APPENDIX H9

Ecological assessments

APPENDIX H9.1

Significant species in Upper Spencer Gulf

H9.1 Commentary on significant species in Upper Spencer Gulf

H9.1.1 Introduction

This appendix provides information used to support a response in Section 17.9.1 of the Supplementary EIS.

Respondents have sought specific information to support the conclusion, made in Section 16.6.6 of the Draft EIS, that neither construction nor operation of the desalination plant or landing facility would result in adverse effects on significant species, including nationally listed species, in Upper Spencer Gulf.

As discussed in Sections 16.3.5, 16.3.7, 16.6.6 and Appendix O3 of the Draft EIS, significant species potentially occurring in Upper Spencer Gulf were identified from relevant sources. These included 45 marine species listed under various categories in state or national legislation, and a number of species with no formal status, but nevertheless considered to be significant as they are normally found in the tropics, are endemic to Upper Spencer Gulf or Spencer Gulf, or are uncommon (see Table H91.1 for a list of these species). Impacts on the Australian Giant Cuttlefish were considered in detail in Section 16.6.7 of the Draft EIS.

The potential risk to significant species was considered in terms of the following criteria and environmental features outlined in Section 16.6.6 and 16.6.2 of the Draft EIS:

- their occurrence in Upper Spencer Gulf
- their mobility
- the availability of suitable habitat in Upper Spencer Gulf (against recorded distribution)
- the potential for return water from the desalination plant and construction activities to affect their habitat
- the likely sensitivity of these species and their food resources to return water and construction impacts
- the north-south salinity gradient within Spencer Gulf.

Further detail, including information provided in Appendices O2 and O3 of the Draft EIS, has been collated below.

H9.1.2 Occurrence in Upper Spencer Gulf

A key source used to determine the occurrence of listed species in Upper Spencer Gulf was the Australian Government's Protected Matters database, which highlights matters of national environmental significance or other matters protected by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in the area of interest. The information provided, however, is indicative only, and comes with the recommendation that local knowledge and information should also be sought where possible (DEWHA 2010a). Consequently, more than 40 sources of records were used to determine whether species were likely to occur in Upper Spencer Gulf (see Appendix O2 of the Draft EIS). These sources included published journal articles, summaries based on museum records, consultancy reports and credible community observations (e.g. community monitoring programs).

Species never previously recorded in Upper Spencer Gulf included 10 Syngnathids (i.e. Pipefish, Pipehorses and Seadragons). Some of these species have been recorded further south in Spencer Gulf in habitats that are not present in Upper Spencer Gulf (e.g. more exposed waters). Others, which utilise seagrass habitat, were not recorded despite extensive trawling in False Bay (McDonald 2008). The other species never previously recorded in Upper Spencer Gulf included four marine mammals and two turtles, all of which were at the limit of their ranges. For example:

- outside Tasmania and Victoria the Australian Fur Seal *Arctocephalus pusillus* is known only from offshore islands (Australian Museum 2009)
- a sub-population of the Indo-Pacific Bottlenose Dolphin *Tursiops aduncus*, rather than the Common Bottlenose Dolphin *T. truncatus*, occurs in Spencer Gulf (Kemper 2004; Bilgmann et al. 2007)
- distribution maps for the turtles indicate only the northern half of Australia (DEWHA 2010b, 2010c, 2010d, 2010e).

H9.1.3 Available habitat and mobility

A number of listed species identified as being present in Upper Spencer Gulf in Appendix O3 of the Draft EIS are highly mobile, wide-ranging species with habitat that extends well beyond the area likely to be impacted by the return water plume, landing facility or associated construction activities (see Sections 17.7, 17.14 and 17.16 of the Supplementary EIS). These are the Great White Shark *Carcharadon carcharias*, 13 marine mammals and four turtles. The Great White Shark, for example, has been regularly recorded up to 20 km from Point Lowly (Shark Watch, unpublished data, 2009), and high dolphin activity is reported at Point Lowly, Fitzgerald Bay and adjacent waters (see Appendix H9.4 of the Supplementary EIS).

Other less mobile or sessile significant species recorded, or potentially occurring at Point Lowly or the proposed landing facility, have alternative habitat within Upper Spencer Gulf, at locations such as the Two Hummock Point/Red Cliff Point area, or near Port Pirie (see Table H9.1.1).

H9.1.4 Interaction between return water and habitat

The only listed species identified as utilising habitat of the type occurring near the outfall (i.e. sand/silt habitat) was the Tiger Pipefish *Filicampus tigris*. Although there could be effects on some Tiger Pipefish individuals near the outfall, effects on the species would be negligible because only a very small proportion of their available habitat would be affected (as stated in Section 16.6.6 of the Draft EIS). Further information about the distribution of the Tiger Pipefish in Upper Spencer Gulf is provided in Section 17.9.5 of the Supplementary EIS.

A number of the non-listed less mobile or sessile species recorded, or potentially occurring near Point Lowly, such as the brown macroalgae *Hormophysa cuneiformis* and *Sargassum decurrens*, are unlikely to inhabit sand/silt habitat at the depth of the outfall (see Table H9.1.1).

H9.1.5 Ecological gradients

Many of the listed species, including Bryde's Whale *Balaenoptera edeni*, the Humpback Whale *Megaptera novaeangliae*, the New Zealand Fur Seal *Arctocephalus forsteri* and the Indo-Pacific Bottlenose Dolphin *Tursiops aduncus*, have been recorded near Port Augusta (refer Appendix O3 of the Draft EIS), suggesting that they are able to tolerate salinities of up to 48 g/L, far in excess of those near the diffuser.

The majority of the listed species and species of conservation concern have been recorded between Point Lowly and the Two Hummock Point/Red Cliff Point area (see Table H9.1.1), indicating that they can tolerate salinities up to 45 g/L, which would exceed those of the return water plume near the diffuser.

The available evidence suggests that effects on significant species would be negligible.

Table H9.1.1: Non-listed species of conservation significance in Upper Spencer Gulf

Species	Common name	Significance[1]	Notes on distribution
Marine plants			
Avicennia marina	Grey Mangrove	TA	Recorded near Port Augusta (Johnson 1976) and known to occur throughout Upper Spencer Gulf
Crouania destriana		UN	Recorded at Point Lowly (see Appendix O1 of the Draft EIS), and at Tiparra Reef and Kangaroo Island and Cape Northumberland (Womersley 1998)
Hormophysa cuneiformis		TA	Recorded at the Landing Facility site (see Appendix O1 of the Draft EIS). Records also from Port Broughton and Port Augusta (Womersley 1987)
Pterothamnion flexile		UN	Recorded only from Fitzgerald Bay and Outer Harbor (Womersley 1998)
Sargassum decurrens		TA	Recorded near Two Hummock Point/Red Cliff Point (Shepherd 1983a)
Cnidarians			
Australocyathis vincentinus	Solitary hard coral	UN	It has been included as 'uncommon' because it has a limited distribution within southern Australia (Baker 2004), but it has been described as being abundant in Gulf St Vincent and Spencer Gulf between 18 and 45 m (Thomas & Shepherd 1982)
Carijoa multiflora	Sponge-covered soft coral	TA	Recorded near Whyalla (Kinhill Stearns 1986), Point Lowly (see Appendix O1 of the Draft EIS; SEA 1981) Two Hummock Point/Red Cliff Point (Shepherd 1973, 1974, 1983a, 1983b) and at the preferred and an alternative landing facility sites (see Appendix O1 of the Draft EIS; BHP Billiton, unpublished data, 2007)
Echinogorgia sp.	A gorgonian coral	EU	Recorded near Two Hummock Point/Red Cliff Point (Shepherd 1983a, 1983b) and an alternative landing facility site (BHP Billiton, unpublished data, 2007)

Table H9.1.1: Non-listed species of conservation significance in Upper Spencer Gulf (cont'd)

