SMITH BAY WHARF

DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX I

PREPARED FOR KANGAROO ISLAND PLANTATION TIMBERS BY ENVIRONMENTAL PROJECTS

JANUARY 2019

SMITH BAY WHARF

DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX I

PREPARED FOR KANGAROO ISLAND PLANTATION TIMBERS BY ENVIRONMENTAL PROJECTS

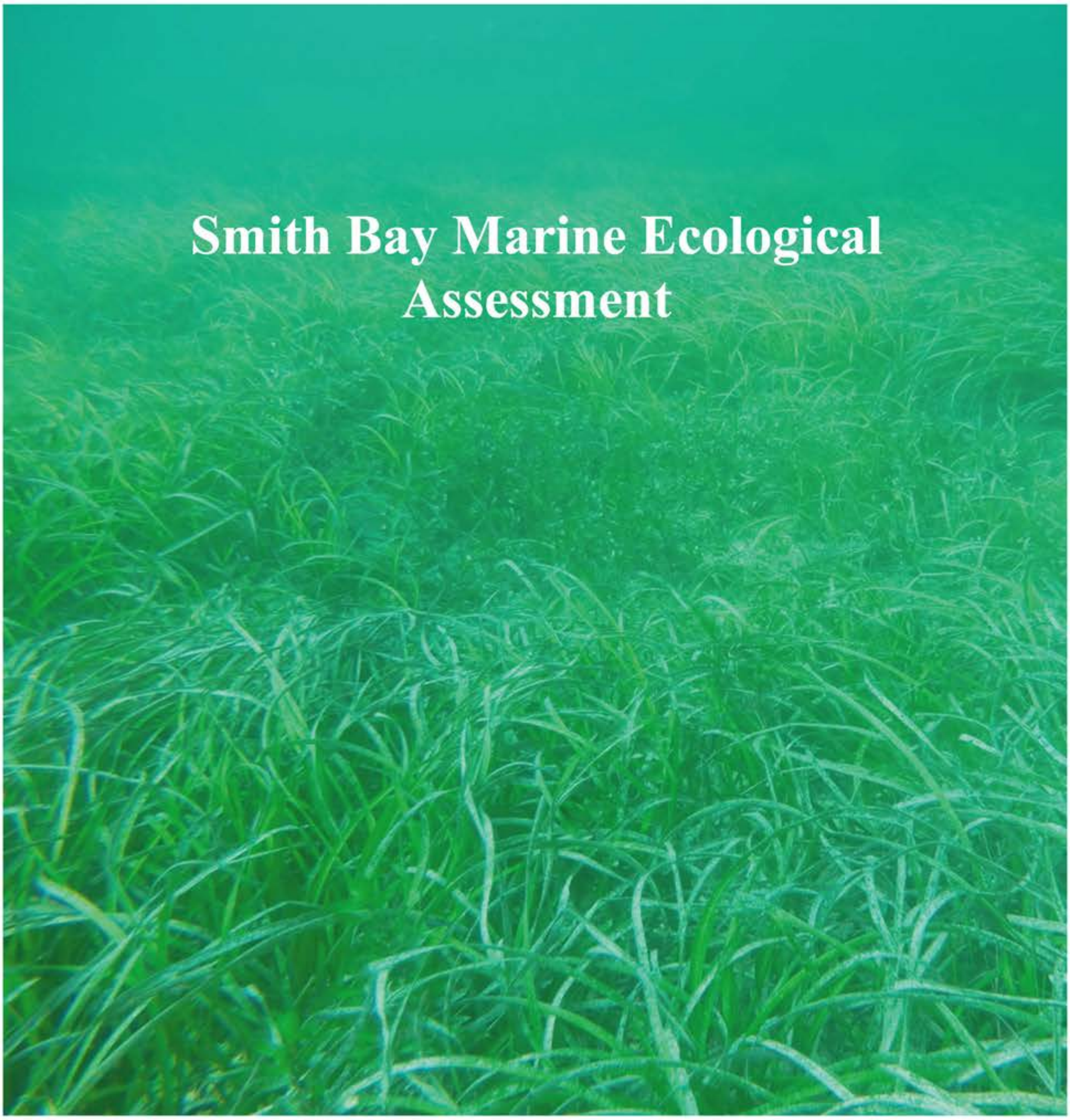
JANUARY 2019

APPENDIX I

APPENDIX I – MARINE ECOLOGICAL ASSESSMENTS

Appendix I1 – Smith Bay Marine Ecological Assessment – SEA

Kangaroo Island Plantation Timbers Pty Ltd



Smith Bay Marine Ecological Assessment

Prepared by: David Wiltshire and James Brook

SEA Pty Ltd

6th September 2018

Table of Contents

List of attachments

Attachment A: Photographs of typical biota and habitats observed during the survey
Attachment B: Listed marine species: marine biological assessment

List of tables

List of figures

Summary

This report provides a marine ecological assessment of the proposal to develop a deep water wharf at Smith Bay to export logs from timber plantations on Kangaroo Island. The principal ecological issues were considered to be:

- the loss of seagrass during dredging of the wharf basin and approaches;
- indirect effects on reef and seagrass communities from increased turbidity and sediment fallout during dredging

The main findings of the assessment are:

- The marine communities at Smith Bay consist of mixed reef and seagrass communities. The seagrasses *Posidonia sinuosa* and *Amphibolis* spp. (*A. antarctica* and *A. griffithii*) grow in patches on rock bottom in depths up to 9 metres, and continuously, but sparsely, over a mixed substrate of sand, pebble and shell fragment at depths of 9–12 metres.
- With one exception, it is considered that none of the listed marine species would be at credible risk from the proposed development.
- The marine listed *Stipecampus cristatus* (ring-backed pipefish) was found in *Posidonia* habitat in the area that would be dredged and is therefore at credible risk of being affected.
- It is considered, however, that the loss of a small amount of pipefish habitat and potentially some pipefish during dredging would have a negligible effect on their overall population and viability in the area.
- Construction of the causeway would result in the direct loss of about 0.5 ha of mixed reef and seagrass habitat that supports dense communities of *Posidonia sinuosa* and *Amphibolis* spp.
- Dredging would result in the direct loss of about 10 ha of relatively sparse seagrass consisting mainly of *Posidonia sinuosa*.
- Indirect impacts on adjacent seagrass communities through turbidity and sedimentation effects associated with dredging and shipping would be likely. The significance of these effects will be assessed through hydrodynamic modelling.
- The ecological significance of the loss of these seagrass communities would be minor as there is a large amount of similar habitat within Smith Bay and elsewhere along the north coast.

1 INTRODUCTION

Kangaroo Island Plantation Timbers (KIPT) proposes to develop a deepwater wharf at Smith Bay on the north coast of Kangaroo Island (Figure 1). The wharf would be capable of accommodating 30,000-deadweight tonne bulk carriers. Although the primary purpose of the wharf would be to export timber from plantations on the island, KIPT proposes to make it available for other shipping uses.

The main features of the development would be:

- construction of a causeway to a floating wharf moored approximately 250 metres off-shore at a depth of 10 metres at its seaward edge
- dredging of a 200 x 50 metres berthing pocket adjacent to the wharf to a depth of 13 metres
- dredging of approaches approximately 600 x 150 metres to a depth of 12 metres (Figure 2)
- on-shore construction of several level tiers over an area of approximately 8 ha to store logs, access roads and associated amenities.

SEA undertook a reconnaissance survey of the site at Smith Bay and an alternative site at Ballast Head for KIPT in November 2015 as part of an investigation of the advantages and disadvantages of each site (LBW Environmental Projects 2016).

Having confirmed that Smith Bay was the preferred location for the seaport, KIPT commissioned the development of preliminary plans for the seaport by Aztec Analysis (2016), and further marine ecological studies at Smith Bay by SEA.

The aims of the following marine studies were to:

- describe the marine ecology of Smith Bay
- assess the ecology of the development site
- identify any significant marine species that may occupy or transit the development site.

Under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* the potential effect of the development on matters of national environmental significance (NES) must be considered. Matters that are relevant to the proposed development include:

- listed threatened species and ecological communities
- listed marine species
- listed migratory species.

This assessment examines the effect the proposed development would be likely to have on the relevant controlling provisions of the EPBC Act. Specifically it includes assessments of:

- the species listed in the EPBC Act Protected Matters Report (KIPT 2016)
- the likelihood that these species occur in the project area
- the significance to the species of the habitat in the project area
- the risk to each species posed by the development
- the potential impacts on the species identified from the Protected Matters Report.

Figure 1: Smith Bay location map.

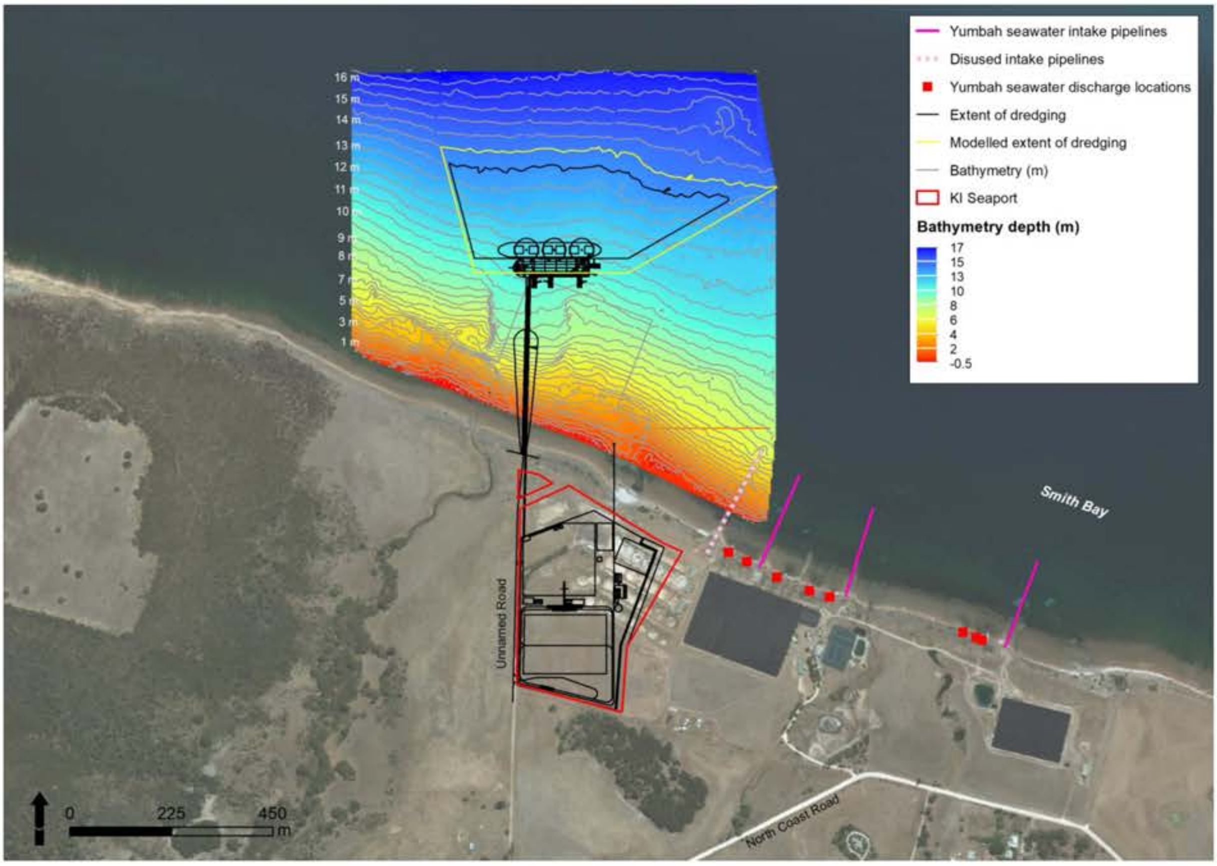


Figure 2: The Smith Bay site showing the preliminary design of the floating wharf, causeway, dredged approaches and berthing pocket.

2 REGIONAL SETTING

Smith Bay is on the north coast of Kangaroo Island, about 20 km west of Kingscote, between Emu Bay and Cape Cassini. It lies within the Cassini biounit of the Gulf St Vincent bioregion (Edyvane 1999).

The north coast is a relatively moderate to low energy environment as it is largely sheltered from the prevailing south westerly swells in the Southern Ocean (Edyvane 1999). Nevertheless, it does at times receive relatively small westerly swells that refract around the island and decline in size and energy as they travel east. The north coast is also sheltered from waves generated by strong south-westerly winds in winter, and the prevailing south-easterly winds and sea breezes in summer. It is, however, exposed to waves generated by occasional strong northerly winds.

The relatively sheltered conditions along the north coast of Kangaroo Island have supported the development of isolated but extensive seagrass communities in sheltered bays where there is sandy substrate. Reef communities have developed in the areas with rocky substrate.

The marine habitats of the region have been mapped at a scale of 1:100,000 using satellite imagery (DEWNR 2016a, Edyvane 1999). This mapping shows continuous reef habitat extending about 800 metres offshore, with bare sand further offshore (Figure 3). It is of limited use at the scale of the present study, however, as it does not capture any of the complexity of the mixed reef, sand and seagrass habitats at Smith Bay. Extensive seagrass communities have been mapped at a similar scale in Emu Bay, west of Smith Bay (Figure 3). This mapping shows seagrass in Emu Bay is limited to waters five to eight metres deep. It should be noted that the bathymetry mapping based on navigation charts (DEWNR 2016b) is inaccurate in Smith Bay (and possibly elsewhere) and the 10 metre contour is only 200–250 metres from shore rather than one kilometre.

Seagrass communities in South Australia are generally confined to relatively shallow water where there is sufficient light for photosynthesis. They are invariably denser and more robust in relatively shallow water (< 8 m), and decline in density in the deeper water (>8 m). The depth limit of the seagrasses *Posidonia* spp. and *Amphibolis* spp. in Spencer Gulf and Gulf St Vincent are reported to be approximately eight metres (Irving 2014).

In Kangaroo Island waters, seagrass cover, diversity and epiphytic load have been studied by Southgate (2005) within several bays east of Smith Bay. The seagrass in Emu Bay was found to be healthy with good cover and relatively little epiphytic load. Seagrass further to the east in Nepean Bay, however, was found to be in poor health and showed signs of high epiphytic load and declining cover linked to high nutrient loads (Southgate 2005). The fauna associated with seagrass in Nepean Bay and two other bays further east were surveyed using beam trawls in summer 2005/06 and winter 2006 (Kinloch et al. 2007).

Seagrass communities are generally thought to be a very important component of coastal marine ecosystems because.

- they are the primary source of productivity within the detritus-based food chain.
- seagrass leaves provide an enormous surface area for colonisation by epiphytic algae and epizoic fauna, which greatly increases the habitat diversity and productivity of the system.
- the dense leaf canopy baffles the action of waves, preventing erosion and the re-suspension of sediments. Suspended sediments tend to be trapped by seagrasses and bound by their fibrous roots, resulting in increased water clarity.

- they are considered to support the larval, juvenile and adult life stages of a number of commercially and recreationally important fish species, such as *King George whiting (Sillaginodes punctata), southern garfish (Hyporhamphus melanochir) and Western Australian salmon (Arripis truttacea)* (Edgar 2001; McDonald and Tanner 2002; Jones et al. 2008).

The rocky reef habitat along the north coast supports invertebrate communities that are generally diverse and extensive relative to those in other parts of the state. Reef fish, invertebrate and/or macroalgal communities have been surveyed on the north coast, although not in Smith Bay, by various community-based programs supported by professional scientists (McArdle et al. 2015, Shepherd et al. 2002, Shepherd and Brook 2007, Reef Life Survey 2016). Reef species of particular conservation or commercial significance (McArdle et al. 2015) recorded during these surveys include *western blue groper (Achoerodus gouldii), harlequin fish (Othos dentex), western blue devil (Paraplesiops meleagris), queen snapper (Nemadactylus valenciennesi), long-snouted boarfish (Pentaceropsis recurvirostris), southern rock lobster (Jasus edwardsii) and blacklip abalone (Haliotis rubra).*

The marine parks closest to Smith Bay are the Southern Spencer Gulf Marine Park to the west and the Encounter Marine Park to the east, each about 20 km distant.

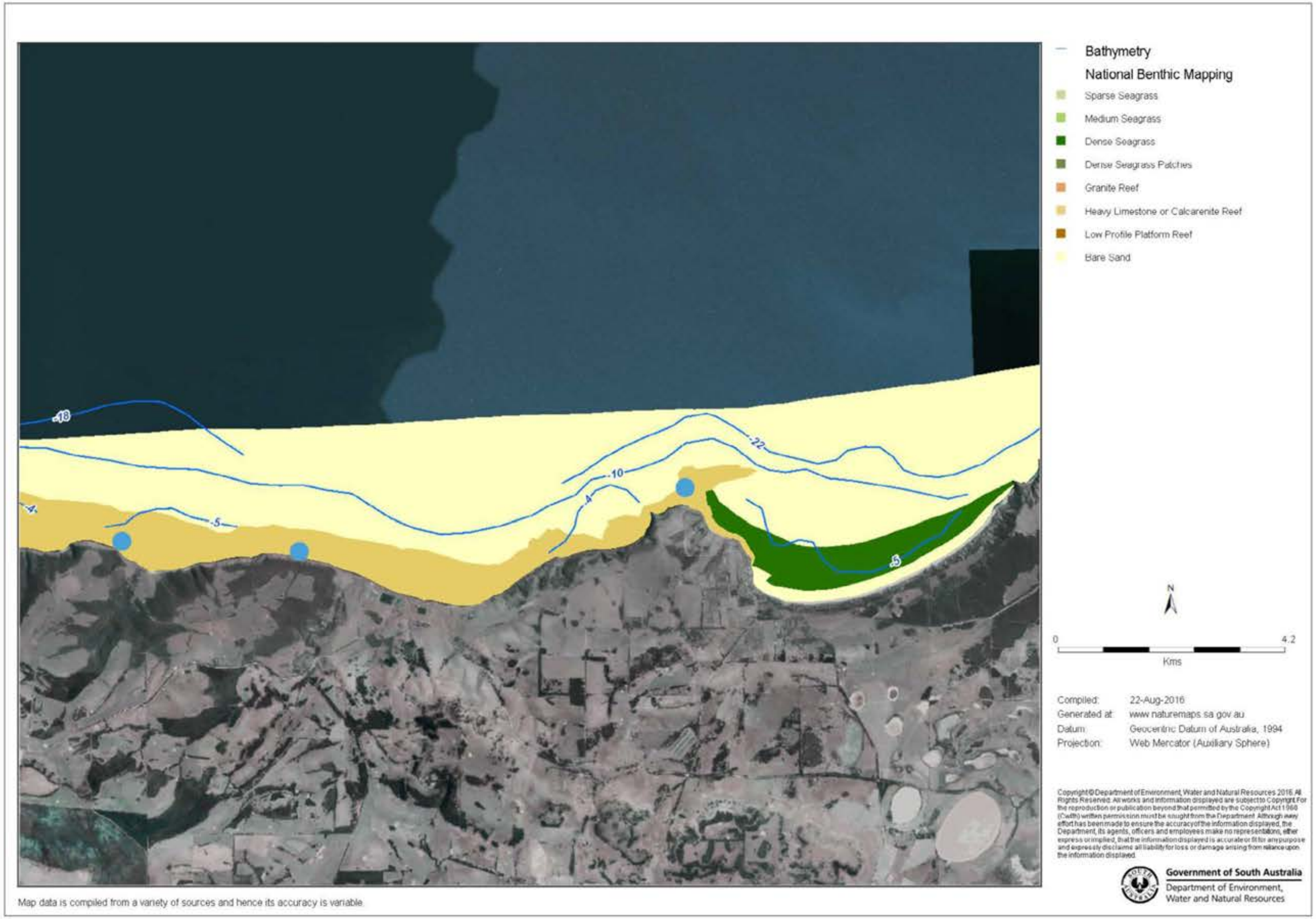


Figure 3: Existing habitat mapping for the central north coast of Kangaroo Island. Smith Bay is slightly west of the centre of the map. Blue dots indicate locations of independent reef survey sites. Source: DEWNR 2016a, b; Reef Life Survey 2015

3 METHODS

3.1 First survey

An initial marine survey of the development site was undertaken on 3 August 2016 by David Wiltshire and James Brook of SEA.

Habitats near the site were surveyed by divers using scuba equipment and underwater cameras. Notes on marine communities were taken on waterproof paper. The survey focused on the locations of the proposed causeway, the floating platform and the dredged pocket and approaches.

Transects were swum perpendicular to the shore to a depth of approximately 10 m, followed by transects parallel to the shore at a depth of 11–12 metres. The survey focused on the locations of the proposed causeway, the floating platform and the dredged pocket and approaches.

The type and approximate percentage cover of habitats, and the identity and approximate abundance of organisms were noted using a three-category logarithmic scale (1–2; 3–10; 11–100). The presence of any introduced species was also noted. A species list was generated for fish, large mobile invertebrates, sessile invertebrates, macroalgae and seagrass. Taxa were generally identified to the lowest taxonomic level possible in the field (typically genus or species).

The benthic communities in Smith Bay were also surveyed photographically from a kayak using a remotely operated underwater camera that was dropped to the seafloor at numerous locations. The track taken by the kayak is shown in Figure 4.

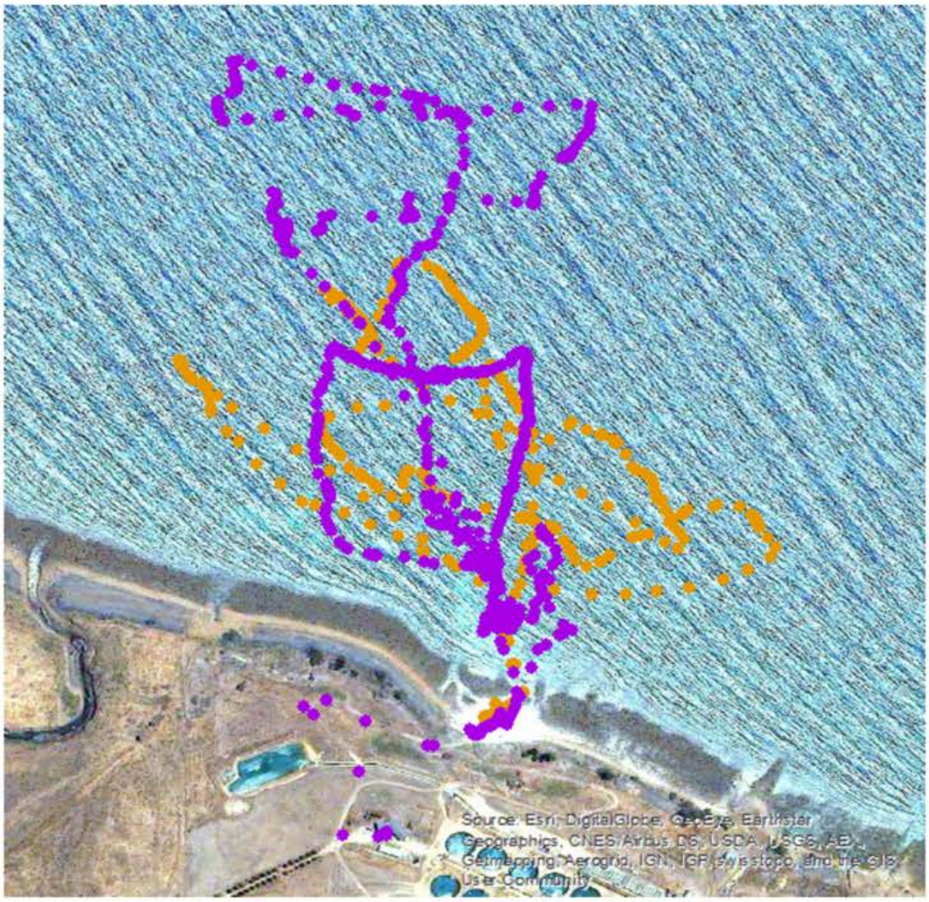


Figure 4. Tracks for kayak-based underwater photo surveys. Orange = November 2015, Purple = August 2016.

3.2 Second survey

A second marine survey of the development site and surrounding area was undertaken on 28–29 November 2017 by David Wiltshire and James Brook of SEA.

Habitats were surveyed by divers using scuba equipment and underwater cameras at 15 sites within 400 metres of the development site, arranged in three rows representing relatively shallow, medium and deep sites (Figure 5). At each site a 30 metres transect was laid due north (magnetic) from the GPS mark. The cover of macroalgae and seagrass and the abundance of fish and invertebrates occurring within one metre of the transect were recorded using the same logarithmic scale as for the first survey.

3.3 Third survey

A third marine survey of the development site and surrounding area was undertaken on 25 August 2018 by David Wiltshire and James Brook of SEA.

Habitats were surveyed by divers using scuba equipment and underwater cameras at 6 sites in 14–15 metres depth (Figure 5). At each site a ten minute timed search was undertaken within a 20 metre radius of the anchor. The cover of macroalgae and seagrass and the abundance of fish and invertebrates were recorded using the same logarithmic scale as for the first two surveys.

Table 1. Grid locations of marine survey sites.

Site	Depth (m)	Latitude	Longitude
Second survey			
SB01	6.5	-35.58803	137.4189148
SB02	11.3	-35.58676	137.4194183
SB03	15.6	-35.58485	137.4201355
SB04	6.8	-35.58937	137.4238129
SB05	10.4	-35.58838	137.4241028
SB06	13	-35.58638	137.4248199
SB07	7.3	-35.59014	137.4262543
SB08	10.5	-35.58878	137.426651
SB09	13.6	-35.58696	137.4273682
SB10	4.5	-35.591	137.4284821
SB11	9.5	-35.58963	137.4291077
SB12	13.1	-35.58781	137.429718
SB13	7.3	-35.59304	137.4345093
SB14	9.5	-35.59177	137.434906
SB15	11.7	-35.58995	137.4357452
Third survey			
SB16	14	-35.5863	137.4257
SB17	13.8	-35.5863	137.4268
SB18	14.1	-35.5863	137.4278
SB19	15	-35.5863	137.4288
SB20	14.5	-35.5865	137.4301
SB21	15.1	-35.5856	137.4278

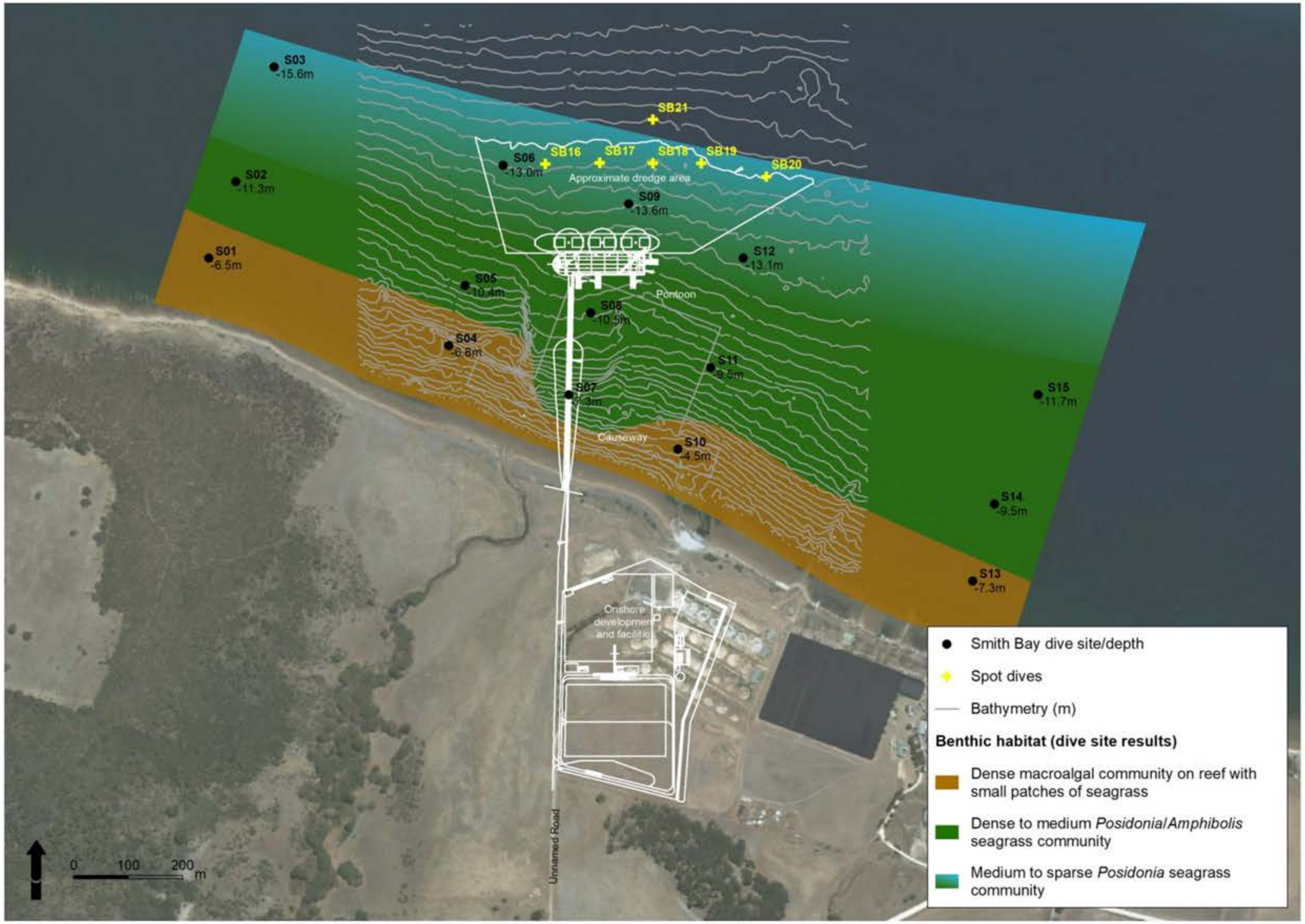


Figure 5. Location of marine survey sites in Smith Bay.

