specific management 49
- Residual impacts 49
- Limitations 50
- Conclusion 51

References 52

Appendices

Appendix A: Historical fauna species lists 55

Appendix B: On-site flora survey quadrate images 59

Appendix C: Marine intertidal survey site images 61

Appendix D: Infrared camera, songmetre and Anabat™ recording sites and shore transect location 64

Appendix E: On-site intertidal flora and fauna survey raw data 65

Appendix F: Ecology of species at risk 69

Introduction

Background

Golder Associates Pty Ltd approached Donato Environmental Services (DES) for a qualitative and quantitative assessment of flora and fauna within the Lipson Island Conservation Park, including the intertidal environments.

The work includes a baseline assessment of the ecology and the potential impacts to the Lipson Island Conservation Park as a result of the proposed port construction and operation (this will include the impact of artificial light from the port). The assessment is to include, but is not limited to, details on breeding cycles and migratory species that may occupy the area.

Figure 1. Location of Lipson Island and proposed Sheep Hill Port

Project description

The following project description is derived from the Centrex Metals Development application [1]:

> *Incorporated in 2001, Centrex Metals Ltd (Centrex) is a publicly listed South Australian iron exploration and mining company. Centrex has extensive tenement holdings over iron ore resources and exploration targets on Eyre Peninsula in the southern Gawler Craton.*
>
> *The extensive iron formations of Eyre Peninsula contain significant inferred resources of hermatite and or magnetite. Hermatite has traditionally been regarded as direct-shipping ore that can be exported without the need for beneficiation. Magnetite requires beneficiation (concentration with or without pelletising) to produce either iron concentrates or direct reduction grade iron ore pellets suitable for the export market.*

There is a lack of deep port facilities available to export hermatite and magnetite resources from proposed Centrex operations. To address this lack of infrastructure, Centrex has proposed a facility at Sheep Hill, Eyre Peninsula, South Australia.

A development proposal was submitted to the Minster for Urban Development and Planning on 7 December 2010 with a request for the proposed Sheep Hill Marine Port (Port) approximately 21 km north-east of Tumby Bay to be declared a major project under Section 46 of the Development Act 1993. This project was formally gazetted as a major project on 6 January 2011, including the Port road access corridor and slurry pipelines.

Central to this is development of suitable infrastructure that can facilitate cost-effective and environmentally responsible transportation options for industry. Sheep Hill offers a significant regional opportunity to develop an alternative port and shipping option to Port Lincoln and a more localised option compared to Whyalla for the southern and mid regions of Eyre Peninsula, reducing transport distances.

Centrex proposes to construct a deep-water marine port in Spencer Gulf, with a view to exporting Centrex's iron ore from Eyre Peninsula and providing the mineral industry with effective access to international markets. Centrex is proposing to develop the site as a multi-user bulk commodity export facility capable of accommodating Cape class vessels (180 000 to 240 000 tonne capacity) suitable for export up to 20 million tonnes of ore per annum (mtpa) from a single berth configuration and single ship loader. The proposal also includes a road transport and infrastructure access corridor that will generally follow the alignment of the existing ungazetted Swaffers Road from Lincoln Highway. The Port may also serve as a multi-use export gate for grain, and other mining companies in the Eyre Peninsula region.

Investment in the Port is estimated to total $180 million, including detailed design and construction of the jetty, materials handling system and ship loader, site access and establishment of on-site services and site preparation for a fully enclosed storage facility.

The location of the Port was selected on the basis of seawater depth to accommodate Cape class vessels without dredging, within a reasonable distance from the shore, as well as its close proximity to Centrex's mineral reserves on the Eyre Peninsula. Marine shipping facilities outside of Eyre Peninsula, such as Port Adelaide or Darwin, are high cost transport options, which will result in larger carbon footprints.

Description of Lipson Island

Lipson Island Conservation Park is situated 150 m offshore from the lower eastern Eyre Peninsula, South Australia, 20 km north of Tumby Bay and 1.5 km south from the port proposed by Centrex. It is designated a conservation reserve in 1980 and managed under the *National Parks and Wildlife Act* 1972 (NPW Act). No management plan has been adopted for the reserve.

Formal biological surveys have not been undertaken on Lipson Island Conservation Park, although it is known to contain breeding populations of Little Penguins, Crested Terns Sooty Terns, Rock Dove and Black-faced Cormorants. Migratory waders are also known to roost on the island. The island is accessible

at low tide, although little visited (P. Wilkins pers. comm. [2]). DES has conducted opportunistic ornithological surveys of Lipson Island since 1984, where at times up to 1000 Crested Tern and 500 Black-faced Cormorant have been recorded.

Satellite imagery around Lipson Island Conservation Park shows extensive clearing of native vegetation and conversion to cereal cropping and grazing on improved pastures. Limited remnant vegetation is evident along foreshores, roadsides and on farmland. Lipson Island Conservation Park comprises primarily tidal-exposed rock and is poorly vegetated with some saline-tolerant terrestrial vegetation.

It is a low-lying intertidal island with a total area of 6 ha and consists of a granite platform with a limestone capping. The limestone capping is also covered by sand and grit on the outer rim of the island that is subject to tidal movement. As determined by aerial photography there is some vegetation on the centre of the island. On the outer rim of the island little or no vegetation exists and consists of exposed rocky outcrops, sand and grit. The tidal swing can be up to 1.6 m [3].

Lipson Island experiences a typical coastal Mediterranean climate. Average annual rainfall for the area is 330 mm with the wettest months being June to August and the driest months being December to February [4]. Mean minimum temperature is 14°C, which coincides with the wettest months, and the mean maximum temperature is 22°C, coinciding with the driest months [4]. Frosts are extremely rare.

Study objectives

The objectives of this baseline study, assessment and subsequent report are to:

- characterise the existing flora and fauna species and habitat types with reference on species and communities of conservation significance (local, regional, state or national);
- identify potential project constraints associated with flora and fauna;
- identify relevant legislation, standards and policies that may apply to the project;
- interpret the implications of the baseline study results to provide advice on the port design and management; and
- identify, interpret and mitigate the potential impacts from port construction and consequent operation on both terrestrial and intertidal flora of Lipson Island Conservation Park, and fauna with a focus on breeding and roosting migratory species and species of legislative concern.

Legislation

The most pertinent environmental legislation is summarised below. This summary is not exhaustive and additional legislation applies to the proposed development.

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

The *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) enables the Commonwealth Government to join with the states and territories to provide a national scheme of environment protection and biodiversity conservation. The Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) is responsible for administering the Act.

The EPBC Act is applicable to actions that are likely to have a significant impact on a matter of national environmental significance. Matters considered to be of national environmental significance are:

- World Heritage properties;
- National Heritage places;
- Ramsar Convention on wetlands of international significance;
- threatened species and ecological communities;
- migratory species;
- nuclear actions;
- Commonwealth marine areas; and
- additional matters of national environmental significance (prescribed actions).

South Australian legislation

A number of the state's pieces of legislation is pertinent to the proposed development and subsequent assessment of environmental risks. Relevant legislation, but not an exhaustive list, is discussed below.

Native Vegetation Act 1991

The *Native Vegetation Act* 1991 is administered by the Native Vegetation Council (NVC) and provides incentives and assistance to landowners in relation to the preservation and enhancement of native vegetation and regulates the clearance of native vegetation.

Native vegetation, as defined by the *Native Vegetation Act* includes any naturally occurring local native plants, it does not include dead plants or plants sown or planted by a person unless under certain circumstances. This covers the full range of native species, from tall trees to small ground covers, native grasses, wetland plants such as reeds and rushes, and marine plants. The plants may comprise natural bushland or they may be isolated plants in a modified setting, such as single trees in pastured paddocks. Dead trees that provide habitat for nationally threatened species listed under the EPBC Act are protected by the *Native Vegetation Act*. *The Native Vegetation Act* covers the whole of South Australia, except parts of metropolitan Adelaide.

Depending on the circumstances the NVC will assess applications for clearance against the principles set out in the *Native Vegetation Act*. The principles of the *Native Vegetation Act* relating to the Lipson Island project include:

- the conservation, protection and enhancement of the native vegetation of the state and, in particular, remnant native vegetation, in order to prevent further:
  - reduction of biological diversity and degradation of the land and its soil; and
  - loss of opportunity and quality of native vegetation in the state, and loss of critical habitat;
- the encouragement of research into the preservation, enhancement and management of native vegetation; and
- the encouragement of re-establishment of native vegetation in those parts of the state where native vegetation has been cleared or degraded.

Development Act 1993

The *Development Act* 1993 provides for the planning and regulation of developments, use and management of land and buildings, the design and construction of buildings, and maintenance and conservation of land and buildings.

Centrex submitted a referral to the Department of Planning and Local Government in December 2010. On 6 January 2011, the project was declared a major project by the Minister of Urban Development and Planning. The next step in the approvals process will include community consultation and a submission of a public environment report.

National Parks and Wildlife Act 1972

The *National Parks and Wildlife Act* 1972 (NPW Act) provides for the establishment and management of South Australian reserves and the conservation and management of flora and fauna in a natural environment. The NPW Act lists species of conservation significance requiring protection under the law. Plant species and fauna species can be listed at a range of levels comprising: endangered; vulnerable; and rare. Each listing level is offered a different level of protection, endangered being the highest and rare the lowest. Lipson Island is declared a conservation park under this legislation.

Natural Resources Management Act 2004

The *Natural Resources Management Act* 2004 promotes sustainable and integrated management of the state's natural resources and provides for their protection. The *Natural Resources Management Act*, which repeals the *Animal and Plant Control (Agricultural Protection and Other Purposes) Act* 1986, the *Soil Conservation and Land Care Act* 1989 and the *Water Resources Act* 1997, is administered by the Department of Environment and Natural Resources (DENR).

Marine Parks Act 2007

The *Marine Parks Act* 2007 protects and conserves marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive, adequate and representative system of marine parks, and assist in:

- maintenance of ecological processes in the marine environment;
- adaptation to the impacts of climate change in the marine environment;
- protecting and conserving features of natural or cultural heritage significance;
- allowing ecologically sustainable development and use of marine environments;
- providing opportunities for public appreciation, education, understanding and enjoyment of marine environments;
- sustaining the potential of the marine environment to meet the reasonably foreseeable needs of future generations;
- safeguarding the life-supporting capacities and processes of the marine environment; and
- avoiding, remedying or mitigating any adverse effects of activities on the marine environment.

The following principles should be taken into account in connection with achieving ecologically sustainable development for the purposes of the *Marine Parks Act*:

- decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations;
- if there are threats of serious or irreversible harm to the marine environment, lack of full scientific certainty should not be used as a reason for postponing measures to prevent harm;
- decision-making processes should be guided by the need to evaluate carefully the risks of any situation or proposal that may adversely affect the marine environment and to avoid, wherever practicable, causing any serious or irreversible harm to the marine environment;
- the present generation should ensure that the health, diversity and productivity of the marine environment is maintained or enhanced for the benefit of future generations;
- a fundamental consideration should be the conservation of biological diversity and ecological integrity;
- environmental factors should be taken into account when valuing or assessing assets or services, costs associated with protecting or restoring the marine environment should be allocated or shared equitably and in a manner that encourages the responsible use of the marine environment, and people who obtain benefits from the marine environment, or who adversely affect or consume natural resources, should bear an appropriate share of the costs that flow from their activities;
- if the management of the marine environment requires the taking of remedial action, the first step should, insofar as is reasonably practicable and appropriate, be to encourage those responsible to take such action before resorting to more formal processes and procedures;
- consideration should be given to other heritage issues, and to the interests of the community in relation to conserving heritage items and places;
- the involvement of the public in providing information and contributing to processes that improve decision making should be encouraged; and
- the responsibility to achieve ecologically sustainable development should be seen as a shared responsibility between the South Australian Government, the local government sector, the private sector, and the general community.

Environment Protection Act 1993

The *Environment Protection Act* 1993 provides for the protection of the environment and defines the Environment Protection Authority's (EPA) functions and powers. The *Environment Protection Act* promotes ecologically sustainable development and the use of precautionary principles to minimise environmental harm. Under the *Environment Protection Act* polluters bear an appropriate share of the costs and responsibilities of protecting the environment from their activities.

Coastal Protection Act 1972

The *Coastal Protection Act* 1972 makes provision for the conservation and protection of the beaches and coast of South Australia, including:

- to protect the coast from erosion, damage, deterioration, pollution and misuse;
- to restore any part of the coast that has been subjected to erosion, damage, deterioration, pollution or misuse;
- to develop any part of the coast for the purpose of aesthetic improvement or to render that part of the coast more appropriate for use or enjoyment by those who may resort thereto;
- to manage, maintain and, where appropriate, develop and improve coastal facilities that are vested in, or are under the care, control and management of, the Board;
- to report to the Minister upon any matters that the Minister may refer to the Board for advice; and
- to carry out research, cause research to be carried out or contribute towards research into matters relating to the protection, restoration or development of the coast.

Methodology

Survey methods

The information collected for this report was through both desktop and field survey effort. Desktop and database searches were carried out to obtain any available pre-existing information extending up to 1 km from Lipson Island (desktop survey area extent). An intensive on-site field survey program was undertaken on Lipson Island and the supra (area of spray) and intertidal zones (area between high and low tide marks) on 29 and 30 May 2011.

Desktop survey

A search of published literature and relevant databases was carried out prior to the field survey to determine the potential presence of conservation-significant flora and fauna species (Appendix A), comprising:

- South Australian Biological Survey flora and fauna database (sourced from Naturemaps, DENR, 2010);
- Biological Database of South Australia;
- Australian Natural Resources Atlas: Eyre York Block
- South Australian Museum;
- an EPBC protected matters search;
- Birds Australia Atlas database; and
- published scientific papers and reference books where relevant.

The results of the desktop survey were used to identify flora and fauna species known to occur in the area, or that are likely to inhabit the survey area based on suitable habitat types. The field survey design was updated based on the results of the desktop information in order to survey all habitats within the survey area.

Literature survey

The ecology of some species of conservation significance is presented in this report primarily from literature sources. Literature sources included peer-reviewed journals and other publicly available sources. Databases included the EPBC Species Profile and Threats (SPRAT) database. The main search engine was the Web of Knowledge.

Field survey

Permits and licences

A relevant permit was obtained prior to field survey commencement. All works were undertaken in accordance with the permit:

- to Undertake Scientific Research – Lipson Island Baseline Flora and Fauna Survey. Permit Number: Q25944-1.

A relevant PIRSA permit had already been registered to a DES Marine Biologist sub-consultant:

- PIRSA permit 9902352; WEC 43/2008.

Terrestrial flora survey

Due to Lipson Island's small size and the fact that flora on Lipson Island is limited, the flora quadrants were simply chosen based on where the vegetation was present. The northern end of the island was specifically avoided by all DES staff to ensure the breeding colony of the Black-faced and Pied Cormorants including young were not disturbed (Figure 2), hereafter referred to as the exclusion zone.

Two quadrates each 10 x 10 m square were located where vegetation cover was present. A third quadrant immediately to the north and a fourth quadrant immediately to the south of the vegetation were also chosen. These final two

quadrants were predominantly rock and sand. All quadrants were surveyed extensively using methods stated in the Biological Survey of South Australia [5, 6] to provide an inventory of species present, abundance and habitat. The floristic and habit information collected at each site comprised:

- GPS coordinates using a hand-held 12-satellite GPS device (accuracy around +/- 5 m);
- general site description;
- vegetation classification and all species present identified;
- evidence of weeds and feral animals;
- soil, rock, crust and groundcover description;
- digital photograph with reference numbers, and
- any other relevant information.

Reference photographs were taken at each quadrate. These images are presented in Appendix B.

Field identifications of plant species were made using the reference book, Flora of South Australia [7].

Marine intertidal survey

Sites were selected following a reconnaissance visit to Lipson Island on the first sampling day. This was to determine the number of macrohabitats present and the areas accessible to sample safely. An additional consideration for the sampling site locations was to minimise disturbance to breeding birds. Following protocols of best practice according to Birds Australia for roosting and breeding seabirds, the northern third of the island was set aside as a sampling exclusion zone (Figure 2). Over the remainder of the island six sites were selected to represent each of the broad habitat types present (sand, tide pool, semi-sheltered sand/rock, semi-sheltered rock, exposed rock and exposed rock platform: Appendix C) and to target the range of intertidal biota (fishes, invertebrates and flora). Access to intertidal habitats was governed by tidal stage, but also prevailing weather and swell conditions.

Three sites (sites 3, 4 and 5: Figure 2) were safe and appropriate for the deployment of combined search inventory and quantitative descriptive methods (Figure 3), representing different macrohabitats of semi-exposed areas on the south and west of the island. These sites were defined by a 25 m vertical and 5 m horizontal transect from the high tide to low tide mark at the time of sampling. These transects were then divided into 5 x 5 m quadrats, in the upper, middle and lower intertidal zone (matching tide zones) and were subjected to up to 20 minutes of active searching (observation, gentle rock turning and replacement) to record the following:

- species inventory (presence only);
- types of microhabitats (e.g. sand, grit, rock); and
- percentage cover of major vegetation units.

Within each of the 5 x 5 m quadrats, three 1 x 1 m quadrates were randomly placed over varying microhabitats. This allowed focused search effort to contribute to inventory data, but also provided some quantitative data on

species richness and abundance. Each quadrat was subject to up to 15 minutes study to record the following:

- species richness and abundance of each species (flora and fauna);
- percentage cover was used for calcified tube worms *Galeolaria caespitose*; and
- percentage cover of each vegetation type.

Two other intertidal sites, which were not conducive to standard zone-based transects, were searched opportunistically for 40 minutes at low tide to provide a species inventory. Site 2 was a tide pool that flowed across the island at high tide and swell. Site 6 was exposed rock shelves on the eastern side of the island that could only be safely and effectively searched on low swell (and tide). Opportunistic searching was undertaken for biota other than fish at site 1.

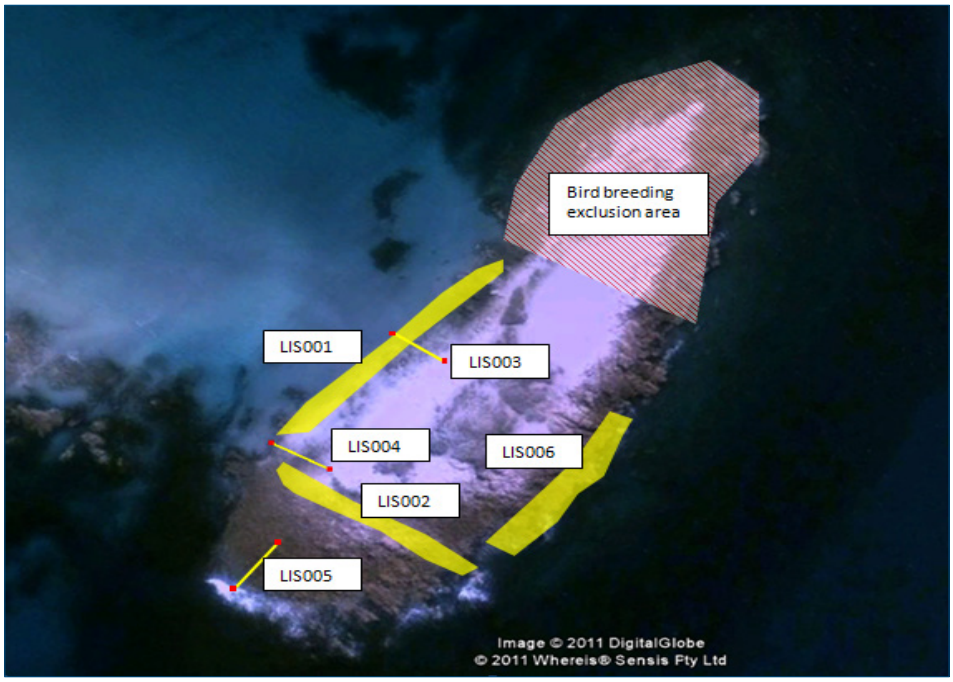

Figure 2. Intertidal sampling locations marked on Lipson Island

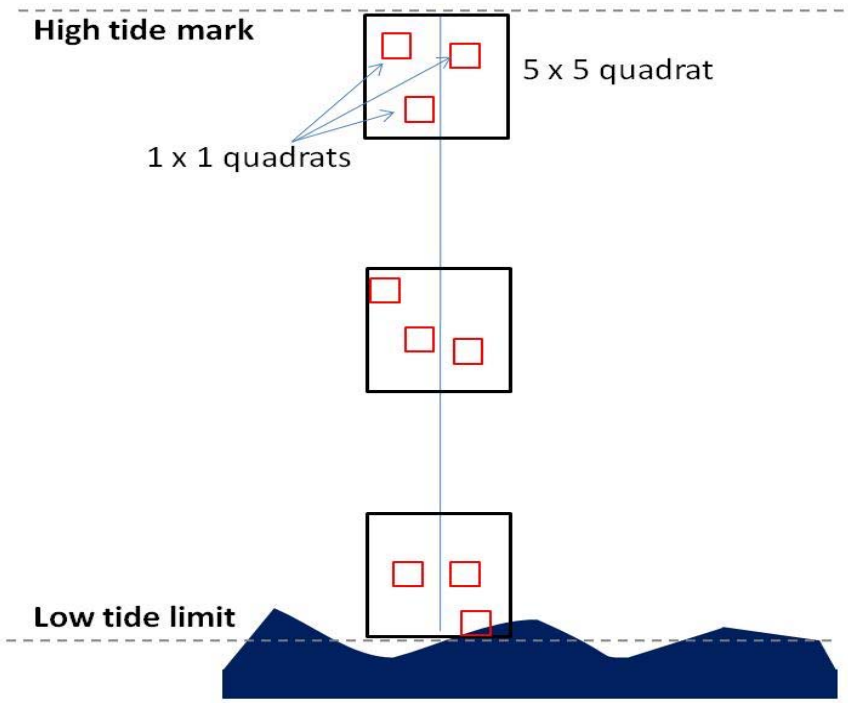

Figure 3. Structure of intertidal transect/quadrat sites

Marine invertebrates and flora

The sampling of invertebrates and flora at each site was conducted at three spatial scales to include large dominant macrohabitat types (i.e. sand, rock/sand, rock and exposed shore), intertidal zones (i.e. high, middle and low) and microhabitats within zones. Permit conditions governed that no biota could be handled or moved and hence identification was limited to field visual assessment and later photographic examination against field identification books [8-10]. Only living invertebrates (i.e. excluding discarded shells) and attached flora (e.g. excluding washed up kelp) were recorded and enumerated.

Note, sampling sites 5 and 6, and to a lesser degree site 2, could only be efficiently and safely sampled due to a shift in prevailing swell conditions from the south-east on a northerly wind change on the second day of sampling. The wind change resulted in more exposed low tide habitats and low swell minimising the force of wave impacts.

Marine fish

Sampling for fishes occurred at low tide at two dedicated sites. Site 1, dominated by sand on the western side of the island, was conducive to seine netting, and sampling here included eight 10 m hauls of a 4 m beach seine with a mesh diameter of 4 mm and heavy leads to target benthic species. Site 2 was located in a small connecting channel running between the east and west side of the island, essentially acting as a continuous tide pool with high structural integrity (Figure 2 and Appendix C). Twelve collapsible baited traps were placed in the creek and set for different diurnal tide phases (i.e. over high tide and low tide) as well as a nocturnal set retrieved the following morning. Limited suitable habitat for fishes elsewhere (a few small rock pools or under rocks only) meant that fish sampling was opportunistic at other sites. Fish species were identified in the field and returned to the point of capture. All fish sampled were photographed using a 12.1MP waterproof digital camera for later validation against field keys [11].

Terrestrial fauna survey

Mammals, reptiles and amphibians

Due to Lipson Island's small size of 6 ha, rocky nature, geographical flat terrain and expected low or no ambulatory fauna, it was deemed ineffective to set up Elliott trap and pitfall transects. The entire island could be observed by a simple approach of a slow walk and recording all opportunistic observations. The deliberate walks searching for tracks or scats of ambulatory fauna were conducted for 20 minutes per day on both days by three members of DES. Additionally, opportunistic observations were conducted for the entire two days while on the island.