Species	Common name	Significance[1]	Notes on distribution
Edwardsia vivipara	An anemone	UN	Known from low-energy coasts in Gulf St Vincent and Spencer Gulf (Thomas & Shepherd 1982)
Scytalium sp.		EU	Recorded near Point Lowly (SEA 1981) and Two Hummock Point/Red Cliff Point (Shepherd 1983a)
Virgularia gustaviana	Short Quill Sea Pen	TA	Recorded near Two Hummock Point/Red Cliff Point (Shepherd 1983a)
Worms			
Ancoratheca australiensis	Flatworm	ES	Recorded near Two Hummock Point/Red Cliff Point (Shepherd 1983a)
Phoronis albomaculata		TA	Recorded at Point Lowly/Germein Bay (Emig & Roldan 1992)
Phoronis psammophila		TA	Recorded at Whyalla/Germein Bay (Emig & Roldan 1992)
Crustaceans			
Amaryllis spencerensis	Amphipod	ES	Recorded south of Whyalla and near mouth of Spencer Gulf (Lowry & Stoddart 2002)
Platynympha longicaudata	Isopod	UN	Recorded at Port Pirie (Hutchings et al. 1993, Ward and Hutchings 1996, Ward et al. 1986)
Pseudopleonexes sheardi	Amphipod	ES	Recorded at Yatala Harbor (Just 2002)
Schizophrys aspera	Sponge Crab	TA	Recorded in Port Bonython jetty surveys (unpublished BHP Billiton data). Occurs commonly on jetty pylons in Gulf St Vincent and Spencer Gulf (Edgar 2008)
Molluscs			
Primovula cruenta	Egg Cowrie	ES	Recorded at Douglas Point (Gowlett-Holmes and Holmes, 1989)
Sepiadarium sp.	Lace Bottletail Squid	UN	Distribution shown as Spencer Gulf and Gulf St Vincent (Norman and Reid 2000), but known only from Edithburgh in Gulf St Vincent (Norman, M, Head of Science, Museum Victoria, pers. comm. 31 May 2010)
Trochodota shepherdii		UN	Recorded at Port Pirie (Hutchings et al. 1993). Found in Spencer Gulf and Gulf St Vincent, to a depth of 10 m (Thomas & Shepherd 1982)
Tucetona broadfooti	Heart cockle	UN	Recorded at Point Lowly (see Appendix O1 of the Draft EIS))
Zoila friendii thersites	Black Cowrie	UN	Recorded near Two Hummock Point/Red Cliff Point (Shepherd 1973, 1983a)
Echinoderms			
Amphiura trisacantha		UN	Recorded near Two Hummock Point/Red Cliff Point (Shepherd 1983a) and Port Pirie (Hutchings et al. 1993)
Astralium rutidoloma	Granular Small Star/Star Shell	UN	Recorded at Port Pirie (Hutchings et al. 1993)
Fish			
Bathygobius kreffti	Frayed-fin Goby	TA	Recorded at Backy Point and in other records from the Whyalla area (Baker 2010, cited as Baker 2008 in the Draft EIS)
Filicampus tigris	Tiger Pipefish	TA	Recorded near Point Lowly (SEA 1981). See also Section 17.9.5 of the Supplementary EIS
Ophiclinops pardalis	Spotted Snake Blenny	UN	Recorded at Chinaman's Creek (Baker 2008)

Notes:
[1] UN = uncommon; ES = endemic to Spencer Gulf; EU = endemic to Upper Spencer Gulf; TA = tropical affinities

H9.1.6 References

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APPENDIX H9.2

Regional significance of the Point Lowly sponge community

H9.2 THE REGIONAL SIGNIFICANCE OF THE POINT LOWLY SPONGE COMMUNITY

H9.2.1 INTRODUCTION

This appendix provides information used to support a response in Section 17.9.2 of the Supplementary EIS.

Respondents have sought confirmation that the sponge community covering several hectares near Point Lowly is considered to be of regional significance. As discussed in Section 16.3.7 of the Draft EIS, the community is of regional conservation significance due to the high diversity and density of sponges and associated species. Subsequent investigations of other sponge communities in Upper Spencer Gulf have been undertaken to determine whether the Point Lowly community is unique.

H9.2.2 SPONGE COMMUNITIES IN UPPER SPENCER GULF

After studying the literature and anecdotal stories, the following potential sponge communities within Upper Spencer Gulf were investigated:

- A community at Two Hummock Point, previously known to the BHP Billiton marine biology consultants, was again located. Inspection by divers revealed that this community appeared smaller and was considerably less dense than that at Point Lowly. It was nevertheless considered to be significant.
- BHP Billiton marine biology consultants searched for a number of communities identified by Shepherd (1983a) near Red Cliff Point, but these could not be found. Either the maps were inaccurate (they were produced before the availability of GPS), or the extensive sand movement typical of the area has covered these communities (Shepherd 1983b). Nevertheless, some isolated sponges were collected at these sites.
- A prawn trawl fishery bycatch study recorded three to four sponges from limited sampling at three rarely trawled sites near and at a similar depth to the Point Lowly sponge community (Sorokin and Currie 2009; Currie et al. 2009). Inspection of one of these sites south of Port Bonython jetty by divers revealed a similar number of taxa to the Point Lowly and Two Hummock Point communities, but the sponges were very sparsely distributed.

Sponges are filter feeders that rely on water movement for food supply. The presence of relatively dense sponge communities at Point Lowly and Two Hummock Point is consistent with the relatively fast current speeds (refer to the animation provided with Section 16.3.2 of the Draft EIS) and exposed rocky substrate at those locations. The lack of rocky substrate in other areas of strong currents has probably limited the establishment of extensive sponge communities elsewhere in Upper Spencer Gulf.

H9.2.3 DISTRIBUTION OF SPONGE TAXA IN SPENCER GULF

Introduction

The species composition of the sponge community at Point Lowly was compared with reference sites in Upper Spencer Gulf, including the Two Hummock Point sponge community and the trawl survey site south of Port Bonython jetty. The number of sponge taxa not recorded elsewhere in Spencer Gulf was also determined and compared for the three sites.

Methods

Sponges were sampled by divers (BHP Billiton Marine Biology consultants) at Point Lowly and two reference sites: the Two Hummock Point sponge community and the prawn bycatch survey site (see Figure H9.2.1). Divers collected one sample of each morphologically distinct sponge (based on shape, texture and colour) encountered during a dive time of approximately 15 minutes at each site.

Most existing information on the distribution of sponges in Spencer Gulf is from the prawn trawl bycatch study at 120 sites in Spencer Gulf between Port Lincoln and Point Lowly (Sorokin and Currie 2009; Currie et al. 2009). During this study, sponges were removed from one level Nally bin (96 L) of the total bycatch from a 30-minute trawl. Based on predictive modelling, the species recorded in this study are considered to be only a small fraction of the sponge fauna of Spencer Gulf (Sorokin and Currie 2009).

The sponges recorded from the dive surveys in Upper Spencer Gulf (including six additional sites, shown in Figure H9.2.1, dived while searching for sponge communities), and the trawl surveys at sites between Point Lowly and Port Lincoln, were compared by sponge taxonomists. The result was a single inventory of sponges recorded in Spencer Gulf which, despite being incomplete, provided an indication of the proportion of sponge taxa at Point Lowly and at the reference sites that are unique to their respective sites within Spencer Gulf.

Results

The species recorded from the sites sampled by divers are summarised in Table H9.2.1. Species richness (i.e. the number of species) was similar at the two recognised sponge communities and the trawl survey site, with 12 to 14 species at each site. Each site had only one species in common with the other two sites. Divers perceived that a search time of approximately 15 minutes was adequate, with few, if any, additional species being collected towards the end of the dive.

Richness was much lower at the Backy Point and Douglas Point sites, with one and four species respectively. Richness at four sites near Red Cliff Point varied from two to eight species, and 15 species in total. At the trawl site south of the Port Bonython jetty, three of the 13 species recorded were found by trawling (Sorokin and Currie 2009), and 12 by divers, suggesting that the diver method more effectively samples species richness than trawling.