3.4 Synthesis of the survey results

Non-metric Multidimensional Scaling (nMDS) was applied to the abundance class data from the first three surveys to provide a scatter plot which reflected the similarity of the sites to each other in a two dimensional format. The logarithmic classification scale reduced the bias associated with the inconsistent sampling effort between the three surveys. Analysis was performed using the PRIMER software suite, Version 6 (Clarke and Warwick 2001; Clarke and Gorley 2006).

3.5 Listed species

A literature review was undertaken of marine fauna, seagrasses, macroalgae and marine habitats recorded in the vicinity of the development. The major sources of information included:

- Commonwealth Department of the Environment and Energy Protected Matters Search Tool (extracted February 2016) using a 10 km buffer
- Department of Environment and Water and Natural Resources Biological Database of South Australia (BDSA)
- Bryars, S 2003, An Inventory of Important Coastal Fisheries Habitats in South Australia, Fisheries Habitat Program, Department of Primary Industries and Resources of South Australia (PIRSA), Adelaide
- Tanner, JE, & Bryars, S 2007, Impacts of land-based abalone aquaculture discharges on the adjacent marine environment (Chapter 5), in, *Environmental Audit of Marine Aquaculture Developments in South Australia*. SARDI Aquatic Sciences.
- Department for Environment and Heritage Baker, JL 2004, Towards a System of Ecologically Representative Marine Protected Areas in South Australian Marine Bioregions - Technical Report, report to prepared by JL Baker, Coast and Marine Conservation Branch, Department for Environment and Heritage, Adelaide
- Brock, DJ & Kinloch, MA 2007, *Reef Fish Biodiversity on Kangaroo Island*, Coast and Marine Program, Kangaroo Island Natural Resources Management Board
- Kinloch, M et al. 2007, *Seagrass Biodiversity on Kangaroo Island*, Coast and Marine Program, Kangaroo Island Natural Resources Management Board
- McArdle, A, Lashmar, K & Klein, H 2015, *Diving deeper: a community assessment of Kangaroo Island's rocky reefs*, Natural Resources Kangaroo Island
- Shepherd et al. 2009, Summary of Reef Fish Surveys on Northern Kangaroo Island, 2002–08, Unpublished report
- Cheshire et al. 2000, Overview of the Conservation Status of Australian Marine Macroalgae: A report to Environment Australia, Department of Environmental Biology, University of Adelaide

The following criteria were used in assessing the risk to each species (see Attachment B):

- mobility/alternative habitat:
  - a = mobile species
  - b = sedentary or not particularly mobile species
  - c = species with extensive alternative habitat in the area
  - d = species with limited alternative habitat in the area

- distribution:
  - 1 = regularly recorded in or near the study area
  - 2 = occasional records in or near the study area

- 3 = rarely recorded in or near the study area

- credible risk, which takes into account:
  - their occurrence in the Smith Bay region
  - the availability of alternative suitable habitat around Smith Bay
  - their mobility (ability to temporarily move away from the area of impact)
  - the potential for construction to affect the habitat available to these species
  - the likely sensitivity of these species to construction impacts.

4 RESULTS

4.1 Overview

The list of species recorded during the two subtidal surveys is in Table 2. Photographs of habitats and organisms are in Attachment A.

The substrate at Smith Bay consists mainly of rock and reef with a relatively thin veneer of sand that has accumulated in places over the rock. The nearshore section of reef consists of both sheet silcrete and loose rock. Further off-shore (9–15 metres) the seafloor is a mixture of rubble and sand.

The marine communities consist of mixed reef and seagrass communities. The seagrasses *Posidonia sinuosa* and *Amphibolis* spp. (*A. antarctica* and *A. griffithii*), which are long-lived and considered to be particularly important ecologically, grow in patches among rock bottom in depths up to 9 metres, and continuously over a mixed substrate of sand, pebble and shell fragment at depths of 9–15 metres. There are isolated, small patches of *Zostera nigricaulis* and *Halophila australis*, relatively short-lived primary colonisers that tend to recover from disturbance much more rapidly than *Posidonia* spp. and *Amphibolis* spp.

There were few fish recorded during either survey, with notable exceptions being a large school on each survey and 11 species of fish recorded off-transect on the second survey near the intake structure for the Yumbah abalone farm. It should be noted that the small (<0.5 m) swell present during the first survey caused significant re-suspension of sediment which reduced visibility to less than 5 m. Reef fish typically shelter within reef crevices rather than forage in the water column when visibilities are below this threshold (Barrett and Buxton 2002).

A single unidentified seal was seen about 100 metres from shore in Smith Bay during the initial survey, and an Australian sealion *(Neophoca cinerea)* was observed at one site at a depth of 15 metres during the third survey.

4.2 Intertidal beach habitat

The intertidal beach area of Smith Bay consists almost entirely of round rocks and boulders that have been weathered and smoothed by wave action. There is only one small section of beach where the rocks and boulders have been cleared to form a small area from which to launch boats. The intertidal communities typically consist mainly of molluscs including *Nerita*, *Bembicium* and *Austrocochlea*, the polychaete *Galeolaria*, and crustaceans including the barnacles *Chthamalus*, and the crabs *Leptograpsus variegatus* and *Ozius truncatus.*

4.3 Initial subtidal survey

4.3.1 Mixed reef and seagrass habitat (to 10 metres depth)

The subtidal habitats to 10 metres depth were patchy with areas of reef, seagrass, bare sand and mixed reef/seagrass, with approximate covers of 30% seagrass, 60% macro-algae and 10% bare rock or sand.

Areas of reef to three metres depth consisted mainly of boulders of 0.5–1 metres relief that supported canopy-forming fucoid macroalgae including *Cystophora siliquosa* and *Cystophora moniliformis*, with an understorey including *Osmundaria prolifera*, *Caulerpa flexilis* and the red coralline *Haliptilon roseum*. Small patches of seagrass *Posidonia sinuosa* were also present.

From about four metres depth there were areas of bare sand and dense stands of seagrass comprising *Posidonia sinuosa*, *Amphibolis antarctica* or *A. griffithii*, or mixed stands of pairs or all of those species. *Posidonia coriacea* was also observed. The seagrass communities are very healthy and vigorous, which probably reflects the clarity of water in the area.

Further offshore to a depth of 9 metres areas of platform reef and rubble supported a less dense but more diverse canopy of macro-algae consisting of several species of *Cystophora*, *Scaberia aghardii* and *Sargassum* spp. Patches of *Lobophora variegata* and the seagrass *Amphibolis* spp. occupied gaps in the canopy, and isolated, small patches of the *Zostera nigricaulis* were also present. The mobile invertebrate fauna was dominated by gastropods and echinoderms, particularly sea stars, and is typical of reefs in the area (Table 2).

A school of more than 100 *Pseudocaranx* sp. (trevally) was observed in the water column above the seafloor at 9 metres depth.

4.3.2 Seagrass habitat (9–12 metres)

The substrate at depths of 9–12 metres consisted of rubble, rhodoliths, shell fragments and sand, with a relatively sparse (<40 per cent) cover of *Posidonia sinuosa*. The occurrence of *Posidonia sinuosa* in relatively deep water at Smith Bay (compared with communities in Spencer Gulf and Gulf St Vincent) is probably due to the clearer water along the north coast of Kangaroo Island.

Although *Posidonia angustifolia was* not found during the survey, it is also likely to occur in the deeper sections of Smith Bay.

The mobile fauna comprised species typically associated with reef, seagrass or both habitats, and was dominated by doughboy scallop *(Mimachlamys asperrimus)*, queen scallop *(Equichlamys bifrons)*, painted lady *(Phasianella australis)*, vermilion biscuit star *(Pentagonaster dubeni)* and southern sea cucumber *(Australostichopus mollis)*. The most common sessile invertebrate was the stalked ascidian (*Pyura* sp.).

4.4 Second subtidal survey

The results of the second survey confirmed that the inshore habitats at Smith Bay typically comprise reef to a depths up to 9 metres, with seagrass further offshore. The exception was site S07, in 7.3 metres, which was dominated by seagrass. The second survey showed seagrasses at 10–12 metres depth to be more expansive than observed in depths of 7–9 metres during the first survey, while seagrasses over rubble at >12 metres depth were more sparse and had similar communities to those observed at 9–12 metres during the first survey.

A school of more than 1000 yellowtail scad *(Trachurus novaezelandiae)* was observed at site S08. Eleven species were recorded at the Yumbah abalone farm intake structure near site S13, including western blue groper *(Achoerodus gouldii)* and harlequin fish *(Othos dentex)*. Neither species is a listed threatened species but each has life history characteristics that indicate they may be of conservation concern in South Australia (Baker 2008).

Additional observations included a clutch of eggs of southern calamary *(Sepioteuthis australis)* at site S10, and tangled stringy clusters of eggs, likely to be *Aplysia* sp. (a sea hare) at sites S02 (10 clusters) and S05 (one cluster).

4.5 Third survey

The third survey confirmed that seagrasses at depths of 13–14 metres were sparse (5–10 per cent). The dominant seagrass was *Posidonia sinuosa*, with patches of *Amphibolis antarctica* and traces of *Zostera nigricaulis* and *Halophila australis*. Patches of the green macroalga *Caulpera cactoides* were also present. The dominant fauna were the queen scallop *(Equichlamys bifrons)*, doughboy scallop *(Mimachlamys asperrimus)*, erect bryozoans and sea cucumbers.

4.6 Synthesis of survey results

The multi-dimensional scaling scatter plot (Figure 6) shows the overall distinction between the shallow, mid-depth and deep communities, the exception at site S07, and the intermediate position of the initial surveys reflecting the overlap of their depth ranges.

4.7 Introduced species

No introduced species were recorded in Smith Bay during either of the marine surveys.

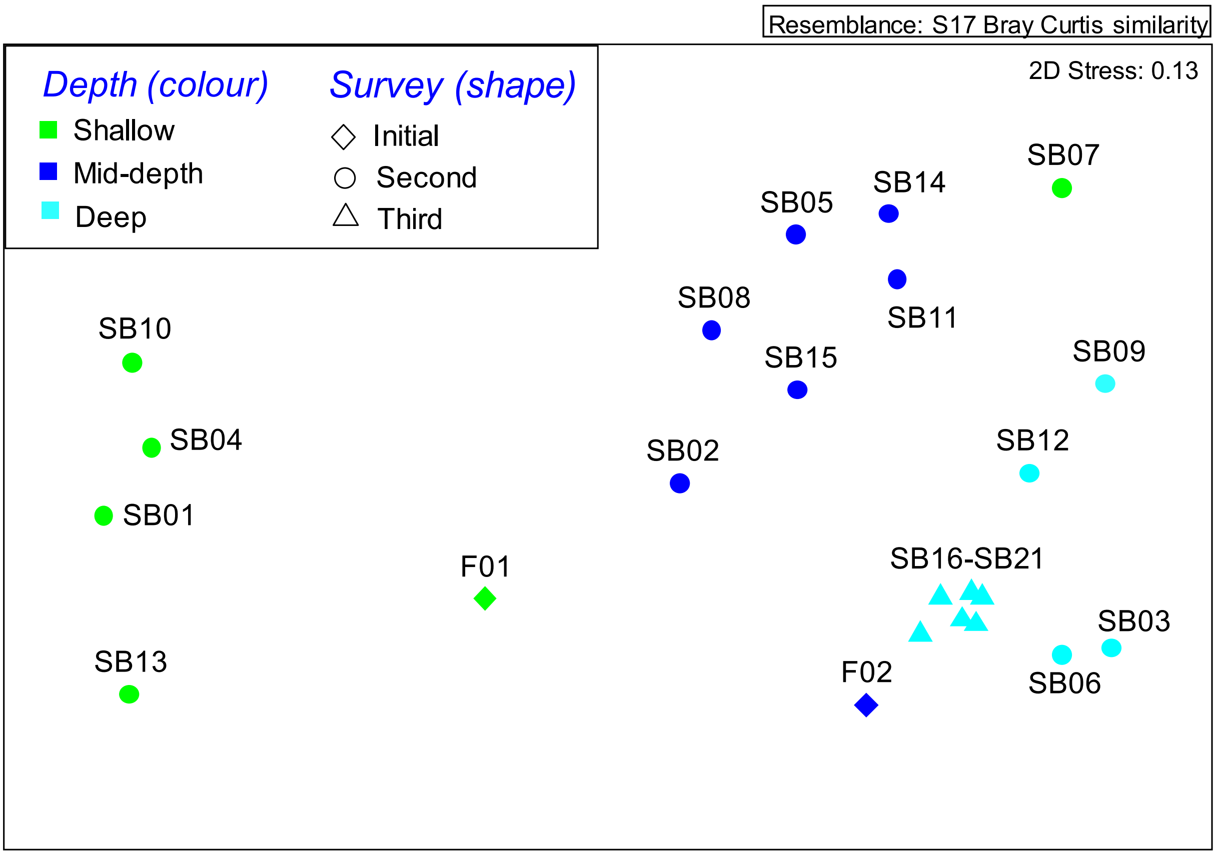


Figure 6. Multi-dimensional scaling scatter plot showing the relative similarity of communities from 23 sites across three surveys.

Table 2. Taxa recorded during the marine surveys. For initial survey, mixed habitat refers to mixed reef, seagrass and sand habitat at depths to 9 metres, and seagrass habitat refers to sparse *Posidonia* habitat over rubble and rhodolith substrate at depths of 9–12 metres. Abundances are expressed as categories: 1 = 1 or 2 individuals or small patches; 2 = 3–10 individuals or patches, 3 = >10 individuals or patches, or a continuous distribution. Regional reef data from the Reef Life Survey program (Reef Life Survey 2016) have been provided for mobile invertebrates only. Note that sampling methods differed between surveys.

Species	Common name (after Edgar 2008 unless denoted by #)	Photo ref(s)	Initial survey: Mixed habitat (0–9 m)	Initial survey: Seagrass (9–12 m)	Reef Life Survey	Second survey (* = incidental off-transect sighting): Mixed habitat (0–9 m) SB01	SB04	SB07	SB10	SB13	Seagrass (9–12 m) SB02	SB05	SB08	SB11	SB14	Sparse seagrass (12–16 m) SB03	SB06	SB09	SB12	SB15	Third survey: Sparse seagrass (12–16 m) SB21	SB22	SB23	SB24	SB25	SB26
Macroalgae																										
Acrocarpia paniculata	Bushy tangleweed		1																							
Avrainvillea ?clavatiramea	Giant lobes#										1		1													
Botryocladia sonderi	Red grapeweed					2	2		1	1	1									1						
Caulerpa brownii	Brown's caulerpa		2																							
Caulerpa cactoides	Cactus caulerpa			1					1										2		3	3		2		
Caulerpa flexilis	Fern caulerpa		1			1				1																
Caulerpa flexilis var. *muelleri*	Mueller's fern caulerpa		1			2				1																
Caulerpa scalpelliformis	Serrated caulerpa																									1
Caulerpa sedoides	Bubble caulerpa		1			2				1				1	1		1									
Caulerpa simpliciuscula	Simple-branched caulerpa																									1
Caulerpa trifaria	Three-cornered caulerpa																									1
Chlorophyta spp.	Green lobed algae#																					1				
Cladosiphon filum	Brown spaghetti weed											3		3	3			3	3							
Codium pomoides	Sea apple		2	2						2	2	1	1													
Codium spongiosum	Green spongeweed																1*									
Colpomenia ?sinuosa	Sinuous bullweed											2		1				3	3							
Cystophora brownii	Brown's cystophora		1				1		1																	
Cystophora expansa	Expansive cystophora		1			2				1																
Cystophora monilifera	Three-branched cystophora	A1	2			3	2			3																
Cystophora moniliformis	Zigzag cystophora	A2	2			2	1		2																	
Cystophora retorta	Open-branched cystophora		1																							
Cystophora siliquosa	Slender cystophora	A1, A2	3			3	3		3	2																

Species	Common name (after Edgar 2008 unless denoted by #)	Photo ref(s)	Initial survey		Reef Life Survey	Second survey (* = incidental off-transect sighting)															Third survey					
			Mixed habitat (0–9 m)	Seagrass (9–12 m)		Mixed habitat (0–9 m)					Seagrass (9–12 m)					Sparse seagrass (12–16 m)					Sparse seagrass (12–16 m)					
						SB01	SB04	SB07	SB10	SB13	SB02	SB05	SB08	SB11	SB14	SB03	SB06	SB09	SB12	SB15	SB21	SB22	SB23	SB24	SB25	SB26
Cystophora subfarcinata	Bushy cystophora					2																				
Dictyosphaeria sericea	Liverwort seaweed	A19	2			2	3		3	1		1														
Gloiosaccion brownii	Poseidon's fingers					2	2		2	1												1				
?Gracilaria sp.	Yellow antlers#					2	1			1																
Haliptilon roseum	Rosy coralline	A3	2					2	3	1	1			2												
Laurencia spp.	Laurencias								1	1														1	1	
Lobophora variegata	Peacockweed	A27	3			2	1		1						1*											
Metagonionlithon sp.	Articulated corallines		2			1	2		1	1	1															
Osmundaria prolifera	Twisted red strapweed		1																							
Peyssonnelia spp.	Lobed red algae		1			2	2		2	1	1		1													
Rhodophyta spp.	Red filamentous algae#																2					1			1	
Rhodophyta spp.	Red lobed algae#																					1				1
Sargassum subgenus *Arthrophycus*	Sargassums	A4	2				3		1	2																
Sargassum subgenus *Phyllotrichia*	Sargassums					1																				
Sargassum subgenus *Sargassum*	Sargassums	A5	2			1	1			2																
Scaberia aghardii	Brown fingerweed	A4	2			1	2			3																
Sporolithon durum	Rhodolith	A13		2																						
Zonaria spiralis	Spiral fanweed					1			1																	
Seagrasses																										
Amphibolis antarctica	Wire weed	A8, A9	2	2				2				3	1	2	2	1	1					1	2	2	1	3
Amphibolis griffithii	Griffith's sea nymph	A8	2					1																		
Halophila australis	Southern paddlegrass					1										1	1									2
Posidonia coriacea	Thin-leafed strapweed		1					1																		
Posidonia sinuosa	Smooth strapweed	A6-A9, A11-A12	2	3		1	1	3			3	3	3	3	3	1	2	3	3	3	3	3	3	3	3	3
Zostera nigricaulis	Black-stemmed eelgrass	A8	1	1				1					1	2	1	1	1				1	1			1	2
Fishes																										
Acanthaluteres brownii	Spiny-tailed leatherjacket									2*																
Achoerodus gouldii	Western blue groper	A20								2*																

Species	Common name (after Edgar 2008 unless denoted by #)	Photo ref(s)	Initial survey		Reef Life Survey	Second survey (* = incidental off-transect sighting)															Third survey					
			Mixed habitat (0–9 m)	Seagrass (9–12 m)		Mixed habitat (0–9 m)					Seagrass (9–12 m)					Sparse seagrass (12–16 m)					Sparse seagrass (12–16 m)					
						SB01	SB04	SB07	SB10	SB13	SB02	SB05	SB08	SB11	SB14	SB03	SB06	SB09	SB12	SB15	SB21	SB22	SB23	SB24	SB25	SB26
Aetapcus maculatus	Warty prowfish	A21							1																	
Austrolabrus maculatus	Black-spotted wrasse									1																
Cheilodactylus nigripes	Magpie perch									1*																
Chelmonops curiosus	Western talma									1*																
Dactylophora nigricans	Dusky morwong									1*																
Dotolabrus aurantiacus	Castelnau's wrasse		1																							
Enoplosus armatus	Old wife									1*																
Girella zebra	Zebra fish									2*																
Helcogramma decurrens	Black-throated threefin									1																
Kyphosus sydneyanus	Silver drummer									2*																
Meuschenia hippocrepis	Horseshoe leatherjacket	A20							1	2*																
Monocathid sp.	Leatherjacket																				1					
Notolabrus parilus	Brown-spotted wrasse		1					1																		
Notolabrus tetricus	Blue-throated wrasse	A20				1			1	2*																
Omegaphora armilla	Ringed toadfish	A15		1										1												1
Othos dentex	Harlequin fish	A19								1*																
Parascyllium ferrugineum	Rusty catshark	A18												1*												
Parascyllium variolatum	Varied catshark	A17				1*																				
Parequula melbournensis	Southern silverbelly							1																		
Pictilabrus laticlavius	Senator wrasse					1	1																			
Pseudocaranx sp.	Trevally		3																							
Scobinichthys granulatus	Rough leatherjacket																									1
Scorpis aequipinnis	Sea sweep									2*																
Siphonognathus beddomei	Pencil weed whiting		1																							
Stipecampus cristatus	Ringed-back pipefish	A14		1																						
Tilodon sexfasciatus	Moonlighter	A20	2							2*																
Trachurus novaezelandiae	Yellowtail scad	A16											3*													
Mobile invertebrates																										
Acrosterigma cygnorum	Western heart cockle																	1			1	1		1	1	
Amblypneustes sp.	Egg urchin			2																						
Anthaster valvulatus	Mottled seastar		1	2														1			1	2			1	1

Species	Common name (after Edgar 2008 unless denoted by #)	Photo ref(s)	Initial survey		Reef Life Survey	Second survey (* = incidental off-transect sighting)															Third survey					
						Mixed habitat (0–9 m)					Seagrass (9–12 m)					Sparse seagrass (12–16 m)					Sparse seagrass (12–16 m)					
			Mixed habitat (0–9 m)	Seagrass (9–12 m)		SB01	SB04	SB07	SB10	SB13	SB02	SB05	SB08	SB11	SB14	SB03	SB06	SB09	SB12	SB15	SB21	SB22	SB23	SB24	SB25	SB26
Astralium squamiferum	Seagrass star		1																							
Austrodomidia octodentata	Bristled sponge crab																			1						
Calliostoma ?armillatum	Pink top shell											1														
Cenolia trichoptera	Orange feather star				3	3	3		3																	
Centrostephanus tenuispinus	Western hollow-spined urchin	A30		1	1									1*												
Coscinasterias muricata	Eleven-armed seastar	A24		2							1*						1				1	1	1			1
Echinaster arcystatus	Pale mosaic seastar		1		1					1																
Echinaster glomeratus	Orange reef star	A23	1	2	1		1		1		1*					1	1	1*	1		1		1	1	2	1
Equichlamys bifrons	Queen scallop	A27	1	2						1						3	2	2	2		3	3	3	3	3	3
Fusinus australis	Southern spindle		1		1						1															1
Gastropoda sp.	Gastropod egg collar																				1			1	1	
Goniocidaris tubaria	Stumpy pencil urchin			1	1																		1			
Haliotis laevigata	Greenlip abalone		1																							
Haliotis spp.	Abalone#		1	2	1									1				2		2		1		2	1	1
Heliocidaris erythrogramma	Purple urchin			1	2																					
Jasus edwardsii	Southern rock lobster				1	1	1																			
Leptomithrax gaimardii	Giant spider crab																				1	1	1			1
Luidia australiae	Southern sand star													1*				1								
Meridiastra gunii	Gunn's six-armed star		1	1	1																		1	1		
Mimachlamys asperrimus	Doughboy scallop	A25	2	3												1			1	1	3	2	3	3	2	2
Nectocarcinus integrifrons	Seagrass swimmer crab				1														1							
Nectria pedicelligera	Multi-spined seastar		1	1	1			1			1										1	1	1	1		
Neodoris chrysoderma	Marigold dorid																				1			1	1	
Pagurid sp.	Grey hermit#		1						1																	
Paguristes frontalis	Southern hermit crab		1	1	2																			1		
Pecten fumatus	King scallop																				1		1			
Pentagonaster dubeni	Vermilion biscuit star	A22	3	3	2						1	3		2			1			2	1	2	1		1	1
Petricia vernicina	Cushion seastar		1	1	2													1	1				1			
Phasianella australis	Painted lady	A26	3	3	1						1		1											1		
Phasianella ventricosa	Swollen pheasant shell		1		1				2					1												

Species	Common name (after Edgar 2008 unless denoted by #)	Photo ref(s)	Initial survey		Reef Life Survey	Second survey (* = incidental off-transect sighting)															Third survey					
						Mixed habitat (0–9 m)					Seagrass (9–12 m)					Sparse seagrass (12–16 m)					Sparse seagrass (12–16 m)					
			Mixed habitat (0–9 m)	Seagrass (9–12 m)		SB01	SB04	SB07	SB10	SB13	SB02	SB05	SB08	SB11	SB14	SB03	SB06	SB09	SB12	SB15	SB21	SB22	SB23	SB24	SB25	SB26
Phasianotrochus eximus	Giant kelp shell				1	1																				
Phyllacanthus irregularis	Western slate-pencil urchin		1		1	4	2		1	1																
Plagusia chabrus	Red bait crab				1				1																	
Plectaster decanus	Mosaic seastar		1	1	1														1			1				
Pleuroploca australasia	Tulip shell	A21	1	2	3			2								1		1	1			2	1	1	1	
Sepia apama	Giant Australian cuttlefish			1	1																					
Stchopodid spp.	Sea cucumbers	A29	2	2	2	1				1	1	1	1				1		2	1	1	2	2	2	2	2
Tellina ?victoriae	Rough tellin#								1																	
Thyone okeni	Burrowing holothurian#												1													
Tucetona flabellata	Fan-like dog-cockle																1									
Uniophora granifera	Granular seastar	A31	1		2					1											1					
Sessile invertebrates																										
Ascidiacea spp.	Unidentified colonial/ compound ascidians	A35-A36	1	1		1	1		1																	
Ascidiacea sp.	Unidentified solitary ascidian																								1	1
Botrylloides anceps	Magnificent ascidian	A34	1																		1					
Botryllus schlosseri	Petal ascidian#																							1		
Bryozoa spp.	Erect byozoans			2										2		3	3		2		3	3	3	3	3	3
Clavelina spp.	A colonial ascidian		1											1*	1*											
Erythropodium hicksoni	Encrusting soft coral		1			1																				
Herdmania grandis	Red-mouthed ascidian	A31	2	2							1		1		1*	1		1*		1	1	1	1	1	1	1
Iodictyuum phoeniceum	Purple bryozoan		1																							
Malleus meridianus	Southern hammer oyster																					1	1			1
Orthoscuticella ventricosa	Orange filamentous bryozoan		1																							
Parmularia smeatoni	Little fan bryozoan												1													
Phallusia obesa	Obese ascidian			1																						
Pinna bicolor	Razor clam	A17		1	1						1					1		1								
Plesiastrea versipora	Green coral		1																							
Polycarpa clavata	Club ascidian	A32	1								2	1												1		
Polycarpa viridis	Mauve-mouthed ascidian	A33	3				2		3	1				3	2					2						
Porifera spp.	Sponges	A37-	3			2	2		2	3	1	2	2	1					1	1	2	1	1	1	1	1

Species	Common name (after Edgar 2008 unless denoted by #)	Photo ref(s)	Initial survey: Mixed habitat (0–9 m)	Initial survey: Seagrass (9–12 m)	Reef Life Survey	Second survey (* = incidental off-transect sighting): Mixed habitat (0–9 m): SB01	SB04	SB07	SB10	SB13	Seagrass (9–12 m): SB02	SB05	SB08	SB11	SB14	Sparse seagrass (12–16 m): SB03	SB06	SB09	SB12	SB15	Third survey: Sparse seagrass (12–16 m): SB21	SB22	SB23	SB24	SB25	SB26
		A42																								
Pyura spp.	Sea tulip		2	2						1				1												
Sycozoa ceribriformis	Brain ascidian			2							2	2			1			1	1	1						
Sycozoa murrayi	Murray's ascidian		2	2																						

4.8 Listed species

Forty-six listed threatened, listed migratory species or listed marine species were identified as potentially occurring near the study area (see Table 3 and Table 4). These included:

- eight threatened (endangered or vulnerable) marine species, mainly whales and turtles
- 32 nationally listed marine species, which included three seal species, three turtles and 26 species of syngnathids (seahorses and pipefish)
- 12 species of whale or dolphin
- 12 migratory marine species.