Lipson Island and the adjacent foreshore were also opportunistically searched for evidence of tracks and scats made by mammals and reptiles.

Due to the timing of the survey, late in autumn, the weather was deemed too cold for reptiles to be opportunistically observed. The habitat of rocky substrate would indicate that some reptiles are likely to be active and observable in warmer months on Lipson Island.

Bat recording

Bats were surveyed using two echolocation recording devices (Anabat™ SD1), which were pre-programmed to commence recording at sunset (17.30 hours) for four continuous hours (sites 346 and 349, Appendix D) on Lipson island.

Anabat™ software [12] was used for recording calls along with Analook software [13] to view calls for bat identification. Only search-phase calls are typically used for bat identification, as these are relatively regular-shaped pulses that bats emit as they navigate through the landscape. The Anabat™ recorded on two nights, for a total of eight hours each. There were no bat calls detected.

Bird survey

Bird surveys were conducted over a two-day period, 29 May to 30 May 2011.

The birds were recorded initially by a 20-minute walk around by two DES staff on the two mornings and then opportunistically throughout the study area during the field survey period. Any birds identified opportunistically, either by direct observation or by call were recorded on data sheets with location and any useful notes. These species are included in site species lists. All species were identified and numbers either counted or estimated.

Due to the island small size, it was not possible to remain on the island at sunset without disturbing birds coming into roost or feed young. Consequently, three Reconyx RC55 or 60 infrared cameras were used to remotely document wildlife roosting presence and diurnal and nocturnal activity. Cameras were programmed to take one photograph every 15 minutes over a 24-hour period. The cameras were set up at sites 346, 348 and 349 (Appendix D, plate 1).

The camera's infrared (heat) and motion detection options were set to very sensitive with a trigger response time of 0.1 second. The cameras, if triggered by heat and motion, will take a series of three photographs. The photographs record location, time, reason for photograph trigger (heat, motion or time lapse) and temperature stamped. Data from the Reconyx RC55 or 60 is recorded onto 4GB compact flash cards. The photographs were then viewed to qualitatively document roosting bird presence and activity. All photographs were viewed and analysed.

Additionally, two Wildlife Acoustics SM1 Song Meters® were used on 29 and 30 May 2011 to document by call, bird presence and relative abundance diurnally and nocturnally on Lipson Island. Song Meters® were set to record sounds within the range 20 to 20 000 Hz, which targets bird calls. The Song Meters® were set up at sites 346 and 349 (Appendix D, plate 1), commenced recording at 11.30 hours on 29 May 2011 and completed at 11.30 hours on 30 May 2011. The Song Meters® recorded calls for 20 minutes every hour on the hour.

It was not necessary to quantify the species activity by calls and the calls were not tabulated. The recorders were deliberately targeting roost and breeding behaviour calls of species that were known by DES staff to roost on Lipson Island such as Little Penguin. Song Meters® were utilised to determine the diversity of species occupying Lipson Island nocturnally. As such it was not necessary to tabulate every call, only random selections of diurnal and nocturnal calls were listened to and the species identified to ascertain avian activity characteristics.

To establish the number of active avian burrows on Lipson Island and the diversity of bird species using these burrows for nesting, transect lines were established and walked. The transect lines were covered in dense shrub to avoid further difficulty and/or missing burrows transect were close together. There were six transacts, each two to three metres apart and 30 m in length in an north-south direction up to and no further than the sampling exclusion zone (Figure 2). This encompassed the entire area where burrows were likely to be located and the area was small enough for every burrow to be counted. Three members of DES walked along these transects counting all burrows, species in residence and breeding stage. No birds were handled and disturbances were kept to a minimum. This resulted in most occupants of the burrows being unrecorded. The burrows were recorded as active or not active. This was determined by footprints and fresh diggings.

A shorebird observation transect along the adjacent mainland shore was established between sites 354 and 355 (Appendix D, plate 2). This survey was carried out from a boat 30 m from the shoreline between the aforementioned points for duration of 40 minutes each day. Every shore bird was identified and counted.

Invertebrates

Butterflies and other invertebrates were recorded opportunistically while the observers were present on the island.

The following reference materials were used for species identification and classification. For birds, The Field Guide to the Birds of Australia [14], and for mammals, two reference guides were referred to: A Field Guide to the Mammals of Australia [15]; and Tracks, Scats and Other Traces [16].

Conservation significant species

The conservation significance of flora, fauna and invertebrates recorded as part of the desktop and field survey was determined according to:

- the EPBC Act for nationally threatened species;
- the EPBC Act for migratory species;
- the NPW Act for species classified as threatened in South Australia; and
- the Biodiversity Plan for Eyre Peninsula [17] for regionally threatened species.

Risk assessment methodology

Approach

The impact assessment approach used here follows that of Standards Australia/ Standards New Zealand 'Environmental risk management – principles and process HB 203:2004', (the risk assessment guide) [18]. The approach takes into account the high degree of complexity of the environment and that decisions regarding impacts must often be made subjectively when there is still significant scientific uncertainty about potential outcomes. At the core of its approach is the concept of environmental risk management [18].

Impacts are defined as changes to the environment resulting from an event or source of risk. The analysis derives a measure of risk for each impact from a combination of two elements:

- likelihood that an impact will occur; and
- consequence of the impact.

The measures of likelihood and impact used in the present study are presented in Tables 2 and 3, respectively. For both likelihood and consequence, each level of the measure is defined by a descriptor and definition. As suggested in the risk assessment guide [18] the levels of each category should reflect the needs of the study and the measures used should reflect the nature and needs of the organisation and activity undertaken. In the present study the measures of likelihood are those described in section 2.5.3 in the risk assessment guide and the measures of the consequence are those described typically used in the resource industry.

Table 2. Qualitative measures of likelihood

Level	Descriptor	Description
A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Could occur
D	Unlikely	Could occur but not expected
E	Rare	Occurs only in exceptional circumstances

Table 3. Qualitative measures of consequence

Category	Definition
1. Catastrophic	Environmental: severe environmental damage. Local species destruction and long recovery period likely. Extensive clean-up required. Impact on a regional scale. Regulatory: license to operate revoked or suspended. Forced site shutdown to closure.
2. Major	Environmental: serious environmental damage with major environmental impact. Requires large clean-up efforts. Extends beyond lease boundary. Regulatory: regulation breach, action by regulator likely. Penalties, e.g. fine or infringement notice issued. Possible or actual prosecution.
3. Moderate	Environmental: moderate and reversible environmental damage. Clean up possible by site personnel. Confined within lease boundary. Regulatory: technical compliance issue. Possible regulator action. Field notice issued. Exceed statutory limit.
4. Minor	Environmental: minor environmental damage restricted to lease and within previously disturbed area. Regulatory: minor technical breach. Internal standard exceeded. Explanation letter to regulator required.
5. Insignificant	Environmental: no or very low environmental damage and impact confined to small area. Regulatory: no potential legal action. Standard or limit not exceeded.

A risk matrix is used to calculate the measure of risk using likelihood and consequence (Table 4). As outlined in the risk assessment guide [18], measures of risk are defined as:

E = Extreme risk: immediate action required;

H = High risk: senior management attention needed;

M = Moderate risk: management responsibility must be specified; and

L = Low risk: manage by routine procedures.

Table 4. Qualitative risk analysis matrix: level of risk

	Consequence				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	M	H	H	E	E
Likely	M	M	H	H	E
Occasional	L	M	M	H	H
Unlikely	L	L	M	M	H
Rare	L	L	L	M	M

As instructed in the risk assessment guide [18], what constitutes an acceptable risk level is specific to the activity being analysed and managed. Extreme, high and moderate risks are considered too high to be acceptable and DES has made recommendations for the management and mitigation of these impacts. The residual risk is the level of risk that remains after implementation of management [18].

Where unknown factors exist DES has applied a precautionary approach [18]. According to the risk assessment guide [18]:

> *Where there are threats of serious or irreversible environmental damage, lack of full scientific uncertainty should not be used as a reason for postponing measures to prevent environmental degradation...rather we put appropriate measures in place in advance of more scientific evidence.*

Impact management and mitigation measures are often implemented through management plans to deal with potential impacts in the construction industry, such as the construction of wharfs/ports or other large projects, and this has been the approach here. Where issues are not readily covered by detailed management plans possible risk management and mitigation measures are suggested. Prescriptive and detailed risk management measures are currently not possible for many issues and potential impacts discussed as final detailed project designs are not available. Where appropriate, general management measures consistent with construction industry standards and issues are provided.

A risk assessment, management and mitigation measures and residual risks are provided in Table 17. The residual risk level is determined on the assumption of successful and timely implementation of all risk management and mitigation measures outlined.

As described in the risk assessment guide [18] the analysis of environmental risk often produces results with a high degree of uncertainty. Inherent reasons for uncertainty in the risk assessment process may include:

- the complexity of the environment and the difficulty in finding a single measure of either impacts on the environment or likelihood they will occur;
- statistical fluctuations due to the vulnerability of the various components of the system under study;
- the lack of reliable data on the environmental impacts from a source of risk; and
- the impacts from a source of risk over time are difficult to predict.

Survey results

Desktop survey results

An EPBC protected matters search was carried out 1 June 2011 (Appendix D). This search was a one-kilometre-point search area of and around Lipson Island. If a species is recorded at an accuracy of one-degree cell, then this will be recorded in the one-kilometre (or any) search within that degree cell.

A total of 27 EPBC listed species were identified as being potentially present in the desktop survey area comprising one shark, three marine reptiles, 16 bird species, three marine mammal species and four plant species (Table 5, see Appendix A for non listed species). No terrestrial reptile or mammal species were recorded. No ecological community listed under the EPBC Act or NPW SA Act was identified in the desktop survey.

Table 5. EPBC protected matters search, Biological Database of South Australia (BDBSA) results for flora species known to or potentially to occur in the desktop survey area (En = endangered; and Vu = vulnerable)

Scientific name	Common name	EPBC status (weed)	EPBC species known to occur within area	EPBC species or species' habitat that may occur	EPBC species or species' habitat likely to occur	BDBSA	NPWS status
Flora							
Caladenia tensa	Greencomb Spider-Orchid	En			X		En
Frankenia plicata		En			X		Vu
Prostanthera calycina	West Coast Mintbush,	Vu			X		Vu
Tecticornia flabelliformis	Bead Glasswort	Vu			X		
Malva preissiana	Australian Hollyhock					X	
Lepidium foliosum	Leafy Peppercress					X	
Nitraria billardierei	Nitre-bush					X	
Atriplex muelleri	Mueller's Saltbush					X	
Enchylaena tomentosa var. tomentosa	Ruby Saltbush					X	

A total of seven invasive flora species (Table 6) have been recorded in the desktop survey area within 1 km, including South Australian declared weeds and one weed of national significance.

Table 6. Invasive weed species recorded in desktop EPBC Act protective matters, NPWS Act schedules BDBSA (* = introduced)

Scientific name	Common name	EPBC status (weed)	NPWSA status (declared weeds)	BDBSA	Weeds of national significance
*Asparagus asparagoides**	Bridal Creeper	X	X		
*Chrysanthemoides monilifera**	Boneseed	X	X		
*Lycium ferocissimum**	African Boxthorn	X	X	X	X
*Mesembryanthemum crystallinum**	Common Iceplant			X	
*Olea europaea**	Olive	X	X		
*Rubus fruticosus**	Blackberry	X	X		
*Ulex europaeus**	Gorse	X	X		

A search of the BDBSA was carried out on 5 June 2011. This search was a one-kilometre-point search area of and around Lipson Island. A total of 7 plant species, 1 reptile and 22 bird species have been recorded in the desktop survey area (Appendix A). No mammals or amphibians were previously recorded according to the BDBSA search.

Four invasive mammal species have been recorded in the desktop survey area (Table 7). The feral cat, red fox and rabbit are all listed as nationally key threatening processes under the EPBC Act. None are expected on the island.

Table 7. EPBC protected matters search, NPWS status, BDBSA results for fish, reptiles and mammals species known to or potentially to occur in the desktop survey area (* = introduced; # = threatening process; En = endangered; Vu = vulnerable; MM = migratory marine; M = marine; m = may occur; and L = likely to occur)

Scientific name	Common name	EPBC status	EPBC treaties	EPBC Species known to occur within area	EPBC Species or species' habitat that may or is likely to occur	NPWSA status	BDBSA
Fish							
Carcharodon carcharias	Great White Shark	Vu	BONN; M		m		
Acentronura australe	Southern Pygmy Pipehorse				m		
Campichthys tryoni	Tryon's Pipefish				m		
Filicampus tigris	Tiger Pipefish				m		
Heraldia nocturna	Upside-down Pipefish, Eastern				m		
Hippocampus breviceps	Short-head Seahorse				m		
Histiogamphelus cristatus	Rhino Pipefish				m		
Hypselognathus rostratus	Knifesnout Pipefish				m		
Kaupus costatus	Deep-bodied Pipefish				m		
Leptoichthys fistularius	Brushtail Pipefish				m		
Lissocampus caudalis	Australian Smooth Pipefish,				m		
Lissocampus runa	Javelin Pipefish				m		
Maroubra perserrata	Sawtooth Pipefish				m		

continued

Scientific name	Common name	EPBC status	EPBC treaties	EPBC Species known to occur within area	EPBC Species or species' habitat that may or is likely to occur	NPWSA status	BDBSA
Notiocampus ruber	Red Pipefish				m		
Phycodurus eques	Leafy Seadragon				m		
Phyllopteryx taeniolatus	Weedy Seadragon				m		
Pugnaso curtirostris	Pug-nosed Pipefish				m		
Solegnathus robustus	Robust Spiny Pipehorse				m		
Stigmatopora argus	Spotted Pipefish				m		
Stigmatopora nigra	Wide-bodied Pipefish				m		
Stipecampus cristatus	Ring-backed Pipefish				m		
Urocampus carinirostris	Hairy Pipefish				m		
Vanacampus margaritifer	Mother-of-pearl Pipefish				m		
Vanacampus phillipi	Port Phillip Pipefish				m		
Vanacampus poecilolaemus	Long-snouted Pipefish				m		
Vanacampus vercoi	Verco's Pipefish				m		
Reptiles							
Caretta caretta	Loggerhead Turtle	En	M		L	En	
Chelonia mydas	Green Turtle	Vu	M		L	Vu	
Dermochelys coriacea	Leatherback Turtle	En	M		L	Vu	
Tympanocryptis lineata	Five-lined Earless Dragon	Vu					X
Mammals							
Eubalaena australis	Southern Right Whale	En	BONN; MM	X		Vu	
Megaptera novaeangliae	Humpback Whale	Vu	BONN; MM		L	Vu	
Neophoca cinerea	Australian Sea-lion	Vu	M		m	Vu	

continued

Scientific name	Common name	EPBC status	EPBC treaties	EPBC Species known to occur within area	EPBC Species or species' habitat that may or is likely to occur	NPWSA status	BDBSA
Orcinus orca	Killer Whale		BONN; MM		m		
Balaenoptera acutorostrata	Minke Whale				m	R	
Balaenoptera edeni	Bryde's Whale		BONN		m	R	
Caperea marginata	Pygmy Right Whale		BONN		m	R	
Lagenorhynchus obscurus	Dusky Dolphin		BONN; MM		m		
Delphinus delphis	Common Dophin				m		
Grampus griseus	Risso's Dolphin				m	R	
Tursiops aduncus	Indian Ocean Bottlenose Dolphin				L		
Tursiops truncatus	Bottlenose Dolphin				m		
Arctocephalus pusillus	Australian Fur-seal				m	R	
Arctocephalus forsteri	New Zealand Fur-seal				m		
Felis catus#*	Feral Cat						
Vulpes vulpes#*	Red Fox						
Oryctolagus cuniculus#*	European Rabbit						
*Capra hircus**	Goat						

A one-kilometre search surrounding Lipson Island of the Birds Australia database identified a total of 27 species (includes unidentified crow and raven species) that have previously been recorded in the search area (Table 8, see Appendix A for non-listed species).

Table 8. EPBC and NPWS Listed avian species known to occur in the survey area from EPBC protected matters search, Biological Database of South Australia (BDBSA), Birds Australia (BA) desktop results. Includes avian species known or likely to breed or potentially occur within area (* = introduced; MM = migratory marine; M = marine; En = endangered; Vu = vulnerable; R = rare; B = breeding; m = may occur; and L = likely to occur.

Scientific name	Common name	EPBC status	EPBC treaties; migratory and/or marine	EPBC protected matters search	EPBC known to or likely to breed	EPBC species or species habitat may or likely to occur	NPW SA	BA	BDB SA
Leipoa ocellata	Malleefowl	Vu	JAMBA; M	X		L	Vu		
Hirundapus caudacutus	White-throated Needletail		CAMBA; JAMBA; M	X		m			
Apus pacificus	Fork-tailed Swift		CAMBA; JAMBA; MM	X		m			
Diomedea exulans gibsoni	Gibson's Albatross	Vu	BONN; MM	X		m	Vu		
Thalassarche melanophris impavida	Campbell Albatross	Vu	BONN; MM	X		m	Vu		
Thalassarche cauta cauta	Shy Albatross	Vu	BONN; MM	X		m	Vu		
Thalassarche bulleri	Buller's Albatross	Vu	BONN; MM	X		m	Vu		
Macronectes giganteus	Southern Giant-Petrel	En	BONN; MM	X		m	Vu		
Macronectes halli	Northern Giant-Petrel	Vu	BONN; MM	X		m			
Eudyptula minor	Little Penguin			X	B			X	X
Phalacrocorax fuscescens	Black-faced Cormorant			X	B			X	X
Ardea modesta	Eastern Great Egret		CAMBA; JAMBA; MM	X		m			
Ardea ibis	Cattle Egret		CAMBA; MM	X		m	R		
Pandion haliaetus	Osprey		BONN	X	L		En		
Haliaeetus leucogaster	White-bellied Sea-Eagle		CAMBA	X	L		En		X
Haematopus fuliginosus	Sooty Oystercatcher						R	X	X
Charadrius veredus	Oriental Plover		BONN; CAMBA; JAMBA; ROKAMBA; M	X		m			
Thinornis rubricollis rubricollis	Hooded Plover (eastern)			X		L	Vu		
Gallinago hardwickii	Latham's Snipe		BONN; CAMBA; JAMBA; ROKAMBA; M	X		m	R		

continued

Scientific name	Common name	EPBC status	EPBC treaties; migratory and/or marine	EPBC protected matters search	EPBC known to or likely to breed	EPBC species or species habitat may or likely to occur	NPW SA	BA	BDB SA
Actitis hypoleucos	Common Sandpiper		CAMBA; ROKAMBA				R		X
Onychoprion fuscata	Sooty Tern			X	B				
Sterna nereis	Fairy Tern	Vu	M	X	B		En		
Hydroprogne caspia	Caspian Tern		CAMBA; JAMBA						X
Thalasseus bergii	Crested Tern			X	B			X	X
Chroicocephalus novaehollandiae	Silver Gull			X	B			X	X
Merops ornatus	Rainbow Bee-eater		JAMBA; M	X		m			
Psophodes nigrogularis leucogaster	Western Whipbird (eastern)	Vu		X		L	En		

Field survey results

Marine desktop surveys

No marine invertebrate species occurrence data exists for Lipson Island and immediate surrounds.

Terrestrial flora survey

Two out of the four flora quadrates, site 350 and 354, consisted of 80% rock and 20% sand with no trace of vegetation (see also Table 9 and Appendix B). Sites 351 and 352 (Figure 4) were dominated by vegetative *Nitraria billardiera* up to 50 cm high, with 80% and 90% coverage, respectively (see also Table 9 and Appendix B). Site 351 also consisted of 2% coverage of *Einadia nutans* with the remaining 18% made up of rock and sand. A trace (<1%) of vegetative *Einadia nutans* less than 5 cm in height was recorded at site 352 with the remaining cover made up of sand and rock (>9%).

Figure 4. Photograph of site 351

Table 9. Sites survey showing percentage cover of rock, sand and vegetation

Site no.	Rock cover (%)	Sand cover (%)	Combined sand and rock (%)	*Nitraria billardiera* (%)	*Einadia nutans* (%)	Total vegetation (%)
350	80	20				
351			18 more sand than rock	80	2	82
352			>9 with more sand than rock	90	<1	<91
353	80	20				

In addition to the quadrats the following species were observed on Lipson Island: African Box Thorn (*Lycium ferocissimum*), one specimen, Ice Plant (*Mesembryanthemum crystallinum*), Milk Thistle (*Silybum marianum*) and Marshmallow (*Malva parviflora*). The latter three were vegetative juveniles.

Marine flora survey

All sites were largely devoid of flora, with minor representation by obscure thin films of various benthic algae in small patches. five broad types were recorded (Table 10). Data from 1 x 1 m quadrats was typical of the very low representation of flora across all sites (i.e. only 1 or 2% of surface area if present at all) (Table 10).

Table 10. Presence of flora for each sampling technique

Phylum	Common name	4 m seine net (sand)	Bait traps and observations (tide pool)	Quadrats (sand and rock)	Quadrats (sheltered rock)	Quadrats (exposed rock)	Observations (exposed coast)
Chlorophyta	Green turfing			x		x	x
Phaeophyta	Brown turfing		x				x
Phaeophyta	Brown encrusting algae					x	x
Rhodophyta	Pink encrusting algae						x
Rhodophyta	Pink coraline algae						x

No introduced marine flora was found in the marine supra and intertidal survey.

Terrestrial fauna survey

Mammals, reptiles and amphibian activity

Two 20-minute walk searches on Lipson Island yielded a zero result for any sightings of ambulatory mammals, reptiles or amphibians. Opportunistic observations for the remainder of the day also produced a zero result.

A detailed search for tracks, scats and any traces of mammal, reptile and amphibian activity on Lipson Island was also conducted over the two-day survey period. These searches did not record any traces to indicate the presence of any mammal, reptile or amphibian populations on Lipson Island. No ambulatory mammals are expected to occur on the island. The lack of reptile observations can be attributed to lack of prevalence at this time of year. The rocky outcrops and protected burrows on the island both represent habitats that are favourable by some species of reptile.

On the adjacent shore to Lipson Island, European Rabbit and the House Mouse (*Mus musculus*) were both prolific in numbers. Fox tracks and a few individual foxes were also observed on the stretch of land opposite Lipson Island. The

island is intertidal, devoid of freshwater and in storm events inundated, which acts as a deterrents for these mammals attempting to inhabit or attempt the crossing from the main land to the island.

Bat activity

The bat detectors did not detect any bat calls. Due to the limited time frame (two nights) it is not reasonable to speculate that bat populations do not frequent the air space on and above Lipson Island. It is expected that bats would be active above bird breeding colonies and guano patches (that attract insects) during the warmer months of the year. Echolocation surveys during the warmer months would be more representative of bat activity of the island.

Bird surveys

An average of 2361 birds per day from 19 native bird species and two introduced species were recorded over the two days, either opportunistically or during surveys on Lipson Island and the adjacent foreshore. A further estimated 500 Black-faced Cormorants were captured on the infrared cameras coming into roost after sunset. Little Penguin calls recorded on Wildlife Acoustic Songmetre® were common after 22.00 hours both nights. This would reflect adult birds returning to their burrows at night and also increased activity of the birds present.

Silver Gull (*Larus novaehollandiae*) was the most common seabird recorded, with Common Starling being the most common bird.

There was an opportunistic sighting of one individual Hooded Plover (*Thinornis rubricollis rubricollis*), which is listed as vulnerable in South Australia under the NPWSA Act 1972, on the foreshore immediately adjacent to Lipson Island on 29 May 2011. Another individual was recorded on the shoreline transect in the immediate vicinity of Sheep Hill. The species is likely to roost on Lipson Island.

The introduced species Common Starling (*Sturnus vulgaris*) had two individual recordings on 29 May 2011 and 2380 recordings on 30 May 2011. Infrared cameras detected large flocks of Common Starling roosting on the southern end of the island. The discrepancy between two field observations can be accounted for by the Common Starling flock leaving the island before the field observers noticed them. On 30 May 2011 the flock was counted from the boat as DES staff was approaching the island.

Imagery captured from the infrared cameras identified Lipson Island as a significant roost. Sunset on 29 May 2011 was 17.24 hours and last light was 17.51 hours. Last light coincides with the arrival of cormorants and Rock Dove to roost on Lipson Island. The extent of bird roosting is provided in Table 11.