Four of the 13 species recorded at Point Lowly have been recorded elsewhere in the gulf (see Table H9.2.1 and Figure H9.2.2). In contrast, 12 out of 14 and 11 out of 12 of the species recorded at the trawl site and Two Hummock Point site, respectively, are the same as (or close to) sponges recorded elsewhere in the gulf.

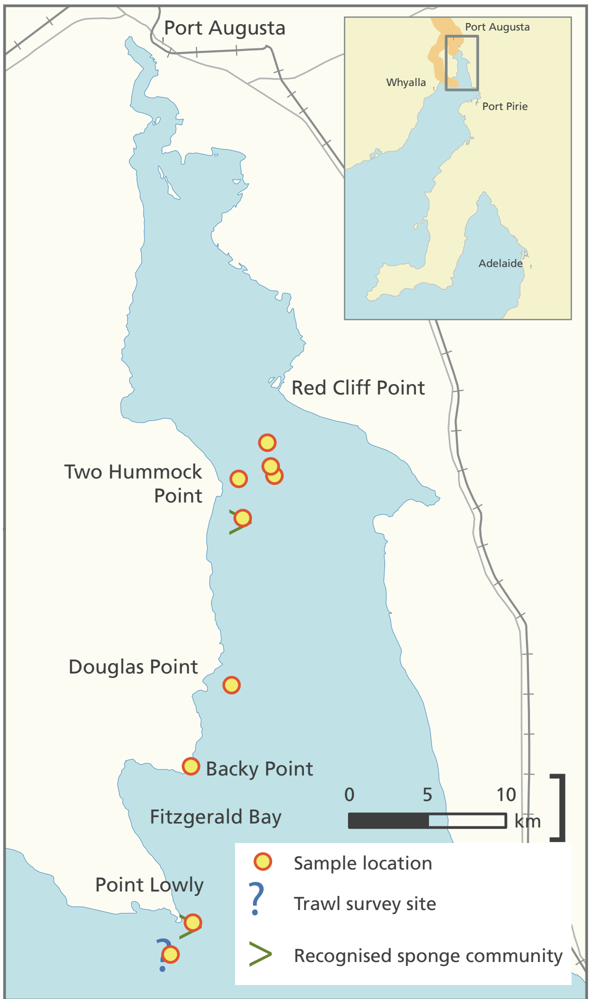

Figure H9.2.1 Diver sampling locations

Table H9.2.1: Identification of sponges from sites sampled by divers in Upper Spencer Gulf

Order[1]	Family	Species	Trawl survey code (Sorokin and Currie 2009), indicating that species was found during trawl surveys	Sites surveyed by diver					
				Trawl site	Point Lowly	Backy Point	Douglas Point	Red Cliff Point[2]	Two Hummock Point
		Class Calcarea			X				
Astrophorida	Ancorinidae	*Ancorina* sp.			X				
Astrophorida	Ancorinidae	*Asteropus* sp.							X
Astrophorida	Ancorinidae	*Ecionemia* sp. 1						X	X
Astrophorida	Ancorinidae	*Ecionemia* sp. 2			X				
Astrophorida	Ancorinidae	*Ecionemia* sp. 3						X	
Astrophorida	Ancorinidae	*Ecionemia* sp. 4		X				X	X
Astrophorida	Ancorinidae	*Jaspis* sp.	(S091)[3]		X				
Astrophorida	Ancorinidae	*Stelletta tuberculata*						X	
Chondrosida	Chondrillidae	*Chondrilla* sp. 1	S093						X
Dictyoceratida	Irciniidae	*Ircinia* sp. 1	S003					X	X
Dictyoceratida	Irciniidae	*Ircinia* sp. 2	S010				X	X	
Dictyoceratida	Irciniidae	*Ircinia* sp. 3	(S035)					X	
Dictyoceratida	Irciniidae	*Ircinia* sp. 4						X	
Dictyoceratida	Irciniidae	*Psammocinia* sp. 1		X	X			X	
Dictyoceratida	Spongiidae	*Leiosella* sp. 1	S024	X					
Dictyoceratida	Spongiidae	*Spongia* sp. 2						X	
Dictyoceratida	Thorectidae	*Fasciospongia* sp. 1	S089						X
Dictyoceratida	Thorectidae	*Luffariella* sp.	S005a						X
Hadromerida	Suberitidae	*Caulospongia* sp. 1	S042a					X	X
Hadromerida	Tethyidae	*Tethya ingalli*	S117	X					
Hadromerida	Tethyidae	*Tethya* sp. 1			X				X
Hadromerida	Tethyidae	*Tethya* sp. 2		X					
Hadromerida	Trachycladidae	*Trachycladus* sp. 1						X	
Halichondrida	Halichondriidae	*Halichondria* sp. 1	S110	X					
Haplosclerida	Callyspongiidae	*Callyspongia* (*Cladochalina*) sp.						X	
Poecilosclerida	Chondropsidae	*Chondropsis* sp. 1	S004a	X					
Poecilosclerida	Chondropsidae	*Chondropsis* sp. 2			X				
Poecilosclerida	Chondropsidae	*Phoriospongia* sp. 1						X	
Poecilosclerida	Desmacellidae	*Biemna* sp.	S021	X[4]					
Poecilosclerida	Iotrochotidae	*Iotrochopsamma* cf *arbuscula*			X				
Poecilosclerida	Microcionidae	*Clathria* (*Clathria*) sp. 1					X		

Table H9.2.1: Identification of sponges from sites sampled by divers in Upper Spencer Gulf (cont'd)

Order[1]	Family	Species	Trawl survey code (Sorokin and Currie 2009), indicating that species was found during trawl surveys	Sites surveyed by diver					
				Trawl site	Point Lowly	Backy Point	Douglas Point	Red Cliff Point[2]	Two Hummock Point
Poecilosclerida	Microcionidae	*Clathria* (*Dendrocia*) sp.			X				
Poecilosclerida	Microcionidae	*Echinochalina* (*Protophlitaspongia*) sp. 1		X					
Poecilosclerida	Microcionidae	*Echinoclathria* sp.	(S041)						X
Poecilosclerida	Microcionidae	*Holopsamma* cf *laminaefavosa*					X		
Poecilosclerida	Microcionidae	*Holopsamma laminaefavosa*	S009	X	X		X		
Poecilosclerida	Raspailiidae	*Echinodictyum mesenterinum*	S052						X
Poecilosclerida	Raspailiidae	*Echinodictyum* sp. 1			X				
Poecilosclerida	Raspailiidae	*Echinodictyum* sp. 2			X				
Poecilosclerida	Raspailiidae	*Echinodictyum* sp. 3	(S020)						X
Poecilosclerida	Raspailiidae	*Echinodictyum* sp. 4	(S020)	X		X			
Poecilosclerida	Raspailiidae	*Echinodictyum* sp. 5	S096	X					
Poecilosclerida	Raspailiidae	*Raspailia* sp.			X				
Verongida	Aplysinellidae	cf *Suberea* sp.		X					
Verongida	Aplysinidae	*Aplysina* sp.			X				
Total species				13	14	1	4	15	12

1 All from Class Demospongiae except the first (Class Calcarea).
2 From four sites with isolated sponges in the vicinity of Red Cliff Point.
3 Brackets indicate that the related species is very similar to but probably not the same as the species referred to in the previous two columns.
4 Recorded on trawl survey only.