The nationally threatened species included the southern right whale *(Eubalaena australis)*, humpback whale *(Megaptera novaeangliae)*, blue whale *(Balaeniptera musculus),* Australian sea-lion *(Neophoca cinerea)*, great white shark (*Carcharodon carcharias)*, loggerhead turtle *(Caretta caretta)*, leatherback turtle *(Dermochelys coriacea)* and green turtle *(Chelonia mydas).*

State-listed marine species potentially occurring in the area include the cetaceans pygmy right whale *(Caperea marginate)*, pygmy sperm whale *(Kogia breviceps*), dusky dolphin *(Lagenorhynchus obscurus)* and strap-toothed whale *(Mesoplodon layardii)*, all of which are listed as rare.

Table 3. Threatened marine species listed under Commonwealth and SA legislation (identified using the Protected Matters Search Tool with a 10 km buffer around Smith Bay).

Scientific name	Common name	EPBC Status	SA Status	Likelihood of occurrence at Smith Bay
Mammals				
Balaenoptera musculus	Blue whale	EN, Mi, Ma	E, P	Unlikely
Eubalaena australis	Southern right whale	EN, Mi, Ma	V, P	Possible
Megaptera novaeangliae	Humpback whale	VU, Mi, Ma	V, P	Unlikely
Neophoca cinerea	Australian sea-lion	VU, Ma	V, P	Likely
Reptiles				
Caretta caretta	Loggerhead turtle	EN, Mi, Ma	E	Unlikely
Chelonia mydas	Green turtle	VU, Mi, Ma	V	Unlikely
Dermochelys coriacea	Leatherback turtle	EN, Mi, Ma	V	Unlikely
Sharks				
Carcharodon carcharias	Great white shark	VU, Mi, Ma	P	Likely

Status: under EPBC Act *1999* (E = Endangered, V = Vulnerable, Mi = listed migratory species, Ma = listed marine species, W = whales and other cetaceans); and under the *South Australian National Parks and Wildlife Act 1972* (E = Endangered, V = Vulnerable, R = Rare), or SA *Fisheries Management Act 2007* (P = Protected)

Table 4. Migratory, marine and protected species listed under Commonwealth and SA legislation (identified using the Protected Matters Search Tool with a 10 km buffer around Smith Bay).

Scientific name	Common name	EPBC Status	SA Status	Likelihood of occurrence at Smith Bay
Fish				
Acentronura australe	Southern pygmy pipehorse	Ma	P	Unlikely
Campichthys tryoni	Tryon's pipefish	Ma	P	Possible
Filicampus tigris	Tiger pipefish	Ma	P	Unlikely
Heraldia nocturna	Upside-down pipefish	Ma	P	Unlikely
Hippocampus abdominalis	Eastern potbelly seahorse	Ma	P	Possible

Scientific name	Common name	EPBC Status	SA Status	Likelihood of occurrence at Smith Bay
Hippocampus breviceps	Short-head seahorse	Ma	P	Possible
Histiogamphelus cristatus	Rhino pipefish	Ma	P	Possible
Hypselognathus rostratus	Knifesnout pipefish	Ma	P	Possible
Kaupus costatus	Deepbody pipefish	Ma	P	Possible
Lamna nasus	Porbeagle, mackerel shark	Mi, Ma	P	Unlikely
Leptoichthys fistularius	Brushtail pipefish	Ma	P	Possible
Lissocampus caudalis	Australian smooth pipefish	Ma	P	Possible
Lissocampus runa	Javelin pipefish	Ma	P	Unlikely
Maroubra perserrata	Sawtooth pipefish	Ma	P	Unlikely
Notiocampus ruber	Red pipefish	Ma	P	Unlikely
Phycodurus eques	Leafy seadragon	Ma	P	Possible
Phyllopteryx taeniolatus	Weedy seadragon	Ma	P	Unlikely
Pugnaso curtirostris	Pug-nosed pipefish	Ma	P	Possible
Solegnathus robustus	Robust pipefish	Ma	P	Unlikely
Stigmatopora argus	Spotted pipefish	Ma	P	Possible
Stigmatopora nigra	Wide-bodied pipefish	Ma	P	Possible
Stipecampus cristatus	Ring-backed pipefish	Ma	P	Known—sighted during marine survey
Urocampus carinirostris	Hairy pipefish	Ma	P	Unlikely
Vanacampus margaritifer	Mother-of-pearl pipefish	Ma	P	Unlikely
Vanacmapus phillipii	Port Phillip pipefish	Ma	P	Possible
Vanacampus poecilolaemus	Long-snouted pipefish	Ma	P	Possible
Vanacampus vercoi	Verco’s pipefish	Ma	P	Possible
Mammals				
Arctocephalus forsteri	Long-nosed fur-seal	Ma		Possible
Arctocephalus pusillus	Australian fur-seal	Ma		Unlikely
Whales and other cetaceans				
Balaenoptera acutorostrata	Minke whale	Ma	P	Unlikely
Balaenoptera edeni	Bryde's whale	Mi, Ma	P	Unlikely
Caperea marginata	Pygmy right whale	Mi, Ma	R, P	Unlikely
Delphinus delphis	Common dolphin	Ma	P	Likely
Grampus griseus	Risso’s dolphin	Ma	P	Unlikely
Lagenorhynchus obscurus	Dusky dolphin	Mi, Ma	R, P	Unlikely
Orcinus orca	Killer whale, orca	Mi, Ma		Unlikely
Tursiops aduncus	Indian Ocean bottlenose dolphin	Ma		Likely
Tursiops truncatus s.str.	Common bottlenose dolphin	Ma		Unlikely

Status: see preceding table

5 DISCUSSION

5.1 Seagrass communities

5.1.1 Direct loss

The construction of a causeway and the dredging of the berthing pocket and approaches would result in the direct loss of about 10 ha of mixed habitat including the seagrasses *Posidonia sinuosa, Amphibolis antarctica and A. griffithii*, and associated invertebrate communities consisting mainly of gastropods, echinoderms, ascidians and sponges. Each of these communities and species is common on both a local and regional scale.

The ecological significance of the loss of this habitat, and in particular the seagrass communities, would be minor as there is a large amount of similar habitat within Smith Bay, at Emu Bay and elsewhere along the north coast. A further mitigating factor is that *Posidonia sinuosa* in the deeper water (>10 metres), which comprises approximately 90 per cent of the seagrass that would be lost, is relatively sparse possibly due to the sub-optimal nature of the coarse substrate, or the lack of light reaching the sea floor.

Removal of seagrass during construction would require the loss to be offset as all native vegetation in South Australia (including seagrass) is protected under the provisions of the *Native Vegetation Act 1991*. Clearance of native vegetation is prohibited unless approved by the Native Vegetation Council (NVC). In most circumstances the NVC will approve the clearance of a small amount of native vegetation subject to the production of an acceptable management plan that describes a significant environmental benefit (SEB) to offset the vegetation loss (see Section 6).

5.1.2 Indirect loss

Dredging can affect seagrass and other marine communities not only through direct physical disturbance of biota inhabiting the sea floor, but also through the effects of the dispersed sediment plume generated during dredging. These effects can include smothering of surrounding biota, light attenuation in the water column reducing productivity of plants and algae and the clogging of feeding structures of filter-feeding organisms (Cheshire and Miller 1999).

Similar secondary impacts on marine communities may occur during construction of the causeway, from re-suspension of exposed sediments during storms, from winnowing of sediments during shipping operations and from sediment run-off from the on-shore construction site.

There is also potential for ongoing loss of seagrass through erosion of the seafloor adjacent to the dredged basin.

The significance of these secondary effects will be determined in a series of studies including:

- sediment coring and analysis of sediments that would be dredged to determine sediment grain size and chemical characteristics
- modelling of the sediment plumes resulting from dredging, causeway construction and re-suspension of sediments
- modelling of sedimentation rates
- modelling of sediment plumes generated by shipping movements.

The outcomes of these assessments will inform the measures that would be taken to minimize secondary impacts on marine communities.

Dredging, construction and operational management plans would be produced in consultation with government regulators before construction began. The plans would prescribe environmental management and monitoring procedures to be adopted to minimise impacts on marine communities during the construction and operational phases of the Project.

5.2 Listed species – risk assessment

The potential risk to each listed species is summarised in Attachment B.

The following listed species are considered likely or possible to occur in Smith Bay:

- southern right whale *(Eubalaena australis)*

- great white shark *(Carcharodon carcharias)*
- Australian sea-lion *(Neophoca cinereal)*
- long-nosed fur seal *(Arctocephalus forsteri)*
- common dolphin *(Delphinus delphis)*
- Indian Ocean bottle-nose dolphin *(Tursiops aduncus)*
- ring-backed pipefish *(*Stipecampus cristatus*)* and various other pipefish species.

Descriptions of each of these species are provided below.

5.2.1 Southern right whale

The southern right whale is a baleen whale that feeds on krill in Antarctic waters during summer and migrates to southern Australian waters in winter to calve in winter/spring. Its name derives from early whalers who considered it to be the 'right' whale to hunt as it lives close inshore, floats when dead and produces copious amounts of oil. Consequently, it was hunted to near-extinction during the 19th century. Over the past three decades, however, its population has increased significantly with more and more females being observed at calving locations such as Victor Harbor and at the head of the Great Australian Bight (Edgar 2008). A more detailed description and assessment of the southern right whale is provided in Appendix I2

5.2.2 Great white shark

The great white shark is the world's largest predatory fish, growing to about six metres. It occupies a cosmopolitan range throughout most seas and oceans with concentrations in temperate coastal seas. Principally known as a pelagic dweller of temperate continental shelf waters, it is found from the intertidal zone to far offshore, and from the surface down to depths over 250 metres. One of its most important habitats is along the southern coast of Australia, and in particular off Port Lincoln and Kangaroo Island. Recent tagging and tracking studies have demonstrated that it often swims long distances along the coast. Their diet consists of a variety of bony fish, such as snapper and bluefin tuna, sea-lions, seals and carrion such as dead whales. Its decline has been attributed to sports-fishing, commercial drumline trophy-hunting and commercial bycatches (Fergusson et al. 2009).

5.2.3 Australian sea-lion

Sea-lions have breeding colonies on islands or remote sections of coastline, ranging from the Houtman Abrolhos inWestern Australia (WA), to The Pages islands, east of Kangaroo Island. Overall, 66 breeding colonies have been recorded: 28 in WA and 38 in SA (Shaughnessy 1999). About 30 per cent of the population inhabit WA waters and 70 per cent in SA. The Australian sea-lion population is neither increasing nor expanding its range (DAFF 2007). An analysis of pup production at the Seal Bay colony on Kangaroo Island showed a decline of 12 per cent between 1985 and 2003 (Shaughnessy et al. 2006).

These mammals use a wide variety of habitats for breeding and resting (Gales et al.1994; Campbell 2005). They prefer the sheltered side of islands and avoid exposed rocky headlands that are preferred by the long-nosed fur-seal *(Arctocephalus forsteri).*

Atlas of Living Australia records show the Australian sea-lion is mainly distributed along the southern coastline of KI (28/08/16, http://www.ala.org.au/). Although it is unlikely to breed in Smith Bay due to unsuitable habitat, it may pass through the bay.

5.2.4 Long-nosed fur-seal

The long-nosed fur-seal (previously known as the New Zealand fur-seal) is found mainly around the southern coast of Australia and New Zealand. Most of the Australian population is in South Australian waters, between Kangaroo Island and Eyre Peninsula. There are isolated records of stray individuals along the north coast, including at Stokes Bay and Kingscote. However, the north coast is not a significant habitat for this species compared with other parts of the Island such as Admirals Arch.

Fur-seal populations in southern Australia were heavily exploited during the early 19th century but numbers have slowly recovered in recent years. South Australia has 29 breeding colonies that produced about 20,400 pups in 2013–14, raising the total state population to around 97,200, with almost half of all pups living in Kangaroo Island waters. (Shaughnessy et al. 2015).

5.2.5 Common dolphin

The common dolphin is found widely around the world, including along the Australian mainland and Tasmanian coasts, often living in large schools that can exceed 1000 animals. In South Australia it is relatively abundant in both sheltered bays and the open ocean, and is highly likely to visit Smith Bay at times. Groups occupy home ranges, feeding on small fish and cephalopods. Common dolphins often follow boats but are wary of divers (Edgar 2008).

5.2.6 The Indian Ocean Bottlenose Dolphin

The Indian Ocean bottlenose dolphin occurs widely world-wide, including around the Australian mainland and Tasmania, and is common throughout South Australian waters. It is highly likely to visit Smith Bay at times. This species moves into estuaries more often than other dolphins and usually lives in groups of five to 20 animals. A resident pod inhabits the Port River estuary in Adelaide. Bottlenose dolphins are inquisitive and often approach divers and boats (Edgar 2008).

5.2.7 Ring-backed Pipefish

Divers found a ring-backed pipefish at Smith Bay in *Posidonia* meadow in August 2016. It is known from Victoria, Bass Strait, northern Tasmania and South Australia. Large numbers have been recorded in Melbourne's Port Philip Bay in spring when they were thought to be breeding. In South Australia, the species has been recorded in south-central Spencer Gulf, Gulf St Vincent (including the metropolitan area and near Edithburgh), and lower western Eyre Peninsula. It has been found in a variety of habitats, including among brown and red macroalgae in sheltered reef habitats; macroalgal habitats and areas of sand; clean sandy areas containing sparse seagrass; near tidal channels in large estuaries; estuaries among open seagrass; and on the edge of a *Posidonia* seagrass bed. The species is usually recorded at depths between three and 15 metres (Baker 2006).

5.3 Listed species - potential impacts

5.3.1 Threatened species (southern right whale, great white shark and Australian sea-lion)

These three threatened species are likely to occasionally and briefly visit Smith Bay as they travel along the coast. Although Smith Bay may provide foraging and resting habitat, the proposed wharf area would not comprise important or critical habitat for any of them.

During wharf construction and operation each of these species may avoid the area and relocate to similar marine habitats that are very abundant along the north coast.

Although ships are known to occasionally strike whales, such incidents are rare, and the risk posed to the southern right whale is considered negligible.

It is concluded that the project poses no credible risk to any of the threatened marine species that may traverse the project area.

5.3.2 Pipefish

The seagrass habitat at Smith Bay was found to support ring-backed pipefish *(Stipecampus cristatus)* so may support other species of pipefish.

Syngnathids have attracted much global-scale conservation attention over the past two decades due to a vigorous international trade in seahorses and pipehorses for traditional medicine, and for aquariums and curios. In 2002, the entire genus of *Hippocampus* was listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Nationally, syngnathids have been afforded a high level of legislative protection, compared with almost all other marine fish, as marine species under the EPBC Act 1999. In South Australia syngnathids are protected from capture under the South Australian Fisheries Act 1982.

Although no syngnathids are currently listed as rare in South Australia their conservation status remains uncertain for several reasons:

- They range from the apparently rare and localised, to the widely distributed and very common.
- There is a lack of agreement about some species' identities.
- For some species, particularly the more cryptic pipefishes, the apparent limited distribution and uncommonness of the species is likely to be an artefact of sampling difficulty (Baker 2006).

Population characteristics of the ring-backed pipefish include:

- apparently restricted distribution of populations in South Australia (known mainly from the gulfs)
- low population densities
- strong habitat association
- probably small home range and low mobility
- probable monogamy
- site-attached reproduction with small brood sizes (Reef Watch 2014).

Dredging of the wharf pocket and approaches would result in the loss of some seagrass habitat and the potential loss of some pipefish. Although pipefish have limited mobility, some are likely to be able to move a short distance away from the area of direct impact during construction. Furthermore, there is an abundance of similar habitat in Smith Bay, Emu Bay and other bays along the north coast which would be expected to support a similar density of pipefish.

A study of the mobile epi-fauna inhabiting seagrass meadows on the north coast using beam trawls recorded 119 pipefish comprising 10 species (Kinloch et al. 2007). Although the ring-backed pipefish was not recorded during this study, the overall density of pipefish within the seagrass meadows was found to be approximately one per 20 square metres.

The loss of a very small amount of habitat and potentially some pipefish during construction would have a negligible effect on their overall population or viability in Smith Bay and on the north coast generally.

There is no reasonable or foreseeable possibility that construction of the wharf at Smith Bay would fragment or decrease the size of populations of any species of pipefish, affect their critical habitat or disrupt their breeding cycles.

It is concluded that the project proses no credible risk to the viability of pipefish on the north coast.

5.3.3 Dolphins and seals

The common dolphin, Indian Ocean bottlenose dolphin and long-nosed fur seal are all relatively abundant in South Australian coastal waters and would frequently traverse Smith Bay as they forage along the north coast of Kangaroo Island. Smith Bay, however, would not comprise important or critical habitat for any of these species.

During construction and operation of the wharf each species may avoid the wharf area and relocate to similar marine habitats that are very abundant in the Smith Bay region. The loss of a very small amount of habitat adjacent to the wharf site would not affect them as there is a vast amount of similar habitat along the north coast.

It is concluded that the project proses no credible risk to the dolphins or seals that traverse Smith Bay.

6 CONCLUSIONS

The following conclusions have been derived from the assessment.

6.1 Seagrass loss

- The construction of a causeway and the dredging of the berthing pocket and approaches would result in the direct loss of about 10 ha of mixed habitat including the seagrasses *Posidonia sinuosa, Amphibolis antarctica and A. griffithii*, and associated invertebrate communities
- The ecological significance of the loss of this habitat, and in particular the seagrass communities, would be minor as there is a vast amount of similar habitat within Smith Bay, at Emu Bay and elsewhere along the north coast.
- Removal of seagrass during construction would require the loss to be offset by the provision of a strategy that provides a significant environmental benefit (SEB).

6.2 Effects on listed species

- Forty eight listed threatened species, listed migratory species and listed marine species potentially occur in the study area.
- Of these, 22 have been recorded around Kangaroo Island only on rare occasions, none is considered to have limited alternative habitat in the study area; and 22 are highly mobile so would be able to move from the area of impact to adjacent unaffected habitat.
- It is considered that none of these species is at credible risk from the proposed development.
- The one possible exception is the marine listed ring-backed pipefish *(Stipecampus cristatus)*, which was found at the development site in *Posidonia* at a depth of about 11 metres during the marine survey. There is therefore a credible risk of individuals being impacted during dredging.

- There is, however, an abundance of similar *Posidonia* habitat in Smith Bay, Emu Bay and other bays along the north coast that would be expected to support a similar density of pipefish. Pipefish are not listed as rare.
- The loss of a very small amount of pipefish habitat and potentially some pipefish during construction would have a negligible effect on their overall population in the Smith Bay area.

7 REFERENCES

Aztec Analysis 2016, Proposed Export Facility at Smith Bay: Preliminary Design Report, Kangaroo Island Plantation Timbers, Adelaide.

Baker, JL 2004, *Towards a System of Ecologically Representative Marine Protected Areas in South Australian Marine Bioregions - Technical Report*, report to Coast and Marine Conservation Branch, Department for Environment and Heritage, Adelaide.

Baker, JL 2006, ‘Syngnathid fish (seahorses, sea dragons, pipehorses and pipefishes)’, in The South-West Marine Region: Ecosystems and Key Species Groups, McClatchie, S, Middleton, J, Pattiaratchi, C, Currie, D & Kendrick, G, (eds), Department of the Environment and Water Resources, Canberra, pp. 469–518.

Baker, JL 2008, *Marine Species of Conservation Concern in South Australia: Volume 1 – Bony and Cartilaginous Fishes*, report for the South Australian Working Group for Marine Species of Conservation Concern, Adelaide (J Baker, consultant), web version published by Reef Watch, Conservation Council of South Australia, Adelaide, viewed 26 March 2008, <http://www.reefwatch.asn.au/pages/bin/view/Publications/SamsccBonyFamilies>.

Barrett, NS & Buxton, C 2002, *Examining underwater visual census techniques for the assessment of population structure and biodiversity in temperate coastal marine protected areas*, Tasmanian Aquaculture and Fisheries Technical Report Series 11.

Brock, DJ & Kinloch, MA 2007, Reef Fish Biodiversity on Kangaroo Island, Kangaroo Island Natural Resources Management Board Coast and Marine Program Report No. CMP07/006.

Bryars, S 2003, *An Inventory of Important Coastal Fisheries Habitats in South Australia, Fisheries Habitat Program*, Department of Primary Industries and Resources of South Australia, Adelaide.

Campbell, R 2005, *Historical distribution and abundance of the Australian sea lion (Neophoca cinerea) on the west coast of Western Australia*. Fisheries Research Report no. 148, Department of Fisheries, Western Australia.

Cheshire, AC & Miller, DJ 1999, *The impact of sand dredging on Benthic Community Structure at Pt Stanvac Dredge Site: Final report on the results of surveys 1992 to 1999*. Report to the Coast Protection Board, South Australian Department of Environment and Natural Resources.

Cheshire, AC, Collings, GJ, Edyvane, KS & Westphalen, G 2000, *Overview of the Conservation Status of Australian Marine Macroalgae: A report to Environment Australia*, Department of Environmental Biology, University of Adelaide.

Clapham, PJ, Young, SB & Brownell, RL Jr 1999, ‘Baleen whales: conservation issues and the status of the most endangered populations’, *Mammal Review*, vol. 29, no. 1, pp. 35–60.

Clarke, KR & Gorley, RN 2006, *PRIMER v6: User Manual/ Tutorial*. PRIMER-E Ltd, Plymouth.

Clarke, KR & Warwick, RM 2001, *Change in Marine Communities: An approach to Statistical Analysis and Interpretation*. Plymouth Marine Laboratory, Plymouth.

DAFF 2007, *National Assessment of Interactions between Humans and Seals: Fisheries, Aquaculture and Tourism*, Department of Agriculture, Fisheries & Forestry, Canberra, viewed 21 September 2017, < http://www.agriculture.gov.au/SiteCollectionDocuments/fisheries/environment/bycatch/sealassessment.pdf >.

DEWNR 2016a, *EGIS data: Marine Benthic Habitats*, Department of Environment, Water and Natural Resources, Adelaide, South Australia, viewed June 2016, http://location.sa.gov.au/lms/Reports/ReportMetadata.aspx?p_no=1224&pu=y&pa=dewnr.

DEWNR 2016b, *EGIS data: Topography - Bathymetry - Navigation Chart*, Department of Environment, Water and Natural Resources, Adelaide, South Australia, viewed June 2016, http://location.sa.gov.au/lms/Reports/ReportMetadata.aspx?p_no=1121&pu=y&pa=dewnr.

Edgar, GJ 2001, *Australian Marine Habitats in Temperate Waters*. Reed New Holland, Australia.

Edgar, GJ 2008, *Australian Marine Life – The Plants and Animals of Temperate Waters*, 2nd Edition, New Holland, Sydney.

Edyvane, K 1999, *Conserving Marine Biodiversity in South Australia Part 2, Identification of Areas of High Conservation Value in South Australia*, SARDI Report Number 39, PIRSA, F2007/000565-9. SARDI Research Report Series No. 816.

Fergusson, I, Compagno, LJV & Marks, M 2009, *Carcharodon carcharias,* The IUCN Red List of Threatened Species 2009, viewed6 September 2017, <http://www.iucnredlist.org/details/3855/0>.

Gales, NJ, Shaughnessy, PD & Dennis, TE 1994, 'Distribution, abundance and breeding cycle of the Australian sea lion *Neophoca cinerea* (Mammalia: Pinnipedia)', *Journal of Zoology*, vol. 234, pp. 353–370.

Gaylard, S 2005, *Ambient Water Quality of Nepean Bay, Kangaroo Island,* Report No 1: 1999–2004, Environment Protection Authority, Government of South Australia.

Gill, PC, Ross, GJB, Dawbin, WH & Wapstra, H 2000, 'Confirmed sightings of dusky dolphins (*Lagenorhynchus obscurus*) in southern Australian waters', *Marine Mammal Science,* vol. 16, pp. 452–459.

Irving, A 2014, 'Seagrasses of Spencer Gulf', in Shepherd, SA, Madigan, SM, Gillanders, BM, Murray-Jones, S & Wiltshire, DJ (eds), *Natural History of Spencer Gulf*, Royal Society of South Australia, Adelaide.

Jones, GK, Connolly, RM & Bloomfield AL 2008, 'Ecology of fish in seagrass', in Shepherd, SA, Bryars, S Kirkegaard, IR, Harbison, P & Jennings, JT (eds), *Natural History of Gulf St Vincent,* Royal Society of SA (inc.), Adelaide pp. 148–161.

KIPT 2016, Kangaroo Island Plantation Timber Ltd. Smith Bay Wharf Development, Referral of Proposed Action, EPBC Act 1999, Commonwealth of Australia.

Kinloch, MA, Brock, DJ, Kirkman, H & Laperousaz, T 2007, *Seagrass Biodiversity on Kangaroo Island*, KI NRM Board Coast and Marine Program Report No. CMP07/004.

LBW Environmental Projects 2016, Kangaroo Island Plantation Timbers Smith Bay Approvals, Draft report for KIPT Pty Ltd.

McArdle, A, Lashmar, K & Klein, H 2015, *Diving deeper: a community assessment of Kangaroo Island's rocky reefs*, Final report, Caring for our Country Community Action Grants No. CEG-1217992-261.

McDonald, B & Tanner J 2002, 'Investigating the Complexity of Seagrass Faunal Relationships in Spencer Gulf at Two Spatial Scales', in Seddon, S, Murray-Jones, S (eds) *Proceedings of the Seagrass Rehabilitation and Restoration Workshop for Gulf St Vincent* 15–16 May, 2001. Department for Environment and Heritage and SARDI Aquatic Science, Adelaide.

Reef Life Survey 2016, Reef Life Survey Data Portal, viewed 24 July 2016, <http://reeflifesurvey.imas.utas.edu.au/static/landing.html>.

Reef Watch 2014, *Seadragons and their friends: a guide to Syngnathidae fishes in South Australia,* Prepared by Janine Baker for the Reef Watch Program, Conservation Council of South Australia, Adelaide.

Reeves, RR, Smith, BD, Crespo, EA & Di Sciara GN 2003, *Dolphins, Whales and Porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans*', International Union for the Conservation of Nature – Species Survival Commission (IUCN/SSC) Cetacean Specialist Group, IUCN, Gland, Switzerland & Cambridge, UK.

Shaughnessy, PD 1999, *The Action Plan for Australian Seals,* Department of the Environment and Energy, Canberra, viewed 21 September 2017, <http://www.deh.gov.au/coasts/publications/seals-action-plan.html>.

Shaughnessy, PD, McIntosh, RR, Goldsworthy, SD, Dennis, TM & Berris, M 2006, 'Trends in abundance of Australian sea lions, *Neophoca cinerea*, at Seal Bay, Kangaroo Island, South Australia', In *Sea Lions of the World,* pp. 37-63, Alaska Sea Grant College Program. University of Alaska, Fairbanks.

Shepherd, SA & Brook, JB 2007, 'Distribution and ontogenetic shifts in habitat and abundance of the temperate western blue groper, *Achoerodus gouldii*', *Journal of Fish Biology,* vol. 71, pp. 1–22.

Shepherd, SA, Baker, JL, Brown, A, Smith, K & Crawford, H 2009, *Summary of Reef Fish Surveys on Northern Kangaroo Island, 2002-08.* Unpublished report.

Shepherd, SA, Brook, JB & Brown, A 2002, *A preliminary survey of the western blue groper on Kangaroo Island.* Report for Reef Watch, Adelaide.

Southgate, R 2005, *The health and cover of seagrass in the bays of eastern Kangaroo Island.* Kangaroo Island Natural Resources Management Board, Kingscote.

Tanner, JE, & Bryars, S 2007, *Innovative Solutions for Aquaculture Planning and Management – Project 5, Environmental Audit of Marine Aquaculture Developments in South Australia.* FRDC Project 2003/223. Fisheries Research and Development Corporation and South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Aquatic Sciences Publication No F2007/000766-1 SARDI Research Report No. 190.

Attachment A: Photographs of typical biota and habitats observed during the survey

Figure A1. Reef habitat covered by *Cystophora* spp.including *Cystophora monilifera, Cystophora siliquosa* (2–3 m depth).

Figure A2. Reef habitat covered by *Cystophora* spp.including *Cystophora moniliformis* (centre) (3–4 m depth) .

Figure A3. Reef habitat covered by *Cystophora* spp. and coralline turfing algae including *Haliptilon roseum* (3–4 m depth).

Figure A4. Reef habitat covered by *Sargassum* sp. subgenus *Arthrophycus* and *Scaberia aghardii* (4–5 m depth)

Figure A5. *Sargassum* sp. subgenus *Sargassum* (6–8 m depth)

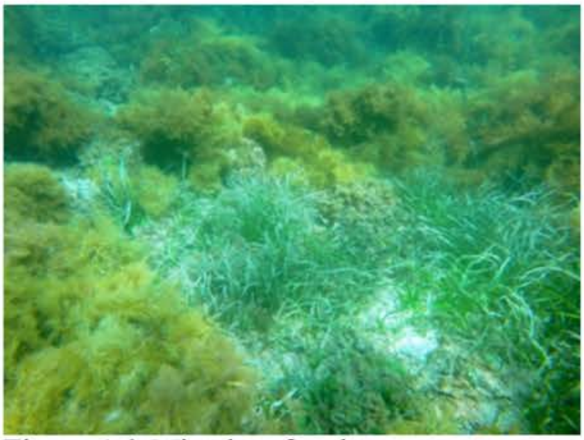


Figure A6. Mixed reef and seagrass (*Posidonia sinuosa*). (6–7 m depth)

Figure A7. *Posidonia sinuosa* adjacent to sand (3 m depth).