Table 11. Camera site 348 (north-facing) on 29 to 30 May 2010

Time in hours	Cormorants	Rock Dove	Silver Gull
29 May 2011			
16:45	0	25	3
17:00	0	50	1
17:15	20	200	6
17.30	100	200	4
17.45	200	200	0
18.00	300+	200+	0
30 May 2011			
07.00	300+	200+	0
07.15	200+	200+	0
07.30	30	0	3
07.45	0	0	15

On Lipson Island 87 active burrows were recorded, no inactive burrows were observed. Twenty-six Little Penguin (*Eudyptula minor*) were recorded in active burrows, including five juveniles. Four eggs were also counted.

Silver Gull had four active nests in burrows (more were present amongst the vegetation), in which eight juveniles and two eggs were counted (Table 12). Rock Dove had four active burrows, in which two juveniles and four eggs were counted.

The remaining 53 burrows were classified as active. The bird species in residence were not observed due to the depth of the burrows. However, observations of scats and tracks around burrow entrances would indicate that the Little Penguin would be the most likely occupants. This further supported by audio recordings with Little Penguin being vocal and activity at night.

Table 12. Active burrows with bird species present

	Active burrows	Contents
Little Penguin	26	5 juveniles (4 eggs)
Silver Gull	4	8 juveniles (2 eggs)
Rock Dove	4	2 juveniles (4 eggs)
Unidentified sp.	53	

On the most northern point of Lipson Island in the DES survey exclusion zone, Black-faced Cormorant (*Leucocarbo fuscescens*) and Pied Cormorant (*Phalacrocorax varius*) were observed using Lipson Island as a nesting/breeding and roosting site. Due to the sensitive age of the juveniles of both these species, DES staff observed and recorded observations from a distance and with pre-programmed infrared cameras. The juvenile birds were still before fledgling and covered in down so unable to fly or swim. A maximum total on any one day was 263 adults and 241 juvenile Black-faced Cormorants and 13 adult and 8 juvenile Pied Cormorants recorded on the island during daylight hours (Table 13).

Table 13. Diurnal avian survey results of Lipson Island. Numbers refer to adults and those in brackets refer to the number of juveniles (# = estimation; * = introduced)

	29 May 2011	30 May 2011
Little Penguin	26 (5)	
Australasian Gannet	2	3
Black-faced Cormorant	159 (123)	104 (118)
Pied Cormorant	7 (6)	5 (2)
White-faced Heron	1	
Sooty Oystercatcher		1
Crested Tern	2	4
Pacific Gull	2	2
Silver Gull	550 (150#)	550 (150#)
Rock Dove*	39 (2)	85 (2)
Rock Parrot	12	4
Superb Fairy-wren		1
Common Starling*	2	2380

Shore transects were used to identify other species that might roost on the island but were disturbed by DES staff presence. The results of the two shore transect surveys are provided in Table 14. Of note is the observation of a Hooded Plover. This is likely the second Hooded Plover observed adjacent to Lipson Island.

Table 14. Results of Lipson Cove shore transect (site 354 to 355)

	29 May 2011	30 May 2011
Australian Pelican	5	
Black-faced Cormorant		1
Pied Cormorant	2	4
Red-capped Plover	6	2
Hooded Plover	1	
Sooty Oystercatcher		3
Crested Tern	4	4
Pacific Gull	2	4
Silver Gull	28	53
Nankeen Kestrel	2	1
Brown Falcon		2
Galah		2

Marine fauna results

Mammals

There was an opportunistic sighting of a female Australian Sea Lion (*Neophoca cinerea*), which has recently been listed as threatened (vulnerable) under Commonwealth EPBC Act. The sea lion had captured and subsequently eaten a Little Penguin. It is possible that this sea lion regularly feeds on Little Penguins and other seabirds particularly juveniles that breed and roost on the island. This chance event probably adds support to Lipson Island being a significant bird roost and rookery.

Invertebrates

A total of 38 fauna taxa were recorded with a presence summary for all sites and methods provided in Table 15. This is the best estimation of species richness for the island under the rapid, visual survey approach employed, however additional species are likely to occur as indicated by informal nomenclature for several taxa where: similar species could co-occur (i.e. denoted with 'spp.' or 'forms'); and or broadly diagnosable groups were identified (i.e. to class or family), in both cases collection or more detailed physical examination and microscopy is required. The fauna richness was dominated by crustaceans (eight taxa ranging from crabs and shrimp to amphipods), gastropods (11 taxa including snails and limpets) and barnacles (four taxa). Numerically from 1 x 1 m quadrat data (Appendix E) the barnacle, *Chamaesipho tasmanica,* was most commonly recorded (2835 individuals) followed by the small snail, *Austolittorina unifasciata* (*n*= 1202) and black nerite, *Nerita atramentosa* (*n*= 648).

Table 15. Invertebrate fauna taxa presence for all sites

Taxa	Common name/ field description	4m seine net (sand)	Bait traps and observations (tide pool)	Quadrats (sand and rock)	Quadrats (sheltered rock)	Quadrats (exposed rock)	Observations (exposed coast)
Actinopterygii – ray-finned fishes							
Aldrichetta forsteri	Yellow-eye mullet	10					
Platycephalus speculator	Bluespot flathead	4					
Lesuerina platycephala	Flathead sandfish	2					
Favonigobius lateralis	Favonigobius lateralis		1				
Tetractenos glaber	Smooth toadfish	1					
Malcostraca – higher crustaceans							
Brachynotus spinosus	Little shore crab		x			x	
Cyclograpsus audouinii	Smooth shore crab		x		x	x	
Nectocarcinus integrifrons	Rock crab		x			x	
Ozius truncatus	Reef crab		x		x	x	
Palaemon serenus	Rock shrimp		x			x	
Amphipoda spp.	Amphipods		x	x	x	x	
Deto marina	Sea slater		x		x	x	
Ligia australiensis	Isopod		x				
Brachiopoda – barnacles							
Ibla quadrivalvis	Yellow goose barnacle					x	
Chamaesipho tasmanica	Barnacle colonal		x	x	x	x	x

continued

Taxa	Common name/ field description	4m seine net (sand)	Bait traps and observations (tide pool)	Quadrats (sand and rock)	Quadrats (sheltered rock)	Quadrats (exposed rock)	Observations (exposed coast)
Chthalamus antennatus	Barnacle six plates		x			x	x
Tetraclitella purpurascens	Barnacle flat (grey and white forms)		x		x	x	
Bivalvia – cockles, clams and scallops							
Brachiodontes rostratus	Larger mussel					x	
Lasaea australis	Little pink bivalve		x	x	x	x	
Ostrea angasi	Thin white oyster		x			x	
Xenostrobus pulex	Little black mussel		x	x	x	x	
Gastropoda – snails							
Austolittorina unifasciata	Tiny snail (grey and brown forms)		x	x	x	x	x
Austrocochlea concamerata	Top shell (white spots)		x	x	x	x	x
Bembicium vittatum	Periwinkle		x	x	x	x	
Diacathais orbita	Dog whelk		x	x		x	
Lepsiella vinosa	Tunicate		x		x	x	
Nerita atramentosa	Black nerite		x	x	x	x	x
Cellana solida	Large limpet		x			x	x
Cellana tramoserica	Variegated limpet		x	x		x	x
Patella laticostata	Giant limpet					x	x
Notoacmea spp.	Small apex limpet		x	x	x	x	x
Siphonaria diemenesis	Striped limpet			x		x	x
Polycheata – sea worms							
Polycheata spp.	Sea worms			x	x		
Galeolaria caespitosa	Calcified tube worms		x			x	x
Oligochaeta – aquatic and terrestrial worms							
Oligochaeta (1 species)	Seaweed worm				x		
Anthozoa – anemones and corals							
Actinia tenebrosa	Red anemone		x		x	x	x
Isanemonia australis	Larger pink anemone					x	
Dermospongiae – sponges							
Dermospongiae spp.	Yellow and orange encrusting					x	

Table 16. Taxa richness of intertidal biota grouped by phylum for different sites on Lipson Island

Class	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Fishes	4	1				
Crustaceans		8	1	4	7	
Barnacles		3	1	2	4	2
Bivalves		3	2	2	4	
Snails and limpets		9	8	6	11	8
Worms		1	1	2	1	1
Anemones		1		1	2	1
Sponges					1	
Surface algae		1	1		2	5

Distinctive patterns of intertidal biota in terms of representation and richness of major groups (phylum) were noted between and within different sites (Table 17). The highest number of fauna taxa was recorded in the exposed rocky shore on the southern side of the island (site 5: n = 30, 78% of total taxa recorded were represented). This was closely followed by the tide pool habitat (site 2: n = 26) despite slightly less survey effort without the 1 x 1 m quadrats. The physical habitat within the 5 x 5 m quadrats is shown in Figure 5, with this data supporting the broad designation of macrohabitats (i.e. site 3 = mostly sand, some rock; site 4 = mostly rock; site 5 = mostly rock, with increasingly permanent tide pools due to greater wave exposure). Across the three quadrat sites, richness increased with increasing structural complexity and wave exposure (i.e. site 3 < site 4 < site 5: Figure 5, see also Appendix E). Examination of patterns of zonation across quadrat sites showed a pattern of increasing taxa richness and abundance with decreasing desiccation or tide height (Figure 6, see also Appendix E). Sea temperate at the time of sampling was 17.0°C.

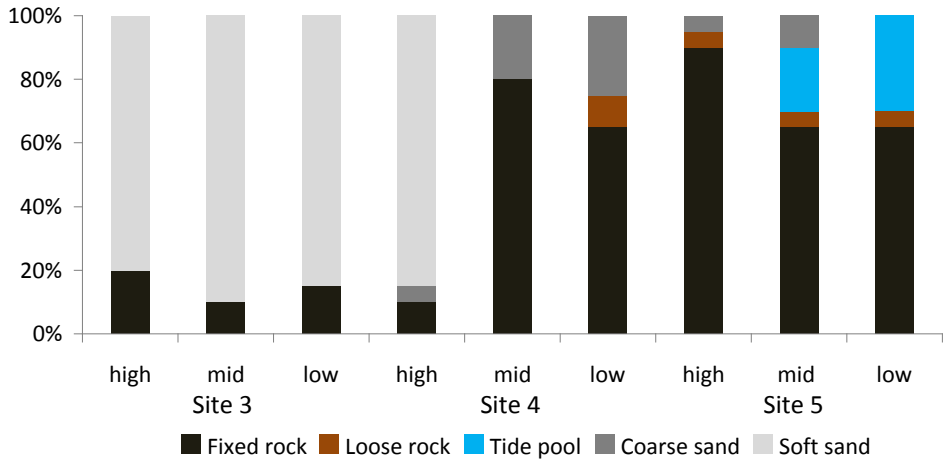

Figure 5. Habitat composition (substrate) for 5 x 5 m quadrats

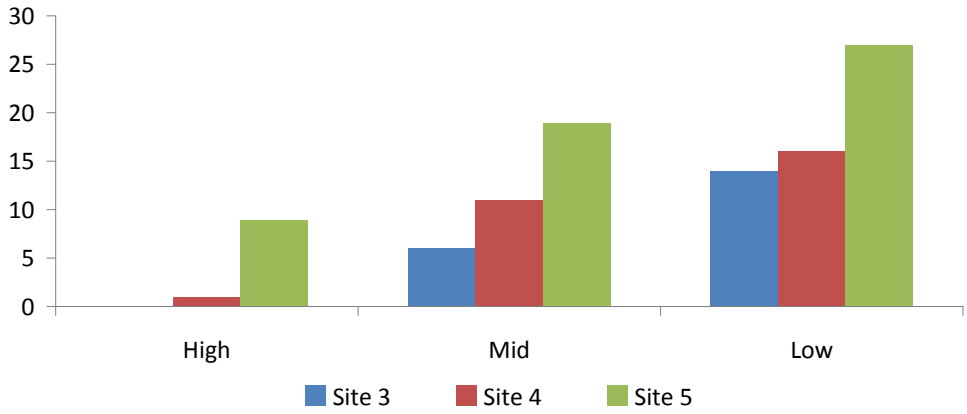

Figure 6. Taxa richness of biota within different tidal zones at transect/ quadrat sites

Impact identification and risk management

DES has identified the potential impacts of the Sheep Hill Port on Lipson Island flora and fauna based on given locations of the port, roads and other associated infrastructure depicted in Figure 1 and described in the development application [1], flora and fauna desktop and field surveys and from industry experience.

The distance of Lipson Island from the proposed development affords benefits to the protection and maintenance of its' biodiversity. This has been also considered in the risk assessment process.

Impact management and mitigation measures are often implemented through monitoring and management plans to deal with specific issues in industry and this has been the approach here. Prescriptive and detailed risk management measures are currently not possible as final detailed project designs are not available. Where appropriate, general management measures consistent with industry standards and issues are provided.

Lipson Island is a gazetted conservation park and managed by NPWS. Monitoring to assess performance of any future management and mitigation procedures may be necessary. This may involve access to Lipson Island and adjacent foreshore and negotiation with the relevant authorities. Site specific biodiversity management on Lipson Island will be determined from monitoring results.

A number of these monitoring or management plans, after a time, are likely to be found to be superfluous and could be discontinued.

The risk matrix process used is a decision-making tool. If the risk assessment determines a residual risk greater than low, then this need not equate to unacceptable impact. The residual impact, although measured by the tool, should not be considered in isolation and decisions must be developed in a broader environmental analysis. Nevertheless the risk assessment tool has identified impacts, mitigation measures and residual impacts.

Uncertainties in the impact assessment

As previously mentioned, the uncertainty regarding the details of the site layout is a limiting factor. DES has received a description of the development application [1] and assessed the impacts on Lipson Island biota. Consequently, any deviations in the design, construction and operation in the development

application will alter the impacts and risks and may therefore require a new assessment of impacts.

Additional uncertainties specific to the impact assessment process relate to limitations of this baseline flora and fauna survey (see Limitations).

The lack of adequate data does however introduce some uncertainty into the impact assessment process as threatened species have been identified on and adjacent to Lipson Island. A greater level of knowledge of these would be desirable and consistent with the precautionary principle incorporated into the relevant standard (risk assessment guide).

The predicted impacts, likelihood, consequence, risk level, recommendations for management and residual risk levels are provided in tables 2, 3 and 4.

Risk assessment results

Table 17. Proposal development design assessment of impacts, consequences, risks, proposed risk management and residual risks on flora and fauna. Residual impacts outlined are those deemed to remain after all listed management practices are implemented. Actual residual impacts will be dependant on management practices applied to each issue.

Impact	Likelihood	Consequence	Risk level	Risk management and mitigation	Residual likelihood	Residual consequence	Residual risk level
Noise disturbance to seabird rookeries and roosts (including drilling, driving and blasting during development, construction and operation)	A	3	H	Noise disturbance to seabird rookeries (breeding sites) and roosts needs to be managed in all phases of the project particularly during construction and development phases. Develop and implement a seabird rookery noise disturbance impact mitigation plan and procedures that include, but are not limited to: • • minimising, measure and monitor noise in the vicinity of Lipson Island seabird rookeries; • • considering discouraging staff access to Lipson Island to minimise cumulative impacts of ambient noise with increased people access and visitation; • • specifically consider with an articulated monitoring plan the breeding rookery of Little Penguin; • • specifically consider with an articulated monitoring plan the breeding rookery of seabirds; • • identifying the extent by monitoring during the migratory season the use of Lipson Island as a migratory wader roosting site, and if necessary develop a specific management plan to mitigate noise pollution; • rationalising, closing and rehabilitating unused vehicle tracks and exploration areas; • minimising activities adjacent to Lipson Island particularly during seabird breeding season and roosting times; and • minimising disturbance to roosting birds by limiting excessive noise activities one hour before and after sunrise and sunset.	D	4	L

continued

Impact	Likelihood	Consequence	Risk level	Risk management and mitigation	Residual likelihood	Residual consequence	Residual risk level
Light disturbance to seabird rookeries and roosts (drilling, driving, blasting and shipping, from shipping lanes, during development, construction and operation)	A	3	H	Light disturbance to seabird rookeries (breeding sites) and roosts needs to be managed in all phases of the project particularly during construction and development phases. Develop and implement a seabird rookery light disturbance impact mitigation plan and procedures that includes, but is not limited to: • designing all pier light during construction and operation that direct light locally and away from Lipson Island; • minimising, measuring and monitoring light pollution in the vicinity of Lipson Island seabird rookeries; • considering limiting staff access to Lipson Island during construction to minimise cumulative impacts of ambient light with increased people access and visitation; • train staff to effectively implement light management; • establish a wildlife death/incident register (during construction and operation periods) so all bird strikes related wildlife deaths and injures on the pier and associated infrastructure are recorded and monitored; • specifically considering with an articulated monitoring plan the breeding rookery of Little Penguin; • specifically considering with an articulated monitoring plan for the breeding rookery of seabirds ; • identifying the extent of use of Lipson Island as a migratory wader roosting site, and if necessary develop a specific management plan; • minimising activities adjacent to Lipson Island particularly during seabird breeding season and roosting times; and • minimising disturbance to roosting birds by limiting excessive light one hour after sunrise and one hour before sunset.	D	4	L
Soil erosion and siltation of adjacent coastal marine environments	C	3	M	Develop and implement a landscape soil erosion control plan that protects the marine environment adjacent to and including Lipson Island that includes, but is not limited to: • standard industry sedimentation controls; • contouring cleared areas to avoid soil loss and gullying; • minimising areas to be cleared; • monitoring cleared areas to determine if erosion is likely or occurring; • covering areas at high risk of erosion with gravel, mulch or other coarse material; and • constructing and maintaining sediment traps to capture silt run-off from cleared areas.	D	4	L

continued

Impact	Likelihood	Consequence	Risk level	Risk management and mitigation	Residual likelihood	Residual consequence	Residual risk level
Weed proliferation	D	3	M	Develop and implement a weed management plan that may include, but is not limited to: • standard industry weed monitoring and controls; and • maintaining a 'clean vehicles and equipment' policy.	D	4	L
Siltation and turbidity pollution of Lipson Island marine environment (particularly during pier construction)	A	3	H	Develop and implement a siltation and turbidity management plan that may include, but is not limited to: • standard industry controls; and • monitoring recommendations provided in ASR (2011).	D	4	L
Dust	A	4	H	Implement best practice dust minimisation activities.	D	4	L
Feral animals impact on seashore foraging seabirds that roost on Lipson Island (fox and cat)	B	2	H	Develop an integrated feral animal management plan that may include, but is not limited to: • eliminating of waste food stuffs that increase feral species population and consequent predator pressure on seabirds that breed and roost on Lipson Island; • population control targeting fox and cats through appropriate means; • managing man-made habitats (such as building infrastructure and sediment dams) to reduce resources for fox and cat; and • monitoring fox and cat populations and impacts as part of Hooded Plover and to a lesser extent Little Penguin, seabird and shorebird (waders) monitoring..	D	4	L
Release of invasive marine species from ballast water	B	2	H	Develop and implement a leading industry standard ballast water management plan that includes, but is not limited to: considering the ecological integrity of the Lipson Island marine environment; considering implementing a monitoring program for intertidal marine species, particularly for invasive species;implementing a ballast water management plan in line with the Australian Government Mandatory Ballast Water Management [19] requirements; andensuring restriction of high-risk ballast water release (prohibited in Australian ports and waters).	C	3	M

continued

Impact	Likelihood	Consequence	Risk level	Risk management and mitigation	Residual likelihood	Residual consequence	Residual risk level
Uncontrolled spill of waste water containing oils, solvents, metals and other containments	B	3	H	Develop and implement an uncontrolled spill (of hazards) management plan that includes, but is not limited to: • implementation of leading standard spill mitigation plan; emergency and contingency plans in the event of uncontrolled releases to the marine environment that may affect Lipson Island; • considering developing seabird de-oiling emergency and contingency procedure; • specifically monitoring the Lipson Island seabird and intertidal environment during uncontrolled hazard spills that may affect the island; • implement best practice procedures for handling hydrocarbons and chemicals, monitoring materials handling, disposal and pollution abatement including familiarisation of site personnel with toxicity levels and properties of chemicals being used, safe handling procedures and ready access to material safety data sheets; and • using bunding and contouring of surfaces to drains to avoid hydrocarbon and chemical runoff into the marine environment that may affect Lipson Island.	D	4	L
Wildlife entanglement from uncontrolled release of hard waste	C	3	M	Develop and implement an uncontrolled release of a hard waste (entrapment and entanglement with hazards) management plan that includes, but is not limited to: • implementation of leading industry standard hard waste mitigation plan; • emergency and contingency plans in the event of uncontrolled releases of hard waste to the marine environment that may affect Lipson Island biodiversity • considering developing a seabird and Australian Sea Lion de-entanglement emergency and contingency procedure; • monitoring and removing entanglement hazards to individuals; • monitoring and removing all hard waste on Lipson Island and the adjacent beach from its supra and intertidial zones and adjacent shoreline; and • using appropriate facilities to contain and eliminate uncontrolled release of hard waste.	D	4	L

continued

Impact	Likelihood	Consequence	Risk level	Risk management and mitigation	Residual likelihood	Residual consequence	Residual risk level
Disturbance to Lipson Island by increased people access (inappropriate people behaviour)	A	3	H	Human presence is a significant disturbance factor to Little Penguin and seabird rookeries (breeding sites) and roosts and needs to be managed in all phases of the project particularly during construction and development phases. Develop and implement a staff access and activity policy that includes, but is not limited to: • interpretative material to inform staff of appropriate and inappropriate behaviour; • management or guide for staff access and behaviour by signage, educational briefings, workshops and other educational material; • minimising disturbance to seabird rookeries and roosts;minimize public and staff waste foodstuffs that benefit Silver Gulls, with education and waste removal; • specifically considering with an articulated monitoring plan for the breeding rookery of Little; • specifically considering with an articulated monitoring plan, the breeding and roosting rookery of seabirds Identifying the extent of use of Lipson Island as a migratory wader roosting site, and if necessary developing a specific management plan to mitigate noise pollution; • rationalising, closing and rehabilitating unused vehicle tracks and exploration areas; and • minimising activities adjacent to Lipson Island particularly during seabird breeding season and roosting times; and	D	4	L
Increased habitat for terrestrial invasive species (e.g. Silver Gull)	A	3	H	Silver Gull is associated with human activity and if not managed will considerably increase in numbers at Lipson Island to the detriment of Little Penguin, migratory waders and other seabird species by direct predation (particularly of eggs and juveniles), harassment and competition for breeding sites. Develop and implement an invasive species (Silver Gull) management plan that includes, but is not limited to: • eliminating accessible waste food stuffs at the development site that would otherwise increase invasive species population; • monitoring Silver Gull populations and impacts as part of Little Penguin and seabird breeding management; • interpretative material to inform public and staff of appropriate and inappropriate (waste food) behaviour; • management or guide of staff access and behaviour by signage, educational briefings, workshops and other educational material; and • minimising disturbance to seabird rookeries and roosts, that facilitate predation by Silver Gull.	C	4	M

Discussion

General ecology

Lipson Island is a designated conservation park and in its simplest terms is a significant bird rookery and roost for species including those listed under various legislation. The intertidal environment, although not significantly abundant, has no recorded invasive species. These are the two ecological criteria that will require protection, monitoring and management to maintain the conservation park integrity. The distance of Lipson Island from the proposed development affords it some protection from potential impacts..

Flora ecology

It is a low-lying intertidal island with extensive areas of bare rock (80%) and sand (10%) with the remaining vegetation dominated by Nitre Bush. Nitre Bush is a perennial salt-tolerant shrub commonly found in saline and coastal areas. Only four other terrestrial flora species were observed on the island. Low terrestrial flora inventory is typical of low-lying islands particularly if populated by large numbers of nesting and roosting seabirds.

Intertidal flora was conspicuously absent with the only presence being disturbance-resistance surface films, for example, seagrass, Neptune's necklace, kelp and filamentous algae. This may reflect recent storm conditions.