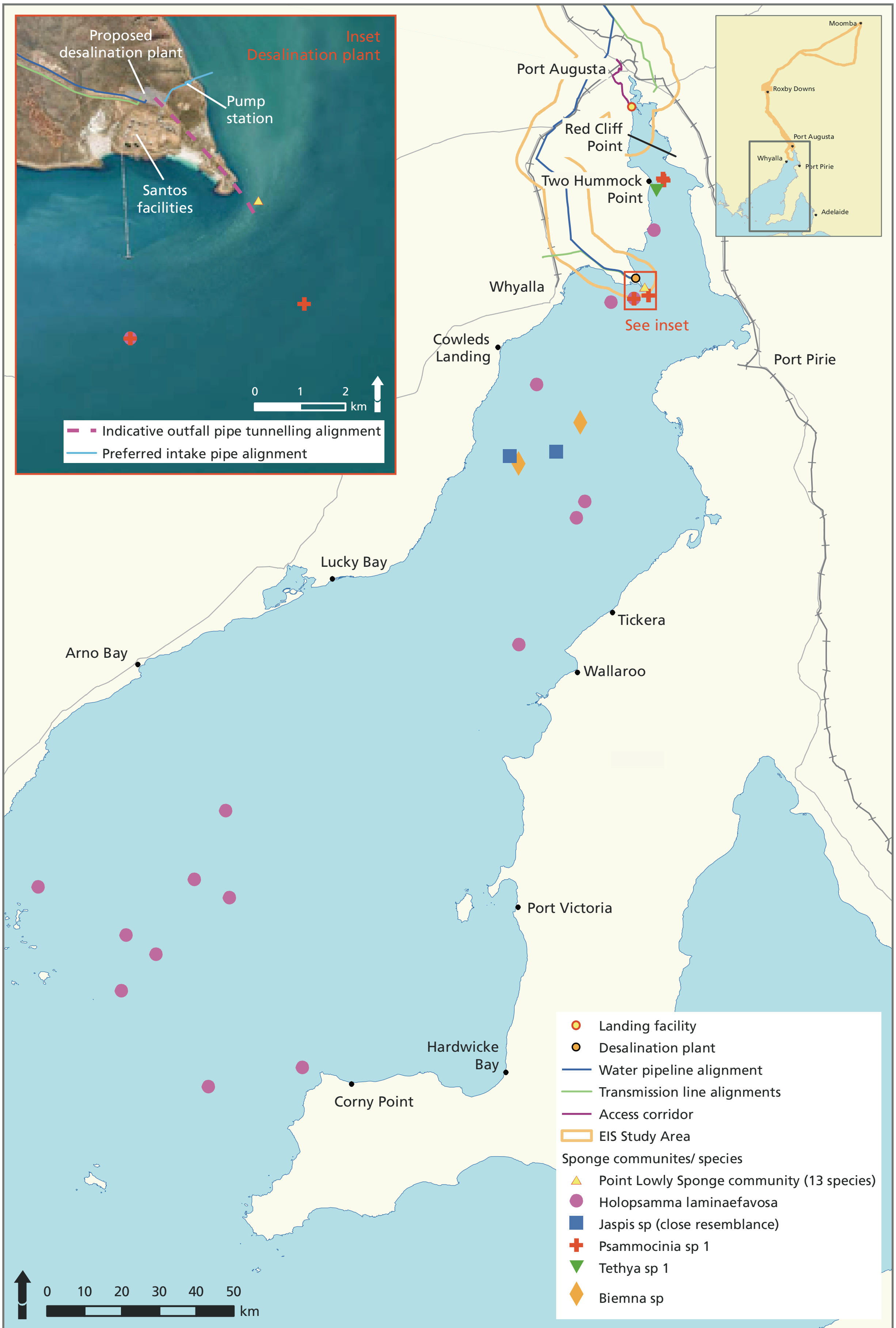

Figure H9.2.2 Spencer Gulf distribution of sponges identified at Point Lowly

H9.2.4 CONCLUSIONS

The following community patterns were evident:

- sponge communities in Upper Spencer Gulf are localised, with limited overlap in species between sites
- the Point Lowly community has a greater proportion of unique sponges (within Spencer Gulf) than the other sites investigated.

The sponge fauna of Spencer Gulf are poorly known, with a species accumulation curve from trawl samples showing (by not reaching its asymptote) that continued sampling would uncover more sponge taxa (Sorokin and Currie 2009). A comparison at one site of the trawl and diver methods suggests that the diver method, which covered much less area (within and across sites) but specifically targeted sponges, was more effective at sampling sponge diversity. Nevertheless, this method may have missed species with similar morphologies to those sampled.

A conservative interpretation of the evidence to date suggests the Point Lowly sponge community is the largest and densest in Upper Spencer Gulf, and it has a relatively high number of species unique within the gulf and particularly the upper gulf. On this basis, the Point Lowly community is considered to be of regional significance in Upper Spencer Gulf.

H9.2.5 REFERENCES

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APPENDIX H9.3

Giant Australian Cuttlefish population surveys

Estimated abundance and biomass of giant Australian cuttlefish *Sepia apama* in the spawning aggregation area of northern Spencer Gulf, South Australia

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Report prepared for the
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Summary

The giant Australian cuttlefish *Sepia apama* forms a dense spawning aggregation in northern Spencer Gulf, South Australia, every austral winter. The annual abundance and biomass of the aggregation have been estimated with underwater strip transects over a period that spans 12 years, with some gaps in the dataset. Surveys were completed in 1998 to 2001, 2005 and 2008 to 2010, but not in 2002 to 2004 nor 2006 and 2007. The conservative interpretation of the combined results suggests that the estimated abundance and biomass have decreased from a fluctuating average of over 170,000 and 180 t between 1999 and 2001 to below approximately 130,000 and 110 t in recent years (i.e. between 2008 and 2010). It is difficult to ascertain whether this decline in population size represents an unusually delayed response to the intense exploitation between 1993 and 1998 or variation in recruitment success possibly in response to changed environmental conditions.

1. Introduction

This report presents the results of the latest underwater survey (in June 2010) of a unique spawning aggregation of the giant Australian cuttlefish *Sepia apama* that occurs every austral winter in the northern Spencer Gulf. The survey was completed as part of a Draft Environmental Impact Statement (EIS) for a proposed desalinisation plant at Point Lowly that is in included in the proposed expansion of the existing BHP Billiton Olympic Dam mine and processing plant and associated infrastructure at Roxby Downs in South Australia (BHP Billiton 2009). The Draft EIS for the expansion includes an assessment of the potential effects of brine discharge from the desalination plant on the marine biota of the northern Spencer Gulf, including *S. apama*. The main spawning aggregation of *S. apama* occurs in the Black Point to Point Lowly area extending west from the proposed brine discharge point.

Underwater surveys of the cuttlefish spawning aggregation began in 1998, in response to concerns over a rapid increase in commercial fishing effort between 1993 and 1997 that was targeted on the spawning population. Between 1998 and 2001, annual surveys were completed by the South Australian Research and Development Institute (SARDI) as part of their stock assessments (Hall and McGlennon 1998; Hall 1999; Hall 2000; Hall 2002). These initial surveys indicated that cuttlefish abundance and biomass remained relatively stable between 1999 and 2001 following the closure of the area to commercial fishing in 1998. However, in 2005, a survey commissioned by the Coastal Protection Branch of the South Australian Department for Environment and Heritage (DEH), in response to anecdotal concerns over decreased abundances in 2004, suggested that the biomass had decreased by approximately 33% since 2001 (Steer and Hall 2005). During 2006 and 2007, no surveys were completed but anecdotal evidence suggested that abundances had increased again (pers. comm., T. Bramley, Whyalla Diving Services, June 2008). In contrast, however, the two most recent surveys in 2008 and 2009 (as part of the BHP Billiton Olympic Dam EIS Project) recorded similar or smaller abundances and biomasses compared to those in 2005 (BHP Billiton 2009).

The key objectives of the 2010 survey were: (i) to extend the existing baseline for estimates of the abundance and biomass of *S. apama* in the aggregation area; and (ii) to confirm the current status of the population, i.e. whether it can be considered to be stable, declining or recovering.