Figure A8. *Posidonia sinuosa*, *Amphibolis spp.* and *Zostera nigricaulis* adjacent to rocky substrate (4–5 m depth).

Figure A9. Dense meadows of mixed *Posidonia sinuosa* and *Amphibolis* spp. (4–5 m depth).

Figure A10. Mixed seagrass with epiphytes (5–6 m depth).

Figure A11. Dense meadows of *Posidonia sinuosa* (6–7 m depth).

Figure A12. Sparse *Posidonia sinuosa* on rubble/sand substrate (13 m depth).

Figure A13. Rhodoliths *Sporolithon durum*

Figure A14. Ring-backed pipefish *Stipecampus cristatus*

Figure A15. Ringed toadfish *Omegaphora armilla*

Figure A16. Yellowtail scad *Trachurus novaezelandiae*

Figure A17. Varied catshark *Parascyllium variolatum*

Figure A18. Rusty catshark *Parascyllium ferrugineum*

Figure 19. Harlequin fish *Othos dentex* (near abalone farm intake structure)

Figure 20. Fish community near abalone farm intake structure.

Figure A21. Warty prowfish *Aetapcus maculatus*

Figure A22. Vermilion biscuit star *Pentagonaster dubeni*

Figure A23. Orange reef star *Echinaster glomeratus*

Figure A24. Eleven-armed seastar *Coscinasterias muricata*

Figure A25. Doughboy scallop *Mimachlamys asperrimus*

Figure A26. Painted lady *Phasianella australis* near the liverwort seaweed *Dictyosphaeria sericea*

Figure A27. Queen scallop *Equichlamys bifrons*

Figure A28. Razor clam *Pinna bicolor*

Figure A29. Southern sea cucumber *Australostichopus mollis*

Figure A30. Western hollow-spined urchin *Centrostephanus tenuispinus*

Figure A31. Granular sea star *Uniophora granifera* and red-mouthed ascidian *Herdmania grandis*

Figure A32. Club ascidian *Polycarpa clavata*

Figure A33. Mauve-mouth ascidian *Polycarpa viridis* near the peacockweed *Lobophora variegata*

Figure A34. Magnificent ascidian *Botrylloides magnacoecum*

Figure A35. Unidentified compound ascidian

Figure A36. Unidentified colonial ascidian


Figure A37. Sponge


Figure A38. Sponge


Figure A39. Sponge


Figure A40. Sponge


Figure A41. Sponge


Figure A42. Sponge

Attachment B: Listed marine species: risk assessment

Priority marine flora and fauna species include those species recognised by state or national (EPBC Act 1999) legislation. The table below lists the marine species identified from the database and literature searches. Birds are assessed elsewhere.

Status

Letters under column AUS = the category of threat listed under the *Environment Protection and Biodiversity Conservation Act 1999* (E = Endangered, V = Vulnerable, Mi = listed migratory species, Ma = listed marine species, W = whales and other cetaceans) and under column SA = the category of threat listed under the *South Australian National Parks and Wildlife Act 1972*) (E = Endangered, V = Vulnerable, R = Rare) or *Fisheries Management Act 2007* (P = Protected)

Mobility/alternative habitat

Letters under column Mobility/Alt. hab.: a = mobile species, b = sedentary or not particularly mobile species, c = species with extensive alternative habitat in the area, d = species with limited alternative habitat on the north coast of Kangaroo Island.

Distribution

Numbers under column Distribution: 1 = regularly recorded in or near the study area, 2 = occasional records in or near the study area, 3 = rarely recorded in or near the study area.

Credible risk

The potential risk to species was considered in terms of the following criteria:

- their occurrence around Kangaroo Island
- their mobility
- the availability of alternative suitable habitat around Kangaroo Island
- the potential for construction activities to adversely affect key habitat of these species
- the likely sensitivity of these species to construction impacts.

Table references (see Section 7)

Scientific name	Common name	Status		Notes	Mobility/Alt. Hab.	Distribution	Credible risk?
		AUS	SA				
Sharks and rays							
Carcharodon carcharias	Great white shark	V, Mi	P	Recorded in the region. Visits the area for feeding (e.g. snapper).	a, c	1	No
Lamna nasus	Mackerel shark	Mi	P	Species or species habitat known to occur in area.	a, c	3	No
Fish							
Acentronura australe /Idiotropiscis australis	Southern pygmy pipehorse	Ma	P	The few records to date in SA have mainly come from red algae in southern Gulf St Vincent and Investigator Strait. (see Baker 2008 for summary of distribution and habitat, based on specimens recorded to date).	b, c	3	No
Campichthys tryoni	Tryon's pipefish	Ma	P	Recorded in seagrass beds in region (Baker 2006)	b, c	2	No
Filicampus tigris	Tiger pipefish	Ma	P	Three specimens had been lodged at the South Australian Museum prior to 1982.	b, c	3	No
Heraldia nocturna	Upside-down pipefish	Ma	P	All SA records to date are from southern part of the gulfs and Kangaroo Island. Similar habit and habitat to *M. perserrata* (see Baker 2008 for summary of SA records).	b, c	3	No

Scientific name	Common name	Status		Notes	Mobility/Alt. Hab.	Distribution	Credible risk?
		AUS	SA				
Hippocampus abdominalis	Eastern potbelly seahorse	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Hippocampus breviceps	Short-head seahorse, short-snouted seahorse	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Histiogamphelus cristatus	Rhino pipefish, Macleay's crested pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Hypselognathus rostratus	Knife-snouted pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Kaupus costatus	Deep-bodied pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Leptoichthys fistularius	Brushtail pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Lissocampus caudalis	Australian smooth pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Lissocampus runa	Javelin pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	3	No
Maroubra perserrata	Sawtooth pipefish	Ma	P	All SA records to date are from southernmost part of gulfs and Kangaroo Island. It utilises rocks, ledges, fissures/crevices and caves, resting on sponges, or sheltering behind sea urchins (see Baker 2008 for summary of SA records).	b, c	3	No
Notiocampus ruber	Red pipefish	Ma	P	The few records from SA have been from lower Gulf St Vincent, Kangaroo Island and south-east SA (Baker 2008). Associated with filamenous red macroalgae, sponges, and possibly seagrasses (latter as indicated by records in eastern part of the southern Australian range).	b, c	3	No
Phycodurus eques	Leafy seadragon	Ma	P	See Baker 2008 for summary of Leafy Seadragons in SA.	b, c	2	No
Phyllopteryx taeniolatus	Weedy seadragon	Ma	P	Possible (Baker 2006).	b, c	3	No
Pugnaso curtirostris	Pug-nosed pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Solegnathus robustus	Robust pipehorse	Ma	P	Almost all records from trawl, in a limited area of eastern Great Australian Bight – (see Baker 2008).	b, c	3	No
Stigmatopora argus	Spotted pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Stigmatopora nigra	Wide-bodied pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Stipecampus cristatus	Ring-backed pipefish	Ma	P	Individual found at Smith Bay in *Posidonia* meadow during August 2016 (see summary of SA distribution in Baker 2008).	b, c	2?	No

Scientific name	Common name	Status		Notes	Mobility/Alt. Hab.	Distribution	Credible risk?
		AUS	SA				
Urocampus carinirostris	Hairy pipefish	Ma	P	There are only two known records in SA to date, both from the eastern Great Australian Bight (1965 and 2004, SA Museum data). This is a very small and inconspicuous species (see Baker 2008 for summary of this species in SA).	b, c	3	No
Vanacampus margaritifer	Mother-of-pearl pipefish	Ma	P	There are few museum records (SA Museum and Museum of Victoria) (see summary of SA distribution in Baker 2008).	b, c	3	No
Vanacampus phillipi	Port Phillip pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Vanacampus poecilolaemus	Long-snouted pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Vanacampus vercoi	Verco's pipefish	Ma	P	Species or species habitat known to occur in area.	b, c	2	No
Mammals							
Arctocephalus forsteri	Long-nosed fur seal	Ma	P	Isolated records of stray individuals. Not a significant habitat for this species, compared with other parts of SA.	a, c	2	No
Arctocephalus pusillus	Australian fur seal, Australo-African fur seal	Ma	R, P	Most Australian fur seals found in SA occur off Kangaroo Island and the south-east, with occasional records from other locations (e.g. Encounter Bay and southern Eyre Peninsula).	a, c	3	No
Balaenoptera acutorostrata	Minke whale	W	P	Records from near Port Lincoln, south of Eyre Peninsula and in south-east SA.	a, c	3	No
Balaenoptera edeni	Bryde's whale	W, Mi	P	Isolated records. Normally found in offshore waters.	a, c	3	No
Balaenoptera musculus	Blue whale	E, W, Mi	E, P	Very infrequently recorded around Kangaroo Island.	a, c	3	No
Caperea marginata	Pygmy right whale	W, Mi	R, P	Rarely recorded around Kangaroo Island. Occasional strandings occur.	a, c	3	No
Delphinus delphis	Common dolphin	W	P	Throughout SA waters. Groups occupy home ranges, feeding on small fish and cephalopods.	a, c	1	No
Eubalaena australis	Southern right whale	E, W, Mi	V, P	Sub-Antarctic waters during spring and summer, migrate north in winter for calving, mating and nursing their young to Victor Harbor, the Great Australian Bight and the gulfs (Reeves et al. 2003).	a, c	2	No

Scientific name	Common name	Status		Notes	Mobility/Alt. Hab.	Distribution	Credible risk?
		AUS	SA				
Grampus griseus	Risso's dolphin	W	P	Rarely recorded around Kangaroo Island. One record at Kingscote.	a, c	3	No
Kogia breviceps	Pygmy sperm whale	W	R, P	Isolated records in the area. Normally inhabit offshore waters.	a, c	2	No
Lagenorhynchus obscurus	Dusky dolphin	W, Mi	R, P	Most of the Australian sightings to date come from around Tasmania (e.g. Gill et al. 2000). There are confirmed sightings from Backstairs Passage area near Kangaroo Island.	a, c	3	No
Megaptera novaeangliae	Humpback whale	V, W, Mi	V, P	Spend summer feeding in temperate and polar waters, and winter calving and mating in warmer tropical waters. However this species is an infrequent visitor to SA coastal waters (Clapham et al. 1999).	a, c	3	No
Mesoplodon layardii	Strap-toothed whale	W	R, P	Isolated records (e.g. SA Museum data, 1983) of stray individuals in the gulfs. Strap-toothed whales are normally found in offshore waters.	a, c	3	No
Neophoca cinerea	Australian sea-lion	V	V, P	Seasonally visit the gulfs to feed on cephalopods and fish, and are regularly observed (particularly during winter and spring). Breed on at least 50 islands off the coast of WA and SA.	a, c	2	No
Orcinus orca	Killer whale, orca	Mi	P	Very rarely recorded around Kangaroo Island as stray individuals.	a, c	3	
Tursiops aduncus	Indian Ocean bottlenose dolphin	W	P	Throughout SA waters.	a, c	1	No
Tursiops truncatus	Common bottlenose dolphin	W	P	Likely to occur in the region occasionally (it is more of an oceanic species than *T. aduncus*).	a, c	3	No
Reptiles							
Caretta caretta	Loggerhead turtle	E, Mi, Ma	E	May potentially visit the region, as stray individuals.	a, c	3	No
Chelonia mydas	Green turtle	V, Mi, Ma	V	Recorded uncommonly, as stray individuals.	a, c	3	No
Dermochelys coriacea	Leatherback turtle	E, Mi, Ma	V	Sighte in southern gulfs. Recently nominated for transfer to Critically Endangered category under the *EPBC Act 1999.*	a, c	3	No

Appendix I2 – Potential Effects of Vessels on the Southern Right Whale – SEA

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

Under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act), the proposed deep water port facility at Smith Bay has been designated a Controlled Action as it is considered that 'the proposed action is likely to have a significant impact on the endangered and migratory southern right whale (*Eubalaena australis*).

1.1 Life history characteristics

Southern right whales are thought to live for at least 50 years (NOAA Fisheries 2012), mature at six to nine years, and have a single calf every three years after a gestation period of about 12 months. These characteristics mean that adult mortality can have a significant effect on the overall population.

1.2 Population structure

Based on the sightings of mothers and calves in nearshore areas throughout winter when they congregate in nurseries close to shore, the main four populations of southern right whales are located off South Africa, Argentina, Australia and sub-Antarctic New Zealand (DSEWPaC 2012).

Genetic studies suggest there are two distinct Australian sub-populations: south-western (incorporating Western Australia and South Australia) and south-eastern (Victoria, Tasmania and New South Wales), with some level of ongoing or recent historical interbreeding (Carroll et al. 2011).

There is some ambiguity in the description of the Australian subpopulations in the available documentation. DSEWPaC (2012) refers to a south-western population extending from Cape Leeuwin in Western Australia to Ceduna in South Australia and a south-eastern population as inhabiting waters between Ceduna and Sydney. However, the work by Carroll et al. (2011) to delineate the sub-populations, and cited by DSEWPaC (2012), includes samples from Encounter Bay, near Victor Harbor, in its south-western group.

1.3 Conservation status

Southern right whales are listed as 'endangered' under the EPBC Act and 'vulnerable' under the NPW Act. Whaling during the nineteenth century reduced numbers from an estimated 60,000 individuals to around 300 in 1920 (Bannister 2001; Bannister 2007). Since a moratorium on commercial whaling took effect in 1986, the species has been recovering; numbers worldwide were estimated at 15,000 in 2010 (NOAA Fisheries 2015), with a global annual population growth rate of about seven per cent approaching the biological maximum (Bannister 2007).

Within Australian waters the south-western sub-population of southern right whales has been monitored closely and is estimated at over 3000, and growing at close to seven per cent annually (Carroll et al. 2014). The whales in South Australian waters are closely linked to the south-western population (Carroll et al. 2011) so their population is expected to be growing at a similar rate.

However, the species' south-eastern population, estimated at 500, is growing at a much slower rate for reasons that are not currently understood.

1.4 Migration paths and habitat use

The southern right whale is a circumpolar species living in the sub-Antarctic and open ocean during the summer months and non-calving years. Studies indicate that their Australian distribution follows a circular, anti-clockwise seasonal migration pattern of a single undivided population (Bannister 2001; Burnell 2001). During the winter season whales travel west along the southern coastline, then south toward summer feeding grounds in the sub-Antarctic waters of the Southern Ocean, then east in the sub-polar latitudes and then finally north again to their wintering grounds. There is no difference in distributional movements between males and non-breeding females (Burnell 2001).

Reproductively mature females generally migrate only during their individual breeding years (every third year) to particular coastal aggregation areas where they stay for two to three months between May and November (DSEWPaC 2012). Behavioural and genetic studies indicate that mothers with calves show a high fidelity to the same aggregation areas (Burnell 2001; Carroll et al. 2011).

Non-calving whales travel the farthest, although calving whales have also been recorded at locations up to 700 km apart within a single season. Migratory paths between the Australian coast and offshore areas are not well known, and the winter distribution of whales not appearing on the Australian coast is unknown (DSEWPaC 2012).

Although mature females are almost never seen in Australian coastal waters in non-calving years –suggesting conception takes place elsewhere – surface-active groups apparently involved in mating have been observed in these waters (DSEWPaC 2012).

Within South Australia, two aggregation areas are recognised as ‘established’ (reliably occupied each year) at Head of Bight and Fowlers Bay, and an additional area is described as ‘emerging’ (not occupied every winter) in Encounter Bay. Head of Bight is classified as a large aggregation area with tens of calving females, usually up to 50 (DSEWPaC 2012) (see Figure 1). It is Australia’s largest aggregation ground for southern right whales and lies within the Great Australian Bight Commonwealth Marine Reserve, where up to 40 per cent of the Australian population of the species are known to visit (Burnell 2001). Fowlers Bay is classified as a small aggregation area of up to 10 calving females.

In addition, an area of historic (pre-whaling) high use with evidence of current use has been identified around the Encounter Bay aggregation, extending from lower Gulf St Vincent across Dudley Peninsula on eastern Kangaroo Island and to the upper Coorong area (DSEWPaC 2012, Figure 1).

Sleaford Bay has also been identified as a site where small, but increasing, numbers of mostly non-calving southern right whales regularly aggregate briefly (DSEWPaC 2012).

The Smith Bay site on Kangaroo Island lies within an area described as the ‘current core coastal range’ for the species (DSEWPaC 2012) (see Figure 1) but is not near any of the known aggregation areas and is just outside the ‘historic high use’ area. Two datasets suggest the Smith Bay site is no more important to migrating whales than any other site along the north coast:

- The Atlas of Living Australia includes more than 3000 South Australian southern right whale sighting records, mainly sourced from the SA Museum (ALA 2017). These include more than 400 sightings off Kangaroo Island, divided approximately evenly between the north and south coast. About 170 of these sightings were within the area of historic high use (on Dudley Peninsula), including about 60 near Cape Willoughby. There are records of 50 sightings spread reasonably evenly along the north coast west of Dudley Peninsula. There are no records in Smith Bay, with the nearest sightings being at Dashwood Bay to the west and Emu Bay to the east.

- The South Australian Whale Centre at Victor Harbor has maintained a log of sightings since 1997 (SA Whale Centre 2017). It has logged about 3000 sightings across the state, but there is an obvious reporting bias, with more than 80 per cent of these sightings from Encounter Bay, where the Whale Centre is based. Nevertheless, there have been 110 sightings reported from Kangaroo Island, of which about 70 were from the area of historic high use. The 16 sightings from the north coast, west of Dudley Peninsula, are spread along the coast, and include one sighting at Smith Bay.

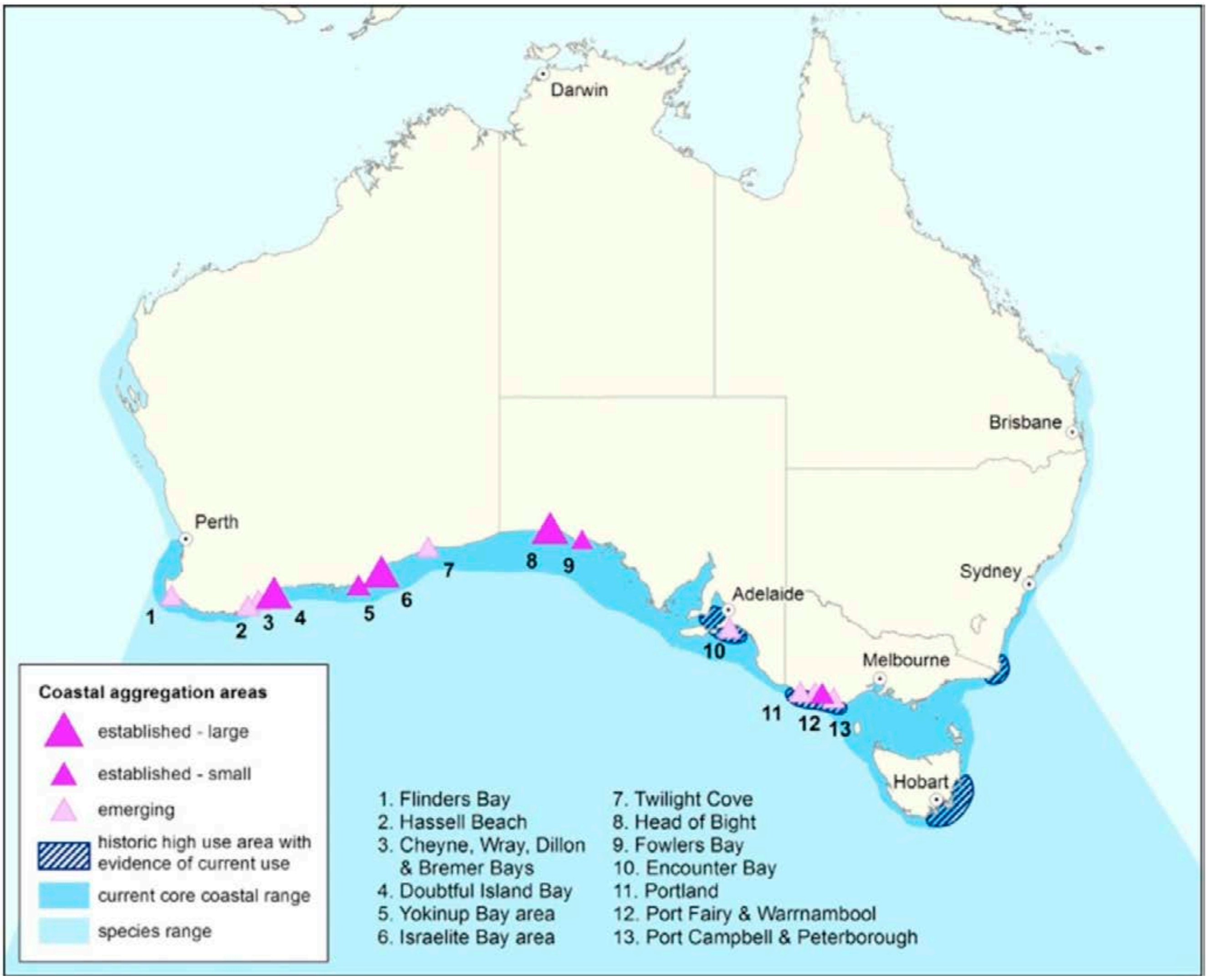


Figure 1. Biologically important areas for southern right whales (Source: DSEWPaC 2012).

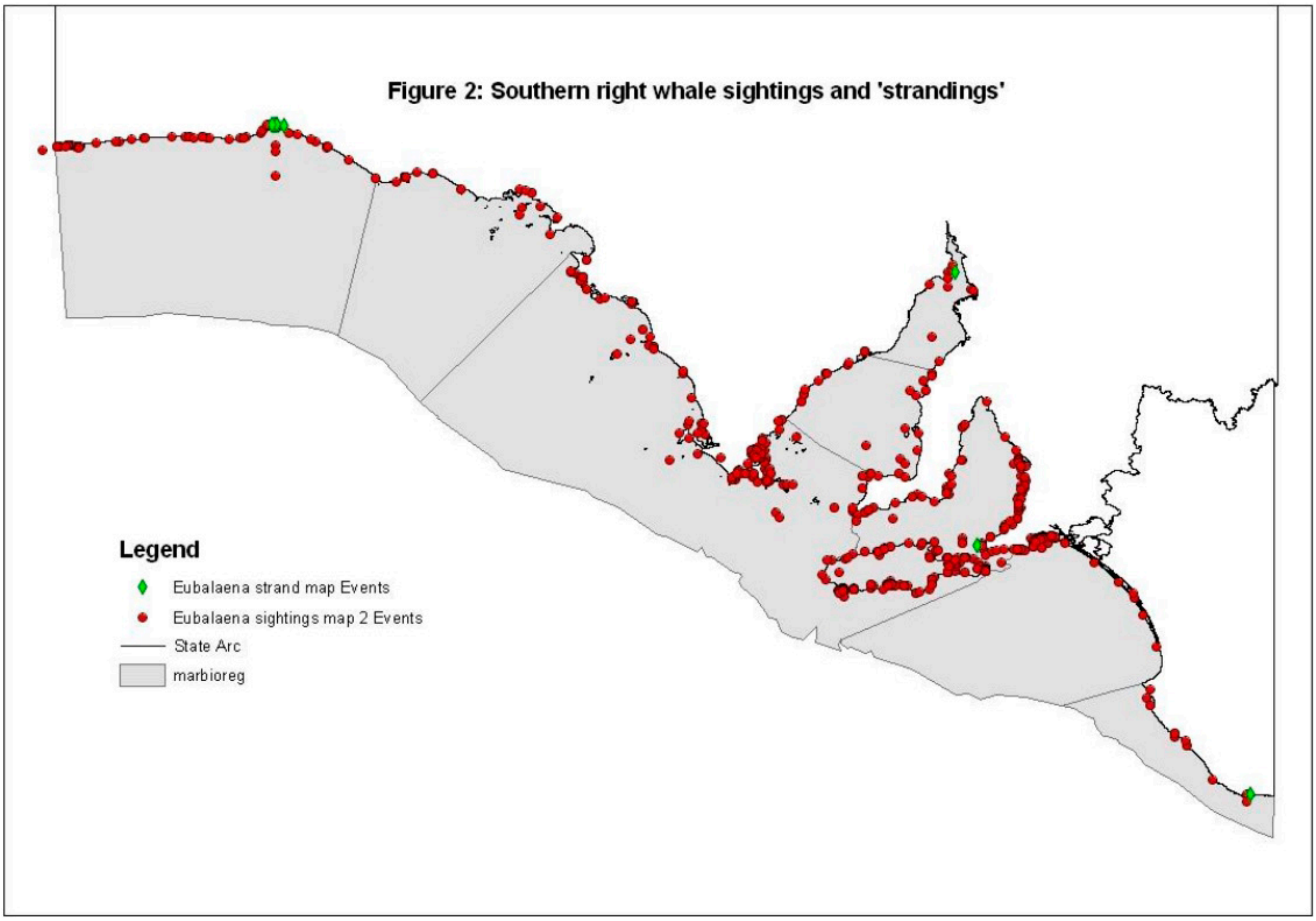


Figure 2. Southern right whale sightings and strandings (Source: Kemper 2008).

1.5 Future habitat use

It seems logical that as the southern right whale population expands they may tend to aggregate in new areas. However, there is evidence to suggest this is unlikely to occur.

As previously discussed, genetic and isotopic studies of the species indicate that mothers and their offspring return annually to the same feeding and calving grounds (Valenzuela et al. 2009; Carroll et al. 2011), suggesting that the species may have limited capacity to explore new feeding grounds even where suitable habitat is available and the population abundance is increasing (DSEWPaC 2012).

Given these ingrained traits, it is unlikely that whales would aggregate in the Smith Bay area. Individual whales, or mother and calf pairs that visit Smith Bay, are likely to be moving from one aggregation area to another (Victoria to Encounter Bay to the Bight) and not using the bay as foraging or nursery grounds.

Connectivity of coastal habitat may be disrupted by human activities, however, an impact assessment should consider the importance of connecting habitat as well as aggregation areas (DSEWPaC 2012).

A research project is being undertaken to develop a large-scale spatially and temporally explicit model that can reliably predict modern-day habitat uses and potential resettlement areas (DSEWPaC 2012).

2. POTENTIAL IMPACTS

2.1 Overview

The Conservation Management Plan for the Southern Right Whale produced by the Australian Government is a recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999*, covering the period 2011–2021 (DSEWPaC 2012).

This plan identifies a number of threats relevant to an assessment of the Smith Bay wharf proposal and are summarised below.

- ‘Entanglement’ includes interaction with marine debris, with ‘injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris’ listed as a key threatening process under the *EPBC Act 1999*. Harmful marine debris includes solid, non-biodegradable floating materials (such as plastics) disposed of by ships at sea.
- ‘Vessel disturbance’ includes collisions and the disruption of the behaviour of animals. The type of vessels involved can range from large commercial ships to recreational vessels, including personal watercraft.
- ‘Noise interference’ sources include some types of dredging, infrastructure construction and operation (particularly pile driving and explosives) and vessel noise (including tender activity), but the cumulative impacts of all sources of noise interference need to be considered.
- ‘Habitat modification’ includes physical displacement or movement disruptions resulting from coastal infrastructure development, and conceivably from acute chemical discharge if toxic sediments are disturbed.

All of these activities are considered to have minor consequences and pose a moderate level of risk to the south-west population of the southern right whale (DSEWPaC 2012).

Further information relevant to assessing the impact of vessel disturbance is provided in the following section, which includes shipping information relevant to assessment of entanglement. Information relevant to the assessment of noise is provided in Appendix N1.

2.2 Vessel disturbance

Southern right whales are considered vulnerable to vessel strike due to their presence in near-shore waters during critical life phases such as breeding, slow swimming behaviour and time spent on the surface (DoEE 2016). Calves are also susceptible to direct disturbance from whale watching vessels and/or low-flying aircraft around calving areas (Jacobs 2015).

Worldwide, between 15 and 40 whale strikes have been reported to the International Whaling Commission (IWC) annually in recent years (DoEE 2016).

There are limited data on incidents where vessels strike large cetaceans in Australian waters. What is known has been compiled from reports given to the International global database (IWC 2015) and a more recent report by Peel et al. (2016). In Australian waters 109 vessel strikes were recorded between 1840 and 2015 (Peel et al. 2016). Records from 1897 to 2015 show that 10 of the 88 collisions were with southern right whales, but at least some of the 22 collisions with an unidentified species (Peel et al. 2016) may have also been with a southern right. It has been suggested that even though humpback whales are much more abundant, southern rights are the main species involved in vessel collisions because they spend more time on the surface (Peel et al. 2016).