Fauna ecology

The transect surveys on Lipson Island discovered 87 active bird nesting burrows indicating that the island is a significant nesting site for Little Penguin and possible other burrow-nesting seabirds. Little Penguin is a high profile species of public concern. Three Wildlife Acoustics SM1 Songmeters® recorded Little Penguin as conspicuously vocal at night and the frequency of calls suggests that more than 26 Little Penguins (those observed) return to the island to roost and raise young at night.

The species is in significant decline in South Australia, although no longer empirical study exists in the state. The prime causes of decline are currently unknown. The species on Lipson Island is also likely in decline. This is important in the context of the proposed development, as a public perception may implicate the development in the likely decline of the species.

The observations of large numbers of birds in breeding colonies of Black-faced and Pied Cormorants on the northern point of Lipson Island emphasises that the island is an essential habitat for local breeding and roosting seabirds. Fairy Tern, Sooty Tern, Crested Tern and possibly short-tailed Shearwater may also breed on the island. The nearest seabirds and Little Penguin rookeries are likely to be on Tumby Island (20 km south) and Sir Joseph Banks Group of Islands (20 km south-east). No breeding rookeries of these species that breed on Lipson Island exist to the north.

The infrared cameras have also shown Lipson Island to be a significant nocturnal roosting site for the local populations of Pied and Black-faced Cormorants, Silver Gull, Rock Pigeon, Common Starling and Crested Tern. During summer months Fairy Tern and the migratory waders (all listed under the EPBC Act and associated treaties), namely Red-necked Stint, Grey Plover and Sanderling, although not observed (because of the timing of the field surveys) or recorded in desktop surveys, are likely to roost on the island. The number that will roost on the island is not known. On rare occasions White-bellied Sea-eagle and Eastern Osprey (both EPBC Act-listed as endangered under NPWS Act) would feed on birds that breed and roost on Lipson Island.

The limitations of the survey period (two days) and the timing of the survey (late autumn) became significant in the zero recordings of bat activity in the air space above the island. In warmer months it would be expected the insectivorous bats would feed on insects that associate with guano (bird droppings). No terrestrial mammals are expected on the island. The lack of recorded reptiles probably reflects the cooler conditions and some reptiles would likely be observed in the warmer months.

The characterisation of the intertidal habitat of Lipson Island revealed a reasonably high diversity of intertidal biota. Groups such as gastropod snails, limpets and crustaceans were particularly well represented. However other groups were conspicuously absent including urchins, seastars and small rock pool fishes such as blennies and gobies. The high wave action around the island and steep shores with few permanent rock pool refuges is likely to naturally limit available habitat for species that prefer more sheltered conditions. The role of a recent large storm event and cool weather in displacing biota and limiting site records is unknown, but cannot be ruled out given moderate amounts of shore debris noted.

Changes in richness and abundance were observed across the intertidal range, with greatest abundance and richness of biota being present in the low tide margins (that emerged from the water for the shortest duration during the tidal cycle). These changes in richness and abundance through the intertidal range are likely to reflect the ecological specialisations of each of the animals (for example resource use, competition, feeding behaviour, and physiological adaptations). In addition, changes in richness and abundance were evident between habitat types, for example, the more exposed and steep coastline on the south of the island had lower and different species richness by comparison to the sandy habitat and tide pool. These factors reflect the importance of the island to harbour such a diversity of habitats within a small area.

Sygnathids, which are listed under the EPBC Act 1999, Tiger Pipefish and Leafy Seadragon may be expected to occur locally in subtidal habitats, along with other marine fishes and invertebrates of state conservation concern [8, 20]. The use of the intertidal habitat by species of recreational importance was detected (i.e. yelloweye mullet and bluespot flathead), however there is unlikely to be broader significance of this habitat in the species ecology.

Conservation significance species

Species of conservation significance is determined in this report by legislative status, breeding on the island and public profile. The likelihood of such species utilising Lipson Island and associated intertidal zone is determined by desktop and field surveys, habitat present and experience. Only species likely to utilise Lipson Island are included.

The species of conservation significance for Lipson Island are (see also Appendix F):

- Australian Sea Lion;
- Little Penguin;
- Hooded Plover;
- Red-necked Stint;
- Grey Plover;

- Sanderling;
- White-bellied Sea-eagle;
- Eastern Osprey;
- Fairy Tern;
- Green Turtle;
- Loggerhead Turtle; and
- Leatherback Turtle.

Introduced species

Introduced flora

Declared weed species for South Australia recorded during the on-site survey comprises:

- African Boxthorn, under the NRM Act the presence of Boxthorn requires control of the plant by the landowner throughout South Australia.

In 1998 the Commonwealth Government endorsed a framework to identify weed species that could be considered weeds of national significance. African Boxthorn is a weed of national significance. In addition, African Boxthorn has been identified as regionally concerning due to its potential for detrimental effects of biodiversity on the Eyre Peninsula [32]. Three other introduced flora were recorded.

No introduced marine flora was found in the current survey.

Introduced fauna

Two introduced fauna species, Common Starling and Rock Dove, were recorded.

No invasive marine fauna was found in the current survey.

Impact identification and management

DES has identified the potential impacts of the port project on flora and fauna of Lipson Island and the associated intertidal and supratidal zones based on:

- the report provided, Development Application and Request for Guidelines – Sheep Hill Marine Port, Eyre Peninsula, South Australia by Centrex Metals LTD. Report number 107661001-R-020-Rev3;
- desktop and field surveys;
- distance form the proposed development;
- literature review; and
- industry experience.

The prime ecological aspects of Lipson Island are the bird rookery and roosts, and biodiversity integrity of the intertidal zone. It is these aspects that mitigation, monitoring and management plans aim to protect. A summary of predicted impacts, likelihood, consequence, risk level, recommendations for management and residual risk levels are provided in Table 17. Residual risk is only assumed and based on the successful and completed implementation of identified monitoring and management plans.

Most of the impact and mitigation measures identified in this assessment are typical of industrial developments of this design, size and location. It is expected that the relevant management plans (listed below) will be developed and implemented prior to commencement of construction:

- seabird rookery noise disturbance impact mitigation plan;
- seabird rookery light disturbance impact mitigation plan;
- soil erosion and siltation management plan;
- weed management plan;
- siltation and turbidity management plan;
- dust abatement plan;
- integrated feral animal management plan;
- industry standard ballast water management plan;
- uncontrolled spill management plan;
- uncontrolled spill contingency emergency plans;
- uncontrolled release of hard waste (of entrapment and entanglement with hazards) management plan;
- wildlife entanglement contingency emergency plans;
- develop and implement a staff and contractor access and activity policy, for Lipson Island; andinvasive species (Silver Gull) management plan.

A number of these monitoring and management plans (listed above), after a time, are likely to be found to be superfluous.

This assessment has also identified some site-specific impacts that require specific monitoring, management or further investigation. These include, but are not necessarily limited to the development of:

- Little Penguin monitoring plan; and
- seabird and shorebird (including migratory waders) rookery and roosting monitoring plan.

The management plans need to be adaptive, to change during commissioning, construction and operation., Monitoring, mitigation and management should be incorporated into an Environmental Management System (EMS), which should be articulated to stakeholders.

Noise disturbance to seabird rookeries and roosts (construction and operation)

Noise during construction and operation will occur at the site of the port project. Some of this noise will extend to Lipson Island, particularly pylon drilling, driving and general construction. There will be ongoing noises during operational phases.

Irregular, unusual or particularly loud noises or intense vibrations can cause disturbance to wildlife. Of particular conservation importance is the Little Penguin, which is sensitive to a range of disturbances. Disturbance from noise may result in lower breeding success and may inhibit individuals from returning from feeding at sea resulting in chicks not being fed and partners not being relieved. Noise, being stressful for couples, may also inhibit the initiation of breeding at the beginning of a breeding season, which may compromise Lipson Island seabird rookery. The survival of Little Penguin breeding activity is likely to be scrutinised by the public. The rookery as elsewhere may be in decline irrelevant of the proposed development, however the public perception is likely

to be different. Establishing population trends of Little Penguin on Lipson Island would not be difficult. This may need to commence prior to the construction.

Breeding populations of penguins, cormorants and gulls, and most likely terns could be affected. The island is reasonably distant (1.5 km) from the proposed development, which will afford some abatement from noise pollution. Low frequency noise is likely to extend further. There is no documented evidence that noise emitted from such types of development at a distance of 1.5 km has affected bird rookeries of the species identified on Lipson Island. Birds are likely to habituate to low level constant noise. The noise levels from the proposed development are unknown, consequently a precautionary principle is used that requires noise and Lipson Island seabird rookery and roost be managed and monitored. It is not expected that the noise effect from the proposed development would effect migratory waders anymore than the noise emitted by the breeding rookery. Seabird rookeries are noisy and the Songmeters recorded frequent episodes above 70 dB. Noise from the proposed development will be of a different nature but may not exceed 70 dB or background levels on the island. Nevertheless the importance of the roost to migratory waders (that is, numbers) is not known.

Impact management and mitigation

Develop and implement a noise abatement management plan and procedures that include, but is not limited to:

- minimising, measuring and monitoring noise disturbances in the vicinity of Lipson Island seabird rookeries;
- considering discouraging staff access to Lipson Island to minimise cumulative impacts of ambient noise with increased people access and (see specific management plan);
- training staff and contractors regarding adverse impacts on penguin and seabird colonies from noise;
- specifically consider with an articulated monitoring plan the breeding rookery of Little Penguin;
- specifically consider with an articulated monitoring plan the breeding rookery of seabirds:
- identifying the extent by monitoring during the migratory season the use of Lipson Island as a migratory wader roosting site, and if necessary developing a specific management plan to mitigate noise pollution;
- rationalising, closing and rehabilitating unused vehicle tracks and exploration areas;
- minimising noise activities adjacent to Lipson Island particularly during seabird breeding season and roosting times; and
- minimising disturbance to roosting birds by limiting excessive noise activities one hour before and after sunrise and sunset.

Light disturbance to seabird rookeries and roosts (development, construction and operation)

There is likely to be some level of disturbance on Lipson Island from wharf lights during construction and operations. Penguins can be shy when landing and

are known to be disturbed by lights. Illumination of Lipson Island foreshore will inhibit penguin landing, increase predation risk and decrease breeding success. Illumination will also allow for increased predation of eggs and young by Silver Gull. The extent of illumination and associated light disturbances to the island at a distance of 1.5 km can be readily managed.

Migratory waders and resident seabirds can be attracted to and collide with lighting and associated infrastructure. Such impacts are poorly quantified or recorded in literature. Although Lipson Island is 1.5 km from the proposed development, migratory waders and resident seabirds readily travel such distances when returning to roost. Collisions with lights, particularly lighthouses are well documented, where they are the sole light source and located on migratory pathways. This is the not the case at the proposed development site. Conditions for significant bird strike are not evident however bird strike monitoring is recommended.

Impact management and mitigation

Develop and implement a light disturbance mitigation plan that includes, but is not limited to:

- designing all pier lighting during construction and operations that directs light beam locally and away from Lipson island;
- minimising, measuring and monitoring light pollution in the vicinity of Lipson Island seabird rookery;
- considering limiting staff and contractor access to Lipson Island during construction to minimise cumulative impacts;
- establishing a wildlife death/incident registrar (during construction and operation periods) so all strike-related wildlife fatalities and injuries on the pier and associated infrastructure are recorded and monitored;
- training staff to efficiently implement light management;
- specifically considering, with an articulated monitoring plan, the breeding rookery of Little Penguin in conjunction with the noise management plan;
- specifically considering, with an articulated monitoring plan, the breeding rookery of seabirds in conjunction with the noise management plan;
- identifying the extent of use by monitoring during the migratory season of Lipson Island as a migratory roost site, and if necessary develop and implement a specific management plan;
- minimising activities adjacent to Lipson Island particularly during seabird breeding season (currently unknown) and roosting times; and
- minimising disturbance to roosting birds by limiting excessive light one hour before and after sunrise and sunset.

Soil erosion and siltation of adjacent coastal marine environments

Port construction on land can cause excessive amounts of sediment and debris to enter the marine environment. Soil erosion can have a detrimental effect on the flora and fauna of the intertidal zone of Lipson Island. The intertidal zone species are predominately benthic and sessile. Many larval forms also rely on suitable conditions for settlement and hence recruitment to the local site. This life history has a strong link to this potential impact.

Control of soil erosion during port developments is readily implemented. The effect on Lipson Island will depend on the effectiveness of such controls as well as environmental conditions such as rainfall, tidal movements, currents and other weather conditions. Such information has not been provided and consequently a precautionary principle is used that requires soil erosion management plans and monitoring. The distance of Lipson Island to the proposed development affords some protection from this potential impact and should be readily managed.

Impact management and mitigation

Develop and implement a soil erosion and siltation control plan that protects the marine environment of Lipson Island and adjacent shores that includes, but is not limited to:

- standard industry sedimentation controls;
- diverting and or channeling storm water away from disturbed or exposed areas;
- preventing soil erosion by minimising disturbed areas during construction projects, and covering areas at high risk of erosion with gravel, mulch or other coarse materials;
- rehabilitating required areas as soon as practical;
- constructing and maintaining sediment traps to capture silt run-off from cleared areas;
- contouring cleared areas to avoid soil loss and gullying;
- minimising the area to be cleared; and
- monitoring cleared areas to determine if erosion is likely to occur.

Weed proliferation

Spread of weeds may increase due to large areas being disturbed during construction and increased traffic transporting invasive seeds to the proposed development site. Lipson Island contains large numbers of breeding and roosting seabirds. These large numbers limit vegetative growth, including weed growth by trampling, guano concentration and use as nesting material. Although weed seeds are likely to be transported to the island, weed establishment will remain difficult..

Impact management and mitigation

Develop and implement a weed management plan that includes, but is not limited to:

- monitoring, mapping and controlling weeds during project development and operation;
- maintaining a 'clean vehicles and equipment' policy whereby heavy vehicles and equipment (including boots and clothing) are cleaned prior to entering the project area. Other vehicles are to be cleaned if they leave designated access tracks; and
- rehabilitating required areas as soon as practical.

Siltation and turbidity pollution of Lipson Island marine environment

Pier construction including pylon driving will create some siltation and turbidity pollution of the immediate marine environment.

Siltation and turbidity is dependant on the extent of the methods used, current movements and direction that can cause considerable impact of the marine ecological integrity of Lipson Island particularly benthos communities.

During the pile driving process, pile fabric filtering will be used around each pile so that turbidity effects will be minimal [22]. Since Lipson Island is located approximately 1.5 km south of the project, modelling undertaken indicates no significant environmental matters [22].

Control of sedimentation and turbidity during port construction is important. The effect on Lipson Island intertidal zone will depend on effectiveness of the stated controls as well as methods used.

Impact management and mitigation

Develop and implement a siltation and turbidity management plan that may include, but is not limited to:

- standard industry controls; and
- monitoring recommendations provided in ASR (2011).

Dust

Dust is primarily an air-quality issue with impacts on human health, however smothering terrestrial vegetation can effect regional ecology. Should fugitive dust contain metals, other impacts on wildlife through exposure will occur. Dust emissions are typically easy to mitigate with this type of proposed developments. Lipson Island is reasonably distant and upwind of prevailing winds from the proposed development.

Impact management and mitigation

Develop and implement a best practice dust mitigation management plan.

Impact of feral animals (fox and cat) on seashore foraging seabirds that roost on Lipson Island

Feral animals have a range of impacts on native flora and fauna in Australia. Increased predator pressure from foxes and cats can have a devastating effect on resident fauna species. This is particularly pertinent for foreshore foraging species such as migratory waders, Hooded Plover, terns and other species that return to breed or roost on Lipson Island. Fox predation is an identified risk to Hooded Plover and without effective controls the plover will likely become extinct in the immediate locality including Lipson Island.

Foxes and cats typically inhabit human environments and take advantage of microhabitats to sleep, for protection from the elements, breeding and hunting. Foxes and cats benefit from temporary buildings for these resources and their numbers increase dramatically with human food waste provisions.

Impact management and mitigation

Develop an integrated feral animal management plan that may include, but is not limited to:

- eliminating available waste food stuffs;
- population control of foxes and cats;

- monitoring particularly on beaches and controlling fox and cat populations;
- managing man-made habitats (such as building infrastructure and sediment dams) to reduce resources for foxes and cats; and
- monitoring fox and cat populations and impacts as part of the Hooded Plover, and to a lesser extent Little Penguin, seabird and shorebird (waders) management.

Release of invasive marine species from ballast water

The environmental and economic impacts of a marine pest introduction via ships' ballast water have been recognised and can be significant. This study of the marine environment surrounding Lipson Island including the intertidal zone established it as being a healthy ecosystem with zero recordings of any introduced species. High incidences of a wide range of introduced organisms are known from most major ports and some smaller harbours/marinas in southern Australia [33] including in the Eyre Peninsula [34]. These can be transported via ship fouling or within ballast, sourced internationally, but also arriving through domestic pathways [34-36]. Important introduced organisms that may result from increased shipping include (but are not limited to) the Round Goby, Trident Goby, Green Crab, Pacific Oyster, Green Mussel and European Fan Worm [37]. Ballast water management, guidelines and industry standards are widely available under the *Quarantine Act* 1908 [19].

Impact management and mitigation

Develop and implement a leading industry standard ballast water management plan that includes, but is not limited to:

- considering the ecological integrity of the Lipson Island marine environment;
- considering implementing a monitoring program for intertidal marine species;
- implementing a ballast water management plan in line with the Australian Government Mandatory Ballast Water Management [19] requirements; and
- ensuring restriction of high-risk ballast water release (prohibited in Australian ports and waters [19]).

Uncontrolled spill of wastewater containing oils, solvents, metals and other containments

A range of hydrocarbons and chemicals will be used on site and spills will invariably occur that can have impacts on marine flora and fauna of Lipson Island. The impact of a hydrocarbon or chemical spill on flora and fauna is dependent on many factors such as the nature of the chemical (i.e. solubility in water), volume, the toxicity of the chemical spill to flora and fauna, the volume spilt and distance from Lipson Island. Surface water, ground water and direct spills can impact on the marine environment. Lipson Island is afforded some protection being located 1.5 km away. Hydrocarbons and metal contaminants depend on tidal, current and weather conditions, which can plume to such distances. Of particular concern on Lipson Island are the roosting and breeding seabirds, such as Little Penguins, which are debilitated by oil spills [38, 39] leading to toxicity [39]. Hazards need to be released or reach Lipson Island to cause a detrimental effect. Wildlife, including Little Penguin and Australian Sea Lion, will be attracted to the port facility where it can come into contact with such hazards.

Some pollutants have specific properties relating to environmental impacts such as bioaccumulation, biomagnification or particular toxicity to aquatic life forms. Information on such properties is generally readily available and often included in material data safety sheets. Management of hydrocarbons and chemicals is often well developed throughout industry and usually articulated in hydrocarbon and chemical spill management plans.

This assessment considers the construction and operation of the port. The products that the port will transport and handle, which could contain various hazards including metals, are not considered by this report.

Impact management and mitigation

Develop and implement an uncontrolled spill (of hazards) management plan that incorporates best management standards during both construction and continual operations and includes, but is not limited to:

- implementing a leading industry standard spill mitigation plan;
- emergency and contingency plans in the event of uncontrolled releases to the marine environment that may affect Lipson Island;
- consider developing a seabird de-oiling emergency and contingency procedure;
- monitoring Lipson Island seabird and intertidal environment during uncontrolled hazard spills that may affect the island;
- implementing best practice for handling hydrocarbons and chemical materials handling, disposal and pollution abatement, safe handling procedures and ready access to material safety data sheets; and
- using bunding and contouring of surfaces to drains to avoid hydrocarbon and chemical run-off into the marine environment that may affect Lipson Island.

Wildlife entanglement from uncontrolled release of hard waste

Port construction and operation (and increased human activity) can result in a significant increase in hard waste (for example ropes, and plastics). Hard waste can have a harmful and visible effect on local marine and seabird fauna. Plastic as it breaks down becomes more readily ingestible and releases harmful toxins that disrupts hormones [40]. Once ingested, plastic cannot be digested or passed by an animal so stays in the gut [39] and it sates their hunger, leading to starvation, a recognised risk to EPBC Act threatened species [40]. Wildlife can be attracted to remains of food in cans. These can cut and trap animals that come in contact with them. Birds and fish get tangled up or strangled by can collars and rope. In Little Penguins, fishing nets [38, 39], lines and six pack holders have caused broken limbs and nerve damage in the legs [38]. Such hazards need not reach Lipson Island to be detrimental to wildlife, as wildlife will be attracted to the port where they can come into contact with the hazards.

Hard waste is currently collected from the Lipson Cove and adjoining beaches by volunteers on a monthly basis. The waste is categorised according to type, volume and source.

Impact management and mitigation

Develop and implement an uncontrolled release of hard waste (of entrapment and entanglement with hazards) management plan that includes, but is not limited to:

- a leading industry standard hard waste mitigation plan;
- emergency and contingency plans in the event of uncontrolled releases of hard waste to the marine environment that may affect Lipson Island biodiversity;
- considering developing a seabird and Australian Sea Lion de-entanglement emergency and contingency procedure;
- monitoring and removing entanglement hazards;
- monitoring hard waste in the vicinity of Lipson Island and adjacent shoreline; and
- use appropriate facilities to contain and eliminate uncontrolled release of hard waste.

Disturbance to Lipson Island by increased people access (inappropriate people behaviour)

Any planned improvement of the access roads, structures and commencement of a new industry will attract and introduce a significant increase of human traffic to the area. Increased awareness of Lipson Island Conservation Park and the adjacent beaches will result in increased human activity, using the area as a recreational destination (for example fishing, hiking, beach walking). Human presence brings a range of issues for management that includes direct and deliberate disturbance to seabird rookeries and roosts, noise, inappropriate behaviour, hard waste, weeds, disease and trampling. The presence of domestic cats and dogs will likely increase with human activity.

The presence of humans on Lipson Island and the foreshore can be directly detrimental to breeding success of seabirds and Little Penguins. The nesting burrows on Lipson Island are built in a sandy substrate. They are fragile and at risk of collapsing under the weight of increased human traffic. Disturbance of adults and young has repeatedly been documented as detrimental to breeding success. Dogs will chase and disturb migratory wading birds on adjacent foreshores and attack and kill juvenile chicks that are unable to fly or flee. One of the most common terrestrial threats to Hooded Plover, migratory waders and Little Penguins are dogs, causing injury or death [38]. Even the presence of dogs on leashes can and will attract other dogs by their scent to the area.

Although the proposed port development does not directly facilitate human activity to the broader region (other than staff), the development will increase public interest and visitation. With current public road access and camping adjacent to Lipson Island an increase in human presence and detrimental behaviour is inevitable without active management.

Human presence is a significant disturbance factor to seabird rookeries (breeding sites) and roosts and needs to be managed in all phases of the project particularly during construction and development phases. The cormorant rookery on Lipson Island appeared particularly sensitive to human presence.

There is expected to be an increase in recreational and angler boats to the Lipson Island locality. This presents further potential disturbances to the Lipson Island ecology, particularly as vessels enable easier direct access to the island.

The more common groups of intertidal fauna found in the current survey with a heavy dependent benthic living (i.e. relatively sessile) have a strong

link to potential development impacts such as increased human visitation (i.e. trampling).

Impact management and mitigation

Develop and implement a staff access and activity policy, impact mitigation plan that includes, but is not limited to:

- interpretative material to inform staff of appropriate and inappropriate behaviour;
- management or guide for staff access and behaviour by signage, inductions, educational briefings, workshops and other educational material.
- minimising disturbance to seabird rookeries and roosts;
- specifically considering, with an articulated management plan, the breeding rookery of Little Penguin;
- specifically considering, with an articulated management plan, the breeding rookery of seabirds;
- identifying the extent of use of Lipson Island as a migratory wader roosting site and if necessary develop a specific management plan to mitigate noise pollution;
- rationalising, closing and rehabilitating unused vehicle tracks and exploration areas; and
- minimising activities adjacent to Lipson Island particularly during the seabird breeding season and roosting times.

Increased habitat for terrestrial invasive species (for example, Silver Gull)

The presence of Silver Gulls is strongly tied to human activities and structures such as ports. Inappropriate and increased provision of food resources will increase local Silver Gull populations.