2. Methods

Densities of *S. apama* were surveyed in the aggregation area between 31 May and 2 June 2010 according to the methods developed by Hall and Fowler (2003), reiterated in BHP Billiton (2009) and summarised again below. The aggregation area was divided into three sub-areas based on fishing history (Fig. 1). These were: (i) a "closed-closed area" that was originally closed to fishing before the 1998 season; (ii) an "open-closed area" that was originally left open to fishing in 1998, but was later closed half way through the season; and an "open-open area" that has always remained open to fishing (Fig. 1). These sub-areas were further divided into three to five sites to allow for discontinuities in hard substrate. On average, sites consisted of 600 m of coastline, but ranged from 280 m to 1.2 km (Hall and Fowler 2003). Two additional sites were also surveyed: Backy Point, 12 km north of the main aggregation area; and the OneSteel Wall, 15 km southwest of the main aggregation area near Whyalla. One closed-closed site, SANTOS Jetty, was not surveyed. Data for Backy Point were excluded from 2000, 2008 to 2010 aggregation area totals to facilitate comparisons with estimates from other years.

Fig.1. Aerial photograph of the main spawning aggregation area with the locations of sampling sites indicated. Sites in the open-closed area are indicated in yellow, closed-closed area in green and open-open area in red.

To survey each site, four SCUBA divers worked in pairs to complete four 50 x 2 m strip transects in each habitat within the site. One diver in each pair counted and estimated the mantle length (ML, to the nearest cm) and sex of all cuttlefish that were encountered within each transect. This provided an average density of cuttlefish 100 m^{-2}. To correct for observer bias, at the end of the survey, each diver estimated the ML and sex of 30 cuttlefish underwater that were subsequently captured (under permit) with a landing net and measured and sexed accurately on the surface, then promptly released back into the water. Estimated lengths were corrected for observer bias and then converted to weights according to the average length-weight relationship (Hall and Fowler 2003), to estimate the average weight of cuttlefish 100 m^{-2}.

Abundance and biomass estimates were calculated for each habitat in each site by multiplying the average density and average weight, respectively, by the corresponding area of habitat (as determined by Hall and Fowler 2003). Total abundance and biomass estimates for each sub-area and for the entire aggregation area were then estimated by summing across appropriate sites. No attempt was made to interpolate estimates for sites not surveyed in any given year; they were simply omitted from totals for that year. This protected against overestimation and ensured estimates were conservative. The cumulative commercial catch (until the end of May each year) was added to the estimate of biomass for the fished area to account for any cuttlefish removed before the survey. Catch has been negligible and confidential (fewer than five fishers involved) for the last 6 years, so the addition of the catch to biomass estimates has had little effect on more recent totals. However, between 1997 and 1999 significant catch was removed and this needed to be considered with respect to total biomass. Only that taken from January to end of May for each year was included in the totals.

In this 2010 report, abundance estimates were also aggregated according to another specific combination of sites to determine the proportion of cuttlefish that are found in close proximity to both the outfall location (around Point Lowly) and intake location (Fitzgerald Bay). To this end, estimates were aggregated according to the following combinations: (1) six sites from False Bay to SANTOS Tanks combined; (2) three sites around Pt Lowly combined; and (3) Fitzgerald Bay and (4) Backy Point presented individually.

Many sources of error were incorporated in the estimates of uncertainty for the estimates of biomass and abundance, including measurement or method error and those associated with the sampling design. To estimate this uncertainty the procedure outlined by Taylor (1982) for the propagation of uncertainties through serial calculations was used. The uncertainties in the estimates of biomass were higher than those for abundance due to the added sources of measurement error involved in the calculation of weights from visually estimated lengths. Data from previous surveys are reproduced in this report to place 2010 results in context (Hall and Fowler 2003; Steer and Hall 2005; BHP Billiton 2009; Hall 2009). Comparisons were facilitated by various percent change estimates, calculated as the difference between years divided by the starting value, and then multiplied by 100.

In 2010, two sites were resurveyed later in season because of a seemingly anomalous result recorded at Stony Pt on 1 June during the usual peak abundance survey. Additional transects were completed in the urchin habitat at Stony Pt at the end of the initial survey week (on 3 June) and one month later (on 1 July). WOSBF was also resurveyed on 1 July for comparison. These temporal data were interpreted with reference to other data collected from three sites (Black Point, Stony Point and Fitzgerald Bay) during 1998, 1999 and 2000 and two sites (Black Point and WOSBF) during 2009 (Hall and Fowler 2003; Hall 2009).

3. Results

3.1 Abundance

In early June 2010, the estimated total abundance of *S. apama* in the aggregation area was 106 027 cuttlefish (Table 1). This represented a 13% decrease in abundance from 2009, and a 40% decrease from 2001 (but was still 29% greater than that recorded in 2008). Therefore, in all years since 2001, the estimated abundances have been at least 28% smaller and in the worst case of 2008 were 57% smaller. Although some algal habitats were omitted in the 2005 survey, which may have accounted for a small proportion of biomass and abundance, these were included in the surveys between 2008 and 2010.

Compared to estimates from 2009, the abundance in the open-closed area remained relatively consistent from 97 979 in 2009 to 99 782 in 2010 and those in the open-open area were over 50% greater. But there was an unprecedented 83% decrease in abundances in the closed-closed area (Table 1, Fig. 2). Although this sub-area has shown consistently greater decreases in abundance since 2001 compared to the open-closed area, this trend was more pronounced in 2010.

Table 1. Annual estimates of *S. apama* abundance (± SD) in the whole aggregation area and each sub-area during peak spawning (1998 to 2001, 2005 and 2008 to 2010). No surveys were completed in 2002 to 2004, or 2006 and 2007. Data from: [a]Hall and Fowler (2003); and [b]Steer and Hall (2005). Data for Backy Point were excluded from 2000, 2008 to 2010 totals to facilitate comparisons with estimates from previous years.

Area	Year							
	1998[a]	**1999[a]**	**2000[a]**	**2001[a]**	**2005[b]**	**2008**	**2009**	**2010**
Closed-closed (± SD)	33 064 (± 7 375)	42 381 (± 20 170)	47 413 (± 7 353)	53 628 (± 10 191)	32 715 (± 15 260)	18 197 (± 10 097)	24 111 (± 9 650)	4 026 (± 891)
Open-closed (± SD)	51 999 (± 11 685)	133 055 (± 27 704)	122 134 (± 35 747)	121 752 (± 18 679)	92 895 (± 20 165)	53 020 (± 12 192)	97 979 (± 16 405)	99 782 (± 15 330)
Open-open (± SD)	3 570 (± 1 885)	7 205 (± 3 251)	1 559 (± 841)	1 782 (± 1 309)	2 175 (± 1 302)	4 077 (± 1 697)	1 050 (± 577)	2 218 (± 843)
Whole aggregation (± SD)	**88 634** (± 13 945)	**182 642** (± 34 422)	**171 106** (± 36 505)	**177 161** (± 21 318)	**127 785** (± 25 322)	**75 295** (± 15 921)	**123 139** (± 19 042)	**106 027** (± 15 379)