Since 1981, three collisions have been reported between vessels and southern right whales in South Australian waters – all between July and November (Peel et al. 2016) – and in at least two of these incidents the whale died (Kemper et al. 2008; Spencer Gulf Port Link 2013) (see Figure 3).

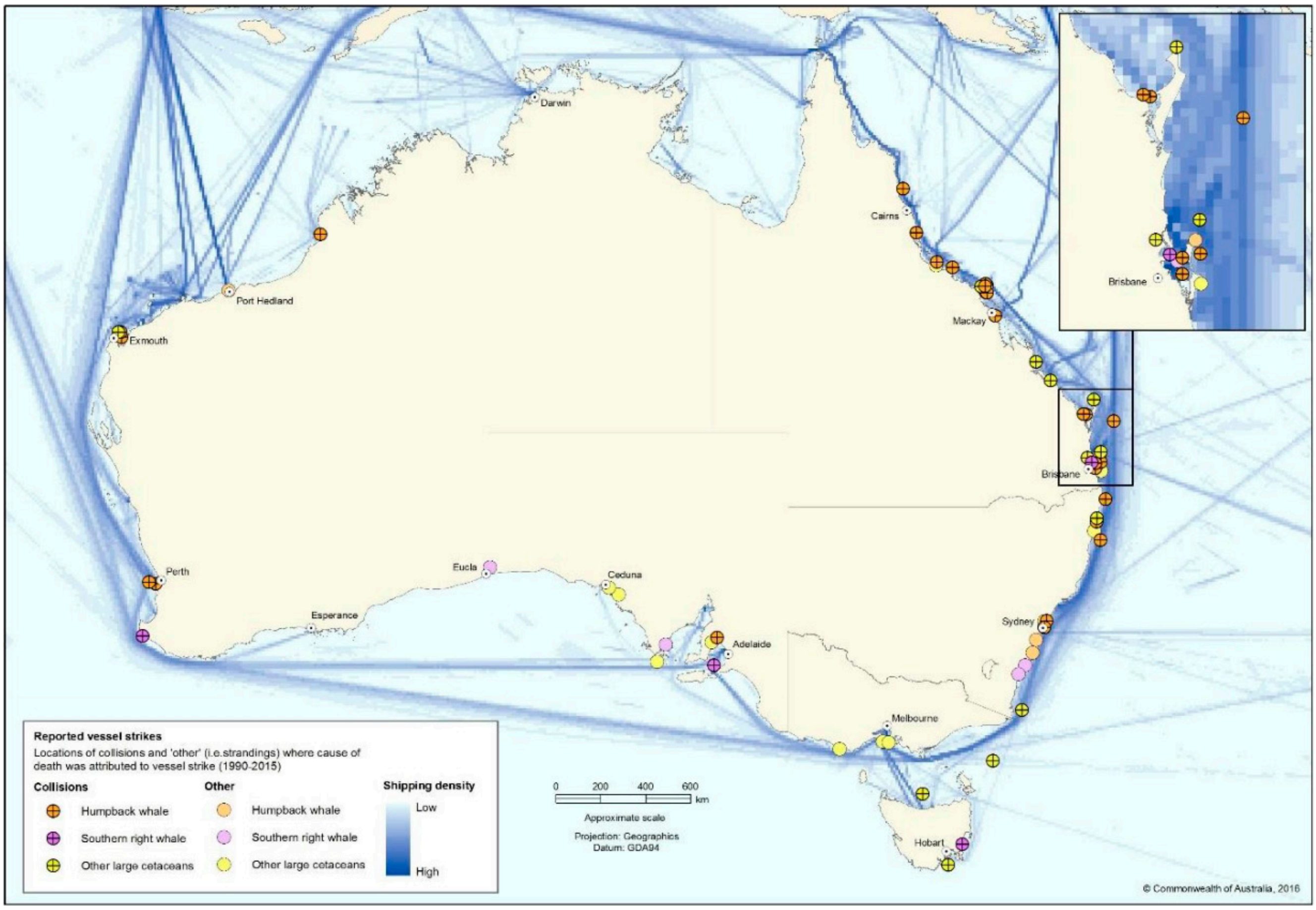


Figure 3. Location of reported vessel collisions, or strandings where death was attributed to vessel collision (Source: DOEE 2016).

The major problem with records of collisions to date is the vast knowledge gaps, especially concerning true numbers of vessel strikes on different species. Despite the obligation under the *EPBC Act 1999* to report any collisions that may result in a cetacean being injured or killed, it is likely that some go undetected or are not reported (DOEE 2016). It is difficult to reach conclusions on the rate of vessel strike in Australia based on data that are incomplete and potentially biased and non-representative (Peel et al. 2016). A preferable approach is to relate the risk to densities of vessels and whales (International Whaling Commission 2015).

There were approximately 2000 vessel calls to South Australian ports managed by Flinders Ports in 2017 (Flinders Ports 2018) and estimates from earlier years suggest that an additional 150 calls from Port Bonython, Whyalla and Ardrossan (Bryars et al. 2016, Flinders Ports 2013), There were approximately 60,000 recreational vessels registered in South Australia in 2014 (DPTI 2018).

Areas surrounding major Australian ports, primarily along the east and west coasts where shipping activity is highest, may be cause for concern. Melbourne, Brisbane, Newcastle, Dampier, Sydney, Port Hedland, Fremantle, Darwin and Gladstone harbours or ports had the highest number of ship calls during the 2013–14 period, and all except Darwin lie on whales' migratory routes and/or close to areas where they aggregate (DoEE 2016, see Figure 4). Shipping density in the biologically important areas for southern right whales along the southern coast of Australia is relatively low (see Figure 4).

The steady increase over the past decade in shipping activity in Australia and the predicted escalation in the future, coinciding with the growth in the southern right whale's south-west population, suggest the probability of vessel collisions with this species will also increase (DoEE 2016).

The risk of vessel strike is managed mainly via the Australian Maritime Safety Authority's (AMSA) shipping notices to shipowners and operators. In response to the International Maritime Organisation's (IMO) circular on minimising the risk of whale strike to member countries (IMO 2009), AMSA released shipping notices in 2011 and 2016.

AMSA's Marine Notice 15/2016 (*Minimising the risk of collisions with cetaceans*):

- provides guidance to shipowners and operators on reducing the risk of collision with cetaceans
- provides information on the location and migration periods of threatened whale species in Australian waters
- reminds shipowners, operators and seafarers of their obligations to report all whale strikes within Australian waters (AMSA 2016).

The notice urges seafarers to:

- maintain a watch for cetaceans, especially during key times and at key locations mentioned in the Mariner Notice
- warn other vessels using all appropriate means of communication in the event of sightings
- consider reducing vessel speed in areas where cetaceans have been sighted
- consider modest course alterations away from sightings (AMSA 2016).

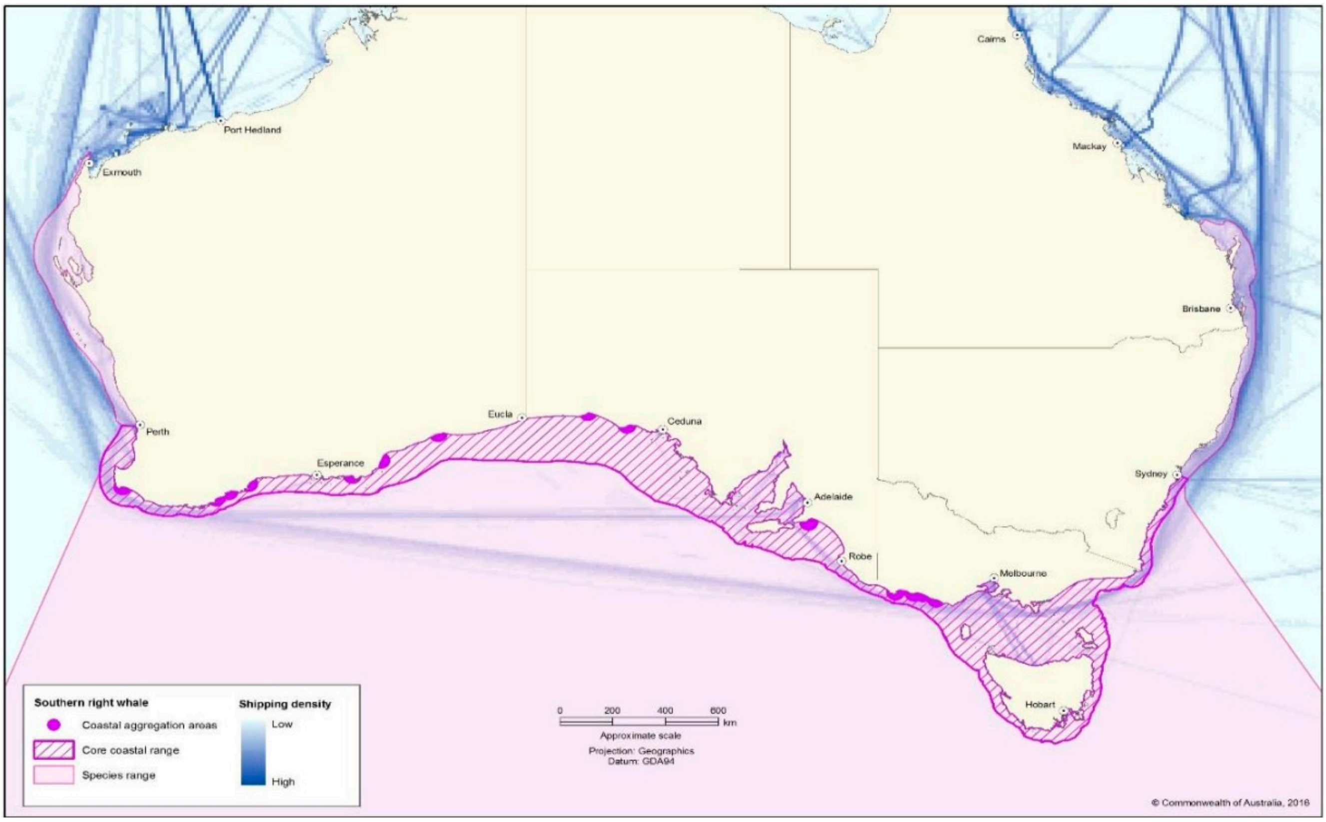


Figure 4. Shipping intensity in relation to important areas for southern right whales (Source: DOEE 2016).

3. REFERENCES

Atlas of Living Australia 2017, *Eubalaena australis (Desmoulins*, *1822) southern right whale*, viewed 18 September 2017, <http://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:99e19958-7c6e-4f22-ad50-44027af1e418>.

Australian Maritime Safety Authority 2016, *Marine Notice 15/2016: Minimising the risk of collisions with cetaceans*, Australian Maritime Safety Authority , Canberra, viewed 22 August 2017, <https://apps.amsa.gov.au/MOReview/MarineNoticeExternal.html>.

Bannister, JL 2001, 'Status of southern right whales (*Eubalaena australis*) off Australia', *Journal of Cetacean Research and Management*, vol. *2* (special issue), pp. 103–110.

Bannister, JL 2007, *Southern Right Whale Aerial Survey and Photoidentification*, *Southern Australia*, *2006*, Final Report, to 28 February, on work done under the Agreement between the Commonwealth of Australia and the Western Australian Museum signed on 14 March 2006.

Bryars, S, Brook, J, Meakin, C, McSkimming, C, Eglinton, Y, Morcom, R, Wright, A & Page, B 2016, Baseline and predicted changes for the Upper Gulf St Vincent Marine Park, DEWNR Technical report 2016/24, Government of South Australia, through Department of Environment, Water and Natural Resources, Adelaide

Burnell, SR 2001, 'Aspects of the reproductive biology, movements and site fidelity of right whales off Australia', *Journal of Cetacean Research and Management*, vol. *2* (special issue), pp. 89–102.

Carroll, E, Patenaude, N, Alexander, A, Steel, D, Harcourt, R, Childerhouse, S, Smith, S, Bannister, J, Constantine, R & Baker, C 2011, 'Population structure and individual movement of southern right whales around New Zealand and Australia', *Marine Ecology Progress Series*, vol. 432, pp. 257–268.

Carroll, EL, Jackson, JA, Paton, D & Smith, TD 2014, 'Two Intense Decades of 19th Century Whaling Precipitated Rapid Decline of Right Whales around New Zealand and East Australia', *PLoS ONE* 9, e93789.

Department of the Environment and Energy 2016, *Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna*, Department of the Environment and Energy, Commonwealth of Australia, Canberra.

Department of Planning, Transport and Infrastructure 2012, *Underwater Piling Noise Guidelines*, Department of Planning, Transport and Infrastructure, Adelaide.

Department of Planning, Transport and Infrastructure 2018, Boat Registrations, viewed August 2018, https://data.sa.gov.au/dataset/boat-registrations. Department of Planning, Transport and Infrastructure. Adelaide.

Department of Sustainability, Environment, Water, Population and Communities 2012, *Conservation Management Plan for the Southern Right Whale: A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 2011–2021*, Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Flinders Ports 2018, Key statistics: Annual Statistics 2017. Summary Report, viewed August 2018, https://www.flindersports.com.au/ports-facilities/port-statistics.

International Maritime Organization 2009, *Guidance Document for Minimising the Risk of Ship Strikes with cetaceans*, International Maritime Organization – Marine Environment Protection Committee, viewed 22 September 2017, <https://www.amsa.gov.au/file/1448/download?token=GXkxI0yh>.

International Whaling Commission 2015, Ship strike database, viewed 24 June 2015, <https://iwc.int/ship-strikes>.

Jacobs 2015, *Central Eyre Iron Project: Port Site Marine Assessment*, Jacobs Pty Ltd report E-F-34-RPT-0039, as Appendix Q of Iron Road 2015, *Central Eyre Iron Project Environmental Impact Statement.*

Kemper, C 2008, *Analysis of South Australian Museum's cetacean data: distribution*, *seasonal trends and circumstance of death*, report for the Department of Environment, Water, Heritage and the Arts, South Australian Museum, Adelaide.

Kemper, C, Coughran, D, Warneke, R, Pirzl, R, Watson, M, Gales, R & Gibbs, S 2008, 'Southern right whale (*Eubalaena australis*) mortalities and human interactions in Australia, 1950–2006', *Journal of Cetacean Research and Management*, vol. 10, no. 1, pp. 1–8.

Ketten, DR 1997, 'Structure and function of whale ears', *Bioacoustics*, vol. 8, no. 1–2, pp. 103–135.

National Research Council 2003, *Ocean Noise and Marine Mammals*, National Research Council (US) Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals, National Academies Press, Washington.

National Oceanic and Atmospheric Administration. Fisheries 2012, *Southern Right Whale (Eubalaena australis)*, National Oceanic and Atmospheric Administration, Maryland, USA, viewed 21 September 2017, <https://www.fisheries.noaa.gov/species/southern-right-whale>.

National Oceanic and Atmospheric Administration Fisheries 2015, *Southern right whale (Eubalaena australis) 5-year review: summary and evaluation*, National Oceanic and Atmospheric Administration, Office of Protected Resources, Maryland, USA.

Peel, D, Smith, JB & Childerhouse, S 2016, *Historical data on Australian whale vessel strikes*, presented to the IWC Scientific Committee, SC/66b/HIM/05.

SA Whale Centre 2017, Live Sightings Log, South Australian Whale Centre, viewed 18 September 2017, < http://www.sawhalecentre.com.au/whale-sightings/sightings-log/>.

Spencer Gulf Port Link 2013, *Port Bonython Bulk Commodities Export Facility: Draft Environmental Impact Statement*, Adelaide, South Australia.

Valenzuela, L, Sironi, M, Rowntree, V, Seger, J 2009, 'Isotopic and Genetic Evidence for Culturally Inherited Site Fidelity to Feeding Grounds in Southern Right Whales *Eubalaena australis'*, *Molecular Ecology*, vol. 18, pp. 782–791.

Attachment 1: Whale strike probability modelling by BMT WBM Pty Ltd.

BMT WBM Pty Ltd
Level 8, 200 Creek Street
Brisbane Qld 4000
Australia
PO Box 203, Spring Hill 4004

Tel: +61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.bmtwbm.com.au

Electronic Transmission

To:	SEA	CC:	Tegan Stehbens, Maria Pedicini
Attention:	David Wiltshire	Date:	11 September 2018
Fax No:	Email	Document Ref:	M.B22454.001.01.WhaleStrike.docx
From:	Toby Devlin	No. of pages:	4

Dear David

RE: WHALE STRIKE PROBABILITY MODELLING

The following memorandum describes modelling of the risk of potential whale-strike in southern Australian coastal waters. This modelling has been undertaken for Kangaroo Island Plantation Timbers (KIPT) to quantify the risk of regular KIPT shipping movements striking Southern Right Whales during the annual migration.

1 Methodology

Two key methods have been undertaken to quantify the whale-strike likelihood: a theoretical probability formulation, and then a stochastic Monte-Carlo simulation to validate the theory.

In order to constrain the problem for both methods, a series of assumptions have been made:

- Southern Right Whale migration averages 260 whales migrating into southern Australian coastal waters over two months, and returning six months later. **Note:** This is an unknown and sensitivity is commented on in section 2;
- KIPT shipping occurs every 14 days with a single ship moving from East to West;
- Whales move at the water surface at all times;
- Whales migrate at an average speed of 3kt;
- Shipping moves at an average speed of 15kt;
- Both whales and ship are modelled as points that move in a straight line with no change in behaviour i.e. no avoidance of collision on part of either whale or ship;
- The threshold for a strike is the whale and ship being within the same 10m x 10m area, and;
- The shipping zone is approximately a 1000km by 200km domain.

1.1 Theoretical Model

The theoretical model calculates the expected number of whale-ship collisions while the whale crosses the track of the ship's bow. Each whale must cross the 10m threshold of the ship's track at some point in its migration, and at an average speed of 3kt this will take ~6.5 seconds. In the same period, the ship is able to cover 50m. With a 10m threshold (+/-5m) for collision, the ship can be from 5m east up to 55m west of the whale when the whale begins its crossing and still collide with it at some stage before it reaches the other side (Figure 1-1).

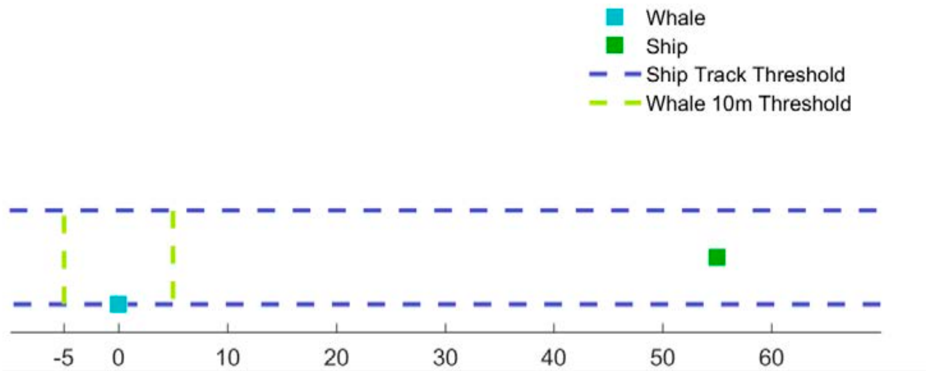


Figure 1-1 Example of Whale Crossing

The probability of the ship being within this 60m length has been found to be the same as the percentage of time it spends within any 60m out of the time it spends anywhere else. At the assumed speed, the ship can cover 60m in 7.8 seconds out its 14-day cycle or a probability of 1 in 160 000 that the ship is within any 60m length at any point.

This can be extended to determine that for 260 whales crossing twice per year (520 crossings in total); the average number of whale-strikes is 0.00334 per year (**1 every ~300 years**) with a standard deviation of 0.058 strikes per year.

1.2 Monte-Carlo Model

To validate the methodology above, a Monte-Carlo model has been developed. This model has been developed in the MATLAB coding environment, and simulates 260 whales at a random starting location along the southern boundary, migrating north from a random time in a two-month period, and returning six months later. It also models the ship making an East-West crossing every 14 days. At any point in time, the distance between the ship and the whales is calculated, and if they both lie in the same 10m x 10m area then a strike is recorded. Figure 1-2 shows a snapshot of the ship in green moving across the domain and the whales in black making the crossing.

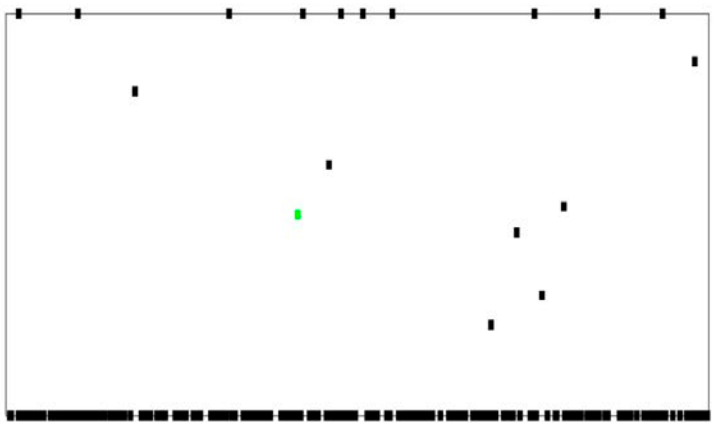


Figure 1-2 Snapshot from Monte-Carlo Model

The model was run for 10-million simulated years (each with a different set of random starting conditions for each whale) in order to converge on the expected long-term average. Over this period there were a total of 32654 whale-strikes recorded; leading to an average of 0.00326 per year, or **1 every 306 years**. As this agrees with the previous calculation, the theoretical model is considered validated given the assumptions made.

2 Sensitivity

An analysis of the theoretical model has been used to examine the sensitivity of the various parameters. The risk of a strike is linear to both the number of ships per year, and the number of whale crossing per year, i.e. if twice as many whales cross per year, then the risk of a strike doubles. The expected number of strikes is hyperbolic to the speeds of both the whales and the ship, i.e. a faster ship will have fewer strikes because it spends less time within the potential strike domain, but will still have a minimum of one strike per 360 years (Figure 2-1). The seemingly contradictory result that faster ship speeds will result in less strikes is a consequence of the assumption that neither the whale or the ship will actively try to avoid a collision.

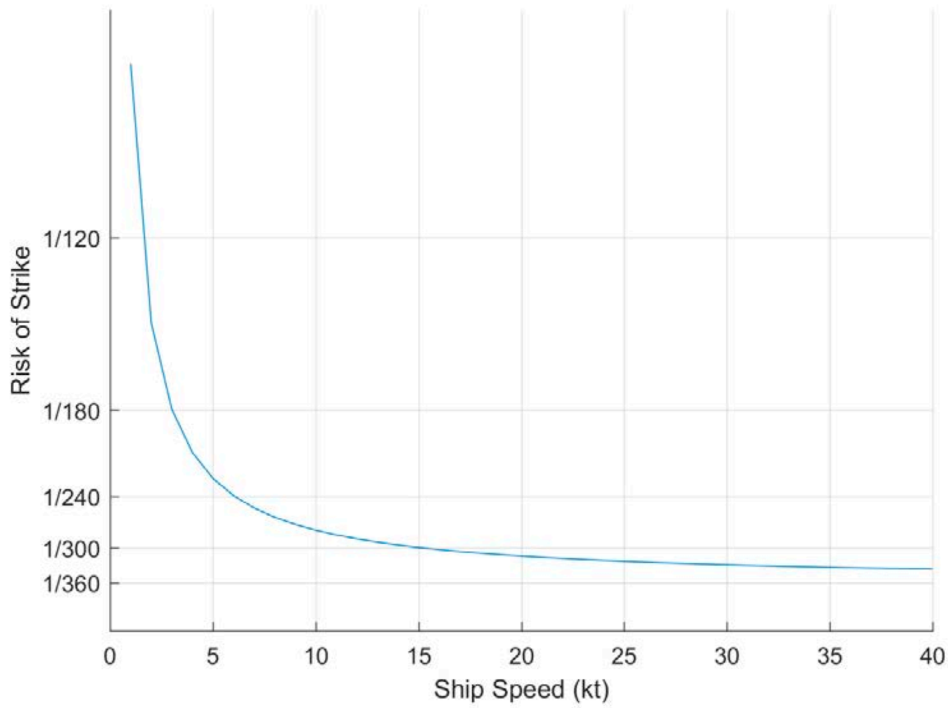


Figure 2-1 Sensitivity of Ship speed to Strike Risk

Based on a review of the underlying assumptions for the derived probability (i.e. whales move at the surface at all times), it is considered likely that this should be an upper bound solution given the estimated population density and frequency of shipping movements.

3 Conclusion

A theoretical model was developed to determine the whale-strike risk, and a Monte-Carlo model was developed to validate the result. The theoretical model has determined that the probability of a whale strike occurring in a given year is 3.3×10^{-3} or **1 whale strike every 300 years** and the Monte-Carlo model confirmed this result within an acceptable margin of error. This is an upper bound probability – assuming worst-case conditions – and many variables discounted could serve to reduce this likelihood.

Appendix I3 – Commercial and Recreational Fisheries – SEA

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

The nearest ports/ramps from which commercial and recreational fishers operate are at Kingscote and Emu Bay, about 20 and five kilometres east of Smith Bay, respectively. Beach launching of boats at Smith Bay is possible but occurs infrequently.

The following fisheries include Smith Bay within their permitted waters of operation:

- marine scalefish
- sardine
- Gulf St Vincent prawn
- Northern Zone rock lobster
- Central Zone abalone
- southern and eastern scalefish and shark
- charter boat
- recreational.

2. MARINE SCALEFISH FISHERY

Marine scalefish fishery catch and effort statistics are reported for areas called marine fishing areas (MFAs) which generally span one degree of latitude and longitude unless adjacent to land. Smith Bay lies within MFA 41, which is one of the smallest, spanning seven per cent of a square degree (Figure 1). Annual catches for the most important species have been published for MFAs that were fished by at least five fishers and flagged as ‘confidential’ for the others. Catches are summarised in Table 1.

Between 2011–12 and 2015–16, annual catches for MFA 41 were (Fowler et al. 2012; 2013; 2014; 2015; 2016):

- less than 10 tonnes of King George whiting (Sillaginodes punctate) during 2011–12 and between six and 15 tonnes in subsequent years
- less than 10 tonnes of snapper (Pagrus auratus)
- less than five tonnes of southern calamari (Sepioteuthis australis) during years other than 2014–15, when the catch was confidential
- less than four tonnes of silver trevally (Pseudocaranx georgeanus)
- less than four tonnes of snook (Sphyraena novaehollandiae) 2011–12 to 2013–14, and confidential for subsequent years
- less than five tonnes of Australian salmon (Arripis truttacea) during 2012–13 and 2013–14, and confidential for other years
- less than five tonnes of gummy shark (family Triakidae) during 2012–14
- confidential (for at least some years) for garfish, cuttlefish, Australian herring, wrasse, yelloweye mullet, mud cockle, leatherjackets, yellowfin whiting, mulloway and bronze whalers.

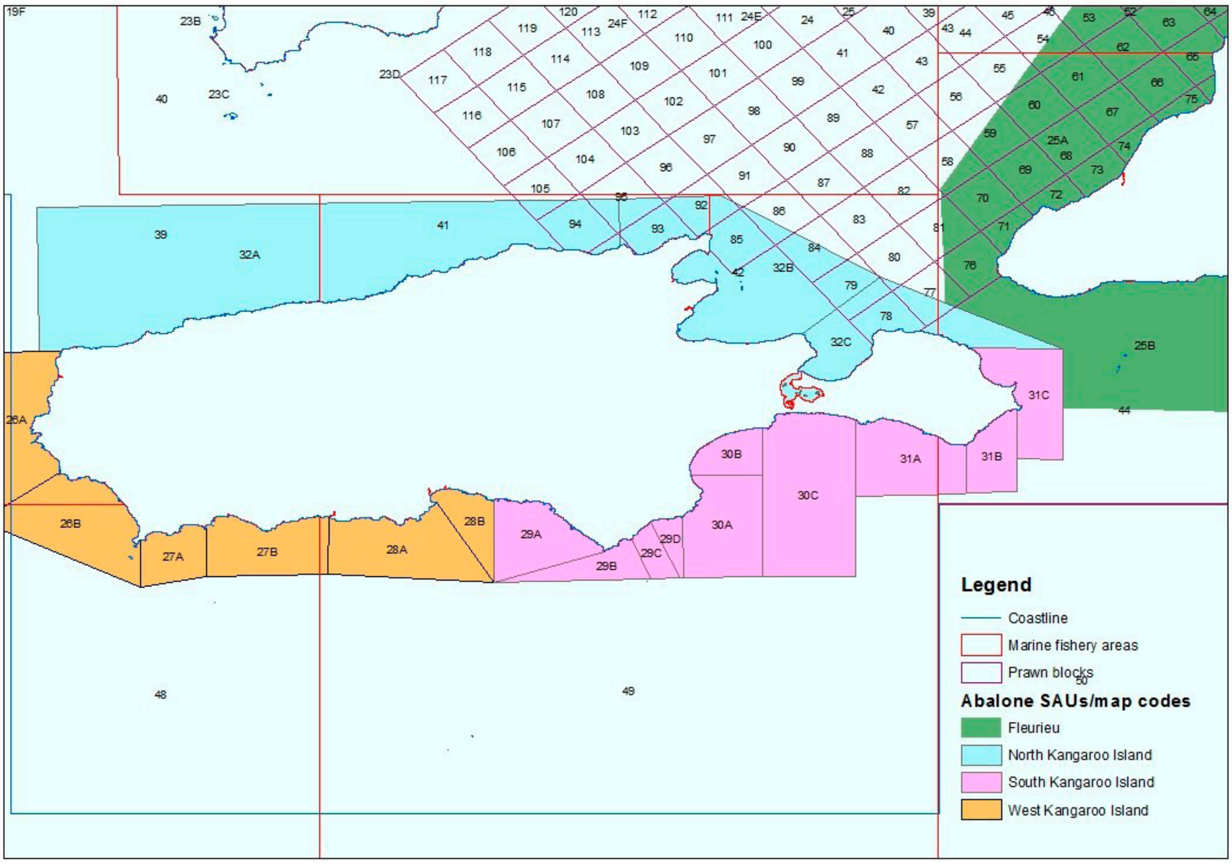


Figure 1. Fisheries reporting areas overlapping Smith Bay (shown by arrow) along the north coast of Kangaroo Island.