If not managed Silver Gull will increase in numbers at Lipson Island to the detriment of other seabird species by direct predation (particularly of eggs and juveniles) and competition for breeding sites. This is facilitated with disturbance to seabird rookeries from human presence. This could be a rapid process and would likely come to the attention of the local birdwatching community.

Impact management and mitigation

Develop and implement a Silver Gull management plan that includes, but is not limited to:

- eliminating waste food at the development site that increases invasive species' population;
- monitoring Silver Gull populations and impacts as part of Little Penguin and seabird breeding management;
- interpretative material to inform public and staff of appropriate and inappropriate behaviour;
- managing or guiding staff access and behaviour by signage, educational briefings, inductions, workshops and other educational material; and
- minimising disturbance to seabird rookeries and roosts that facilitate predation by Silver Gull.

Specific management

This assessment has also identified two site-specific impacts that require monitoring, management or further investigation. These include but may not be limited to:

- Little Penguin monitoring plan; and
- seabird management plan.

Prescriptive management is beyond the scope of this study and dependent on the completion of the final design and management practises of the proposed development. Nevertheless management considerations typical for Little Penguin and seabirds have been provided below. Some of these considerations are also relevant and included in other proposed monitoring, management and policies provided in the risk assessment.

Considering the proposed development and the findings of this study, an articulated Little Penguin monitoring plan would consider:

- monitoring the Little Penguin population trend and active breeding sites during and after construction, and during operation;
- peak breeding season (currently unknown on Lipson Island) and peak molting season; and
- improving Lipson Island as a breeding habitat with the installation of artificial burrows;

Considering the propose development and findings of this study, an articulated breeding rookery of seabirds management plan would consider:

- monitoring the seabird breeding population trends; and
- considering peak breeding seasons (currently unknown on Lipson Island); and
- identifying the extent of use of Lipson Island as a migratory wader roosting site and if necessary developing a specific management plan to mitigate noise pollution.

Monitoring Little Penguin and seabird trends on Lipson Island would be a reasonably straightforward task and need not involve considerable disturbance to the breeding colonies.

Residual impacts

If the risk assessment determines a residual risk greater than low, then this need not equate to acceptable impact. The residual impact, although measured by the tool, should not be considered in isolation and decisions must be developed in a broader ecological, social and financial cost benefit analysis. Nevertheless, this risk assessment tool has identified the residual impacts greater than low (this assumes successful implementation of all mitigation measures and management procedures). The residual impacts greater than low were:

- release of invasive marine species from ballast water; and
- increase in habitat and provisions for invasive species (e.g. Silver Gull) to the detriment of the seabird rookery and roost.

These residual impacts maybe be further managed and assessed once detailed project design and further study is completed.

Limitations

The baseline study for this project was conducted over two days, 29 and 30 May 2011. Consequently the data attained from this study period is seasonally biased. From desktop surveys and our prior knowledge of the area we can predict that migratory waders, all listed under the EPBC Act and associated treaties, would be present in the summer months. Red-necked Stint, Grey Plover and

Sanderling are likely to forage on adjacent foreshore and roost on Lipson Island. The Crested Tern (*Sterna bergii*) and Fairy Tern (*Sterna nereis*), as determined by habitat provision, are also likely to breed on the island. It is highly probable that the Short-tailed Shearwater (*Puffinus griseus*) would use the same active burrows that Little Penguins use in the summer months for nesting and breeding. This increases the total significance of Lipson Island Conversation Park and the significance of the burrows located on the island.

Furthermore little is known of the species that were observed on the island over the two-day period regarding population density and current population trends. We can report that they exist on the island but we cannot ascertain if the local populations are increasing or decreasing over a period of time or even quantify what the population size of the local resident wildlife is. Hence it will be difficult to determine if the construction of the harbour will ultimately be a benefit or a detriment to the avian species currently using the island for breeding and roosting without established ongoing monitoring. This has been partially addressed with the provisional list of management plans.

Additionally the marine biota list is also limited due to the time constraints and seasonality of the data collected. While the major groups have been documented a more complete listing would have benefited from appropriate organism handling and representative voucher specimens for lodgement with the South Australian Museum. There is no doubt that a similar survey in summer and for a lengthier period would harvest a more abundant diversity of marine biota. The opportunistic observation of the female Australian Sea Lion similarly reveals that we can conclude that they do exist in the vicinity however there is no data to establish if there is a local population, breeding or non-breeding of this species, which is listed as vulnerable under the EPBC act.

The development application issued by Centrex Metals has provided insufficient details on the following:

- quantity and wattage of lights to be used and hours of operation;
- intended shipping lanes in and out of the Gulf (e.g. distance from the island), time and ballast management; and
- expected noise levels and frequency.

Conclusion

Most of the impact and mitigation measures identified in this assessment are typical of project developments such as ports. The distance of Lipson Island from the proposed development affords some protection. To address most of the impacts identified typical industry leading practice management plans are necessary. These include, but are not limited to:

- weeds and invasive marine species management plan;
- integrated feral animal management plan;
- uncontrolled spill (of hazards) management plan;
- staff access and activity policies;
- noise, lights, shipping and other disturbance management plans;
- industry standard ballast water management plan;
- siltation and turbidity management plan;
- sediment control plan;
- best practise dust minimisation activities;
- uncontrolled release of hard waste management plan; and
- Silver Gull management plan

The management plans need to be adaptive to flora and fauna monitoring information, fauna incident reports, changing conditions and the different phases of the port project during construction and operation.

This assessment has also identified some site-specific impacts that require management or further investigation. These include but are not necessarily limited to Little Penguin and seabird management plans.

Lipson Island conservation park main ecological values are the bird rookery and roost and intact intertidal zone. These values are addressed with the relevant management plans. A number of these management plans, after a time, are likely to be found to be superfluous.

There is no recognised requirement to refer this proposed development to the EPBC Act or the Department of Sustainability, Environment, Water, Population and Communities.

References

1. Bureau of Meteorology. Tide predictions for South Australia. 2011 [cited 2011 May]; Available from: www.bom.gov.au.
2. Golder Associates, Development Application and Request for Guidlines- Sheep Hill Marine Port, Eyre Peninsula, South Australia. 2011, Centrex Metals LTD: Adelaide, South Australia.
3. Wilkins, P., Visitation at Lipson Island, D. Donato, Editor. 2011: South Australia.
4. Bureau of Meteorology. Climate statistics for Australian locations. 2011 [cited 2011 May]; Available from: www.bom.gov.au.
5. Heard, L. and B. Channon, eds. Guide to a native vegetation survey (agricultural region) using the biological survey of South Australia methodology. 1st ed. 1997, Department of Environment and Natural Resources: South Australia.
6. Owens, H., ed. Guidelines for vertebrate surveys in South Australia using the biological survey of South Australia. 1st ed. 2000, Department of Environment and Natural Resources: South Australia.
7. DENR, Flora of South Australia. 2007, Department of Environment and Natural Resources: Adelaide, South Australia.
8. Gowlett-Holmes, K., A Field Guide to the Marine Invertebrates of South Australia. 2008, Sandy Bay, Tasmania: notomares.
9. Edgar, G.J., Australian Marine Life. Revised ed. 2000, Sydney: Reed Books.
10. Saunders, B., Shores and Shallows of Coffin Bay: an Identification Guide. 2009, Adelaide: Australian Printing Specialists.
11. Gomon, M., D. Bray, and R. Kuiter, eds. Fishes of Australia's South Coast. 2008, Reed New Holland: Sydney.
12. Corben, C., Analook. Bat call analysis system. 2000.
13. Pizzey, G. and F. Knight, The Field Guide to the Birds of Australia Seventh Edition ed. 2006, Sydney,Australia: Harper Collins Publishers. .
14. Menkhors, T.P. and F. Knight, A Field Guide to the Mammals of Australia. 2001, Melbourne, Australia: Oxford Press.
15. Triggs, B., Tracks, Scats and Other Traces: A Field Guide to Australian Mammals. 1996, Australia: Oxford University Press.
16. Matthews, E., A. Oppermann, and R.W. Inns, Biodiversity Plan for Eyre Peninsula. 2001, Department of Environment and Heritage: South Australia.
17. Standards Australia, HB 203:2004 Environmental risk management - Principles and process. 2006, Standards Australia/Standards New Zealand Third Edition: Canberra.
18. Australian Quarantine and Inspection Service, Australian Ballast Water Management Requirements, Department of Agriculture Fisheries and Forestry, Editor. 2008: Canberra ACT.
19. Baker, J.L., Status of marine species at risk in South Australia: Technical Report - bony and cartilaginous fish. Electronic book, web pages and CD prepared for the South Australian Working Group for Marine Species of Conservation Concern. in press, South Australian Department for Environment and Heritage, Marine and Coastal Community Network of SA, and Threatened Species Network: Adelaide.
20. Matthews, E., A. Oppermann, and I. R.W., Biodiversity Plan for Eyre Peninsula. 2001, Department of Environment and Heritage: South Australia.

21. ASR Ltd., Port Spencer Public Environmental Report Sediment Transport Modelling. 2011, Marine Consultaing and Research: 21 October 2011, Raglan, New Zealand.

22. Furlani, D.M., A guide to the introduced marine species in Australian waters. Technical Report No. 5. 1996, Centre for Research on Introduced Marine Pests, CSIRO: Hobart.

23. Dittmann, S., S. Cameron, and K. Conlon, Increasing knowledge on introduced species in the marine environments of the Eyre Peninsula.Report to the Eyre Peninsula Natural Resources Management Board. 2010, Flinders University: Adelaide. p. 26.

24. Bertozzi, T. and M. Hammer, Port River gobies: native and in need of conservation or introduced and requiring eradication? 2007, Evolutionary Biology Unit, South Australian Museum: Adelaide. p. 6.

25. Bertozzi, T. and M. Hammer, The identification and distribution of endemic, exotic and translocated species of gobies in Spencer Gulf, South Australia. 2009, Evolutionary Biology Unit, South Australian Museum: Adelaide. p. 15.

26. Hayes, K., et al., National priority pests - Part II: ranking of Australian marine pests. . 2005, Department of Environment and Heritage, Australian Government: Canberra.

27. D'Amore, W.A. and R.E. Jessop, Causes of sickness and injury in little penguins (Eudyptula minor) rehabilitated at Phillip Island, Victoria, Australia. Penguin Conservation, 1995. 8(1): p. 6-12.

28. Harrigan, K.E., Causes of Mortality of Little Penguins Eudyptula minor in Victoria. Emu, 1991. 91: p. 273–277.

29. Peter, J., Birds in focus: Plastic, plastic everywhere. Wingspan, 2010. 20(4): p. 8.

Appendices:

A: Historical fauna species lists

B: On-site flora survey quadrate images

C: Marine intertidal survey site images

D: Infrared camera, songmetre and Anabat™ recording sites and shore transect location

E: On-site intertidal flora and fauna survey raw data

F: Ecology of species at risk

APPENDICES

DES
DONATO
ENVIRONMENTAL SERVICES

Carbon Planet
Donato Environmental Services is Carbon Managed.

Appendix A: Historical fauna species lists

The following species lists have been collated by DES from a number of sources these include data from a 1 kilometre point search from Birds Australia II database (www.birdata.com.au), the South Australian Biological database (1km point search from Lipson island) and Department of Environmental and Natural resources.

Their status under the Environmental Protection for Biological Conservation (EPBC) 1999 Act (including international treaty status), National Parks and Wildlife Act 1972 (NPW) of South Australia is included.

Table 1. Synganathidea fish species recorded as potentially occurring in the search area as identified by the EPBC protected matters search. All are conservation significant species.

Scientific name	Common name
Acentronura australe	Southern Pygmy Pipehorse
Campichthys tryoni	Tryon's Pipefish
Filicampus tigris	Tiger Pipefish
Heraldia nocturna	Upside-down Pipefish, Eastern
Hippocampus breviceps	Short-head Seahorse
Histiogamphelus cristatus	Rhino Pipefish
Hypselognathus rostratus	Knifesnout Pipefish
Kaupus costatus	Deep-bodied Pipefish
Leptoichthys fistularius	Brushtail Pipefish
Lissocampus caudalis	Australian Smooth Pipefish,
Lissocampus runa	Javelin Pipefish
Maroubra perserrata	Sawtooth Pipefish
Notiocampus ruber	Red Pipefish
Phycodurus eques	Leafy Seadragon
Phyllopteryx taeniolatus	Weedy Seadragon
Pugnaso curtirostris	Pug-nosed Pipefish
Solegnathus robustus	Robust Spiny Pipehorse
Stigmatopora argus	Spotted Pipefish
Stigmatopora nigra	Wide-bodied Pipefish
Stipecampus cristatus	Ring-backed Pipefish
Urocampus carinirostris	Hairy Pipefish
Vanacampus margaritifer	Mother-of-pearl Pipefish
Vanacampus phillipi	Port Phillip Pipefish
Vanacampus poecilolaemus	Long-snouted Pipefish
Vanacampus vercoi	Verco's Pipefish

Table 2. Avian species previously recorded or potentially could occur within a one kilometre area of Lipson Island: includes avian species known or likely to breed or potentially occur within area. * denotes introduced, MM migratory marine, M marine, En endangered, V vulnerable, R rare, B breeding, M may occur, L likely to occur.

Scientific name	Common name	EPBC Status	EPBC Treaties; Migratory and/ or marine	EPBC protected matters search	EPBC Known to or likely to breed	EPBC species or species habitat may or likely to occur	NPW SA	BA	BDB SA
Leipoa ocellata	Malleefowl	Vu	JAMBA; M	X		L	Vu		
*Columba livia**	Rock Dove							X	X
Ocyphaps lophotes	Crested Pigeon							X	X
Hirundapus caudacutus	White-throated Needletail		CAMBA; JAMBA; M	X		M			
Apus pacificus	Fork-tailed Swift		CAMBA; JAMBA; MM	X		M			
Diomedea exulans gibsoni	Gibson's Albatross	Vu	BONN; MM	X		M	Vu		
Thalassarche melanophris impavida	Campbell Albatross	Vu	BONN; MM	X		M	Vu		
Thalassarche cauta cauta	Shy Albatross	Vu	BONN; MM	X		M	Vu		
Thalassarche bulleri	Buller's Albatross	Vu	BONN; MM	X		M	Vu		
Macronectes giganteus	Southern Giant-Petrel	En	BONN; MM	X		M	Vu		
Macronectes halli	Northern Giant-Petrel	Vu	BONN; MM	X		M			
Eudyptula minor	Little Penguin			X	B			X	X
Phalacrocorax sulcirostris	Little Black Cormorant							X	X
Phalacrocorax varius	Pied Cormorant							X	X
Phalacrocorax fuscescens	Black-faced Cormorant			X	B			X	X
Pelecanus conspicillatus	Australian Pelican							X	
Ardea modesta	Eastern Great Egret		CAMBA; JAMBA; MM	X		M			
Ardea ibis	Cattle Egret		CAMBA; MM	X		M	R		
Egretta novaehollandiae	White-faced Heron							X	X
Pandion haliaetus	Osprey		BONN	X	L		En		
Haliaeetus leucogaster	White-bellied Sea-Eagle		CAMBA	X	L		En		X
Falco cenchroides	Nankeen Kestrel							X	
Haematopus fuliginosus	Sooty Oystercatcher						R	X	X
Charadrius ruficapillus	Red-capped Plover							X	X
Charadrius veredus	Oriental Plover		BONN; CAMBA; JAMBA; ROKAMBA; M	X		M			

continued

Scientific name	Common name	EPBC Status	EPBC Treaties; Migratory and/ or marine	EPBC protected matters search	EPBC Known to or likely to breed	EPBC species or species habitat may or likely to occur	NPW SA	BA	BDB SA
Thinornis rubricollis rubricollis	Hooded Plover (eastern)			X		L	Vu		
Vanellus tricolor	Banded Lapwing							X	
Gallinago hardwickii	Latham's Snipe		BONN; CAMBA; JAMBA; ROKAMBA; M	X		M	R		
Actitis hypoleucos	Common Sandpiper		CAMBA; ROKAMBA				R		X
Onychoprion fuscata	Sooty Tern			X	B				
Sterna nereis	Fairy Tern	Vu		X	B		En		
Hydroprogne caspia	Caspian Tern		CAMBA; JAMBA						X
Thalasseus bergii	Crested Tern			X	B			X	X
Larus pacificus	Pacific Gull							X	X
Chroicocephalus novaehollandiae	Silver Gull			X	B			X	X
Merops ornatus	Rainbow Bee-eater		JAMBA; M	X		M			
Lichenostomus virescens	Singing Honeyeater							X	X
Epthianura tricolor	Crimson Chat							X	
Epthianura aurifrons	Orange Chat							X	
Psophodes nigrogularis leucogaster	Western Whipbird (eastern)	Vu		X		L	En		
Lalage sueurii	White-winged Triller							X	
Rhipidura leucophrys	Willie Wagtail							X	X
Corvus coronoides	Australian Raven							X	X
Corvus mellori	Little Raven								X
Alauda arvensis	Eurasian Skylark							X	
Megalurus gramineus	Little Grassbird								X
Cincloramphus cruralis	Brown Songlark							X	
Hirundo neoxena	Welcome Swallow							X	
*Sturnus vulgaris**	Common Starling							X	X
Anthus novaeseelandiae	Australasian Pipit							X	
Gymnorhina sp.									X
	Crow & Raven species							X	

APPENDIX A

Table 3. Mammal species previously recorded or potentially could occur within a one kilometre area of Lipson Island: includes avian species known or likely to breed or potentially occur within area. * denotes introduced, MM migratory marine, M marine, En endangered, V vulnerable, R rare, B breeding, M may occur, L likely to occur.

Scientific name	Common name	EPBC status	EPBC treaties; migratory and/or marine	EPBC species known to occur	EPBC species or species habitat may or likely to occur	NPW SA
Eubalaena australis	Southern Right Whale	En	BONN; MM	X		Vu
Megaptera novaeangliae	Humpback Whale	Vu	BONN; MM		L	Vu
Orcinus orca	Killer Whale		BONN; MM		M	
Balaenoptera acutorostrata	Minke Whale				M	R
Balaenoptera edeni	Bryde's Whale		BONN		M	R
Caperea marginata	Pygmy Right Whale		BONN		M	R
Lagenorhynchus obscurus	Dusky Dolphin		BONN; MM		M	
Delphinus delphis	Common Dophin				M	
Grampus griseus	Risso's Dolphin				M	R
Tursiops aduncus	Indian Ocean Bottlenose Dolphin				L	
Tursiops truncatus	Bottlenose Dolphin				M	
Arctocephalus pusillus	Australian Fur-seal				M	R
Arctocephalus forsteri	New Zealand Fur-seal				M	
Neophoca cinerea	Australian Sea-lion	Vu			M	Vu

Appendix B: On-site flora survey quadrate images

Plate 1. Lipson Island showing the four surveyed quadrates and quadrate number. Map modified from Google earth©.

Plate 2. DES On-site photo of flora quadrate number 350.

Plate 3. DES On-site photo of flora quadrate number 351.

Plate 4. DES On-site photo of flora quadrate number 352.

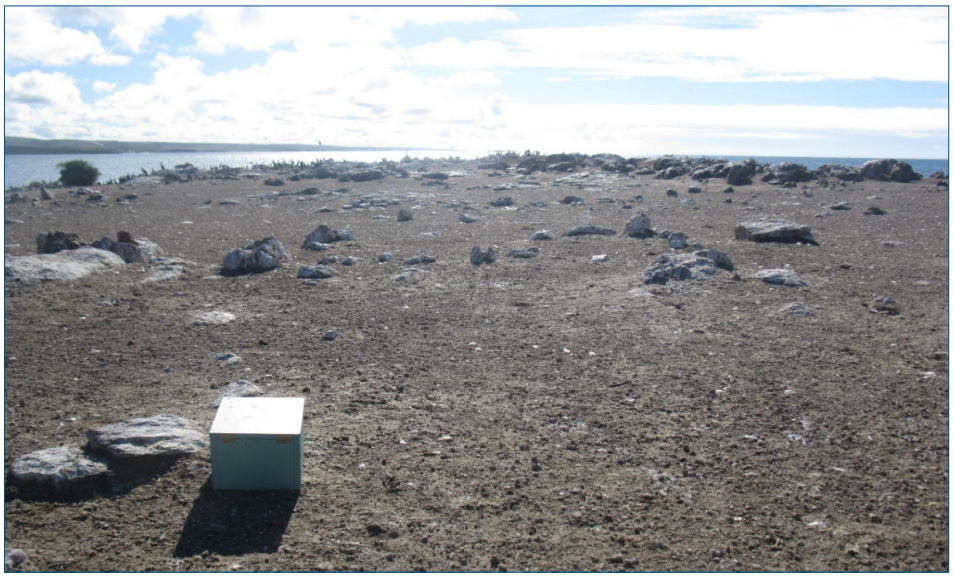

Plate 5. DES On-site photo of flora quadrate number 353.

Appendix C: Marine intertidal survey site images

Plate 1. Intertidal site 1.

Plate 2. Intertidal site 2.

Plate 3. Intertidal site 3.

Plate 4. Intertidal site 4.

Plate 5. Intertidal site 5.

Plate 6. Intertidal site 6.

Appendix D: Infrared camera, songmetre and Anabat™ recording sites and shore transect location

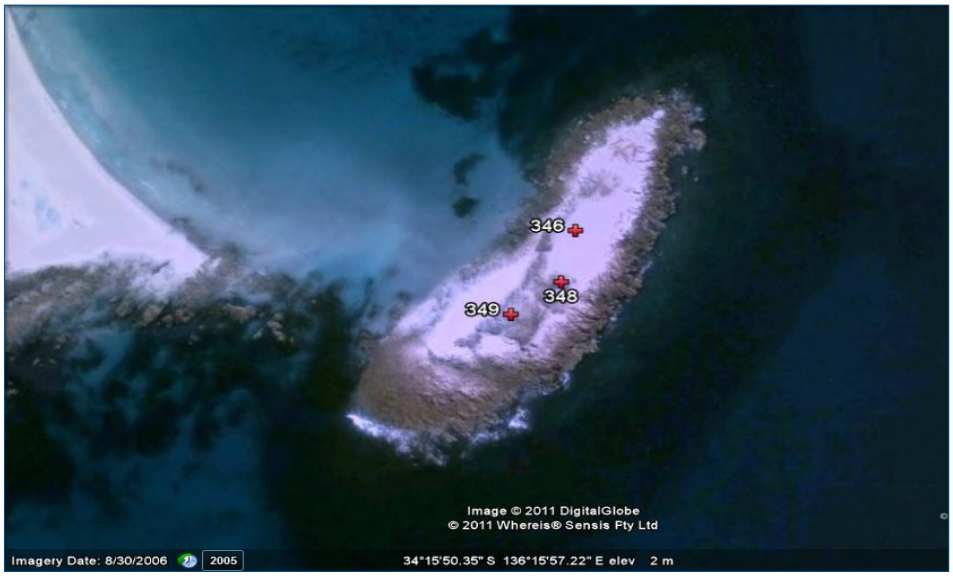

Plate 1. Lipson Island showing sites 346, 348 and 349 where Infrared cameras, Anabat™ and songmetre recorders were placed overnight (indicated by a plus sign). Image adapted from Google Earth©.

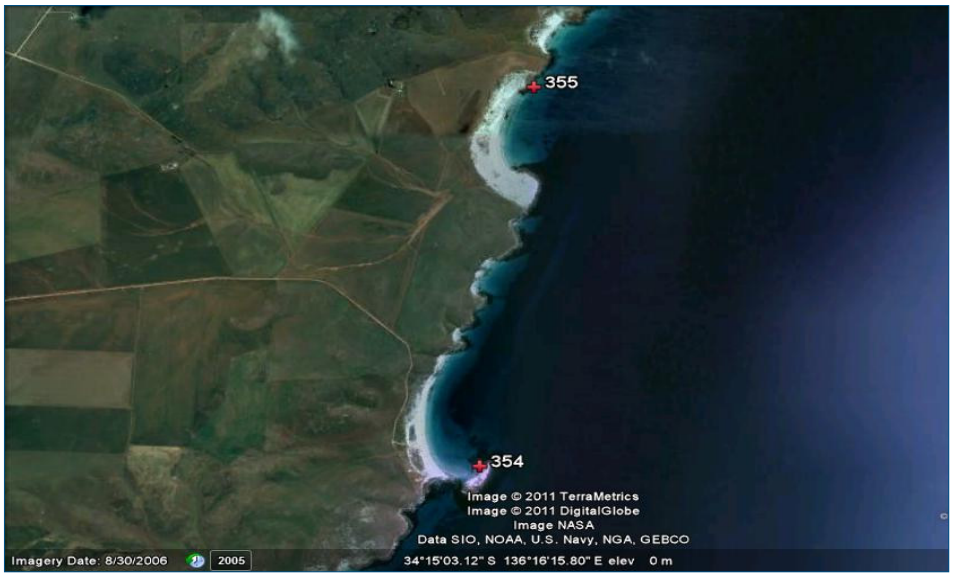

Plate 2. Lipson Island and adjacent foreshore showing shore transect 354 to 355 (indicated by plus signs). Image adapted from Google Earth©.