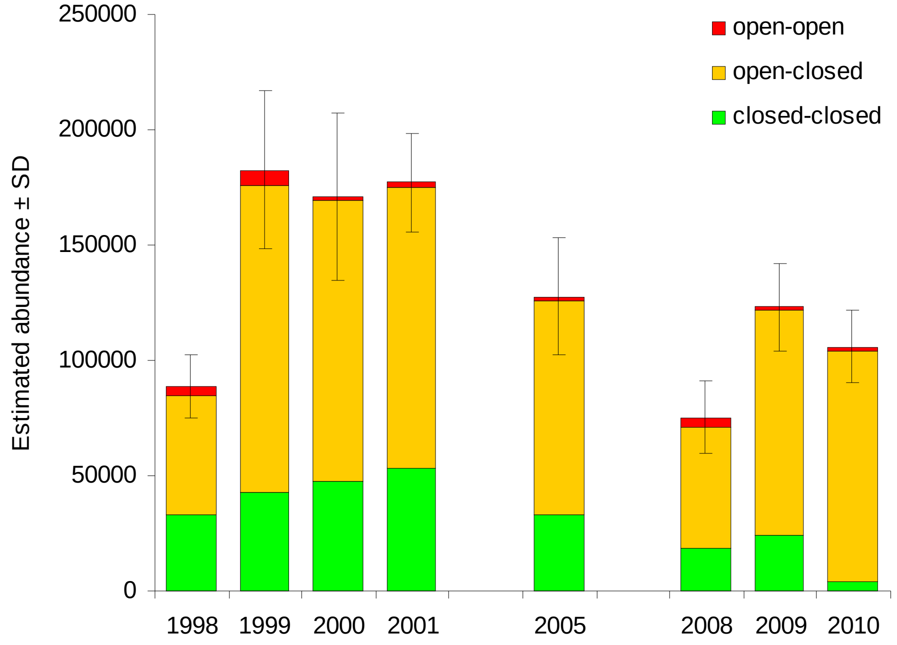


Fig. 2. Annual estimates of *S. apama* abundance (t ± SD) in the aggregation area during peak spawning (1998 to 2001, 2005 and 2008 to 2010), with the proportion in each sub-area indicated by different colours. Commercial fishing occurred within the open-closed area during half of 1998. No surveys were completed in 1997, 2002 to 2004, or 2006 and 2007. Data for 1998 to 2001 from Hall and Fowler (2003) and 2005 from Steer and Hall (2005).

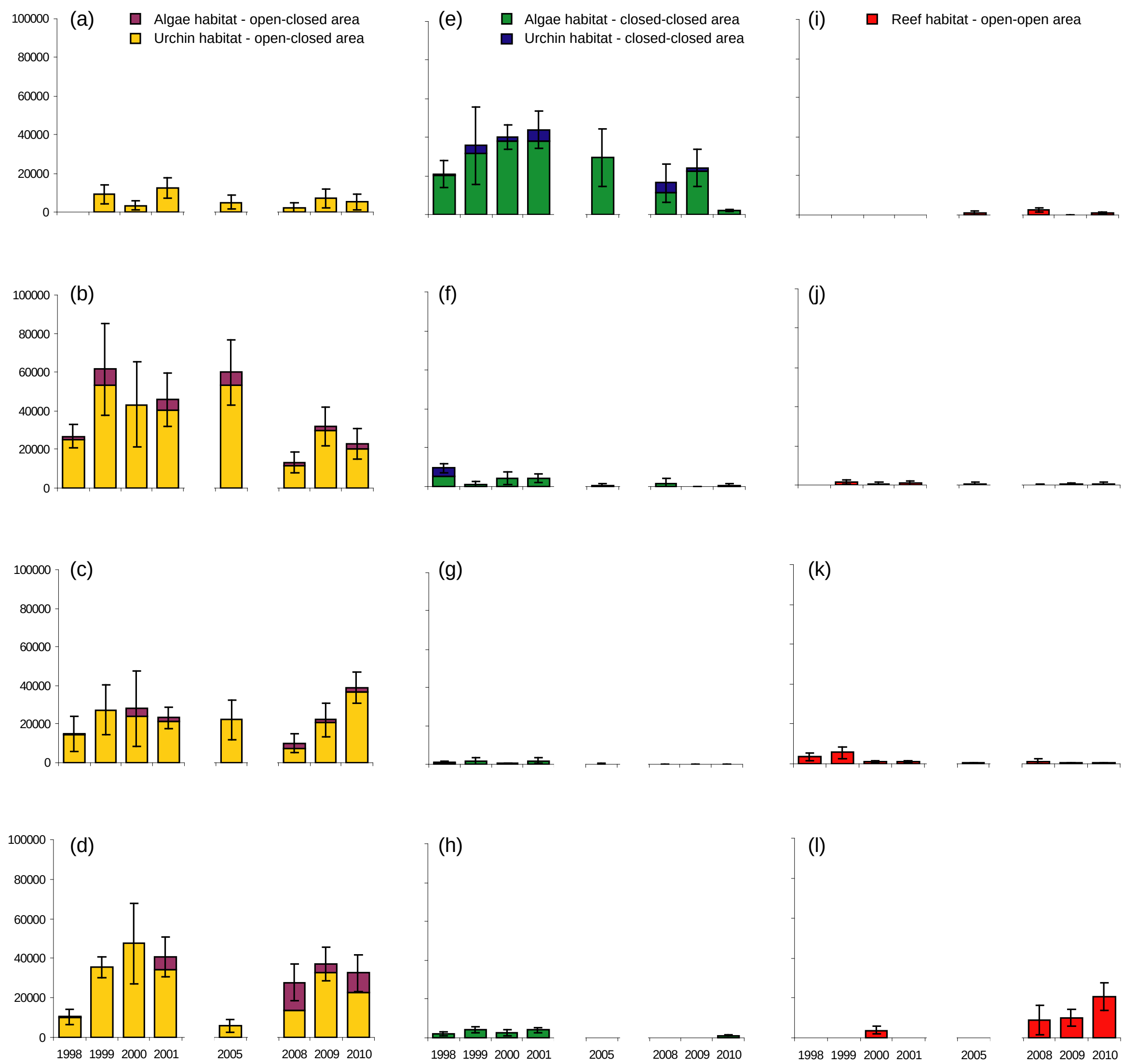
The spatial distribution of abundances among sites and habitats in 2010, were generally similar to those recorded in 2009 (Fig. 3) except for the following three departures: (1) abundances at 3rd Dip in the open-closed area were almost double that recorded in 2009, and were the highest ever recorded for the site (Fig. 3c); (2) abundances at Stony Pt in the closed-closed area were drastically reduced and the smallest ever recorded at the site (Fig. 3e); and abundances at Backy Pt in the open-open area were almost double that recorded in 2009 and the largest ever recorded (Fig. 3l).

Other general trends were consistent with those observed in 2009. In the open-closed area Black Point has historically supported the highest abundance in the aggregation area, even when the site was fished heavily in 1998. However, since 2005 the abundance at Black Point has decreased from 59 930, to just 13 223 in 2008, 31 966 in 2009 and 23 006 in 2010. In contrast, the three other sites in the open-closed area (False Bay, 3rd Dip and WOSBF) all increased in abundance in 2009 and remained at similar or greater levels in 2010 (Fig. 3a,c,d).

In the closed-closed area, only Stony Point has consistently supported relatively high abundance, which averaged approximately 40 000 between 1999 and 2001 (Fig. 3e) and then decreased to 29 229 in 2005, was even smaller in 2008 (16 342) and 2009 (24 058) and then was drastically lower in 2010 (2 165). Since this site usually accounts for most of the abundance in this sub-area, this had considerable effect on overall abundance in this sub-area.

Consistent with previous years, in 2010, the abundances at three sites in the open-open area were negligible (Fig. 3i-k) and only Backy Point had high densities of cuttlefish (Fig. 3j). Despite the narrow area of reef present at this site, these very high densities equated to an abundance of 20 796, which was almost double that recorded in 2008 and 2009.

Fig. 3. Annual estimates of *S. apama* abundance (± SD) for each site (1998 to 2001, 2005 and 2008 to 2010) in the open-closed area (a-d), closed-closed area (e-h) and open-open area (i-l). Commercial fishing occurred within the open-closed area during half of 1998. Sites were: (a) False Bay (not surveyed in 1998); (b) Black Pt; (c) 3rd Dip (from Black Pt); (d) WOSBF (west of the SANTOS boundary fence); (e) Stony Pt; (f) SANTOS Tanks; (g) Pt Lowly West; (h) OneSteel Wall (near Whyalla, not surveyed in 2005, 2008 or 2009); (i) Pt Lowly Lighthouse (only surveyed in 2005, 2008 to 2010); (j) Pt Lowly East (not surveyed in 1998), (k) Fitzgerald Bay; and (l) Backy Point (12 km north of the main aggregation area, only surveyed in 2000, 2008 to 2010). Data for 1998 to 2001 from Hall and Fowler (2003) and 2005 from Steer and Hall (2005).