Table 1. Summary of catches in areas overlapping Smith Bay

Fishery	Species	Area	Period	Catch (tonnes)	Percentage of total fishery catch	Source
Marine scalefish	King George whiting	MFA 41	2011–12 to 2015–16	24–70	1.6–4.8	Fowler et al. 2012; 2013; 2014; 2015; 2016
	snapper			5–41	0.2–1.4	
	southern calamary			4–20 plus 1 year confidential catch	0.2–1.1[A]	
	silver trevally			5–17	10–35	
	snook			3–12 plus 2 years confidential catch	2.2–8.8[A]	
	Australian salmon			2–10 plus 3 years confidential catch	0.5–2.3[A]	
	gummy shark			1–5 plus 4 years confidential catch	0.9–4.6[A]	
Sardine	Australian sardine	100 km^2	1999–2014	150–1100	0.03–0.2	Ward et al. 2015
Gulf St Vincent prawn	western king prawn	Prawn blocks 93 and 94	2007–08 to 2015–16	nil	0	Beckmann & Hooper 2016
Northern Zone rock lobster	southern rock lobster	MFA 41	1993–2011	64	0.5	Ward et al. 2012
Central Zone abalone	greenlip abalone	North Kangaroo Island	2006–15	4.3	0.9	Burnell et al. 2016
	blacklip abalone			<0.3	0	
Southern and eastern scalefish and shark	gummy shark	North of Kangaroo Island	2006–08	32	0.5[B]	Goldsworthy et al. 2010, Georgeson et al. 2014

[A] Assumes that confidential years are similar to known years. Likely to be an overestimate.

[B] 2.3 per cent of the total catch from South Australian waters.

3. SARDINE FISHERY

For the sardine fishery, the latitude and longitude are recorded each time a net is deployed and the related catches are displayed spatially in the stock assessment at a scale of 100 square kilometre blocks (Ward et al. 2015). Sardines were caught off the north coast of Kangaroo Island during 1999 and between 2003 and 2012. Catches in the block encompassing Smith Bay were 50–100 tonnes in 2005 and 100–1000 tonnes in 2006. Catches of less than 100 tonnes were also recorded in the next adjacent block offshore from Smith Bay during 2003 and 2004 and in the block immediately west of Smith Bay during 2011 (Ward et al. 2015).

4. PRAWN FISHERY

Fishing in the Gulf St Vincent prawn fishery is permitted in all waters greater than 10 metres deep that are north of the geodesic joining Gulf St Vincent, Investigator Strait and Backstairs Passage. Prawn catch and effort are reported for diagonal areas generally spanning about eight kilometres by eight kilometres (i.e. 64 km^2) (Figure 1). Smith Bay does not lie within a prawn block but is located between blocks 94 to the west and 93 to the east. Between 2007–08 and 2015–16 there were no catches reported for blocks 93 or 94 (Beckmann & Hooper 2016). Prawn trawling does not take place over seagrass.

5. ROCK LOBSTER FISHERY

Catch and effort in the Northern Zone rock lobster fishery are reported using same MFAs as the marine scalefish fishery. Between 1993 and 2011 an average of 3.4 tonnes a year, totalling 64 tonnes, were harvested from MFA 41 of the northern fishery, representing 0.5 per cent of the catch from that fishery (Ward et al. 2012).

6. ABALONE FISHERY

The Central Zone abalone fishery uses ‘map codes’ of various sizes that are aggregated to form ‘spatial assessment units’ (SAUs). Smith Bay is at the eastern end of Map Code 32A (just left of 32B), within the North Kangaroo Island SAU (Figure 1). Annual catches of blacklip abalone in the North Kangaroo Island SAU were less than 0.6 tonnes between 1979 and 2004 and less than 0.1 tonnes between 2005 and 2015, representing a negligible percentage of the Central Zone catch during the latter period (Burnell et al. 2016). Catches of greenlip abalone in the North Kangaroo Island SAU were variable and averaged less than 1.5 tonnes a year between 1979 and 2015, representing 0.9 per cent of the Central Zone blacklip abalone catch between 2006 and 2015 decade (Burnell et al. 2016). Catches of blacklip and greenlip abalone at map code scales are not generally published but could be requested from the South Australian Research and Development Institute (SARDI) for those years when at least five of the six Central Zone licence holders fished the relevant map code.

7. EASTERN SCALEFISH AND SHARK FISHERY

The gillnet, hook and trap sector of the Southern and Eastern scalefish and shark fishery includes waters offshore from Victoria, Tasmania and South Australia (including some SA coastal waters) and is managed by the Australian Government. About 638 tonnes of gummy shark were taken between Point Fowler on Eyre Peninsula and Kangaroo Island between 2006 and 2008 (Goldsworthy et al. 2010), but fishing effort is now concentrated in Victoria as a result of spatial closures to reduce the bycatch of Australian sea lions and common dolphins (Georgeson et al. 2014).

8. CHARTER BOAT FISHERY

Charter boat fishery licence holders complete a compulsory logbook for each trip in which they report the MFA fished and details of the catch. Stock assessment reports have amalgamated the MFAs into five fishing regions. However, with MFA 41 within a region spanning all of Gulf St Vincent and Kangaroo Island (Tsolos 2013; Tsolos & Boyle 2015; Steer & Tsolos 2016), any request for catch details for MFA 41 would be refused if that MFA were fished by fewer than five licence holders using that area. Between 2009–10 and 2011–12, Kingscote was used as a port by only one operator (Tsolos 2013). Western River Cove

(40 km west of Smith Bay) and American River were each used by three operators. It is likely that licence holders departing from mainland ports use the north coast of Kangaroo Island at times.

9. RECREATIONAL FISHERY

Information on recreational fishery participation and harvest has been collected through surveys in 2000–01 (Jones & Doonan 2005), 2007–08 (Jones 2009) and 2013–14 (Giri & Hall 2015). The data collected were spatially resolved into 35 individual fishing regions across South Australia, but catches for all surveys and participation rates during 2013–14 were reported using amalgamated regions including one spanning all of Gulf St Vincent and Kangaroo Island. The numbers of fishers using the north coast of Kangaroo Island (from Cape Borda to Antechamber Bay) were 8394 and 7736 during 2000–01 and 2007–08 respectively, and the numbers of days fished were 30,117 and 27,885 respectively. The number of fishers represented 2.3 and 1.3 per cent of the South Australian total in those years respectively, and 2.6 and 1.6 per cent of the number of fishing days respectively.

10. REFERENCES

Beckmann, CL & Hooper, GE 2016, *Gulf St Vincent Prawn Penaeus (Melicertus) latisulcatus Fishery 2015–16*, Fishery Assessment Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000782-6, SARDI Research Report Series No. 919.

Burnell, O, Mayfield, S, Ferguson, G & Carroll, J. 2016, *Central Zone Abalone (Haliotis laevigata and H. rubra) Fishery*, Fishery Assessment Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000611-7, SARDI Research Report Series No. 927.

Fowler AJ, McGarvey R, Steer MA, Feenstra JE 2012, *South Australian Marine Scalefish Fishery – Stock Status Report 2011–12*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, F2007/000565-7, SARDI Research Report Series No. 681.

Fowler, AJ, McGarvey, R, Steer, MA & Feenstra, JE 2013, *The South Australian Marine Scalefish Fishery Status Report – Analysis of Fishery Statistics for 2012–13*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000565-8, SARDI Research Report Series No. 747.

Fowler, AJ, McGarvey, R, Steer, MA & Feenstra, JE 2014, *The South Australian Marine Scalefish Fishery Status Report – Analysis of Fishery Statistics for 2013–14*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000565-9, SARDI Research Report Series No. 816.

Fowler, AJ, McGarvey, R, Steer, MA & Feenstra, JE 2015, *The South Australian Marine Scalefish Fishery – Fishery Statistics for 1983–84 to 2014–15*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000565-10, SARDI Research Report Series No. 882.

Fowler, AJ, McGarvey, R, Steer, MA & Feenstra, JE 2016, *Fishery Statistics for the South Australian Marine Scalefish Fishery: 1983–84 to- 2015–16*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000565-11, SARDI Research Report Series No. 935.

Georgeson, L, Stobutzki, I & Curtotti, R (eds) 2014, *Fishery status reports 2013–14*, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Giri, K & Hall, K 2015, *South Australian Recreational Fishing Survey*, Fisheries Victoria Internal Report Series No. 62.

Goldsworthy, SD, Page, B, Shaughnessy, PD & Linnane, A 2010, *Mitigating Seal Interactions in the SRLF and the Gillnet Sector SESSF in South Australia*, Report to the Fisheries Research and Development Institute, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2009/000613-1, SARDI Research Report Series No. 405.

Jones, GK 2009, *South Australian Recreational Fishing Survey*, PIRSA Fisheries, Adelaide, South Australian Fisheries Management Series, Paper No 54.

Jones, GK & Doonan, A 2005, *2000–01 National Recreational and Indigenous Fishing Survey*, South Australian Fisheries Management Series, Primary Industries and Resources SA, Government of South Australia, Paper no. 46.

Steer, MA & Tsolos, A 2016, *South Australian Charter Boat Fishery 2014–15*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000847-4, SARDI Research Report Series No. 932.

Tsolos, A 2013, *South Australian Charter Boat Fishery Report 2012*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000847-3, SARDI Research Report Series No. 686.

Tsolos A & Boyle M 2015, *Non-confidential 2014–15 data summary of the South Australian Charter Boat Fishery*, Data summary to PIRSA Fisheries and Aquaculture.

Ward, TM, Burch, P, Gorman, D & Begg, GA 2012, *Estimates of historical commercial fishery catches/effort in final sanctuary and habitat protection zones in South Australia's Marine Parks*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2011/000307-8, SARDI Research Report Series No. 670.

Ward, TM, Whitten, AR & Ivey, AR 2015, *South Australian Sardine (Sardinops sagax) Fishery: Stock Assessment Report 2015*, Report to PIRSA Fisheries and Aquaculture, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2007/000765-5, SARDI Research Report Series No. 877.

Appendix I4 – Ecological Effects of Dredging – SEA

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

Dredging can lead to various adverse impacts on the marine environment. These can be especially significant when dredging or disposal of dredged material happens near sensitive marine environments, such as seagrass beds.

The main potential impacts include physical removal and/or burial of marine communities and increased turbidity and sedimentation which, respectively, reduces light availability for plants and smothers biota. Seagrasses appear to be particularly susceptible to dredging impacts (Erftemeijer & Lewis 2006).

There are numerous examples of significant loss of seagrass beds due to dredging and associated activities during the past 50 years. Two of the largest losses have been in Moreton Bay, Queensland, where thousands of hectares of seagrass have been lost, and in Laguna Madre, Texas, where 15,000 ha have been lost (Erftemeijer & Lewis 2006).

Several extensive studies of the effects of turbidity and sedimentation on marine communities in South Australia and elsewhere provide a guide to the probable effects of dredging at Smith Bay. The key studies are:

- The Adelaide Coastal Waters Study (Fox et al. 2007), which includes technical papers on the effects of sediment and turbidity on seagrasses (Westphalen et al. 2005; Collings et al. 2006).
- Studies associated with a significant dredging program at Port Stanvac, south of Adelaide, in the 1990s focusing on sand and seagrass communities (Cheshire & Miller 1999), and on macroalgal communities (Turner 2004).
- A study of the effects of the dredging program associated with the Adelaide Desalination Plant (Victory et al. 2010).
- An international review, including many Australian studies, of the impact of dredging on seagrasses (Erftemeijer & Lewis 2006).
- A Western Australian review of the effect of dredging on key ecological processes for marine invertebrates, seagrasses and macroalgae (Short et al. 2017; Fraser et al. 2017).

2. REVIEW OF DREDGING EFFECTS

2.1 Key environmental effects

Dredging can harm marine communities in numerous ways, including (Airoldi 2003; Cheshire & Miller 1999; Erftemeijer & Lewis 2006; Thorhaug & Austin 1976):

- • physical removal of benthic vegetation and biota at the dredging site
- burial of benthic vegetation and biota at the spoil disposal site
- increased turbidity and light attenuation in the water column, thereby reducing the productivity of seagrass and algae communities and potentially leading to their decline and loss
- increased sedimentation and smothering or scouring of adjacent seagrass and reef communities, leading to their decline and loss
- sediment deposition resulting in changes to the physical characteristics of the substrate

- clogging and damaging filter feeding and breathing organs of marine organisms such as fish and shellfish, potentially leading to their death
- the release of sediments with high biological and/or chemical oxygen demand (BOD and COD), resulting in reduced dissolved oxygen concentrations in the water column, which can result in the death of fish and other marine biota
- the potential release of nutrients and pollutants from (contaminated) sediments, which can adversely affect the health of marine communities
- changes in the nutrient balance of the sediments that can create advantageous conditions for opportunistic organisms, thus altering the structure of benthic (bottom-dwelling) communities
- hydrographic changes that can have indirect e□ects on seagrasses through increased rates of erosion of seagrass communities
- ongoing resuspension of unconsolidated sediments in areas denuded of seagrass, resulting in chronic turbidity problems that can prevent recovery of seagrass, sometimes for decades.

Although increased turbidity and sedimentation are usually regarded as the primary mechanisms by which seagrass communities are indirectly impacted by dredging programs, the role of nutrient release from the sediments may have been underestimated (D. Wiltshire, personal observation). Nutrient enrichment associated with wastewater disposal and agricultural run-off has long been associated with seagrass decline, although the exact mechanism of its action is not well understood. Hypotheses include the stimulation of excessive growth of epiphytes and phytoplankton, thereby reducing the light available to seagrasses (Shepherd et al. 1989; Bryars et al. 2011), and direct toxic effects (Burkholder et al. 1992).

Two instances of seagrass decline and loss in False Bay in upper Spencer Gulf may have been caused by the release of ammonia from sediments on the tidal flats by the erosion of tidal channels (Wiltshire et al. 2004), and from anoxic sediments in the shipping channel by increased shipping operations (Wiltshire 2014).

2.2 Critical thresholds

The effect of dredging on seagrass communities to a large extent appears to depend on their sensitivity to increased turbidity and sedimentation. The critical thresholds at which these factors affect seagrass species are reviewed by Erftemeijer & Lewis (2006).

2.2.1 Turbidity

The penetration of sufficient light – that is, photosynthetically active radiation of sunlight – into the water column is imperative for the growth and survival of seagrasses. Water transparency, which affects the maximum depth at which seagrasses can grow, is determined by the natural water colour, concentration of suspended solids and phytoplankton concentration (Erftemeijer & Lewis 2006). Reduced light due to turbidity has been identified as a major cause of seagrass loss (Shepherd et al. 1989).

Minimum light requirements of most seagrass species appear to vary between 15 and 25 per cent of surface irradiance (SI), although some species are reported to survive on less than 5 per cent (Erftemeijer & Lewis 2006). The length of time that seagrasses can survive light intensities below their minimum requirements is highly variable, ranging from weeks to many months (Erftemeijer & Lewis 2006).

2.2.2 Sedimentation

Sedimentation can harm seagrasses by burying plants in extreme situations, or by settlement of fine sediments on seagrass leaf blades, particularly in low-wave-energy environments, thereby reducing the light available to plants for photosynthesis (Shepherd et al. 1989). The impact of sedimentation is often greater in situations where epiphytes are abundant on seagrass leaves, which can occur under nutrient-enriched conditions, as leaves with abundant epiphytes are able to trap a greater amount of sediment (Shepherd et al. 1989). Furthermore, with the additional weight of epiphytes and sediment, seagrass leaves often sink to the bottom, which makes them more vulnerable to being buried (Shepherd et al. 1989).

Several studies have documented deterioration of seagrass meadows by sedimentation and smothering, even at moderate burial depths such as 5 cm (Erftemeijer & Lewis 2006). For example, burial of the seagrass *Zostera marina* for 24 days by 4 cm of sediment (25 per cent of their height), and 16 cm (75 per cent of their height), resulted in greater than 50 per cent and 100 per cent mortality respectively (Mills & Fonseca 2003).

The ability of seagrasses to survive burial by sediments is reported to be highly variable, ranging from significant mortality of *Posidonia oceanica* in response to sedimentation rates of 5 cm a year (Manzanera et al. 1995), to good survival of *Cymodocea serrulata* and *Enhalus acoroides* in the Philippines in response to 10–13 cm a year (Vermaat et al. 1997).

2.2.3 Seagrass recovery

The ability of seagrass species to endure and recover from periods of reduced light depends on their morphological and physiological characteristics (Cheshire et al. 2002).

Small, fast-growing (short-lived) species such as *Halophila australis* do not survive long once environmental conditions become adverse. Being opportunists, however, they tend to recolonise quickly following an impact (Cheshire et al. 2002).

Species with larger below-ground biomass, such as *Posidonia* species, are better adapted to longer periods of sub-minimal light. These species tend to have greater stored reserves that can be mobilised to sustain the plant temporarily during periods of reduced light. They tend to be slow-growing, long-lived and more resistant to short- to medium-term disturbances; however, if the impact persists to the point where these plants have depleted all their reserves, they die. Once they are lost, re-colonisation is unlikely, or very slow (Cheshire et al. 2002).

2.3 Key dredging studies

An international review of the effects of dredging on seagrass communities by Erftemeijer & Lewis (2006) examined 45 documented cases of dredging operations in or near seagrass communities. The review reported that, of the 45 case studies, 26 accounted for a total loss of 21,023 ha of seagrass, 12 reported adverse (in some cases catastrophic) effects on seagrasses, but did not quantify the loss, and a further seven reported no significant impacts on seagrass beds. Most of the no-impact cases involved recent dredging programs, which probably reflects the implementation of more effective impact mitigation measures.

The effects of a sand dredging program at Port Stanvac, south of Adelaide, were intensively studied for several years. The program included four dredging events, the first three of which removed less than 200,000 m^3 of sand over two to three months, and the final event removed about 600,000 m^3 over one month (Cheshire & Miller 1999). By comparison, dredging at Smith Bay would remove 57,000 m^3 of sediment (Aztec Analysis 2017) – about 10 times less than that at Port Stanvac.

In the former cases, benthic communities recovered within 12 months; however, the final larger event resulted in a longer-term influence on the area, with significant effects on adjacent seagrass and reef systems being recorded (Cheshire & Miller 1999; Turner 2004).

In the case of seagrass, there was no difference in measured densities, but divers' visual observations of shorter blade length and higher amounts of epiphytic growth suggested that the quality of the seagrasses had been adversely affected by the dredging program up to 500 metres from the dredging location.

Similarly, Turner (2004) reported long-term effects on macroalgae communities. The sand dredging was shown to result in the deposition of 10 mm of fine sediment on Noarlunga and Horseshoe reefs

(1–2 km and 2–3 km from the dredging site, respectively). Some of the deposited sediment remained 10 months later (Turner 2004). Follow-up surveys revealed that the sedimentation from the plume had primarily affected newly recruiting individuals, with few juveniles surviving to one year. Over the following few years, the effect of this recruitment failure cascaded into effects on the adult community of macroalgae. Recruitment of *Cystophora* was less affected than that of *Ecklonia* and *Sargassum* (Turner 2004).

The main recommendation arising from this study was that dredging should never remove more than 200,000 m^3 and any single operation should not last less than two and a half months. This has since been more concisely specified as not exceeding a daily removal rate of 2600 m^3 (Cheshire 2017).

The study also recognised that recovery was assisted if the area dredged was relatively small compared with equivalent surrounding habitat, providing enough biota for recolonisation by immigration or larvae.

It was also recommended that methods such as fluorometry should be used to monitor the health of surrounding seagrass and algal communities before, during and after dredging events to assess the stresses of sedimentation and reduced light on these organisms (Cheshire & Miller 1999).

The Adelaide Desalination Plant dredging program removed about 4000 m^3 over 28 days (Victory et al. 2010), about 10 times less than proposed for Smith Bay. The dredge spoil and seawater were treated on a barge on site before the return of supernatant water to the sea. Seawater treatment was considered to be highly successful, with the turbidity plume attaining the Water Quality Policy (EPA 2003) trigger level for the protection of marine ecosystems (10 NTU) within 400 metres of the dredging site, and background levels

(2 NTU) at reefs 600 metres from the site. No visible plumes arising from the construction activities were evident. It was concluded that the dredging program caused no harm to the marine environment (Victory et al. 2010).

2.4 Conclusions

The review of Erftemeijer & Lewis (2006) reached the following conclusions about dredging effects:

- The significance and extent of damage to seagrass communities appeared to be a function of:
  - the scale of the dredging operation
  - the proximity of the seagrass beds to the operation
  - the type and composition of the sediment being dredged
  - the type and mode of operation of the dredging equipment
  - the dredging rate
  - the effectiveness of the mitigating measures applied during dredging.
- Although many studies have reported significant adverse impacts on seagrass beds from dredging, several other (mostly recent) studies have reported no impacts on nearby seagrasses due to greater environmental safeguards being in place.

- Some of the case studies have shown that even large-scale dredging operations do not always have significant impacts on seagrass beds.
- Development of criteria to protect seagrasses must acknowledge that they tolerate periods of naturally high turbidity and can withstand some increase in the frequency of turbid events.
- In areas that experience large natural fluctuations in background turbidity, seagrasses and other benthic communities often display a greater resilience than in areas with minimal natural turbidity fluctuations.
- Turbidity changes induced by dredging will result in adverse environmental e□ects only when the turbidity generated is significantly larger than the natural variation of turbidity and sedimentation rates in the area.
- Dredging often generates no more increased suspended sediments than is generated by commercial shipping, bottom fishing or severe storms.

The studies of Cheshire & Miller (1999) and Turner (2004) concluded that the dredging programs at Port Stanvac had significantly affected the adjacent seagrass and reef communities up to 500 metres and several kilometres, respectively, from the dredging site. It was concluded that a maximum daily dredging rate of 2600 m^3 considerably reduced impacts on adjacent communities (Cheshire & Miller 1999).

The study of Victory et al. (2010) of the Adelaide Desalination Plant dredging program concluded that with careful management and treatment of the dredge water and spoil, it was possible to effectively eliminate adverse environmental effects associated with the dredging program.

3. SENSITIVITY OF SMITH BAY COMMUNITIES TO SEDIMENTATION AND TURBIDITY

The Western Australian review of the effect of dredging on key ecological processes for marine invertebrates, seagrasses and macroalgae provides useful insights into the likely sensitivity of species at Smith Bay to dredging impacts, and potential measures that may be adopted to manage impacts (Short et al. 2017; Fraser et al. 2017).

Short et al. (2017) developed criteria for the assessment of vulnerability to dredging for marine invertebrates, seagrasses and macroalgae based on life history characteristics and other considerations (see Table 2).

Some of the life history characteristics in Table 2 have also been used to classify seagrass vulnerability to disturbance into three categories:

- Colonising species which have fast turnover times, reach sexual maturity quickly and produce a seed bank
- Persistent species which have slow turnover times, reach sexual maturity slowly and rarely produce a seed bank
- Opportunistic species which lie on a spectrum between the first two (Kilminster et al. 2015).

The criteria in Table 1 below have been applied to the most abundant species recorded at Smith Bay to assess their vulnerability to sedimentation. Additional information from various case studies (Short et al. 2017; Turner 2004; Cheshire & Miller 1999) on impacts associated with turbidity (light reduction) and burying are also considered.

Table 1: Life history and other characteristics used to determine vulnerability to dredging for invertebrates, seagrasses and macroalgae

		Vulnerability Score		
Group	**Characteristic**	**High**	**Medium**	**Low**
Seagrasses	Adult size	Large		Small
	Growth rate	Slow-growing		Fast-growing
	Time to sexual maturity	Long		Short
	Turnover time	Slow		Fast
	Seed bank presence	Absent		Present
	Light requirements	High		Low
	Burying tolerance	Low		High
Macroalgae	Growth rate	Slow-growing		Fast-growing
	Lifespan	Longer-lived (years)		Shorter-lived (days/months)
	Reproductive strategy	Less complex (fewer stages)		More complex (more stages)
Invertebrates	Feeding strategy	Autotrophs/filter feeders	Grazers/predators	Deposit feeders
	Movement	Sessile	Weakly mobile	Mobile
	Morphology	Encrusting	Cup-shaped	Upright
	Lifespan	Short-lived		Long-lived
	Reproductive strategy	Semelparous		Iteroparous
	Reproductive season	Discrete		Protracted
	Developmental strategy	Brooders	Lecitho- / plankto-trophs	Asexual

3.1 Seagrasses

Seagrasses are highly sensitive to changes in water quality, sediment loading and other inputs that accumulate as a result of the modification of watersheds and coastal water bodies (Dennison et al. 1993). Seagrasses are affected by dredging in several ways. They are directly affected at the dredge and disposal sites, where they are often physically removed or buried, and indirectly affected by temporary reduction in dissolved oxygen, increase in pollutants and nutrients from contaminated sediments, or bathymetric changes which may sometimes occur with dredging activities (Erftemeijer & Lewis 2006). Most importantly, seagrasses are affected by increased turbidity, which reduces light available for photosynthesis, and by burial, which can result in significant negative effects on shoot density and leaf biomass, physiology and productivity (Erftemeijer & Lewis 2006).

Larger species are likely to resist burial, as they would have a greater emergent photosynthetic area than a shorter species, which would be smothered by relatively less sediment and would be unlikely to have large carbohydrate reserves to maintain them over periods of minimal light (Westphalen et al. 2005).

The most common seagrass recorded during surveys at Smith Bay was *Posidonia sinuosa*, in patches up to depths of 10 metres and with an almost continuous distribution at depths of 10–12 metres. There were also several (3–10) patches of *Amphibolis antarctica* and *A. griffithii* and traces of *Posidonia coriacea* and *Zostera nigricaulis*.

3.1.1 *Posidonia*

The life history characteristics of *Posidonia* spp. include large adult size, moderate growth rate, years until sexual maturity and turnover times of years, and absence of a seed bank. Collectively, these characteristics have indicated a vulnerability index of 'medium' (Short et al. 2017).

Posidonia sinuosa can occur over depths between two and 35 metres (Westphalen et al. 2005). It has relatively high light requirements (7–24 per cent of surface irradiance) compared with *Posidonia coriacea* (7–8 per cent) (Short et al. 2017). Its large body allows carbon storage, enabling it to comfortably survive short-term reductions in light levels after a dredging event, but after extensive periods of shading these species tend to experience significant loss of biomass and shoot density, with minimal recovery (Short et al. 2017). Shading study sites of *P. sinuosa* included:

- the Adelaide coast, where shading resulted in a loss of leaves but retention of shoot density over the first six months, after which the community declined (Neverauskas 1988)
- Cockburn Sound, WA, where shading to 2–24 per cent of surface irradiance (unshaded at 29 per cent) for 198 days resulted in both shoot density, and leaf length and growth, decreasing with increased shading, with minimal recovery after 400 days and a recovery time of 3.5–5 years (Collier et al. 2009)
- Albany, WA, where shading to light levels of 0–10 per cent of surface irradiance for 148 days reduced shoot density, primary production and leaf production per shoot, with no recovery after 245 days (Gordon et al. 1994).

Burial studies of *Posidonia* have generally shown that sediment cover of 5 cm has resulted in reduced biomass and burial in 15 cm for about 50 days has resulted in 50–100 per cent mortality (50 per cent for *P. sinuosa*) (Short et al. 2017).

3.1.2 *Amphibolis*

The life history characteristics of *Amphibolis* include medium adult size, moderate growth rate, years until sexual maturity and long turnover times, and absence of a seed bank. Collectively these characteristics have indicated a vulnerability index of 'medium/low' (Short et al. 2017).