APPENDIX D

Appendix E: On-site intertidal flora and fauna survey raw data

Table 1. Intertidal flora and fauna quadrate survey data for site 3

		Site 3 (sand and rock)											
Common name/ field description	Taxa	LIS002-L-5x5	LIS002-La-1x1	LIS002-Lb-1x1	LIS002-Lc-1x1	LIS002-M-5x5	LIS002-Ma-1x1	LIS002-Mb-1x1	LIS002-Mc-1x1	LIS002-H-5x5	LIS002-Ha-1x1	LIS002-Hb-1x1	LIS002-Hc-1x1
Yellow-eye mullet	*Aldrichetta forsteri*												
Bluespot flathead	*Platycephalus speculator*												
Flathead sandfish	*Lesuerina platycephala*												
Favonigobius lateralis	*Favonigobius lateralis*												
Smooth toadfish	*Tetractenos glaber*												
Little shore crab	*Brachynotus spinosus*												
Smooth shore crab	*Cyclograpsus audouinii*												
Rock crab	*Nectocarcinus integrifrons*												
Reef crab	*Ozius truncatus*												
Rock shrimp	*Palaemon serenus*												
Amphipods	*Amphipoda spp.*		2		1								
Sea slater	*Deto marina*												
Isopod	*Ligia australiensis*												
Yellow goose barnacle	*Ibla quadrivalvis*												
Barnacle colonal	*Chamaesipho tasmanica*	Yes	4		200				8				
Barnacle six plates	*Chthalamus antennatus*												
Barnacle flat	*Tetraclitella purpurascens*												
Larger mussel	*Brachiodontes rostratus*												
Little pink bivalve	*Lasaea australis*			60	70								
Thin white oyster	*Ostrea angasi*												
Little black mussel	*Xenostrobus pulex*		50	110	100				4				
Tiny snail	*Austolittorina unifasciata*	Yes	5	94	211	Yes	50	1	34				
Top shell	*Austrocochlea concamerata*			9									
Periwinkle	*Bembicium vittatum*	Yes											
Dog whelk	*Diacathais orbita*												
Tunicate	*Lepsiella vinosa*	Yes		50	7	Yes							
Black nerite	*Nerita atramentosa*				18	Yes			33				
Large limpet	*Cellana solida*												
Variegated limpet	*Cellana tramoserica*	Yes											
Giant limpet	*Patella laticostata*												
Small apex limpet	*Notoacmea spp.*	Yes	2										
Striped limpet	*Siphonaria diemenesis*	Yes	2	30	30								
Sea worms	*Polycheata spp.*				1								
Calcified tube worms	*Galeolaria caespitosa*												
Seaweed worm	*Oligochaeta (1 species)*												

continued

Common name/ field description	Taxa	Site 3 (sand and rock)											
		LIS002-L-5x5	LIS002-La-1x1	LIS002-Lb-1x1	LIS002-Lc-1x1	LIS002-M-5x5	LIS002-Ma-1x1	LIS002-Mb-1x1	LIS002-Mc-1x1	LIS002-H-5x5	LIS002-Ha-1x1	LIS002-Hb-1x1	LIS002-Hc-1x1
Red anemone	*Actinia tenebrosa*												
Larger pink anemone	*Isanemonia australis*												
Yellow& orange encrustinging	*Dermospongiae spp.*												
Green turfing		Yes				Yes			2%				
Brown turfing													
Brown encrusting													
Pink encrusting algae													
Pink coraline algae													

Table 2. Intertidal flora and fauna quadrate survey data for site 4

Common name/field description	Taxa	Site 4 (rock sheltered)											
		LIS001-L-5x5	LIS001-La-1x1	LIS001-Lb-1x1	LIS001-Lc-1x1	LIS001-M-5x5	LIS001-Ma-1x1	LIS001-Mb-1x1	LIS001-Mc-1x1	LIS001-H-5x5	LIS001-Ha-1x1	LIS001-Hb-1x1	LIS001-Hc-1x1
Yellow-eye mullet	*Aldrichetta forsteri*												
Bluespot flathead	*Platycephalus speculator*												
Flathead sandfish	*Lesuerina platycephala*												
Favonigobius lateralis	*Favonigobius lateralis*												
Smooth toadfish	*Tetractenos glaber*												
Little shore crab	*Brachynotus spinosus*												
Smooth shore crab	*Cyclograpsus audouinii*	Yes	2	2		Yes							
Rock crab	*Nectocarcinus integrifrons*												
Reef crab	*Ozius truncatus*	Yes		1	6								
Rock shrimp	*Palaemon serenus*												
Amphipods	*Amphipoda spp.*	Yes	2	1	27	Yes	2		1				
Sea slater	*Deto marina*	Yes		1									
Isopod	*Ligia australiensis*												
Yellow goose barnacle	*Ibla quadrivalvis*												
Barnacle colonal	*Chamaesipho tasmanica*	Yes	30	280	222	Yes							
Barnacle six plates	*Chthalamus antennatus*												
Barnacle flat	*Tetraclitella purpurascens*		9	3	3	Yes		4					
Larger mussel	*Brachiodontes rostratus*												
Little pink bivalve	*Lasaea australis*	Yes		50	170			60	75				
Thin white oyster	*Ostrea angasi*												
Little black mussel	*Xenostrobus pulex*	Yes											
Tiny snail	*Austolittorina unifasciata*	Yes	51	299	100	Yes	5	56	11				
Top shell	*Austrocochlea concamerata*	Yes			4	Yes		9					

continued

APPENDIX E

Common name/field description	Taxa	Site 4 (rock sheltered)											
		LIS001-L-5x5	LIS001-La-1x1	LIS001-Lb-1x1	LIS001-Lc-1x1	LIS001-M-5x5	LIS001-Ma-1x1	LIS001-Mb-1x1	LIS001-Mc-1x1	LIS001-H-5x5	LIS001-Ha-1x1	LIS001-Hb-1x1	LIS001-Hc-1x1
Periwinkle	*Bembicium vittatum*												
Dog whelk	*Diacathais orbita*					Yes							
Tunicate	*Lepsiella vinosa*	Yes	20	15	59	Yes		14					
Black nerite	*Nerita atramentosa*		20		30								
Large limpet	*Cellana solida*												
Variegated limpet	*Cellana tramoserica*												
Giant limpet	*Patella laticostata*												
Small apex limpet	*Notoacmea spp.*				11	Yes							
Striped limpet	*Siphonaria diemenesis*												
Sea worms	*Polycheata spp.*	Yes			1				1				
Calcified tube worms	*Galeolaria caespitosa*												
Seaweed worm	*Oligochaeta (1 species)*				1					Yes			
Red anemone	*Actinia tenebrosa*				2								
Larger pink anemone	*Isanemonia australis*												
Yellow& orange encrustinging	*Dermospongiae spp.*												
Green turfing													
Brown turfing													
Brown encrusting													
Pink encrusting algae													
Pink coraline algae													

Table 3. Intertidal flora and fauna quadrate survey data for site 5

Common name/ field description	Taxa	Site 5 (exposed rock)											
		LIS003-L-5x5	LIS003-La-1x1	LIS003-Lb-1x1	LIS003-Lc-1x1	LIS003-M-5x5	LIS003-Ma-1x1	LIS003-Mb-1x1	LIS003-Mc-1x1	LIS003-H-5x5	LIS003-Ha-1x1	LIS003-Hb-1x1	LIS003-Hc-1x1
Yellow-eye mullet	*Aldrichetta forsteri*												
Bluespot flathead	*Platycephalus speculator*												
Flathead sandfish	*Lesuerina platycephala*												
Favonigobius lateralis	*Favonigobius lateralis*												
Smooth toadfish	*Tetractenos glaber*												
Little shore crab	*Brachynotus spinosus*	Yes				Yes			2		1	2	3
Smooth shore crab	*Cyclograpsus audouinii*	Yes				Yes	1		2	Yes	4	2	12
Rock crab	*Nectocarcinus integrifrons*	Yes							2				
Reef crab	*Ozius truncatus*	Yes							1				
Rock shrimp	*Palaemon serenus*	Yes		1						Yes			

continued

Common name/ field description	Taxa	Site 5 (exposed rock)											
		LIS003-L-5x5	LIS003-La-1x1	LIS003-Lb-1x1	LIS003-Lc-1x1	LIS003-M-5x5	LIS003-Ma-1x1	LIS003-Mb-1x1	LIS003-Mc-1x1	LIS003-H-5x5	LIS003-Ha-1x1	LIS003-Hb-1x1	LIS003-Hc-1x1
Amphipods	*Amphipoda spp.*					Yes							2
Sea slater	*Deto marina*					Yes				Yes		8	7
Isopod	*Ligia australiensis*												
Yellow goose barnacle	*Ibla quadrivalvis*	Yes		25					1				
Barnacle colonal	*Chamaesipho tasmanica*	Yes	1900		45	Yes		66	80				
Barnacle six plates	*Chthalamus antennatus*	Yes	20		5			6	4				
Barnacle flat	*Tetraclitella purpurascens*		80			Yes		2	13				
Larger mussel	*Brachiodontes rostratus*				2				1				
Little pink bivalve	*Lasaea australis*								21		2		3
Thin white oyster	*Ostrea angasi*	Yes			8								
Little black mussel	*Xenostrobus pulex*	Yes	200		30			30	30				
Tiny snail	*Austolittorina unifasciata*	Yes	20	21	25	Yes	22	113	69	Yes	2	9	4
Top shell	*Austrocochlea concamerata*							3				8	4
Periwinkle	*Bembicium vittatum*	Yes											
Dog whelk	*Diacathais orbita*	Yes	1	2									
Tunicate	*Lepsiella vinosa*	Yes	75	48	66	Yes	47	64	94	Yes	10	56	23
Black nerite	*Nerita atramentosa*												
Large limpet	*Cellana solida*			1									
Variegated limpet	*Cellana tramoserica*	Yes	1	1	5	Yes	5						
Giant limpet	*Patella laticostata*	Yes		1									
Small apex limpet	*Notoacmea spp.*	Yes	1	1	1	Yes			9				
Striped limpet	*Siphonaria diemenesis*	Yes											
Sea worms	*Polycheata spp.*												
Calcified tube worms	*Galeolaria caespitosa*	Yes	10%	10%	4%								
Seaweed worm	*Oligochaeta (1 species)*												
Red anemone	*Actinia tenebrosa*	Yes	25	1	1			1	3				
Larger pink anemone	*Isanemonia australis*	Yes											
Yellow& orange encrustinging	*Dermospongiae spp.*	Yes											
Green turfing		Yes											
Brown turfing													
Brown encrusting			1%		1%								
Pink encrusting algae													
Pink coraline algae													

Appendix F: Ecology of species at risk

Little Penguin (Eudyptula minor)

Distribution

The Little Penguin occurs in temperate marine waters [1], around the coast of Tasmania, the southern coast of mainland Australia, New Zealand and offshore islands and the Chatham Islands [2]. They mainly breed on offshore islands occasionally on the mainland at isolated sites [3]. Breeding in South Australia includes from the Victorian boarder to Encounter Bay; Kangaroo Island; Gulf of St.Vincent and Spencer Gulf including Lipson cove, Lipson island and the Sir Joseph Banks Group (refer to figure 1); Cape Catastrophe to the Western Australian boarder [3].

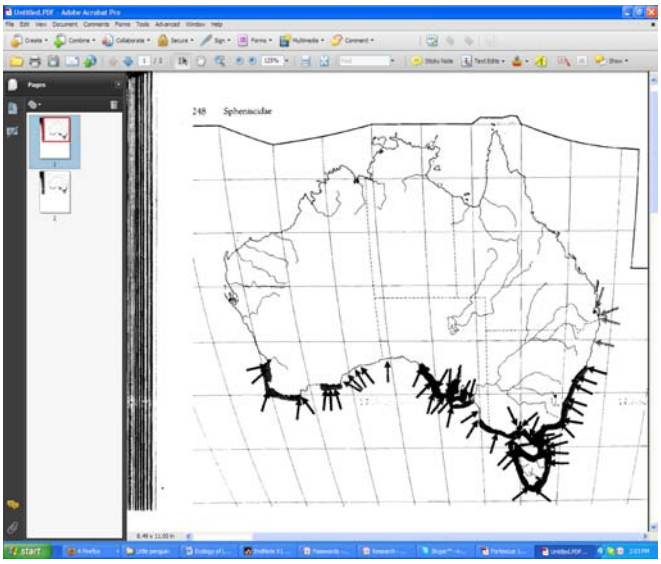

Figure 1. Shows distribution and some breeding sites of the Little Penguin (*Eudyptula minor*) around Australia. (Map from Marchant and Higgins 1990 [3])

The range of the Little Penguin is large with a narrow distribution [1]. The overall population is unknown, although the estimated population in Australia was thought to be under 1,000,000 individuals (estimation as of 1992) [4]. Colonies on both the Australian mainland and Tasmania consist of at least 10 pairs [5]. Across its range breeding occurs more on islands in Bass Strait and Tasmania [6]. Populations are declining however not rapid enough to be classified as vulnerable [1]. Although the lack of long term population data [5, 7] makes it difficult to determine population trends [5]. The use of gill nets [5, 6], habitat destruction [1, 5] (including a changes in vegetation such as weeds [7]), introduced predators [1, 5], oil pollution [1] chemical pollutants [7], rubbish dumped at sea, disease [1, 6] and starvation [1, 6, 8] are responsible for the decline [1, 6]. Populations have also declined (or in some cases completely disappeared [5, 6]) were human habitation has impacted on breeding sites [1, 5, 6] such as continual human proximity and habitat defragmentation such as roads [6]. In 1987 the decline of penguins on Phillip island was 22% in 3 years [6]. Penguins are disturbed by movement and light at their colonies [5]. Unmonitored and uncontrolled viewing of penguin colonies may result in obstruction of access points for birds to their burrows [5]. The use of inappropriate illumination may delay the return of an adult bird and consequently the feeding of chicks during the breeding season [5]. The Little Penguin has been known to exploit resources and inhabit anthropogenic structures, such as the case in Melbourne, Victoria where a population nests

between boulders on the St. Kilda breakwater [9]. The colony is subject to threats such as predators, lighting, boating noise and human visitation [9]. Although nesting was preferred in areas where there was higher restriction to the breakwater, they made use of the publically available area when nest areas were not necessarily limited [9]. Nesting has increased over a six year period [9]. It is unknown whether this is related to breeding success or recruitment of breeding pairs. A population in Tasmania's Derwent estuary has responded to rehabilitation with breeding pairs doubling within 5 years [10]. Weed eradication, habitat restoration and artificial burrows fencing and reinforcement of cliff facing nest sites have lead to the increase [10].

Legislation

The Little Penguin is currently not listed as threatened under the Environmental Protection for Biological Conservation (EPBC) 1999 Act, or the National Parks and Wildlife Act 1972 (NPW) of South Australia. It is listed as marine under the EPBC act [11]. Although not listed as threatened this species are a high profile species of public conservation concern.

Migratory

The Little Penguin is a non-migratory species.

Habits and Habitat

Little Penguin habitat is the marine environment with particular use of the neritic; oceanic; intertidal (rocky/sandy shoreline, beaches, sand bars, spits); coastal/supratidal zones (seacliffs, rocky offshore islands, coastal sand dunes and coastal freshwater lakes) [12]. Prey is usually small shoaling fish [3, 8]; barracouta, anchovies (the pilchard *Sardinops sagax* is key prey for Phillip Island populations [8]) or cephalopods such as arrow squid, less often crustaceans [1, 3, 6] and on occasion have been known to consume crab larvae, ells and seahorses [6]. Rocks and seaweed present in the stomach indicates that penguins also feed on the sea floor [6]. Dietary differences between mainland Australia and Tasmania occur with squid more important in the diets of Bass Strait than Victorian populations and krill constitutes more of the diet in Tasmanian waters [6]. A shift from fish lead to declines in breeding success for Phillip Island populations [8].

Foraging is at sea from and hour before dawn to an hour before dusk for most birds [3, 6] 95% within the first 2 hours [6] with the remaining arriving up to two hours after dusk [3, 6]. Little penguins capture prey by pursuit diving [1, 13] both mid-water and demersal [13], frequently swimming round a shoal of fish in concentric circles before plunging [1]. Usually a shallow diver [6], it is known to dive up to 69 m and usually feeds lengthways [1]. Distance from colony has been recorded to up to 13.8 km [13].

Roosting is generally solitary or in pairs when loafing or sleeping; either in burrows during the day (if ashore) or night alternatively on the ground surface [3]. At sea roosting activity remains unknown [3]. Roosts are usually within territories and although protected from prevailing wind they are usually unconcealed [3]. Often there is regular use of a roost by the same individuals [3].

Pair bonding is sustained or long-term monogamous with a likelihood of divorce 18% pa [3]. Little Penguin pairs are within the penguin colony throughout most of the year alternatively in smaller groups or solitary at sea [3]. Phillip island, young birds, have a different range in the non-breeding season from the adults

as a consequence the age composition of flocks varies between these areas [3]. After feeding tight groups are formed before dusk, as birds move closer to shore they break up into smaller groups before arriving onshore and moving away from the beach front and dispersing into territorial pairs within their colony [3, 6].

A colony forming species with nesting in burrows on sandy or rocky islands often at the base of cliffs or in sand dunes [1, 3, 5, 6], in caves of crevices along rocky coasts, grasslands and herbfields with good soil depth for burrowing [3] or hollow logs [5]. Distance between burrows (nests) is usually between 5 and 10 metres [3], rarely closer than 2 metres [3, 5, 6]. Burrows usually used throughout the year, occasionally outside of breeding season and for moulting [3]. Preening is usually performed near their burrow as are most other activities, occasionally young will venture from the burrow a fair distance to meet parents returning from sea [3]. Although extremely territorial [6] occasionally breeding colonies are shared with other seabirds such as shearwaters [3, 6].

Breeding can occur in all months, the exact timing dependant on locality and the year [1, 14]. Successful breeding started earlier in the season in one study on Philip Island [15] however there was no difference in a 21 study according to Nisbet et.al. [14]. Early breeding was dependent on age (with younger being more successful) and the length of pair-bond [14]. On Phillip Island moulting is between February and April with birds visiting more frequently with an increase in attendance from 20% in the 16th week before laying to 70+% in the week before laying, with more regular peaks in attendance in weeks 7,4 and 1 and males presenting more than females [3]. Mean dates for laying varied from August to November although occurring in all months from May to December [3] Duration is 13-22 weeks from June to September in ten sessions [3]. On Bruny Island in Tasmania, duration of laying is 8-11 weeks with first eggs appearing in September to October [3]. On Bruny and Penguin Islands birds abandon colony after breeding [3]. Phillip Island birds return to the same colony year after year with pairs utilising the same burrow, new pairs more likely to change burrow [3]. Males generally choose burrow site with both sexes digging and cleaning using bill and feet although the male does the greater share [3]. On occasion burrows may have two entrances or the burrow may only be a scrape under a bush [6]. On Phillip Island, length of burrows is 43cm, entrances 14 cm high x 22cm [3]. Nests vary from a few sparse strands of vegetation to thick mats of vegetation [3, 6] and feathers collected from no more than 3-4 metres of burrow [3].

Incubation period is usually 35 [15] - 36 days [2] although the range is 33 – 37 days [6] with 68 hours usually passing between the laying of the first egg and the second [2]. Incubation shifts are usually 1-2 days [6] or 3-4 days [15] although can be up to 10 days [6]. Clutch consist of 2 eggs [2]. Hatching success is 60% [6]. A combination of causes include predation, flooding, parental inattention, accidental breakage, death of a parent or contamination from micro-organisms [6]. A second clutch may be layed although even with successful clutches it is not uncommon for a penguin pair to double brood [6]. When food is scarce little penguins engage in brood reduction strategy concentrating their efforts on the strongest chick [6]. Eggs are white when first laid with discolouration occurring due to excreta [6]. Hatching can take between 24 hours to 3 days to complete for individual eggs[6] with chicks weighing on average 45 grams [6]. Rarely are the eggs camouflaged by pigmentation as eggs are usually laid in burrows or under

cover, although exposed nests do have camouflaged eggs [6]. Young spend 59 days in the nest [2] parents guarded their young for 14.5 days on Phillip Island during the 1995-1996 breeding season with the range being 8 – 25 days [15]. Both sexes incubate and look after the young until fledging [3, 15]. When chicks are five weeks old they wait outside the nest to be feed by the parents [6]. After fledging dispersal is wide and young are not seen back at the natal colony for approximately 1 year [6]. Breeding commences from 2-3 years old [2, 6] on Bruny Island, 3-4 years at the natal colony for Victorian populations [6].

White-bellied Sea-eagle (*Haliaeetus leucogastor*)

Distribution

The White-bellied Sea-eagle has a large range [16] extending from Tasmania through to south-east Asia to India [17, 18]. This eagle occurs on most of the islands of Bass Strait [17] and southern Australia including Kangaroo island [19] and Spencer gulf. It's population is estimated to be <10,000 mature individuals although the population trend is declining [16, 20] particularly in Australia in response to habitat degradation [21]. Critical habitat for this species is their nesting habitat [17]. Threats to this species includes habitat degradation, disturbance and loss particularly to nests [17].

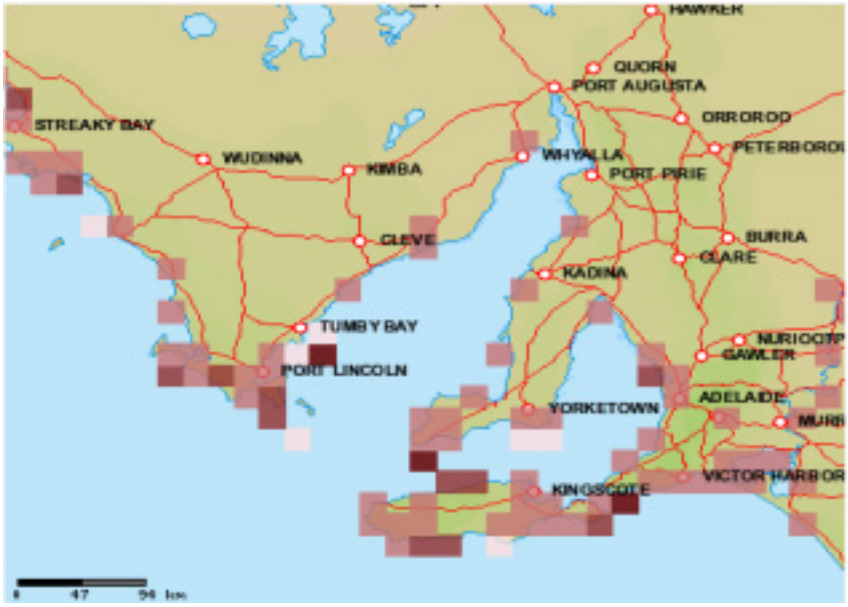

Figure 2. Distribution of the White-bellied Sea-Eagle around Spencer Gulf, South Australia. Map from Birdata [22].

Legislation

The White-bellied Sea-eagle is currently not listed as threatened under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. Under the National Parks and Wildlife Act 1972 (NPW) of South Australia it is listed as Endangered. Although not listed as threatened this species are a high profile species of public conservation concern.

Migratory

The White-bellied Sea-eagle is listed as a migratory marine species under the EPBC act [11] and is protected by the China-Australia Migratory Bird Agreement (CAMBA).