The recombination of sites according to broad geographical areas, clearly demonstrated that most (97.1 ± 1.9%, averaged across all years) of the cuttlefish abundance occurred between False Bay and SANTOS, when Backy Point was not included in totals. The areas around the intake (Fitzgerald Bay) and outfall (Point Lowly) typically only accounted for on average 1.4 ± 1.5% and 1.6 ± 1.0%, respectively (Table 2). When Backy Point was included in totals (in the four years for which data are available) it accounted for 9.3 ± 6.0% of the totals.

Table 2. Annual estimates of *S. apama* abundance (± SD) (1998 to 2001, 2005 and 2008 to 2010) aggregated according to specific groupings required for EIS purposes: six sites from False Bay to SANTOS Tanks, three sites around Pt Lowly, one site in Fitzgerald Bay and Backy Pt; surveyed during peak spawning (in 1998 to 2001, 2005 and 2008 to 2010). No surveys were completed in 2002 to 2004, or 2006 and 2007. Data for 1998 to 2001 from Hall and Fowler (2003) and 2005 from Steer and Hall (2005).

Area	Year							
	1998[a]	**1999[a]**	**2000[a]**	**2001[a]**	**2005[b]**	**2008**	**2009**	**2010**
False Bay to SANTOS (± SD)	82 167 (± 13 763)	169 831 (± 34 181)	166 424 (± 36 462)	169 639 (± 21 196)	125 451 (± 25 287)	71 218 (± 15 830)	122 036 (± 19 033)	102 533 (± 15 353)
Pt Lowly (± SD)	904 (± 672)	2 923 (± 2 094)	1 196 (± 691)	2 570 (± 1 747)	1 861 (± 1 292)	2 856 (± 1 227)	768 (± 533)	1 877 (± 825)
Fitzgerald Bay (± SD)	3 570 (± 1 885)	5 620 (± 3 101)	851 (± 513)	867 (± 585)	473 (± 260)	1 222 (± 1 172)	335 (± 246)	394 (± 204)
Backy Pt (± SD)			3 969 (± 1 672)			9 000 (± 7 646)	10 174 (± 4 275)	20 795 (± 6 856)

3.2 Biomass

The biomass estimates allow survey data to be combined with catch data from Marine Scalefish Block 21 (that encompasses the aggregation area) for comparison with the total catch taken in 1997 (Fig. 4). It also provides some perspective on the relative size/weight of individual animals between years. The estimated total biomass of *S. apama* in the aggregation area decreased from 184.3 t in 2001, to 121.6 t in 2005 and was just 80.6 t in 2008 (Table 3). Overall this represented a 129% decrease in total biomass since 2001 (Fig. 4). In 2009, the biomass increased again to 104.7 t, but this was still smaller than that recorded in 2005, and 43% smaller than that in 2001. In 2010, biomass decreased again to 83.4 t, to almost the same level as the minimum recorded in 2008. The overall percent decrease in biomass has been greater than that in abundance, which suggests that either more smaller cuttlefish were present or that the average size of cuttlefish has been smaller in 2009 and 2010. Size distributions of male *S. apama* recorded on transects at Black Point each year (Fig. 5), indicate that both scenarios may be occurring, with a reduction in the size of the smaller cohort and less very large (> 300 mm DML) cuttlefish present in 2008 to 2010 compared to preceding years (1999 to 2001).

Table 3. Annual estimates of *S. apama* biomass (t ± SD) in the whole aggregation area and each sub-area during peak spawning (1998 to 2001, 2005 and 2008 to 2010). No surveys were completed in 1997, 2002 to 2004, or 2006 and 2007. Commercial cuttlefish catch (t) from Marine Fishing Area 21 (which includes the aggregation area) are also indicated as potential biomass removed from the open-closed and open-open sub-areas. Data from: [a]Hall and Fowler (2003); and [b]Steer and Hall (2005). Data for Backy Point were excluded from 2000, 2008 to 2010 totals to facilitate comparisons with estimates from previous years.

Area	Year								
	1997	1998[a]	1999[a]	2000[a]	2001[a]	2005[b]	2008	2009	2010
Closed-closed (± SD)		39.1 (± 9.7)	51.3 (± 25.9)	44.7 (± 6.4)	51.1 (± 10.5)	27.7 (± 13.9)	19.1 (± 11.7)	20.0 (± 10.6)	2.5 (± 0.9)
Open-closed (± SD)		55.8 (± 14.0)	158.9 (± 33.4)	133.0 (± 39.5)	130.5 (± 25.5)	92.1 (± 28.2)	57.4 (± 15.7)	84.0 (± 19.7)	79.2 (± 19.1)
Open-open (± SD)		3.4 (± 1.7)	8.3 (± 3.7)	1.4 (± 0.9)	1.7 (± 1.4)	1.8 (± 1.1)	4.0 (± 2.1)	0.7 (± 0.5)	1.7 (± 0.9)
Whole aggregation (± SD)	No survey	**98.2** (± 17.1)	**218.5** (± 42.5)	**179.1** (± 40.1)	**183.3** (± 27.6)	**121.6** (± 31.5)	**80.6** (± 19.7)	**104.7** (± 22.4)	**83.4** (± 19.1)
Commercial catch	244.4	109	3.7	N/A	1	N/A	N/A	N/A	N/A
Total aggregation		**207.2**	**222.2**	**179.1**	**184.3**	**121.6**	**80.6**	**104.7**	**83.4**

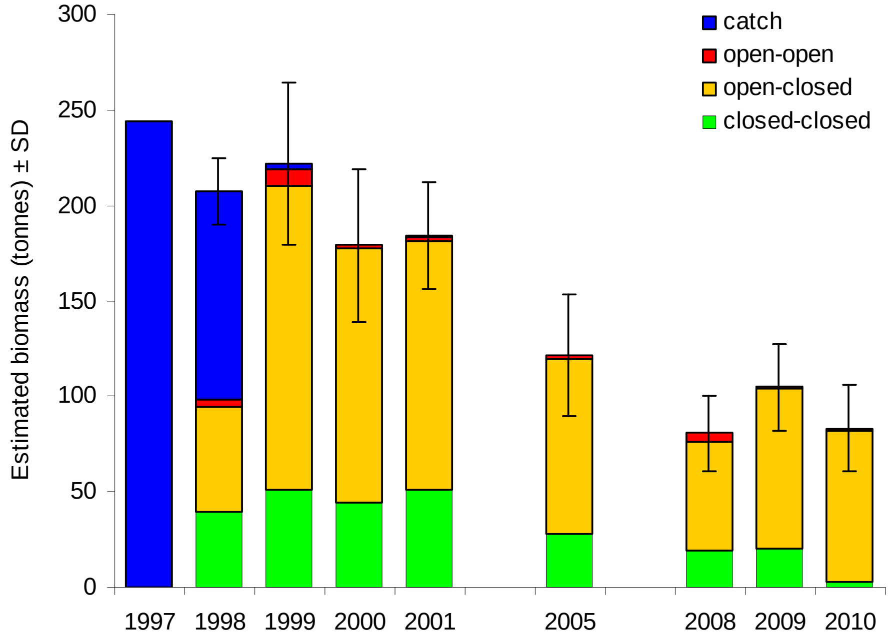


Fig. 4. Annual estimates of *S. apama* biomass (t ± SD) in the aggregation area during peak spawning (1998 to 2001, 2005 and 2008 to 2010), with the proportion in each sub-area and that accounted for by catch (in Marine Fishing Area 21) indicated by different colours. Commercial fishing occurred within the open-closed area during half of 1998. No surveys were completed in 1997, 2002 to 2004, or 2006 and 2007. Data for 1998 to 2001 from Hall and Fowler (2003) and 2005 from Steer and Hall (2005).