No data were obtained from the literature on the minimum light requirements of *Amphibolis* during a review by Westphalen et al. (2005). *A. griffithii* meadows have been shown to recover from shading experiments in Jurien Bay (WA), mimicking dredging scenarios lasting for three months followed by a 10-month recovery period, despite biomass losses of up to 72 per cent. However, there was no recovery after two years following 6–9 months of shading (McMahon et al. 2011). There is also evidence indicating that this genus is resilient to sedimentation and burial (Bearlin et al. 1999), and growth rates were unaffected following burial in 10 cm of aerobic sediment along the Adelaide coast (Clarke 1987).

Shepherd et al. (1989) list several cases of *Amphibolis* loss off the metropolitan coast for which turbidity and sedimentation can be at least partially blamed: pre-1949 loss south of the Outer Harbour breakwater; 1978–82 loss at the Port Adelaide sludge outfall (now closed); the 1968–82 loss around the Glenelg sludge outfall (now closed); and the 1935–85 loss in the inshore regions from Brighton to Semaphore. But in all cases other factors have also been implicated (Westphalen et al. 2005).

3.1.3 Zostera

The life history characteristics of *Zostera* spp. include small adult size, rapid growth rate, months to years until sexual maturity and turnover times of months to years, and the presence of a seed bank. Collectively, these characteristics have indicated a vulnerability index of 'medium/low' (Short et al. 2017).

Zostera nigricaulis[1] appears to have a relatively low minimum light requirement of only 2–9 per cent sub-surface irradiance (Duarte 1991; Bulthuis 1983; Campbell et al. 2003).

In temperate environments, *Zostera* spp. has shown limited resilience to burial, with 70–90 per cent mortality under 2–4 cm of sediment (Mills & Fonseca 2003; Cabaço & Santos 2007). Shepherd et al. (1989) reported this as a cause of the species' decline in Westernport Bay, Victoria, and suggested that the loss of 445 ha of *Z. nigricaulis* in northern Adelaide waters between 1965 and 1985 may have been due to sediment accretion on the leaf surface.

3.2 Macroalgae

Sediment deposition affects reef biota through a combination of smothering, scouring and modifying the physical characteristics of the substrate (Airoldi 2003), and can thereby influence macroalgal community structure (Turner 2004).

Generally, organisms that rely on sexual reproduction are more vulnerable than those using vegetative means, probably due to the lack of substrate stability and likelihood of smothering of new recruits. In contrast, organisms with sediment trapping morphologies, opportunistic species as well as those with physical adaptations to sediment tend to do well in sediment-affected environments (Airoldi 2003).

Short et al. (2017) assign vulnerability to different life history characteristics for macroalgae (see Table 2) and provide vulnerabilities for two examples: the kelp *Ecklonia*, which was not recorded at Smith Bay, and the canopy-forming fucoid *Sargassum*, which was found in patches.

The most abundant macroalgae recorded during surveys of Smith Bay in 2016 were the canopy-forming fucoid *Cystophora siliquosa* and the lobed understorey species *Lobophora variegata*. It would be reasonable to assume that *C. siliquosa* is likely to have similar characteristics to *Sargassum*, which is from the same taxonomic family and has been assigned a low vulnerability index score (Short et al. 2017). However, Hotchkiss (1999) characterised the life history of three other *Cystophora* species as long-living and slow-growing, which should indicate a high rather than low vulnerability index score (see Table 2). It is now clear how Short et al. (2017) apply the life history criteria to determine vulnerability index scores, given the low vulnerability index for *Sargassum*, which is slower-growing than *Cystophora* (Turner 2004), and for the kelp *Ecklonia*, which is also long-lived – years rather than months (Short et al. 2017; Shepherd & Edgar 2013).

Lobophora variegata is an opportunistic coloniser which can achieve 40 per cent cover in cleared areas in as little as 2–3 months (Shepherd & Edgar 2013).

Notwithstanding the low vulnerability index scores reported by Short et al. (2017) for *Ecklonia* and *Sargassum*, experience from South Australia suggests it is important to minimise sedimentation during recruitment periods (Turner 2004).

[1] Reported in various studies using its previous name *Heterozostera tasmanica*

3.3 Invertebrates

Short et al. (2017) provide a detailed summary of how the life history characteristics of invertebrates affect their vulnerability to dredging (see Table 2), and detailed tables of the generalised life history characteristics and vulnerabilities of many high-level invertebrate taxa (phyla, class, order) and some representative species from Western Australia or Australia generally.

The most abundant invertebrates at Smith Bay were the ascidian *Polycarpa viridis*, the gastropod *Phasianella australis*, the sea star *Pentagonaster dubeni* and the scallop *Mimachlamys asperrimus*.

The life history characteristics most relevant to the vulnerability of these species to sediment are:

- sessile organisms, such as *Polycarpa viridis*, are generally unable to reorient themselves to mitigate a build-up of particulates
- filter feeders, such as *Polycarpa viridis* and *Mimachlamys asperrimus*, can incur clogged or damaged feeding and breathing organs (Turner et al. 2006)
- broadcast spawners, such as *Phasianella australis*, *Pentagonaster dubeni* and *Mimachlamys asperrimus*, are less vulnerable than brooders but more vulnerable than asexual reproducers. Of the broadcast spawners, lecithotrophs are more vulnerable than planktivores (Short 2017).

The relative vulnerabilities of these species are shown in Table 2.

Table 2: Vulnerability to dredging of the most abundant invertebrate species at Smith Bay

Scientific name	Common name	Vulnerability index	Life history characteristics most relevant to the vulnerability assessment
Polycarpa viridis	Mauve-mouthed ascidian	Medium/high	Sessile, filter feeders
Phasianella australis	Painted lady	Medium/high	Broadcast spawner (Murray 1967, Museums Victoria Sciences Staff 2017)
Pentagonaster dubeni	Vermilion biscuit star	Medium	Broadcast spawner, likely lecithotroph (O'Hara & Byrne 2017)
Mimachlamys asperrimus	Doughboy scallop	Medium/low	Broadcast spawner (Zacharin 1995), filter feeder

4. POTENTIAL ENVIRONMENTAL WINDOWS

One means of mitigating dredging impacts on biota is the use of ‘environmental windows’ by which dredging does not take place during environmentally sensitive periods, typically associated with reproduction and recruitment.

Knowledge of natural turbidity regimes may also indicate times when artificial increases in turbidity and sedimentation may mirror the natural turbidity levels, depending on the level of flow from rivers and storm-driven re-suspension (Short et al. 2017).

A summary of sensitive periods for the most abundant species at Smith Bay is provided in Table 3, with further detail provided below.

Table 3: Sensitive periods for the most abundant species at Smith Bay

Species	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	Factor	Source
Posidonia, Amphibolis, Zostera													Reproduction	Short et al. 2017
Cystophora													Reproduction	Hotchkiss 1999
Sargassum spp.													Reproduction	Short et al. 2017
Lobophora variegata													Growth	Shepherd & Edgar 2013
Polycarpa viridis													Reproduction	Short et al. 2017
Mimachlamys asperrimus													Spawning, settlement	Zacharin 1995
Phasianella australis													Spawning, settlement	Murray 1967
Pentagonaster dubeni													(tbc – none known)	

4.1 Seagrasses

Short et al. (2017) recommend minimising pressure during the summer months to increase flowering and fruiting success and to allow carbohydrates to be generated and stored to support seagrass survival during winter. *Posidonia* species generally flower during winter and fruit over summer, but productivity during summer is likely to be important in determining flowering and fruiting success (Short et al. 2017). *Amphibolis* species flower during autumn, with seedlings released between November and June and being present all year. *Zostera nigricaulis* reproductive structures have been observed in September and mature flowers have been observed during summer. Production is highest during summer and late spring (Short et al. 2017).

4.2 Macroalgae

Three species of *Cystophora* were observed to begin growing reproductive structures from January to June, with egg growth between March and June and release between August and October (Hotchkiss 1999).

The fastest growth in *Lobophora variegata* has been observed in NSW in autumn to spring (Shepherd & Edgar 2013).

Sargassum spp. has been observed reproducing from September to December at Rottnest Island in Western Australia, but there is considerable spatial variation in annual reproductive cycles of *Sargassum* (Short et al. 2017).

4.3 Invertebrates

The doughboy scallop (*Mimachlamys asperrimus*) matures through winter in Tasmania. A major spawning event occurs in late September to mid-October, and minor spawning may be observed in December. Settlement was highest in December following the major spawning event (Zacharin 1995).

4.4 Conclusions

There are no clear environmental windows that offer the opportunity to significantly reduce impacts associated with dredging. Although dredging during winter rather than summer would avoid sensitive periods for the reproduction of seagrasses and invertebrates, it would not benefit macroalgae, which reproduces in winter, and southern right whales, which may visit the area during winter. Consequently, there are no persuasive ecological arguments for dredging during a particular season.

5. REFERENCES

Aztec Analysis 2017, *Kangaroo Island Plantation Timbers (KIPT) Export Facility at Smith Bay. Basis of Design Report*, Unpublished report to KIPT, 28 July 2017.

Airoldi, L 2003, ‘The effects of sedimentation on rocky coast assemblages’, *Oceanography and Marine Biology Annual Review*, vol. 41, pp. 161–236.

Bearlin, AR, Burgman, MA & Regan, HM 1999, ‘A stochastic model for seagrass (*Zostera muelleri*) in Port Phillip Bay, Victoria, Australia’, *Ecological Modelling*, vol. 118, pp.131–148.

Bryars, S, Collings, G & Miller, D 2011, ‘Nutrient exposure causes epiphytic changes and coincident declines in two temperate Australian seagrasses’, *Marine Ecology Progress Series*, vol. 441, pp. 89–103.

Bulthuis, DA 1983, ‘Effects of in-situ light reduction on density and growth of the seagrass *Heterozostera tasmanica* (Martens ex Aschers.) den Hartog in Western Port, Victoria, Australia’, *Journal of Experimental Marine Biology and Ecology*, vol. 67, pp. 91–103.

Burkholder, JM, Mason, KM & Glasgow, HB 1992, ‘Water-column nitrate enrichment promotes decline of eelgrass *Zostera marina*: evidence from seasonal mesocosm experiments’, *Marine Ecology Progress Series*, vol. 81, pp.163–178.

Cabaço, S & Santos, R 2007, ‘Effects of burial and erosion on the seagrass *Zostera nolti*’, *Journal of Experimental Marine Biology and Ecology*, vol. 340, pp. 204–212.

Campbell, S, Miller, C, Steven, A & Stephens, A 2003, ‘Photosynthetic responses of two temperate seagrasses across a water quality gradient using chlorophyll fluorescence’, *Journal of Experimental Marine Biology and Ecology*, vol. 291, pp. 57–78.

Cheshire, AC & Miller, DJ 1999, *The impact of sand dredging on Benthic Community Structure at Pt Stanvac Dredge Site: Final report on the results of surveys 1992 to 1999*, Report to the Coast Protection Board, South Australian Department of Environment and Natural Resources.

Cheshire, AC, Miller, DJ, Murray-Jones, S, Scriven, L & Sandercock, R 2002, *The Section Bank: Ecological Communities and Strategies for the Minimisation of Dredging Impacts*, Report to the Office for Coast and Marine, National Parks and Wildlife South Australia, Department for Environment and Heritage. South Australian Research and Development Institute, Aquatic Sciences Division, Adelaide.

Clarke, S 1987, ‘Seagrass-sediment dynamics in Holdfast Bay: summary’, *SA Fish*, vol. 11, pp. 4-10.

Collier, CJ, Lavery, PS, Ralph, PJ & Masini, RJ 2009, ‘Shade-induced response and recovery of the seagrass *Posidonia sinuosa’*, *Journal of Experimental Marine Biology and Ecology*, vol. 370, pp. 89–103.

Collings, G, Miller, D, O’Loughlin, E, Cheshire, A & Bryars, S 2006, *Turbidity and reduced light responses of the meadow forming seagrasses* Amphibolis *and* Posidonia*, from the Adelaide metropolitan coastline*, ACWS Technical Report No. 12 prepared for the Adelaide Coastal Waters Study Steering Committee, South Australian Research and Development Institute (Aquatic Sciences), Publication No. RD01/0208-17, Adelaide.

Duarte, CM 1991, ‘Seagrass depth limits’, *Aquatic Botany*, vol. 40, pp. 363–377.

EPA 2003, *Environment Protection (Water Quality) Policy 2003 and Explanatory Report*. Environment Protection Authority, South Australian Government, Adelaide

EPA 2010, *Water quality guidelines: Dredging and Earthworks Drainage*, EPA 396/10, Environment Protection Authority, South Australian Government, Adelaide.

Erftemeijer, PL & Lewis, RR 3rd 2006, ‘Environmental impacts of dredging on seagrasses: a review’, *Marine Pollution Bulletin*, vol. 52, pp. 1553–1572.

Fox, DR, Batley, GE, Blackburn, D, Bone, Y, Bryars, S, Cheshire, A, Collings, G, Ellis, D, Fairweather, P, Fallowfield, H, Harris, G, Henderson, B, Kämpf, J, Nayar, S, Pattiaratchi, C, Petrusevics, P, Townsend, M, Westphalen, G & Wilkinson, J 2007, *The Adelaide Coastal Water Study Final Report, Volume 1*, Prepared for the South Australian Environment Protection Authority, CSIRO Marine and Atmospheric Research.

Fraser, MW, Short, J, Kendrick, GA, McLean, D, Keesing, J, Byrne M, Caley, MJ, Clarke, D, Davis, AR, Erftemeijer, PLA, Field, S, Gustin-Craig, S, Huisman, J, Keough, M, Lavery, PS, Masini, R, McMahon, K, Mengersen, K, Rasheed, M, Statton , J, Stoddart, J & Wu, P 2017, ‘Effects of dredging on critical ecological processes for marine invertebrates, seagrasses and macroalgae, and the potential for management using environmental windows using Western Australia as a case study,’ *Ecological Indicators* doi:10.1016/j.ecolind.2017.03.026

Gordon, D, Grey, K, Chase, S & Simpson, C 1994, ‘Changes to the structure and productivity of a *Posidonia sinuosa* meadow during and after imposed shading’, *Aquatic Botany*, vol. 47, pp. 265–275.

Hotchkiss, SL1999, *Comparison of the demographics of three species of* Cystophora, PhD thesis. Department of Environmental Biology, University of Adelaide.

Kilminster, K, McMahon, K, Waycott, M, Kendrick, GA, Scanes, P, McKenzie, L, O'Brien, KR, Lyons, M, Furguson, A, Maxwell, P, Glasby, T & Udy, J 2015, 'Unravelling complexity in seagrass systems for management: Australia as a microcosm', *Science of the Total Environment*, vol. 534, pp. 97–109.

Manzanera, M, Pérez, M & Romero, J 1998, 'Seagrass mortality due to oversedimentation: an experimental approach', *Journal of Coastal Conservation*, vol. 4, no. 1, pp. 67–70.

McMahon, K, Lavery, PS & Mulligan, M 2011, 'Recovery from the impact of light reduction on the seagrass *Amphibolis griffithii*, insights for dredging management', *Marine Pollution Bulletin*, vol. 62, pp. 270–283.

Mills, KE & Fonseca, MS 2003, 'Mortality and productivity of eelgrass *Zostera marina* under conditions of experimental burial with two sediment types', *Marine Ecology Progress Series*, vol. 255, pp. 127–134.

Murray, FV 1967, 'Reproduction in the pheasant shell *Phasianella australis', Victoria Naturalist*, vol. 84, pp. 39–40.

Museums Victoria Sciences Staff 2017, '*Phasianella australis* Pheasant Shell', In Museums Victoria Collections, viewed 17 August 2017, <https://collections.museumvictoria.com.au/species/8729)>.

Neverauskas, VP 1988, 'Response of a *Posidonia* community to prolonged reduction in light', *Aquatic Botany*, vol. 31, pp. 361–366.

O'Hara, T & Byrne, M (eds) 2017, *Australian Echinoderms: Biology, Ecology and Evolution*, CSIRO Publishing, Clayton.

Shepherd, SA & Edgar GJ (eds) 2013, *Ecology of Australian Temperate Reefs*, CSIRO Publishing, Collingwood, Victoria.

Shepherd, SA, McComb, AJ, Bulthuis, DA, Neverauskas, VP, Steffensen, DA & West, R 1989, 'Decline of seagrasses', In Larkum, AWD, McComb, AJ & Shepherd, SA (eds), *Biology of seagrasses*, Elsevier, Amsterdam, pp. 346–388.

Short, J, Fraser, M, McLean, D, Kendrick, G, Byrne, M, Caley, J, Clarke, D, Davis, A, Erftemeijer, P, Field, S, Gustin-Craig, S, Huisman, J, Keesing, J, Keough, M, Lavery, P, Masini, R, McMahon, K, Mergersen, K, Rasheed, M, Statton, J, Stoddart, J & Wu, P 2017, *Effects of dredging-related pressures on critical ecological processes for organisms other than fish or coral*, Report of Theme 9 – Project 9.1, prepared for the Dredging Science Node, Western Australian Marine Science Institution, Perth, Western Australia.

Thorhaug, A & Austin, CB 1976, 'Restoration of seagrasses, with economic analysis', *Environmental Conservation*, vol. 3, no. 4, pp. 259–267.

Turner, DJ 2004, *Effects of sedimentation on the structure of a phaeophycean dominated macroalgal community*, PhD thesis, Department of Environmental Biology, University of Adelaide.

Turner, DJ, Kildea, TN & Murray-Jones, S 2006, *Examining the health of subtidal reef environments in South Australia. Part 1: Background review and rationale for the development of the monitoring program*, South Australian Research and Development Institute (Aquatic Sciences), RD03/0252-5, Adelaide.

Vermaat, JE, Agawin, N, Fortes, M, Uri, J, Duarte, C, Marba, N, Enriquez, S & Van Vierssen, W 1997, 'The capacity of seagrasses to survive increased turbidity and siltation: the significance of growth form and light use', *Ambio*, vol. 26, pp. 499–504.

Victory, K, Kildea, T, Bohm, S & Pannell N 2010, *Environmental management driving solutions – a novel approach to minimising environmental impacts associated with construction of the Adelaide Desalination Plant*, Australian Water Association, Adelaide.

Westphalen, G, Collings, G, Wear, R, Fernandes, M, Bryars, S & Cheshire, A 2005, A review of seagrass loss on the Adelaide metropolitan coastline, ACWS Technical Report No. 2, prepared for the Adelaide Coastal Waters Study Steering Committee, South Australian Research and Development Institute (Aquatic Sciences) Publication No. RD04/0073, Adelaide.

Wiltshire, DJ, Mifsud, J, Petrusevics, P, Blackburn, D, & Ralph, D 2004, *False Bay Marine Environment Studies Autumn/Winter 2004*, Unpublished report to OneSteel Ltd.

Wiltshire, DJ 2014, *False Bay Seagrass Monitoring*, Unpublished report to OneSteel Ltd.

Zacharin, W 1995, *Growth, reproduction and recruitment of the Doughboy scallop*, Mimachlamys asperrimus *(Lamarck) in the D'Entrecasteaux Channel, Tasmania, Australia*, Masters thesis, University of Tasmania.

Appendix I5 – Marine Pests and Diseases

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

The introduction of marine pests to Kangaroo Island from overseas and Australian ports is a potential risk associated with construction and operation of the proposed KI Seaport .

The vectors of pest species most relevant to the operation of the facility are:

- the marine disposal of ship ballast water, which can contain cysts, larvae or juveniles
- biofouling (encrusting organisms) on ship hulls that can spread by breaking off during asexual growth, or through the release of spawn.

Although ballast water and biofouling are the two most common vectors of marine pests (Hewett & Campbell 2010), other potential vectors during construction include:

- jack-up barge legs
- anchors
- anchor chains
- mooring lines
- sediment transported on hulls
- any seawater carried incidentally on vessels such as in bilges, inside pipes or pumps.

Introduced marine species can rapidly multiply after a disturbance, removal of competitive indigenous species, or provision of unoccupied hard surfaces (pontoon structures). Dredging can provide essentially barren sites for colonisation that are free from competition by native species.

More than 250 introduced marine species have been recorded in Australia (DAWR 2016a), and more than 20 on Kangaroo Island (Wiltshire et al. 2010). Although most introduced marine species have little impact, some establish large populations rapidly and spread geographically, resulting in adverse effects on native species and/or human activities. These species are referred to as introduced marine pests (DAWR 2016a). Once established, marine pests can prey directly upon, displace or outcompete indigenous species, and could carry diseases which could eliminate native species.

Introduced marine pests are difficult to eradicate, particularly once they have established a large population. Prevention and early detection with rapid response are the most effective strategies for minimising the risks and consequences associated with aquatic pests.

No introduced marine species have been recorded near Smith Bay, including during the marine surveys undertaken there in 2016, 2017 and 2018. The closest records to the east are of the European fan worm at the Bay of Shoals and a number of species at Kingscote, and to the west a barnacle and a number of ascidians at Western River Cove (Wiltshire et al. 2010).

2. PRIORITY PEST SPECIES

A priority list of invasive marine species (IMS) is being developed by the Australian Government, overseen by a Marine Pests Steering Committee that includes representatives of all state and territory governments (DAWR 2015). A priority list was developed previously by the CSIRO (Hayes et al. 2005).

All exotic species are of concern to the South Australian Government, but the Department of Primary Industry and Regions South Australia (PIRSA) (2017) listed a number of marine pests of most concern. Many of these, and other species, have been declared 'noxious' under the Fisheries Management Act 2007 and are also listed on the PIRSA website (PIRSA 2015).

Some of the species from these lists are already established in Kangaroo Island waters, including the European fan worm (*Sabella spallanzanii*) and the vase tunicate (*Ciona intestinalis*), or elsewhere in South Australia, including the aquarium weed (*Caulerpa taxifolia*) and the European green shore crab (*Carcinus maenas*). Others are established elsewhere in Australia and are considered to be potential threats to South Australia, including the Northern Pacific sea star (*Asterias amurensis*), Asian green mussel (*Perna viridis*), Japanese seaweed (*Undaria pinnatifida*), New Zealand screwshell (*Maoricolpus roseus*) and Chinese mitten crab (*Eriocheir sinensis*).

A list of the species ranked as high or medium priority by CSIRO (Hayes et al. 2005) of most concern to PIRSA, declared noxious or recorded on Kangaroo Island is provided in Table 1. Further information is provided below for the species ranked high priority by the CSIRO, those ranked medium priority by the CSIRO and already recorded on Kangaroo Island, and those of most concern to PIRSA. Exceptions that meet those criteria but are considered unlikely to establish in the oceanographic environment at Smith Bay include:

- the microalgae (dinoflagellates) *Alexandrium* spp. which are restricted to coastal, nutrient-enriched sites, particularly harbours, estuaries and lagoons (GISD 2017)
- the golden mussel *Limnoperna fortunei*, primarily a freshwater species (Australian Government 2017)
- the copepod (*Pseudodiaptomus marinus*), which inhabits shallow, nutrient-rich inshore waters (Sabia et al. 2014)
- *Caulerpa taxifolia*, which is known to have established itself only within Port Adelaide; its presence is thought to be related to the nutrient loading and warmer waters of that estuary (Wiltshire et al. 2010)
- the pearl oyster (*Pinctada albina sugillata*), a subtropical species that has become established in South Australia only within Upper Spencer Gulf and Smoky Bay (Wiltshire et al. 2010)
- the Pacific oyster (*Crassostrea gigas*), which prefers sheltered waters in estuaries to a depth of about three metres. Shipping is not a recognised vector for this species (Australian Government 2017)
- the Chinese mitten crab (*Eriocheir sinensis*), a predominantly freshwater species with juveniles relocating from fresh water to saltwater habitats before reproduction
- *Caulerpa cylindracea*, restricted to the Adelaide region (Wiltshire et al. 2010).

Gymnodinium catenatum

Gymnodinium catenatum is a toxic, bloom-forming species of microalgae found in bays and estuaries throughout the world. Vegetative cells can be distributed throughout the entire water column, with cysts being found in sediments. Toxins produced by *G. catenatum* accumulate in shellfish (oysters, mussels and scallops) which then become toxic to humans and other organisms. *G. catenatum* also threatens wild and aquaculture shellfish industries due to economic losses resulting from farm closures (Hayes et al. 2005). On Kangaroo Island it has been recorded in Eastern Cove, Western Cove and American River (Wiltshire et al. 2010).

European fan worm

The European fan worm (*Sabella spallanzanii*) is a filter-feeding tube worm which can compete with native organisms for food and space. Some species of seagrass can be impacted by these worms settling on their fronds (CSIRO 2001). The European fan worm is considered a major threat to benthic assemblages in both hard- and soft- bottom habitats and potentially affects nutrient cycling processes in soft sediments (O'Brien et al. 2006). It has been estimated that S. spallanzanii can filter around 12 m^3/day per square metre of habitat (Stabilia et al. 2006). This rate of filter-feeding can drastically affect the abundance of plankton, including larvae, so the impacts of this species go beyond smothering and biofouling. It has been identified at American River, Kingscote and Bay of Shoals (Wiltshire et al. 2010).

The species can be transported by cargo vessels (either on the hull, in ballast water or attached to cargo), through fisheries and aquaculture (by vessels, accidental translocation through aquaculture farm activities), recreational vessels (hulls and moorings) or through natural dispersal once it has established in an area.

Codium fragile ssp. tomentosoides

Codium fragile ssp. *tomentosoides* is an alga that has been introduced around the world through shellfish aquaculture, recreational boating and transport on ship hulls. This IMS can reproduce sexually, parthenogenetically, and vegetatively which makes eradication difficult. It can propagate from small pieces of the parent plant that can be broken off by propeller wash or hull cleaning (from recreational vessels) and then carried by water currents over long distances, introducing it to new locations. This invasive marine species also tolerates various salinity and water temperature levels and thrives in sheltered habitats. It has been recorded at American River (Wiltshire et al. 2010).

The main threats it poses result from its tendency to overgrow and smother shellfish beds, often attaching to the shells of oysters, mussels, scallops and clams and hindering the movement and feeding of the shellfish.

The Asian date or bag mussel

The Asian date or bag mussel (*Musculista senhousia*) is a small, short-lived mussel native to East Asia. It has been identified within Port Adelaide and southern Spencer Gulf (Jacobs 2015). It can grow rapidly and is capable of marked habitat alteration through reaching high densities (more than 2000 individuals per square metre) on the surface of soft sediments. It can form continuous carpets that smother most other benthic habitat-forming organisms (GISD 2017). The mussel is an opportunistic species capable of fouling wharf piles and artificial structures and can be found from intertidal to subtidal soft-bottom habitats to a depth of 20 metres. This species is a filter-feeder and due to its high densities can have dramatic impacts on plankton abundance and reduce the densities of native bivalves. High densities of this mussel can alter the natural benthic habitat dramatically, changing both the local physical environment and the resident macroinvertebrate assemblage and the growth of nearby seagrass (GISD 2017).

Polysiphonia brodiei

Polysiphonia brodiei is a branched filamentous red macroalga that has become one of the most globally widespread invasive marine species. It has been introduced through ships to Australia, New Zealand and Japan and has been recorded at American River. It is a hull-fouling organism on slow-moving vessels such as barges, and also fouls ropes, buoys and harbour structures such as pylons and boat ramps. Apart from biofouling there are currently no other known impacts from this species (GISD 2017).

Watersipora spp.

Watersipora are encrusting bryozoans whose tolerance of copper-based anti-fouling coatings on ships' hulls provides a non-toxic surface for other fouling species to settle and spread. This species is considered widely invasive in temperate ports (GISD 2017). In addition to assisting in the spread of other IMS, *Watersipora* can also compete with native bryozoans and other encrusting organisms and, once established, are often the most common intertidal bryozoan.

European shore crab

The European or green shore crab (*Carcinus maenas*) is a voracious predator that feeds on many types of organisms, including shellfish and other crabs. It can impact epibenthic (organisms that live on sea-floor sediments) and infaunal (substrate-dwelling) species such as bivalves, other molluscs and crustaceans, through predation, competition, and burrowing (GISD 2017). This species is a potential facilitator of another IMS, *Styela*, which is an invasive club tunicate in some areas (GISD 2017). The crabs could facilitate *Styela* invasions by preying on tunicate predators, enabling *Styela* to establish. The European shore crab is known to consume prey from at least 158 genera and has been widely documented to reduce the diversity and biomass of estuarine communities. The species has been previously identified in Port Adelaide, but recent surveys have failed to detect this crab again (Wiltshire & Deveney 2011).

Asian green mussel

The Asian green mussel (*Perna viridis*) forms dense populations (up to 35,000 individuals per square metre) on a variety of structures including vessels, wharves, mariculture equipment, buoys and other hard substrata. It is susceptible to overgrowth from other fouling organisms that make it difficult to detect despite its vivid green appearance. Although it is primarily found in estuarine habitats, it has a broad salinity and temperature tolerance.