Habits and Habitat

The White-bellied Sea-eagle habitat includes inland wetlands, marine neritic and intertidal and coastal/supratidal including seacliffs and and rocky offshore islands [16]. It usually occurs and nests within 5km of the coast, estuaries or large inland lakes [17]. It favours larger trees especially on large islands usually in mature forests within 5km for a large waterbody or more rarely on sea cliffs and rock stacks [17]. They are often seen perched high in a tree or soaring over waterways.

Birds form permanent pairs that inhabit their territories throughout the year [18]. A skilled hunter, they feed mainly on fish [23], turtles (freshwater [23]) and sea snakes however it does take birds [23] and mammals and carrion including sheep [18]. They harass smaller birds forcing them to drop any food that they are carrying. Sea-Eagles feed alone, in pairs or in family groups [18].

Breeding occurs use coastal cliffs, including those on offshore islands, as breeding sites [24]. Their large stick nests are used for many seasons and can either be placed in a tree up to 30m above ground or on the ground or rocks when there are no suitable trees [18]. Incubation of, usually two [25], white eggs is usually performed by the female [18] during their breeding season from May to October [18, 25]. Fledging dependence period can last at least 2 months, and a juvenile may still roost in the nest area 5 months after fledging [23].

Osprey (*Pandion haliaetus*)

Distribution

Globally, the Osprey has an extremely large range with the an Extent of Occurrence of <20,000 km^2 [26]. Its distribution in Australasia extends from the Phillipines, Indonesia and New Guinea to Australia [27]. The range is similar for the non-migratory subspecies (Eastern Osprey, *Pandion haliaetus cristatus*) which is broadly distributed from New Caledonia in the South Pacific in the east through Papua New Guinea to central in the west and south to southern Australia. In Australia, the Osprey is found on the north and east coast from Broome to the south coast of New South Wales. There is also a southern population from Kangaroo Island to the Great Australian Bight and a western population from Esperance to Cape Keraudren [27]. Most of the population in Australia is found in coastal or near-coastal estuarine habitats [27]. There is evidence that the species has declined overall in south Australia with only historical breeding records being found for upper Spencer Gulf and Murray River [28]. The estimated number of Ospreys in South Australia was 52 breeding pairs in 2005 [28]. Nesting sites are vulnerable on the Eyre Peninsula and Kangaroo Island due to human disturbance [28].

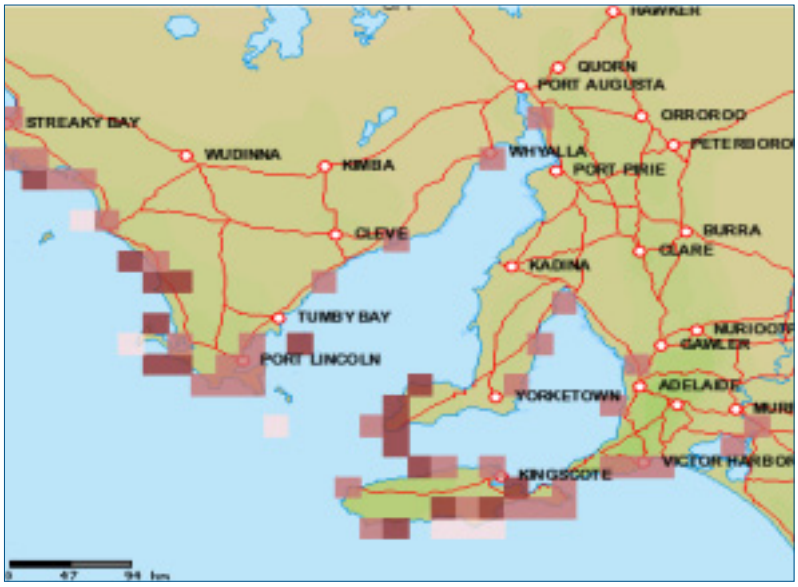

Figure 3. Distribution of the Eastern Osprey around Spencer Gulf, South Australia. Map from Birdata [22].

Legislation

The Opsrey is currently not listed as threatened under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. Under the National Parks and Wildlife Act 1972 (NPW) of South Australia it is listed as Endangered. Although not listed as threatened this species are a species of public conservation concern.

Migratory

The Osprey is listed as a migratory marine species under the EPBC act [11] and is protected by the Convention on the Conservation of Migratory Species of Wild Animals (BONN).

Habits and Habitat

The habitats of the Osprey are varied from forest (tropical to subtropical); wetlands (inland) and marine (intertidal and supratidal) [26]. Prey is mainly fish [27, 29] particularly Mullett and Yellowfin Bream in north-eastern new south Wales populations [29]. Searching the coast for prey it swoops by folding it's wings, drops headlong, with its feet forward to snatch a fish with its talons. It may go right under the water or snatch a fish from the surface, before lifting off again, with strong wing strokes.

The Eastern Osprey is mostly resident or sedentary around their breeding grounds [27]. The core area around the nest (usually 150 m) is aggressively defended from other Ospreys and other Raptor species and potential predators of eggs and/or young [27, 29]. Nests, placed on a cliff or dead trees are made from sticks and driftwood and may be used in consecutive years, as such they become large [27, 29]. Breeding from April to February the osprey clutch is can be from 1 to 4 eggs (typically 2 or 3) [27].The female does most of the incubation which lasts for 33 to 38 days [27]. Fledging from between 7 to 11 weeks with post-feldging being approximately 1 to 2 months [27]. Although not usual, pairs can brood a second in the season [27, 29].

Red-necked Stint (*Calidris ruficollis*)

Distribution

The Red-necked stint migrates from its breeding range in the north eastern Siberia and northern and western Alaska [30] to the southern hemisphere for the non-breeding season [31]. It has a global extent of occurrence of 100,000 to 1,000,000 km^2 [32]. In Australia it's range is widespread [30, 33], being recorded in all coastal regions with sporadic records for inland Australia [33]. Some inland records are of birds on passage, others are not transient birds [33]. The population estimate is approximately 320,000 [34]. Threats to this species are largely on the migration route to Australia these include wetland destruction and alteration, pollution and hunting [30].

Legislation

The Red-necked stint is protected under the Bonn Convention and JAMBA, CAMBA and ROKAMBA.

Migratory

The Red-necked Stint is listed as Migratory and Marine under the EPBC act.

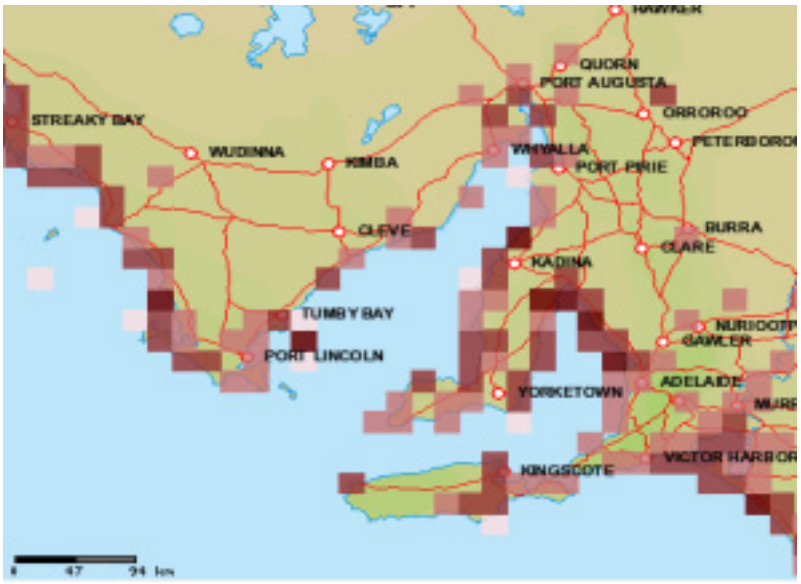

Figure 4. Distribution of the Red-necked Stint around Spencer Gulf, South Australia. Map from Birdata [22].

Habits and Habitat

The Red-necked stint habitat in Australia consists of coastal regions, freshwater and brackish or saline (such as saltworks) wetlands, sheltered sandy beaches and rocky shorelines although prefers mainly estuarine mudflats [30, 33] and shallow wetlands [30]. They have been seen in sewage farms, waterholes, bore drains, dams, flooded paddocks or damp grassland [30]. Most feeding is from muddy sand [33, 35, 36] usually above the waters edge with a slim film of surface water retained [35] for the whole time the mudflat is exposed [30]. Food is obtained from the surface water up to 10mm into the substrate, closer to the waters edge it is obtained by jabbing [33, 35, 36], pecking or probing up to 20mm into the substrate [33, 35]. Food consists of a wide variety of surface dwelling intertidial invertebrates although gastropods and crustaceans are preferred [36] they also eat seeds, insects molluscs and plants in saltmarshes [30]. Different habitat's have also been observed as being utilised for day and night feeding Red-necked

stints utilising high tide in the afternoons or at night [37]. They are gregarious and are often in dense flocks of hundreds or thousands when feeding and roosting [30, 33].

The first birds arrive in Australia in late August [30, 33] though to September [30]. Juvenile birds join the adults for the migration to the wintering grounds in southern latitudes and remain for the summer [30, 31]. This species take a north westerly migration route from the east of Australia [38]. This species migrates from its breeding range in the arctic [30] to the southern hemisphere for the non-breeding season [31].

Grey Plover

Distribution

Globally, the Grey Plover has an extremely large range with the an Extent of Occurrence of <20,000 km^2 [39]. Although the population trend tends to be decreasing [39]. In Australia their range is mainly to the west and southern coasts [27]. Threats to this species includes include economic and social pressures such as wetland destruction and change, pollution and hunting particularly on the East Asian-Australasian Flyway [27, 40].

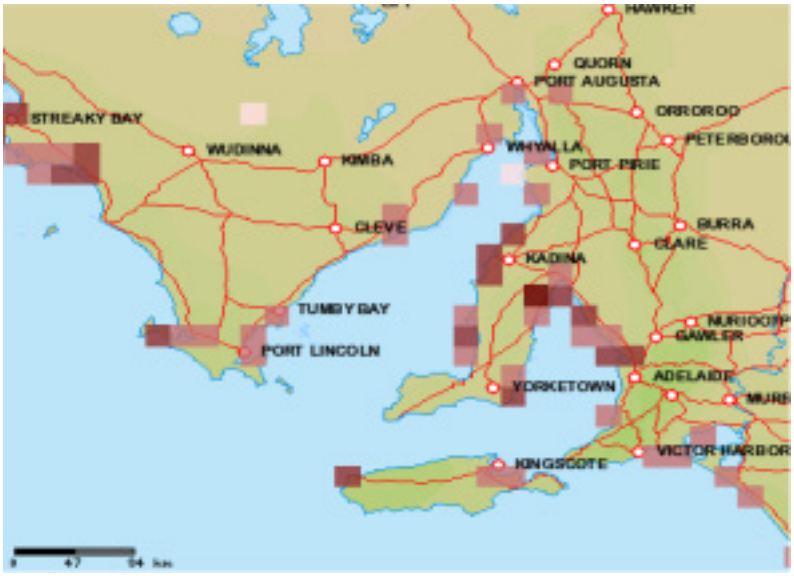

Figure 5. Distribution of the Grey Plover around Spencer Gulf, South Australia. Map from Birdata [22].

Legislation

The Grey Plover is currently not listed as threatened under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. Under the National Parks and Wildlife Act 1972 (NPW) of South Australia it is not listed.

Migratory

The Grey Plover is listed as a migratory marine species under the EPBC act [11] and is protected by the Convention on the Conservation of Migratory Species of Wild Animals (BONN); China-Australia Migratory Bird Agreement (CAMBA); Japanese-Australia Migratory Bird Agreement (JAMBA) and Republic of Korea on the Protection of Migratory Birds (ROKAMBA).

Habits and Habitat

The habitats of the Grey Plover are varied from Grassland (tundra) and marine (intertidal and coastal/supratidal) [27, 39]. The Grey Plover departs its breeding

grounds from late July to September and travels south with movements continuing into November [39]. Travelling north from late may to June this species then breeds from May to August [39]. It often roosts in large flocks sometimes up to thousands of individuals (particularly when breeding [39]). Feeding is diurnal [40] and with a running, stopping and pecking action typical of many species of plovers, gleaning and probing the substrate [27]. During non-breeding season the diet consists of marine polycheate worms, molluscs and crustaceans such as crabs and sand shrimps, occasionally insects or earthworms when on inland habitats during passage [39] and occasionally vegetation and seeds [40]. Nesting in a shallow scrape on dry ground in exposed stony sites [39]. Clutch size is usually 4 and incubation is 27 days [40].

Sanderling (*Calidris alba*)

Distribution

The Sanderling migrates from its breeding range in high arctic tundra [41] north of 70°N [33] mainly in Siberia [41] north of 73°N [33]. It's extent of occurrence is estimated to be between 100,000 to 1,000,000km^2 [42].The population is estimated to be between 620,000 to 700,000 individuals [43]. In Australia, this species is found over a large range along the coastline [41]. While the global trend for this species is unknown [42], threats to this species on its migration route to Australia include wetland destruction and change, pollution and hunting [41].

Legislation

The Sanderling is listed as Marine on the EPBC act and protected under the Bonn Convention and JAMBA, CAMBA and ROKAMBA. It is listed as Rare on the NPWS Act.

Migratory

The Sanderling is listed as Marine and Migratory under the EPBC act.

Figure 6. Distribution of the Sanderling around Spencer Gulf, South Australia. Map from Birdata [22].

Habits and Habitat

The Sanderling occurs mainly on open [33] sandy [41] coastal beaches [41, 44] at the edge of waves, sandbars and spits [41] and occasionally on inland mudflats,

marshes [44], sheltered sandy shorelines of estuaries, inlets and harbours [33]. Roosting occurs on the bare sand in dunes or behind piles of kelp [41]. Feeding by day on mudflats and moving to ocean beaches to forage at night during low tides [37], the Sanderling is a brisk and busy feeder [41]. Surface-tension transport (STT) is usually used for smaller prey [45] while for larger prey the process of distal rhynchokinesis [46] jabbing in the sand for prey, snatching prey and retreating from the waves and then returning to strike again [33, 41]. It was found that STT was the sole method of feeding on small prey in shallow waters of saltworks [45]. Their diet is mainly insects and small crustaceans [33, 41], on occasion small fish and algae [47] and worms [33] however they have been known to eat seeds and buds at nesting areas [41]. Adverse weather conditions can prevent Sanderlings from feeding in the intertidial zone resulting in pecking at the remains of prey (for e.g. Mussels) left over from other species [47].

Sanderlings are gregarious birds and although may scare easily do not fly far when disturbed [33]. They are often found in small to large flocks up to hundreds at their favoured localities [33]. Free association with other wader species is common, they may join mixed roosts but mainly roost within their own species [33].

Breeding season is between June and August [41]. The Sanderling migrates after the breeding season in June through to August from mainly Siberia [41] to southern latitudes. Migrating in large flocks this species travels vast distances without stopping [41]. Birds arriving in Australia most likely breed on New Siberia Island in September where they stay until April, some over-winter in Australia [41]. Birds leaving Australia for the breeding season travel west along the south coast before moving north with some stopping on the north coast [33].

Fairy Tern (*Sterna nereis*)

Distribution

The Fairy Tern occurs in Australia (subspecies *nereis*), New Caledonia (to France) and northern New Zealand [27, 48, 49]. In Australia, coasts of Victoria, Tasmania, South Australia and Western Australia, as far north as Dampier Archipelago [49]. The subspecies *nereis* may number less than 5,000 mature individuals at up to 170 sites, with less than 1,600 pairs in Western Australia, a few hundred pairs in each of Tasmania and South Australia and just a few pairs in Victoria [27, 48]. Stable in Western Australia, numbers have declined rapidly during the last thirty years around the rest of the country [27, 48]. Its decline has been attributed to predation by introduced species, disturbance and inappropriate water level management [27, 48].

Figure 7. Distribution of the Fairy Tern around Spencer Gulf, South Australia. Map from Birdata [22]

Legislation

The Fairy Tern is currently listed as Vulnerable under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. Under the National Parks and Wildlife Act 1972 (NPW) of South Australia it is listed as Endangered. The Fairy Tern is listed as a marine species under the EPBC Act [11].

Migratory

This species is considered a non-migratory species under the EPBC Act [11].

Habits and Habitat

The Fairy Tern feeds in inshore waters around island archipelagos and on the Australian mainland [49]. Prey species are almost entirely fish [49]. Food is obtained by plunging into shallow water [49]. Breeding commences generally from mid to late October to February [48] and occurs in large colonies [49], on sheltered mainland coastlines and close islands usually on sandy beaches above the high tide line but below where vegetation occurs [48]. The subspecies nests in small colonies on coral shingle on continental islands or coral cays, on sandy islands and beaches inside estuaries, and on open sandy beaches [49]. It lays 1 to 2 eggs in a sand scrape [49]. Both sexes share in the incubation of the young [49].

Hooded Plover (*Thinornis rubricollis*)

Distribution

The Hooded Plover occurs on sandy beaches between Jervis bay, New South Wales and the Eyre Peninsula, South Australia as well as in Tasmania and between Esperance and Perth in south-west Western Australia [50]. In South Australia Hooded Plovers have been sighted from the eastern edge of the Great Australian Bight (Fowlers Bay area) through to the South Australian and Victorian border. Hooded Plover has not been recorded in the upper reaches of Spencer Gulf or St Vincent Gulf [51]. The total population size of the Hooded Plover is estimated at 3000 breeding birds. This estimate is considered to be of medium reliability [52].

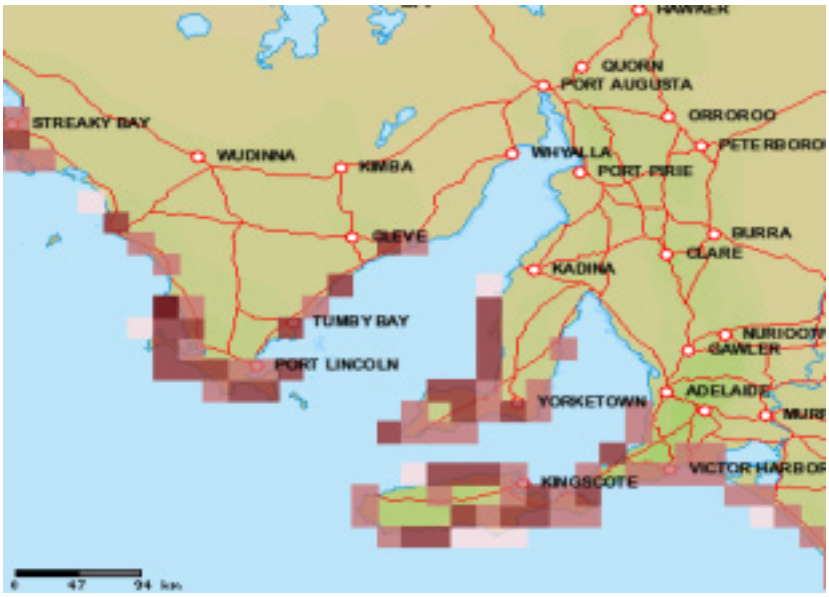

Figure 8 Distribution of the Hooded Plover around Spencer Gulf, South Australia. Map from Birdata [22].

Legislation

The Hooded Plover is currently listed as Vulnerable under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. Under the National Parks and Wildlife Act 1972 (NPW) of South Australia it is listed as Vulnerable.

Migratory

This species is considered a Marine species under the EPBC Act [11].

Habits and Habitat

The Hooded Plover occurs in coastal areas, on or near high energy sandy beaches. They are generally found close to shore, but may occasionally visit sites located a short distance inland [27]. Their preference is also for beached backed by sparsley-vegetated sand dunes that provide shelter and foraging and nesting sites [27]. Hooded plovers diet includes insects, sandhoppers (*Orchestia* Sp.), small bivalves and Soldier Crabs (*Mictyris platycheles*. It forages at all levels of the beach during all tide phases [40]. It is usually seen in pairs or small groups, darting about the water's edge pecking along the shore [40]. The presence of beach-washed seaweed is an important component of their habitat and foraging ecology, with rotting seaweed providing food for invertebrates which Hooded Plovers then prey upon [27].

Breeding commences from August to March with clutches of 2-3 eggs laid in a depression in the sand that may or may not be lined with pebbles, fragments of shell and seaweed [27]. Success rate is low with only 27% of eggs laid surviving and only 0.1 young fledge per pair [27]. The young leave the nest shortly after hatching and accompany the adults until they fledge 33-36 days later [27].

Australian Sea Lion (*Neophoca cinerea*)

Distribution

The extent of the range of Australian Sea Lion historically has been from the islands of Bass Strait towards the west along southern Australia with colonies near Albany Western Australia [53]. Colonies in South Australia produce the most pups with 100 being produced each year [53]. Other colonies only producing

less than 30 each season [53]. Total abundance is estimated to be between 9000 and 12 000 [53].

Figure 9. Distribution of Australian Sea lion Black: current; Grey: past and less likely occurrence.

Legislation

This species is listed as Vulnerable on both NPW SA the Environment Protection and Biodiversity Conservation Act 1999. This species is listed as a Marine species under the EPBC Act.

Migratory

The Australian Sea Lion is a non-migratory species.

The species is endemic to Australian waters and breeds on at least 50 island off the coast of Western Australia and South Australia. Young can be born anytime from January to June after a gestation period of about 12 months. Despite the fact that females give birth to one young and may not breed again for two to three years, pup mortality is high in the first six months after birth. Australian Sea Lions form loose associations within the breeding colonies. Males do not form harems but will guard and then mate with individual females in turn. Females become sexually mature at 4-6 years, males 8-9 years. Australian Sea Lions are known to live for up to 25 years. Australian Sea Lions haul out and breed on rocks and sandy beaches, mainly on offshore islands. Individuals have been known to wander several kilometres inland [54].

Little is known about the diet of Australian Sea Lions, however cephalopods, crustaceans and fish are probably their major prey. Research suggests that they occasionally take penguins as well [54]. This can be confirmed by an opportunistic observation by DES staff, on Lipson island and witnessed a female Australian Sea lion prey upon a penguin. Females feed in relatively shallow near shore waters but also make some use of deeper offshore waters [54].

They are a sedentary species, and they tend to stay around their haulouts and breeding sites. Females may move their pups to other haulout areas to nurse them [54].

Leatherback Turtle (*Dermochelys coriacea*)

Distribution

The species is most commonly reported from coastal waters in central eastern Australia (from the Sunshine Coast in southern Queensland to central NSW); south-east Australia (from Tasmania, Victoria and eastern South Australia) and in south-western Western Australia [55-57]. It is known from waters all around Australia and regularly seen in southern Australian waters [55]. Leatherback Turtles are migrating from Australian waters to breed at larger rookeries in neighbouring countries such as Indonesia, Papua New Guinea and Solomon Islands [56, 58]. Due to the low incidence of Leatherback Turtle nesting on Australian beaches, and their pelagic foraging habits, a number of threats faced by other marine turtles, such as coastal infrastructure and development, feral animal predation and indigenous harvest are not significant threats to those Leatherback Turtles in Australian waters. The main threats faced by Leatherback Turtles in Australia arise from accidental catch or entanglement in commercial fishing operations [56].

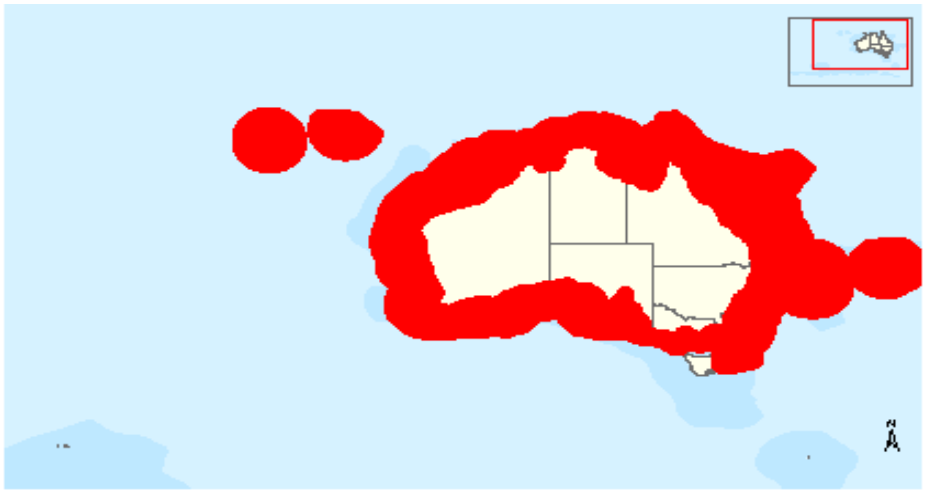

Figure 10. This is an indicative distribution map of the present distribution of the Leatherback Turtle (*Dermochelys coriacea*) in Australian Waters. (Map from the Species Profile and Threat Database).