P. viridis can foul vessels and clog the pipes of water systems of industrial complexes, increasing corrosion and reducing efficiency. Ecologically, *P. viridis* is able to outcompete many other fouling species, causing changes in community structure and trophic (feeding and nutrition) relationships. *P. viridis* has also been recorded with high levels of accumulated toxins and heavy metals and is linked to shellfish poisoning in humans.

Bugula neritina

Bugula neritina is one of the most abundant bryozoans in ports and harbours and an important member of the fouling community. It colonises heavily on any freely available substratum, including many artificial underwater structures and vessel hulls. It has been recorded at Penneshaw jetty.

Japanese seaweed

The Japanese seaweed (*Undaria pinnatifida*) is a brown seaweed that can reach an overall length of one to three metres. It is highly invasive, grows rapidly and has the potential to overgrow and exclude native algal species, indirectly affecting herbivores that would normally consume native species. The species is thought to be transported in ballast water, as hull fouling, or with imported oysters. It has been recorded in Victoria and Tasmania (Hayes et al. 2005).

New Zealand screw shell

The New Zealand screw shell (*Maoricolpus roseus*) appears to prefer areas of coarse or firm substrata, moderate to strong currents, depths up to 130 metres and temperatures between 8°C and 20°C. It can compete with native gastropods for food and space (Australian Government 2017).

North Pacific sea star

The North Pacific sea star (*Asterias amurensis*) is a large sea star that has become established in Tasmania and Victoria. It is a voracious predator, feeds on a wide range of native animals in Australia and can have a major effect on the recruitment of native shellfish populations that form important components of the marine food chain (Hayes et al. 2005).

Megabalanus tintinnabulum

Megabalanus tintinnabulum is a common fouling species of barnacle found in many types of habitat. These include rock and boulder areas, pylons, wharves, vessel hulls and even other organisms such as mussels and algae. It can be found to a depth of 40 metres and is distributed throughout both the intertidal and subtidal zones. It is also able to withstand temperatures up to 35°C.

Table 1: Introduced marine species relevant to Smith Bay

Group	Species	Common name	National priority	PIRSA concern	Declared noxious	Recorded on Kangaroo Island
Ascidians	*Ascidiella aspersa*	European sea squirt				Y
Ascidians	*Botrylloides leachi*					Y
Ascidians	*Botryllus schlosseri*					Y
Ascidians	*Ciona intestinalis*	vase tunicate	M	Y		Y
Ascidians	*Didemnum spp.* (exotic strains only)				Y	
Ascidians	*Styela clava*		M			
Ascidians	*Styela plicata*					Y
Bryozoans	*Bryopsis plumosa*					Y
Bryozoans	*Bugula flabellata*		M			
Bryozoans	*Bugula neritina*		M			Y
Bryozoans	*Schizoporella errata*		M			
Bryozoans	*Tricellaria occidentalis*		M			
Bryozoans	*Watersipora arcuata*		M			
Bryozoans	*Watersipora subtorquata*		M			
Cnidarians	*Balanus eburneus*	(a barnacle)	M			
Cnidarians	*Balanus reticulatus*	(a barnacle)	M			
Cnidarians	*Balanus improvisus*	(a barnacle)			Y	
Cnidarians	*Megabalanus rosa*	(a barnacle)	M			
Cnidarians	*Megabalanus tintinnabulum*	(a barnacle)	M			Y
Cnidarians	*Mnemiopsis leidyi*	comb jelly			Y	
Cnidarians	*Sabella spallanzanii*	European fan worm	M	Y	Y	Y

Group	Species	Common name	National priority	PIRSA concern	Declared noxious	Recorded on Kangaroo Island
Crustaceans	*Carcinus maenas*	European green shore crab	M	Y	Y	
Crustaceans	*Charybdis japonica*	lady crab	M		Y	
Crustaceans	*Eriocheir sinensis*	Chinese mitten crab	M	Y	Y	
Crustaceans	*Hemigrapsus sanguineus*	Japanese shore crab	M		Y	
Crustaceans	*Hemigrapsus takanoi/ penicillatus*	Pacific crab			Y	
Crustaceans	*Pseudodiaptomus marinus*	(a copepod)	M			
Echinoderms	*Asterias amurensis*	Northern Pacific sea star	M	Y	Y	
Fish	*Neogobius melanostomus*	round goby	M		Y	
Fish	*Siganus rivulatus*	rabbit fish			Y	
Fish	*Tridentiger bifasciatus*	shimofuri goby	M			
Macroalgae	*Caulerpa cylindracea*	(green macroalga)		Y		
Macroalgae	*Caulerpa taxifolia*	(green macroalga)		Y	Y	
Macroalgae	*Cladophora prolifera*	(green macroalga)				Y
Macroalgae	*Codium fragile ssp. tomentosoides*	(green macroalga)			Y	Y
Macroalgae	*Grateloupia turuturu*	(red macroalga)			Y	
Macroalgae	*Hincksia sandriana*	(brown filamentous macroalga)				Y
Macroalgae	*Polysiphonia brodiei*	(red macroalga)	M			Y
Macroalgae	*Sargassum muticum*	Asian seaweed			Y	
Macroalgae	*Ulva lactuca*					Y
Macroalgae	*Ulva taeniata*					Y
Macroalgae	*Undaria pinnatifida*	Japanese seaweed	M	Y	Y	
Microalgae	*Alexandrium catenella*					Y
Microalgae	*Alexandrium minutum*		H			Y
Microalgae	*Alexandrium tamarense*					Y
Microalgae	*Gymnodinium catenatum*		H			Y
Microalgae	*Heterosigma akashiwo*					Y
Molluscs	*Corbula amurensis*	Asian clam	M		Y	

Group	Species	Common name	National priority	PIRSA concern	Declared noxious	Recorded on Kangaroo Island
Molluscs	*Crassostrea gigas*	Pacific oyster	M	Y		Y
Molluscs	*Crepidula fornicata*	American slipper limpet			Y	
Molluscs	*Ensis directus*	jack-knife clam			Y	
Molluscs	*Limnoperna fortunei*	golden clam	M			
Molluscs	*Maoricolpus roseus*	New Zealand screwshell	M	Y	Y	
Molluscs	*Musculista senhousia*	Asian date mussel	M		Y	
Molluscs	*Mya arenaria*	soft shell clam			Y	
Molluscs	*Mytilopsis sallei*	black-striped mussel	M		Y	
Molluscs	*Perna perna*	brown mussel			Y	
Molluscs	*Perna viridis*	Asian green mussel	H	Y	Y	
Molluscs	*Pinctada albina sugillata*	pearl oyster		Y		
Molluscs	*Rapana venosa*	rapa whelk			Y	
Molluscs	*Varicorbula gibba*	European clam			Y	
Polychaetes	*Hydroides ezoensis*		M			
Polychaetes	*Hydroides sanctaecrucis*		M			
Polychaetes	*Marenzelleria spp*	red-gilled mudworm			Y	

Source: PIRSA 2015, 2017; Wiltshire et al. 2010; Hayes et al. 2005; P. Jennings, Kangaroo Island NRM group, pers. comm. 23 August 2017.

Note for National Priority, H = high priority, M = medium priority

3. DISEASES

Regarding the proposed KI Seaport and the existing adjacent abalone farm, it would be essential that measures were taken to ensure that no abalone-related diseases were introduced. The two most significant diseases are abalone viral ganglioneuritis and the parasite *Perkinsus*.

Abalone viral ganglioneuritis

Abalone viral ganglioneuritis causes mass mortalities of abalone (PIRSA 2009). A 2006–07 outbreak in Victoria, within 40 km of the South Australian border, resulted in severe economic loss through a catch that was more than halved. Very little is known about the virus, including how it infects abalone or how long it survives outside the host (PIRSA 2009). There is a risk that it may spread into South Australia through potential vectors such as translocation of stock, discharge from aquaculture facilities, launch and retrieval of anchors or pots, abalone fishing and the use of abalone as berley or bait (PIRSA 2009). Shipping, however, has not been identified as a possible vector.

Abalone parasite Perkinsus

Perkinsus is a genus of protozoan parasites that have been implicated in the death of clams, oysters and abalone worldwide (Goggin & Lester 1995). In South Australia, the native species *Perkinsus olseni* has been known to infect both greenlip and blacklip abalone, causing mortalities or reducing market value in both cultured and wild stocks (PIRSA 2009). Abalone are more susceptible to *Perkinsus* at higher temperatures, and outbreaks are therefore more prevalent north-west of Kangaroo Island; locations known to have persistent, high levels of infection include Neptune Island and the south-eastern tip of Yorke Peninsula (Goggin & Lester 1995). The parasite is transmitted through the release of zoospores from the blistered or decaying mollusc tissue (Theil et al. 2004). The zoospores are motile (capable of motion) and can survive in saltwater for several weeks (DAFF 2012).

4. INSTITUTIONAL ARRANGEMENTS AND POLICIES TO CONTROL MARINE PESTS

Growing concerns about the significance of the problem of marine pests have generated a number of policy developments in relation to their control, including:

- development of the National System for the Prevention and Management of Marine Pest Incursions (Australian Government 2013a)
- a review of National Marine Pest Biosecurity Arrangements (DAWR 2015)
- replacement of the *Quarantine Act 1908* (and Quarantine Regulations 2000) by the *Biosecurity Act 2015* (and Biosecurity Regulations 2016) from 16 June 2016
- ratification of the International Convention for the Control and Management of Ballast Water and Sediments (BWM Convention), which came into force on 8 September 2017
- updates to the *Australian Ballast Water Management Requirements*, now at Version 7 (DAWR 2017a)
- adoption of the *Anti-fouling and In-water Cleaning Guidelines* in 2013 (Australian Government 2015), which replaced the Australian and New Zealand Environment and Conservation Council's Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance
- development of a Code of Practice for Vessel and Facility Management in South Australia (Ballantine 2017)
- development of a Biosecurity Strategy for Kangaroo Island (KI National Resources Management Board 2017).

A summary of the current institutional arrangements and key policy instruments is provided in Table 2. The aspects of these control measures most relevant to the Smith Bay development are described below.

4.1 Biosecurity Act 2015

The *Biosecurity Act 2015* provides a framework for the Commonwealth Department of Agriculture and Water Resources to extend its regulatory responsibilities to ensure consistent domestic ballast water regulations are in place throughout Australia, thereby reducing the risk of transferring marine pests between Australian ports.

These arrangements were implemented upon the BWM Convention coming into force in late 2017. They establish a consistent framework for the management of ballast associated with vessels undertaking domestic transport within Australia and those undertaking international transport.

Relevant aspects of the *Biosecurity Act 2015* are:

- Vessels become subject to Australian biosecurity controls when they enter Australian waters and remain so until they are released from biosecurity control.
- If a vessel intends to visit an Australian port, it must first arrive and be processed at one of the designated first points of entry, unless special permission has been granted.
- Ports can be determined as points of entry on specific request to the Director of Biosecurity.
- Designated points of entry in southern and western Australia include Geraldton, Fremantle, Bunbury, Albany, Esperance, Port Lincoln and Port Adelaide.
- A report must be submitted if ballast water is intended to be discharged in Australian seas.
- Specific records of ballast water discharge must be maintained.

4.2 Ballast water

Vessels entering Australia are required to comply with the Australian Ballast Water Management Requirements, which include:

- Ballast water is expected to be discharged on the high seas before a ship enters Australian waters.
- A report must be submitted at the first point of entry if ballast water is intended to be discharged in Australian territorial seas (12–96 hours before the intended discharge), which can only occur under specific circumstances. It is an offence if this is neglected, updated or incorrect.
- Records must be kept of ballast water use and the ballast water management system in use.
- The transport of high-risk ballast water (from a high-risk source, comprising about five per cent of ballast water) through Australian seas is discouraged.

4.3 Biofouling

The Review of National Marine Pest Biosecurity (DAWR 2015) recommended that Australia introduce mandatory biofouling regulations for international vessels consistent with those set by the International Maritime Organization's *Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species* (IMO 2011). The Australian Government is currently assessing options for biofouling management.

Several guidelines have been produced to manage risks posed by biofouling management measures, including:

- Management of Biofouling for Commercial Vessels (Australian Government 2009a)
- Management of Biofouling for Recreational Vessels (Australian Government 2009b)
- Anti-fouling and In-water Cleaning Guidelines (recently revised) (Australian Government 2015).

The commercial vessel biofouling management guideline provides advice on biofouling management issues including:

- risks associated with fouling organisms
- pest identification
- hull antifouling systems

- susceptible sites for biofouling, including seawater inlet pipes and overboard discharges, hull appendages and niches, internal seawater systems and engine cooling water
- in-water cleaning of hulls.

4.4 Kangaroo Island Biosecurity Strategy

Kangaroo Island has become an important tourist destination based on its outstanding natural environment, and its clean, green image. Effective biosecurity is considered crucial to protecting the Island from the impacts that introduced pests and diseases may have on biodiversity, primary production and social amenity.

Consequently, the Kangaroo Island Natural Resources Management Board (2017) has produced a Biosecurity Strategy for Kangaroo Island to provide a more local focus for the control and management of pests. Fitting within the overarching state, national and international frameworks, the guiding principles of the strategy are summarised as follows.

- Everything that arrives on Kangaroo Island poses some level of biosecurity risk.
- In situations where legislative or policy controls do not exist, other steps will be taken to manage the risk, including building awareness, promoting best practice, developing memorandums of understanding (MOUs), and other regional arrangements.
- Biosecurity is the responsibility of all those who live, travel to or do business on Kangaroo Island. It is crucial that people are aware of and understand the risk unwanted pests and disease pose to the Island's environmental, social and economic well-being, and that they understand their role in minimising this risk.
- All terrestrial, freshwater and marine ecosystems and associated Kangaroo Island industries that depend on a healthy natural environment require protection from introduced pests and diseases.
- Kangaroo Island-specific risks will take into account the absence of certain pests and diseases on the Island, and the potentially significantly greater impacts associated with their spread than on the mainland.

Kangaroo Island's biosecurity system is stated as being built on a number of foundations that determine the response to biosecurity risks. These foundations are:

- that prevention is better than cure
- a risk-based approach
- awareness and understanding
- response arrangements.

The key objectives of the Biosecurity Strategy for Kangaroo Island are to ensure that:

- Surveillance and monitoring systems are in place to help detect biosecurity threats early.
- Current and emerging biosecurity threats are assessed and prioritised to ensure a strategic, targeted risk-based response.
- All agencies, industries, community members and visitors are aware of regional biosecurity requirements on the Island and their roles and responsibilities in implementing biosecurity safeguards and controls.
- Adequate response and control arrangements are in place and the capability exists to respond effectively to high-risk biosecurity threats.
- Management of existing pests and diseases is coordinated across the public and private sectors to limit their spread and impact.

- Appropriate governance arrangements are in place to ensure effective leadership, planning, evaluation and improvement of the Island's biosecurity system.

The strategy identifies strategies, stakeholders, responsibilities and key performance indicators to guide the implementation of each objective.

Table 2: Summary of institutional arrangements and key policy instruments across jurisdictions.

Issue	International	National	South Australia	Kangaroo Island
Institutional arrangements		The Marine Pest Sectoral Committee (MPSC) coordinates the implementation of Australia's National System for the Prevention and Management of Marine Pest Incursions (the National System). It has representatives from the Australian Government and each state and territory (DAWR 2016b, Australian Government 2013a).	Biosecurity SA coordinates state-wide responses to incursions and management of existing pest animal species to minimise impact on primary industries, natural ecosystems and public safety (CISS 2015).	The Kangaroo Island NRM Board develops its own Regional NRM Plan and local programs. It also has responsibility for ensuring declared pest species are effectively managed within its region (CISS 2015).
Ballast water	*International Convention for the Control and Management of Ballast Water and Sediments* (BWM Convention), which came into force on 8 September 2017.	*Australian Ballast Water Management Requirements*, Version 7 (DAWR 2017a) Domestic ballast water management arrangements are being developed under the *Biosecurity Act 2015* to complement the existing requirements for international vessels (Australian Government 2016).		
Biofouling	*2011 Guidelines for the control and management of ships' biofouling to minimise the transfer of invasive aquatic species* (IMO 2011). *International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001* (AFS Convention).	*National Biofouling Management Guidelines for Commercial Vessels* (Australian Government 2009a). *Anti-fouling and in-water cleaning guidelines* (Australian Government 2015). Manages risks posed by biofouling management measures. The Review of National Marine Pest Biosecurity recommended that Australia introduce mandatory biofouling regulations for international vessels consistent with IMO (2011). The Australian Government is assessing options for biofouling management (DAWR 2017b).	*EPA – Code of Practice for Vessel and Facility Management (Marine and Inland Waters)* (Ballantine 2017).	

5. MONITORING

The National System for the Prevention and Management of Marine Pest Incursions includes a monitoring strategy (the National Monitoring Strategy) for the early detection of new pest arrivals. It aims to detect pest species at high-risk locations throughout Australia, including Port Adelaide, but can be applied to other monitoring locations (Australian Government 2013b).

The *Australian marine pest monitoring guidelines* (DAFF 2010a) provide the rationale for the approach to the routine collection of monitoring data and how this data will be used to inform decision-making in the Australian context. The guidelines complement the *Australian marine pest monitoring manual* (DAFF 2010b), which is a 'how to guide' for marine pest monitoring within Australia, intended for use by government and jurisdictional representatives, monitoring designers and those carrying out monitoring programs. The manual describes the agreed, nationally consistent processes, procedures and standards for monitoring design, sampling and analysis.

Adherence to the complete monitoring process as outlined in the manual and guidelines is not recommended for small-scale surveys with limited budgets, due to the complex processes and stringent quality assurance and control requirements involved (DAFF 2010a).

A recent review of the National Monitoring Strategy found that it has not been effectively implemented, and recommended the development of a new strategy for obtaining surveillance information from a wider range of sources (DAWR 2015).

6. RESPONSE TO INCURSIONS

Biosecurity SA coordinates state-wide responses to incursions and management of existing pest animal species to minimise impact on primary industries, natural ecosystems and public safety (CISS 2015).

The Commonwealth Government also provides information to assist in emergency response or pest management activities, including the following:

- The Australian Emergency Marine Pest Plan (Australian Government 2005) is an emergency response document that describes the intended generic response to a marine pest emergency event within Australia.
- The national control plan for the European fan worm (Aquenal 2008) presents the nationally agreed management response plan to reduce the impacts and minimise the spread of *S. spallanzanii* (one of the species already established on Kangaroo Island) in Australian waters. It includes practical management approaches to prevent, control or manage the impacts of *S. spallanzanii*, contingency plans for new incursions, recommendations for public awareness strategies and future research and development and estimated budgets and resource requirements to implement the control plan.

7. MANAGEMENT PLANS AND PROCEDURES AT SMITH BAY

If the KI Seaport proposal were approved, detailed Construction and Operational Environmental Management Plans (CEMP and OEMP) would be produced before construction began. Frameworks for both the CEMP and OEMP are provided in the Draft EIS.

The CEMP and OEMP would include detailed Marine Pest Management Plans produced in consultation with Biosecurity SA and the Biosecurity Advisory Committee of the Kangaroo Island Natural Resources Management Board.

Key requirements of the plans would include:

- All vessels using the pontoon would be required to comply with the most recent policies and guidelines relevant to the management of biofouling and ballast water disposal.
- Baseline marine surveys would be undertaken in the marine study area for species present, providing a robust baseline detailing the presence of existing pest species.
- Ongoing monitoring would be used to detect new species (including pests), allowing for an early response to the introduction of pests.
- Particular attention would be paid to risks associated with the potential introduction of abalone diseases, including potentially banning ships from ports where there are known abalone diseases.
- The presence of marine pests would be immediately reported to the relevant authorities.
- Practical response plans and strategies for the control of key pest species would be developed and implemented as required in consultation with Biosecurity SA.

Specific measures (to be explained in detail in the CEMP and OEMP) that would reduce the risk of marine pests being introduced to Smith Bay include:

- The floating pontoon (purchased in Korea) would be sandblasted and repainted inside and out before arrival at the KI Seaport. Anti-fouling paint would be used. It would not be ballasted until it was on site. Periodically, it would be towed to Port Adelaide for slipping, cleaning and repainting.
- A small number of dedicated vessels would be used exclusively to transport logs and woodchips to north Asia to enable contracted volumes and delivery times to be achieved. It is not expected that this could be achieved by sourcing ‘unknown’ ships on the spot market. The most likely vessels are those currently exporting timber from southern WA ports, where the timber supply is coming to an end.
- Vessels would be ballasted when arriving at the KI Seaport, but the ballast water would have been exchanged three times in the ocean before arrival, according to standard protocols, to limit the spread of marine organisms between ports.

Care would be taken to ensure that the Marine Pest Management Plan was consistent with the Kangaroo Island Biosecurity Strategy and that it satisfied the requirements of the Kangaroo Island Natural Resources Management Board. For example, the following proposed strategies in the Marine Pest Management Plan would be cross-checked for consistency against the relevant strategies (in brackets) and key performance indicators from the Kangaroo Island Biosecurity Strategy (KINRM Board 2017):

- maintaining effective working relationship with Biosecurity SA and the KINRM Board (1.1, 1.4, 1.5, 1.6, 3.1, 3.4, 3.5, 4.2, 6.2, 6.3)
- details of monitoring program (1.2, 1.3)
- appropriate reporting (1.4, 1.5, 4.1, 5.6, 6.4)
- response Plan (4.1, 4.2, 4.3)
- regular review to assimilate new information or circumstances (1.1, 2.1, 2.3, 3.4, 3.5, 6.1, 6.5)
- community extension (3.3, 3.6).

The adoption of the most rigorous biosecurity measures during construction and operation of the KI Seaport would reduce to an acceptable level the risk of marine pests and/or diseases being introduced to Smith Bay.

8. REFERENCES

Aquenal 2008, *National control plan for European fan worm Sabella spallanzanii*. Prepared for the Australian Government. Aquenal Pty Ltd, Hobart.

Australian Government 2005, Australian Emergency Marine Pest Plan (EMPPlan): Control Centre Management Manual, Canberra.

Australian Government 2009a, *National Biofouling Management Guidelines for Commercial Vessels*, National System for the Prevention and Management of Marine Pest Incursions.

Australian Government 2009b, *National Biofouling Management Guidelines for Recreational Vessels*, National System for the Prevention and Management of Marine Pest Incursions.

Australian Government 2013a. *About the National System for the Prevention and Management of Marine Pest Incursions*, viewed 24 July 2017, <http://www.marinepests.gov.au/national-system/Pages/default.aspx>.

Australian Government 2013b. *Monitoring helps detect new marine pests*, viewed 28 August 2018, < http://www.marinepests.gov.au/national-system/how-it-works/Pages/Monitoring.aspx>.

Australian Government 2015, *Anti-fouling and in-water cleaning guidelines*, Department of Agriculture, Canberra.

Australian Government 2016, *Managing ballast water to stop new pests arriving in Australia*, viewed 24 July 2017, http://www.marinepests.gov.au/australian-ballast-water-management/Pages/default.aspx.

Australian Government 2017, *NIMPIS – the National Introduced Marine Pest Information System*, viewed 24 July 2017, <http://data.daff.gov.au/marinepests>.

Ballantine, J 2017, *Code of practice for vessel and facility management (marine and inland waters)*, Environment Protection Authority, Adelaide.

CISS 2015, *Connect: South Australia*, PestSmart, Centre for Invasive Species Solutions, viewed 24 July 2017, <http://www.pestsmart.org.au/connect/sa>.

CSIRO 2001, *Marine Pest Information Sheet: giant fanworm (Sabella spallanzanii)*, Commonwealth Scientific and Industrial Research Organisation.

DAFF 2010a, *Australian marine pest monitoring guidelines*, National System for the Prevention and Management of Marine Pest Incursions, Department of Agriculture, Fisheries and Forestry, Canberra, viewed 22 September 2017, <http://www.marinepests.gov.au/marine_pests/publications/Pages/monitoring_guidelines.aspx>.

DAFF 2010b, *Australian marine pest monitoring manual*, National System for the Prevention and Management of Marine Pest Incursions. Department of Agriculture, Fisheries and Forestry, Canberra, viewed 22 September 2017, http://www.marinepests.gov.au/marine_pests/publications/Pages/monitoring_manual.aspx>.

DAFF 2012, *Aquatic Animal Diseases Significant to Australia: Identification Field Guide 4th Edition*, Infection with Perkinsus olseni, Department of Agriculture, Fisheries and Forestry, Canberra.

DAWR 2015, *Review of national marine pest biosecurity*, Department of Agriculture and Water Resources, Australian Government, Canberra.

DAWR 2016a, *Marine Pests*, Department of Agriculture and Water Resources, Australian Government, Canberra, viewed 24 July 2017, <http://www.agriculture.gov.au/pests-diseases-weeds/marine-pests)>.

DAWR 2016b, *Marine Pest Sectoral Committee*, Department of Agriculture and Water Resources, Australian Government, Canberra, viewed, <http://www.agriculture.gov.au/pests-diseases-weeds/marine-pests/mp-sect-committee>.

DAWR 2017a, *Australian Ballast Water Management Requirements*, Version 7, Department of Agriculture and Water Resources, Australian Government, Canberra.

DAWR 2017b, *Managing biofouling in Australia*, Department of Agriculture and Water Resources, Australian Government, Canberra, viewed 24 July 2017, <http://www.agriculture.gov.au/biosecurity/avm/vessels/biofouling>.

GISD 2017, Global Invasive Species Database, viewed 24 July 2017, <http://www.iucngisd.org/gisd/about.php>.

Goggin, CL & Lester, RJG 1995, '*Perkinsus*, a protistan parasite of abalone in Australia, a review', *Marine and Freshwater Research*, vol. 46, pp. 639-646.

Hayes, K, Sliwa, C, Migus, S, McEnnulty, F & Dunstan, P 2005, *National priority pests: Part II – Ranking of Australian marine pests*, Technical Report for Department of Environment and Heritage by CSIRO Marine Research.

Hewitt, CL & Campbell, ML 2010, *The relative contribution of vectors to the introduction and translocation of marine invasive species*, Report for the Department of Agriculture, Fisheries and Forestry, the National Centre for Marine Conservation and Resource Sustainability, Australian Maritime College, University of Tasmania, Launceston.

IMO 2011, *2011 guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species: resolution MEPC.207(62)*, International Maritime Organization, London, viewed 21 September 2017, <http://www.imo.org/en/OurWork/Environment/Biofouling/Documents/RESOLUTION%20 MEPC.207%5b62%5d.pdf>.

Jacobs 2015, *Central Eyre Iron Project: Port Site Marine Assessment*. Jacobs Pty Ltd report E-F-34-RPT-0039, as Appendix Q of Iron Road 2015, Central Eyre Iron Project Environmental Impact Statement.

KINRM Board 2017, *Biosecurity Strategy for Kangaroo Island 2016–2019*, Kangaroo Island Natural Resources Management Board, Final Draft, July 2017.

O'Brien, AL, Ross, DJ & Keough, MJ 2006, 'Effects of *Sabella spallanzanii* physical structure on soft sediment macrofaunal assemblages', *Marine Freshwater and Research* vol. 57, no. 4, pp: 363-371.

PIRSA 2009, *Ecologically Sustainable Development (ESD) Risk Assessment of the South Australian Abalone Fishery*, Primary Industries and Resources South Australia.

PIRSA 2015, *Noxious fish list*, Primary Industries and Regions South Australia, Government of South Australia, Adelaide, viewed 24 July 2017, http://pir.sa.gov.au/biosecurity/aquatics/aquatic_pests/noxious_fish_list>.

PIRSA 2017, *Aquatic pests*, Primary Industries and Regions South Australia, Government of South Australia, Adelaide, viewed 24 July 2017, <http://pir.sa.gov.au/biosecurity/aquatics/aquatic_pests>.

Sabia, L, Uttieri, M, Schmitt, FG, Zagami, G, Zambianchi, E et al. 2014. '*Pseudodiaptomus marinus* Sato, 1913, a new invasive copepod in Lake Faro (Sicily): observations on the swimming behaviour and the sex-dependent responses to food', *Zoological Studies* vol. 53, p. 49, doi:10.1186/ s40555-014-0049-8.

Stabilia, L, Liccianob, M, Giangrande, A, Fanellia, G & Cavalloa, RA 2006, '*Sabella spallanzanii* filter-feeding on bacterial community: Ecological implications and applications', *Marine Environmental Research* vol. 61, no. 1, pp: 74-92.

Theil, M, Wear, R, Tanner, J, Bryars, S & de Jong, S 2004, *Environmental Risk Assessment of Land Based Aquaculture in South Australia*, South Australian Research and Development Institute (Aquatic Science), Adelaide, SARDI Publication No. RD04/0156.

Wiltshire, K & Deveney, M 2011, *Final monitoring report for the 2010–2011 marine pest survey of Port Adelaide*, South Australia, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2011/000386-1, SARDI Report Series No. 575.

Wiltshire, K, Rowling, K & Deveney, M 2010, *Introduced marine species in South Australia: a review of records and distribution mapping*, South Australian Research and Development Institute (Aquatic Sciences), Adelaide, SARDI Publication No. F2010/000305-1, SARDI Research Report Series No. 468.