Legislation

This species is listed as Vulnerable under National Parks and Wildlife Act and as Endangered under the Environment Protection and Biodiversity Conservation Act 1999.

Migratory

This species is considered a Marine and Migratory species under the EPBC Act.

Habits and Habitat

Adults feed mainly on pelagic soft-bodied creatures such as jellyfish and tunicates, squid and siphonophores [55]. Their preference for jellyfish as a primary prey item makes Leatherback Turtles particularly susceptible to ingestion of plastics [59]. Leatherback Turtles require sandy beaches to nest, with some evidence that coarser sand is more conducive to successful hatching than finer sand [60]. Sand temperatures between 24–34 °C are needed for successful incubation [60]. Beaches free from light pollution are required to prevent disorientation, disturbance and to allow nesting females to come ashore.

Juveniles through to adults reside in a variety of ocean and coastal habitats and span a large latitudinal range [56].

Loggerhead Turtle (*Caretta caretta*)

Distribution

The Loggerhead Turtle occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia [61]. While nesting is concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia, foraging areas are more widely distributed. Females tagged at the south-east Queensland nesting areas have been recorded in waters off Indonesia, Papua New Guinea, Solomon Islands, New Caledonia, Northern Territory, Queensland and NSW [62].

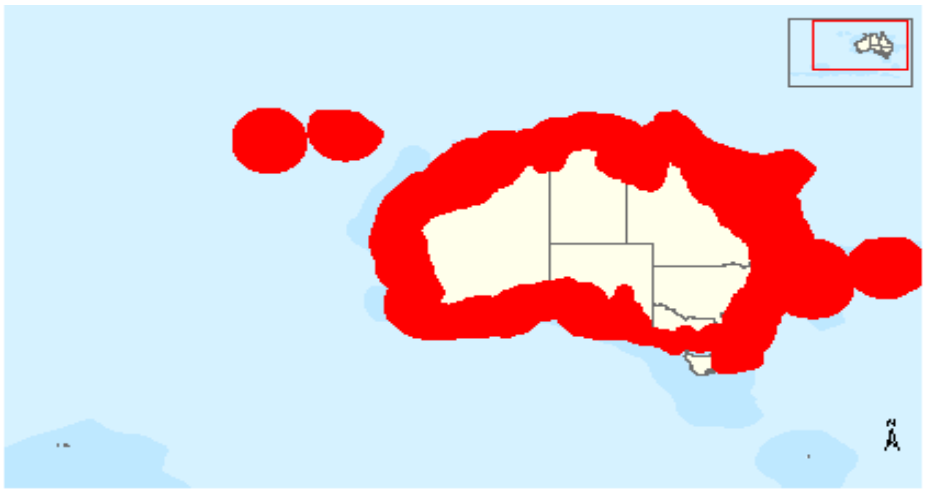

Figure 11. This is an indicative distribution map of the present distribution of the Loggerhead Turtle (Caretta caretta) in Australian Waters. (Map from the Species Profile and Threat Database).

Legislation

The Loggerhead Turtle is listed as Endangered under both the EPBC Act 1999 and the NPWS Act.

Migratory

This species is considered a Marine and Migratory species under the EPBC Act.

Habits and Habitat

Loggerhead Turtles are carnivorous, feeding primarily on benthic invertebrates in habitat ranging from near shore to 55 m [63]. In their juvenile stage, they feed on algae, pelagic crustaceans, molluscs, flotsam and anthropogenic debris [64]. Once it has reached breeding age, it will move between its chosen feeding area and its chosen breeding area for the rest of its life [62]. Loggerhead Turtles in Australia breed from November to March with a peak in late December/ early January [65]. Hatchlings enter the open ocean and begin feeding on small animals. Small Loggerhead Turtles live at or near the surface of the ocean and move with the ocean currents, with much of their feeding in the top five metres of water [66], before recruiting to their chosen inshore or neritic feeding area. Loggerhead Turtles choose a wide variety of tidal and sub-tidal habitat as feeding areas [62]. Loggerhead Turtles show fidelity to both their foraging and breeding areas [62]. When ready for breeding, mature turtles migrate to their chosen breeding area. Nesting females stay within an nesting area during their

nesting period. Once breeding and nesting is complete, turtles return to their favoured foraging areas. In Australia, Loggerhead Turtles nest on open, sandy beaches [66].

Green Turtle (*Chelonia mydas*)

Distribution

The total Australian population of Green Turtles is estimated to be more than 70 000 individuals, distributed across seven regional populations. The seven regional populations of Green Turtles in Australia are thought to represent genetically distinct subpopulations, with a very low level of genetic exchange between regions [67]. Threats to nesting due to habitat disturbance including erosion and erosion control measures such as drift fencing; rubbish; recreational vehicles; shoreline developments; marina and jetty developments; beach cleaning; sand compaction and beach nourishment (adding sand) [68].

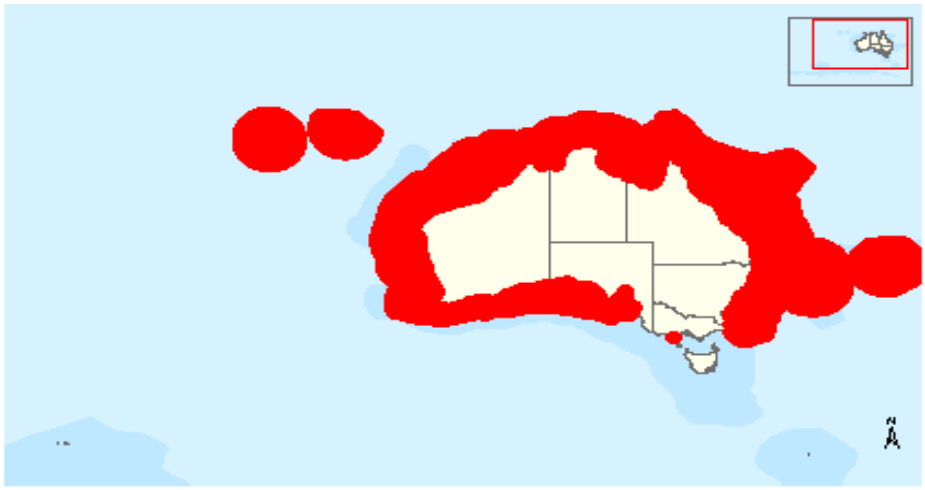

Figure 12. This is an indicative distribution map of the present distribution of the Leatherback Turtle (Dermochelys coriacea) in Australian Waters. (Map from the Species Profile and Threat Database).

Legislation

The Loggerhead Turtle is listed as Endangered under both the EPBC Act 1999 and the NPWS Act.

Migratory

This species is considered a Marine and migratory species under the EPBC Act.

Habits and Habitat

Once Green Turtles reach 30 to 40 cm curved carapace length, they settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds. The shallow foraging habitat of adults contains seagrass beds or algae mats on which Green Turtles mainly feed [68, 69]. Female Green Turtles vary in their age at maturity depending on the different foraging grounds they occupy. Females may reach sexual maturity at between 25 to 50 years of age [70].To develop successfully, marine turtle eggs must be buried in sand that is aerated (but not exposed), low in salt, high in humidity (but not flooded), and between 25°C and 33°C [67]. Nests with intermediate temperatures produce mixed sex hatchlings, depending on the position, and therefore, temperature of individual eggs. Breeding Green Turtles move from their feeding grounds to areas near nesting beaches for mating. The

males then return to their feeding grounds, and the females come up onto the beach to lay their eggs, usually on several different nights [68].

Tiger Pipefish (*Filicampus tigris*)

Distribution

The range of Tiger Pipefish is from Broom, Western Australia to Spencer Gulf in South Australia and Sydney, New South Wales to Moreton Bay in Queensland [71]. The Spencer Gulf population is a relic population (see figure 13) [72].

Figure 13. Distribution of the Tiger Pipefish around Australia showing Spencer Gulf, South Australia population. (CAAB map from Thompson, 2000 [72]).

Legislation

The Tiger Pipefish is currently not listed as Threatened under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. It is also not listed under the National Parks and Wildlife Act 1972 (NPW). Protection is provided under the Fisheries Management Act 2007 (FM) South Australia. The Tiger Pipefish is listed as a marine species under the EPBC Act [11]. This species is species of significant conservation concern.

Migratory

This species is considered a non-migratory species under the EPBC Act [11].

Habits and Habitat

The Tiger Pipefish habitat includes sheltered bays, and estuaries with sandy or muddy bottoms and around seagrass bed edges [72], reef, sand and silt from a depth of 2 to 30 metres [71]. In the eastern part of its range it often can be seen resting motionless on the rubble bottom near the entrance to deep estuaries [71]. A slow moving species, they rely heavily on camouflage for survival among seagrasses, seaweeds and encrusting animals [71]. Feeding on prey species consists of aggregations of mysid shrimps in sheltered bays adjacent to tide channels [72]. Breeding occurs during teh summer months [72]. Males brood several 100 red eggs and give birth to young [72].

Leafy Seadragon (*Phycodurus eques*)

Distribution

The range of the Leafy Seadragon extends from Lancelin in Western Australia to Wilsons Promontory in Victoria [71]. This species is common at a few locations in South Australia [71]. Threats to this species includes habitat destruction from agricultural runoff and urban drains [73]; and sea storms as they are not capable of coping with sudden changes in water pressure and depth.

Legislation

The Leafy Seadragon is currently listed as Vulnerable under the Environmental Protection for Biological Conservation (EPBC) 1999 Act. It is not listed under the National Parks and Wildlife Act 1972 (NPW) of South Australia. Protection is provided under the Fisheries Management Act 2007 (FM) South Australia. The Leafy Seadragon is listed as a marine species under the EPBC Act [11]. This species is a species of significant conservation concern.

Migratory

This species is considered a non-migratory species under the EPBC Act [11].

Habits and Habitat

The Leafy Seadragon habitat includes moderately exposed reefs from a depth of 4 metres to 30 [71]. They live close to the shore in areas containing seagrass [74]. A slow moving species, they rely heavily on camouflage for survival among seagrasses, seaweeds and encrusting animals [71, 74]. Prey species include sea lice that they suck up through their mouths, juveniles feed on smaller zooplankton such as copepods and rotifers [73]. Females lay eggs underneath the males tail (brood pouch), males brood and give birth to young after 4 to 6 weeks. Young are independent instantly [73]. Males give birth to two batches of eggs per year only 5% of young survive [73].

References

1. Birdlife International. *Species factsheet: Eudyptula minor*. 2011 [cited 2011 June]; Available from: www.birdlife.org.
2. Australian Museum. *Birds in Backyards: Eudyptula minor*. 2011 July 2005 [cited 2011 June]; Available from: www.birdsinbackyards.net.
3. Marchant, S. and P.J. Higgins. 1990. *Handbook of Australian, New Zealand and Antarctic Birds*. Vol. 1: Ratites to Ducks, Melbourne: Oxford University Press.
4. Elliott, A., J. Hoyo, and J. Del Sargatal. 1992. *Handbook of the Birds of the World*. Vol. 1: Ostrich to Ducks: Lynx Edicions.
5. Woehler, E., *Population decreases in little penguins Eudyptula minor in southeastern Tasmania, Australia, over the past 45 years.* Marine Ornithology, 2007. **35**: p. 71-76.
6. Stahel, C. and R. Gales. 1987. *Little Penguins*, Sydney: New south Wales University Press.
7. Fortescue, M., *Temporal and spatial variation in breeding success of the Little Penguin Eudyptula minor on the east coast of Australia.* Marine Ornithology, 1999. **27**: p. 21-28.
8. Chiaradia, A., et al., *Changes in diet and trophic position of a top predator 10 years after a mass mortality of a key prey.* ICES Journal of Marine Science: Journal du Conseil, 2010. **67**(8): p. 1710-1720.
9. Giling, D., R. Reina, and Z. Hogg, *Anthropogenic influence on an urban colony of the little penguin Eudyptula minor.* Marine and Freshwater Research, 2008. **59**: p. 647-651.
10. The Tasmanian Conservationist, *Co-existing with Little Penguins in the Derwent Estuary*. 2009.
11. Department of Sustainability Environment Water Population and Communities. *Eudyptula minor*. Species Profile and Threats Database 2011 June [cited; Available from: www.environment.gov.au/sprat.
12. Birdlife International. *Eudyptula minor*. IUCN 2010 Red List of Threatened species. Version 2010.4 2009 [cited 2011 June]; Available from: www.iucnredlist.org.
13. Preston, T., et al., *Foraging behaviour of little penguins Eudyptula minor in an artifically modified environment.* Endangered Species Research, 2007. **3**.
14. Nisbet, I.C.T. and P. Dann, *Reproductive performance of little penguins Eudyptula minor in relation to year, age, pair-bond duration, breeding date and individual quality.* Journal of Avian Biology, 2009. **40**(3): p. 296-308.
15. Chiaradia, A. and K. Kerry, *Daily nest attendance and breeding performace in the Little Penguin Eudyptula minor at Phillip Island, Australia.* Marine Ornithology, 1999. **27**: p. 13-20.
16. Birdlife International. *Haliaeetus leucogastor. In: IUCN 2011. IUCN Red List of Threatened Species*. 2009 [cited 2011 July]; Version 2011.1:[Available from: www.iucnredlist.org.
17. Threatened Species Section. 2006. Threatened Tasmanian Eagles Recovery Plan 2006-2010. Department of Primary Industries and Water. Hobart.
18. Evans, O. *White-bellied Sea-eagle*. Australian Museum 2010 [cited 2011 June]; Available from: http://australianmuseum.net.au/White-bellied-Sea-Eagle.
19. Dennis, T.E., et al., *The distribution and breeding status of White-bellied Sea-Eagle and Osprey populations on Kangaroo Island in 2005.* 2005, Report to Kanagaroo

Island Natural Resources Management Board and Department of Environment and Heritage, South Australia: Kingscote, Kangaroo Island.

20. Department of Sustainability Environment Water Population and Communities. *Haliaeetus leucogastor*. 2011 June [cited; Available from: www.environment.gov.au/sprat.
21. Shephard, J.M., C.P. Catterall, and J.M. Hughes, *Long-term variation in the distribution of the White-bellied Sea-Eagle (Haliaeetus leucogaster) across Australia.* Austral Ecology, 2005. **30**(2): p. 131-145.
22. Birds Australia. *Birddata: Atlas Distribution Maps*. 2011 June [cited 2011 June]; Available from: http://www.birdata.com.au.
23. Debus, S.J.S., *Biology and Diet of the White-bellied Sea-eagle (Haliaeetus leucogaster) Breeding in Northern Inland New South Wales.* Australian Field Ornithology, 2008. **25**: p. 165-193.
24. Dennis, T.E., *Conservation status of the white-bellied sea-eagle, osprey and peregrine falcon on western Eyre Peninsula and adjacent offshore islands in South Australia.* South Australian Ornithologist, 2004. **34**(6): p. 222-228.
25. Birds in Backyards. *White-bellied Sea-eagle*. 2011 [cited 2011 June]; Available from: www.birdsinbackyards.net.
26. Birdlife International. *Pandion haliaetus. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1*. 2009 [cited 2011 June].
27. Marchant, S. and P.J. Higgins. 1993. *Handbook of Australian, New Zealand and Antarctic Birds*. Vol. 2: Raptores to Lapwings, Melbourne: Oxford University Press.
28. Dennis, T.E., *Distribution and status of the Osprey (Pandion haliaetus) in South Australia.* Emu, 2007. **107**: p. 294–299.
29. Clancy, G.P., *The diet of the Osprey (Pandion haliaetus) on the north coast of New South Wales.* Emu, 2005. **105**: p. 87-91.
30. Australian Museum. *Birds in Backyards: Red-necked stint Species Factsheet* 2006 15 August 2006 [cited 2009 June]; Available from: http://www.birdsinbackyards.net.
31. Paton, D.C. and B.J. Wykes, *Re-appraisal of moult of Red-necked Stints in Southern Australia.* Emu 1978. **78**: p. 54-60.
32. Birdlife International. *Calidris ruficollis*. IUCN 2009: Red List of Threatened Species Version 2009.1 2008 [cited 2009 June]; Available from: http://www.iucnredlist.org.
33. Higgins, P.J. and S.J.J.F. Davies. 1996. *Handbook of Australian, New Zealand and Antarctic Birds*. Vol. 3: Snipe to Pigeons, Melbourne: Oxford University Press.
34. Birdlife International. *Species Factsheet: Red-necked Stint*. 2009 [cited 2009 June]; Available from: http://www.birdlife.org.
35. Thomas, D.G. and A.J. Dartnall, *Ecological aspects of the feeding behaviour of two calidridine sandpipers wintering in south-eastern Tasmania.* Emu, 1971. **71**: p. 20-26.
36. Dann, P., *Foraging behaviour and diets of red-necked stints and curlew sandpipers in south-eastern Australia.* Wildlife Research, 2000. **27**: p. 61-68.
37. Rohweder, D.A. and P.R. Baverstock, *Preliminary investigation of nocturnal habitat use by migratory waders (Order Charadriformes) in northern New South Wales.* Wildlife Research 1996. **23**: p. 169-183.
38. Starks, J. and B. Lane, *The northward migration of waders from Australia Febuary to April 1985*. Stilt, 1987. **10**: p. 20-27.

39. Birdlife International. *Pluvialis squatarola. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1*. 2009 [cited 2011 June]; Available from: www.redlist.org.

40. Birds Australia. *Birds in Backyards: Grey Plover*. 2006 [cited 2011 June]; Available from: www.birdsinbackyards.net.

41. Australian Museum. *Birds in backyards: Sanderling*. 2006 15 August 2006 [cited 2006 June]; Available from: www.birdsinbackyards.net.

42. Birdlife International. *Calidris alba In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1*. 2008 [cited 2009 June]; Available from: www.iucnredlist.org.

43. Birdlife International. *Species Factsheet: Calidris alba*. 2009 [cited 2009 June]; Available from: www.birdlife.org/datazone/species.

44. McGill, A.R., *An Australian review of the Sanderling.* EMU, 1950. **50**: p. 197–206.

45. Estrella, S.M., et al., *Small-prey profitability: Field analysis of shorebirds use of surface tension of water to transport prey.* The Auk, 2007. **124**(4): p. 1244-1253.

46. Estrella, S.M. and J.A. Masero, *The use of distal rhynchokinesis by birds feeding in water*. 2007. p. 3757-3762.

47. Petracci, P.F., *Diet of Sanderling in Buenos Aires Province, Argentina.* Waterbirds, 2002. **25**(3): p. 366-370.

48. Birdlife international. *Sterna nereis: In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1*. 2010 [cited 2011 June]; Available from: www.iucnredlist.org.

49. Higgins, P.J. and S.J.J.F. Davies. 1996. *Handbook of Australian, New Zealand and Antarctic Birds: Volume 3 Snipe to Pigeons*. Vol. 3:, Melbourne: Oxford University Press.

50. Birds Australia. *Birds in Backyards: Hooded Plover (Thinornis rubricollis)*. 2011 [cited 2011 June]; Available from: www.birdsinbackyards.net.

51. Backer-Gabb, D. and M. Weston. 2006. South Australian action plan for the Hooded Plover Part D: Southern Fleurieu Action Plan. Department of Environment and Heritage (DEH). South Australia.

52. Garnett, S.T. and G.M. Crowley. 2000. *The Action Plan for Australian Birds*, Canberra: Environment Australia.

53. Van Dyck, S. and R. Strahan. 2008. *The Mamals of Australia*. 3rd ed, Australia: Reed New Holland.

54. Marinebio. *Australian Sea Lion*. 2011 [cited 2011 June]; Available from: http://marinebio.org.

55. Bone, C., *Preliminary investigation into leatherback turtle, Dermochelys coriacea (L.) distribution, abundance and interactions with fisheries in Tasmanian waters. Unpublished Report.* . 1998, Tasmanian Parks and Wildlife Service.

56. Hamann, M., C. , et al., *Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South East Asia.* . 2006, Bangkok: IOSEA Marine Turtle MoU Secretariat.

57. Limpus, C.J.N.M., *Observations on the leatherback turtle, Dermochelys coriacea (L.), in Australia.* Australian Wildlife Research., 1979. **6**: p. 105-116.

58. Limpus, C.J. 1995b *Global overview of the status of marine turtles: a 1995 viewpoint.*, in *Biology and Conservation of Sea Turtles*, K. Bjorndal, Editor. Smithsonian Institution Press.: Washington.

59. Kaplan, I.C., *A risk assessment for Pacific leatherback turtles (Dermochelys coriacea).* Canadian Journal Fishery and Aquatic Sciencies, 1995. **62**(8).

60. Limpus, C.J., N.C. MacLachlin, and J.D. Miller, *Further observations on breeding of Dermochelys coriacea in Australia.* . Australian Wildlife Research., 1984c. **11**: p. 567-571.

61. Limpus, C.J. 1995a. Conservation of marine turtles in the Indo-Pacific region. Queensland Department of Environment and Heritage. Brisbane.

62. Limpus, C.J. 2008a. A biological review of Australian Marine Turtles. 1. Loggerhead Turtle Caretta caretta (Linneaus). Queensland Environment Protection Agency.

63. Plotkin, P.T., M.K. Wicksten, and A.F. Amos, *Feeding ecology of the loggerhead sea turtle Caretta caretta in the northwestern Gulf of Mexico.* Marine Biology, 1993. **115**(1): p. 1.

64. Plotkin, P.T., *The occurrence and diet of juvenile loggerhead sea turtles, Caretta caretta, in the northwestern Gulf of Mexico.* Chelonian Conservation and Biology, 1996. **2**(1): p. 78-80.

65. Limpus, C.J., *A study of the Loggerhead Turtle, Caretta caretta, in eastern Australia.* , in *Department of Zoology*. 1985, University of Queensland.: Brisbane.

66. Spotila, J.R. 2004. *Sea turtles: a complete guide to their biology, behavior, and conservation*, Baltimore, Maryland: The Johns Hopkins University Press and Oakwood Arts.

67. Department of Environment and Heritage (DEH), *Draft Recovery Plan for marine turtles found in Australia: Olive Ridley Turtle Lepidochelys olivacea, Loggerhead Turtle Caretta caretta, Flatback Turtle Natator depressus, Green Turtle Chelonia mydas, Hawksbill Turtle Eretmochelys imbricata and Leatherback.* 2005a.

68. Robins, C.M., et al. 2002. Monitoring the catch of turtles in the Northern Prawn Fishery. Fisheries Research and Development Corporation. Department of Agriculture Fisheries & Forestry. Canberra.

69. Musick, J.A. and C.J. Limpus. 1997 *Habitat utilization and migration in juvenile sea turtles.*, in *The Biology of Sea Turtles*, P. Lutz, & J. A.Musick, Editor. CRC Press Inc.: Boca Raton, Florida. p. 137-163.

70. Chaloupka, M. and C. Limpus, *Trends in the abundance of sea turtles resident in southern Great Barrier Reef waters.* Biological Conservation, 2001. **102**: p. 235-249.

71. Edgar, G. 2000. *Australian Marine Life*. Revised ed, Australia: Reed New Holland.

72. Thompson, V.J. and D.J. Bray. *Tiger Pipefish Filicampus tigris*. 2009 [cited 2011 June]; Available from: http://foa.webboy.net.

73. Threatened Species Network. *Leafy Seadragon*. [cited 2011 June]; Available from: www.wwf.org.au.

74. Threated Species Network. *Leafy Seadragon*. [cited 2011 June]; Available from: www.wwf.org.au.

APPENDIX F