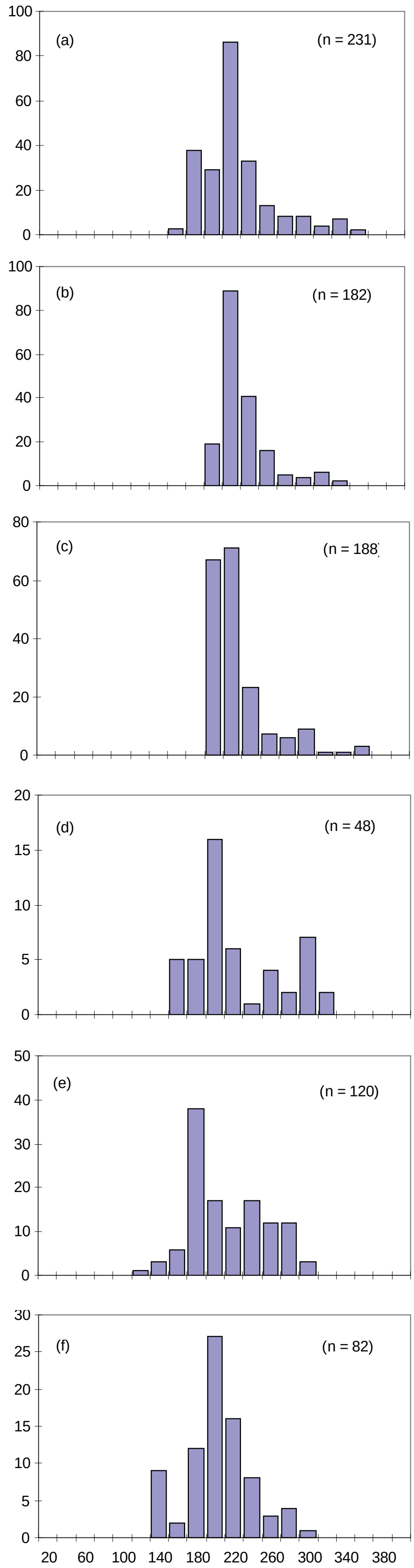


Fig. 5. Size distributions of male *S. apama* recorded on transects at Black Point during June (a) 1999, (b) 2000 and (c) 2001; and (d) 2008, (e) 2009 and (f) 2010. Early data (1999 to 2001) reproduced from Hall and Fowler (2003).

3.3 Temporal variation

The extra surveys completed at Stony Point and WOSBF in early July indicated that densities had increased from 3.5 and 40.5 cuttlefish.100 m^{-2}, respectively, in early June to 17 and 51 cuttlefish.100 m^{-2} in early July. In all years for which more extensive temporal data are available, densities have been consistently elevated by early June, but have only remained elevated until early July in a few instances (e.g. Stony Pt in 2000 and Black Pt in 2009) and only marginally increased if at all during those periods (Fig. 6).

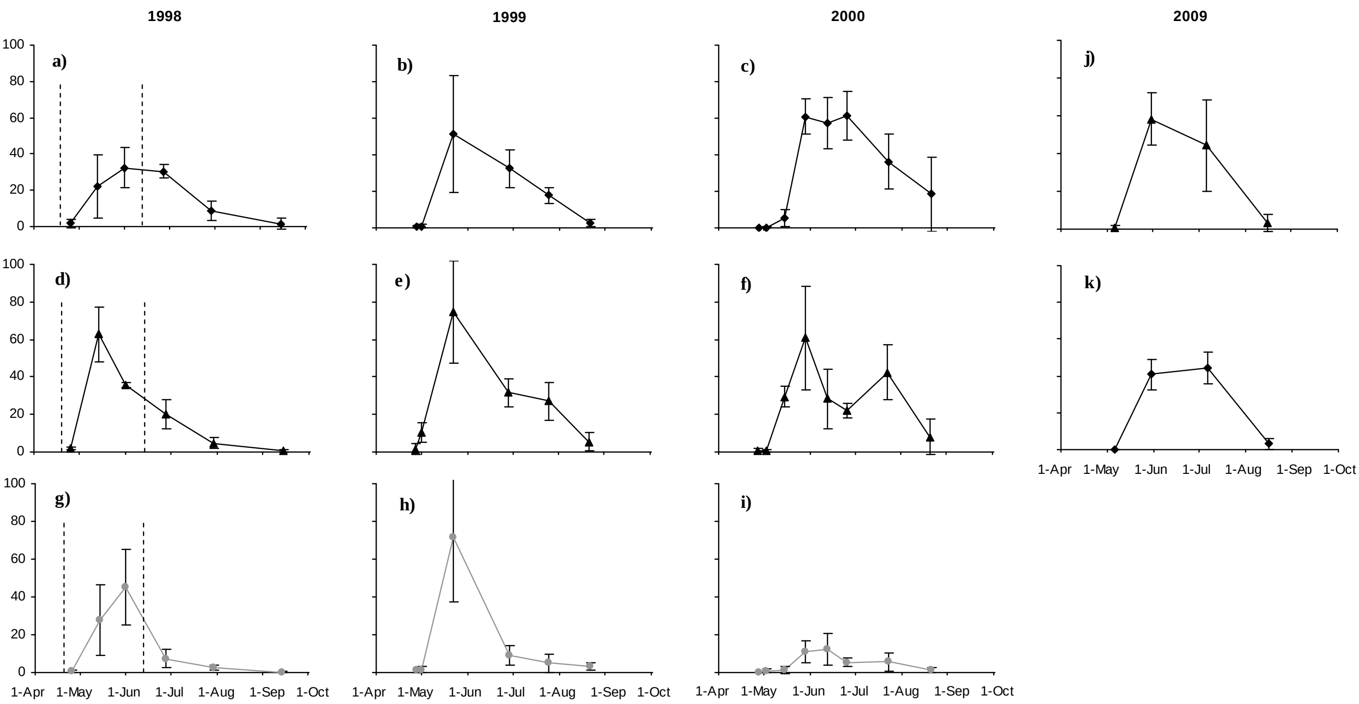


Fig. 6. Within-season temporal variation of *S. apama* densities (cuttlefish 100 m^{-2} ± SD) at three sites during 1998, 1999 and 2000: urchin habitat at Stony Point in the closed-closed area *(a-c)*; urchin habitat at Black Point in the open-closed area *(d-f)*; and reef habitat at Fitzgerald Bay in the open-open area *(g-i)*. Two sites were also sampled during 2009: urchin habitat at WOSBF *(j)* and Black Point *(k)* in the open-closed area. Data for 1998, 1999 and 2000 were reproduced from Hall and Fowler (2003). The dashed lines represent the 32-day period during 1998 when fishing was allowed in the open-closed area (reproduced from Hall 2009)

4. Discussion

The results of this 2010 survey further support conclusions drawn from the 2009 survey, which are reiterated and expanded upon in the following discussion. Given that the three consecutive surveys between 1999 and 2001 recorded relatively little variation in abundance and biomass, and that the three most recent surveys have all recorded consistently smaller estimates, the only conservative interpretation is that the abundance and biomass of cuttlefish in the aggregation area has decreased by at least 28%, since 2001. Between 1999 and 2001, abundance and biomass fluctuated around an average of over 170,000 and 180 t, respectively, but this has apparently decreased to below 130,000 and 110 t, respectively, in recent years (2009 and 2010). Particularly small estimates (of only 75,000 and 80 t, respectively) were recorded in 2008, possibly in response to unfavourable environmental conditions (elevated water temperatures until later in the season and unusually dense patches of *Hincksia* sp. in some habitats; BHP Billiton 2009), but given that biomasses were again lower in 2010 compared to 2009, these particularly small biomasses should act as a warning for the possibility of further declines in the future.

Whether or not the decline in population size can be attributed to decreased recruitment success in response to changed environmental conditions or, a delayed response to the intense fishing pressure between 1993 and 1998, or some other unknown threat, is difficult to conclude. Because of the short lifespan of most cephalopods there is little overlap of successive generations and population sizes are largely determined by the recruitment successes of preceding years (Boyle and Rodhouse 2005). Therefore, the effects of overexploitation on population sizes are expected to manifest rapidly, typically within one to two years. This was not the case for the spawning population, which showed minimal declines and relatively consistent population sizes during the three years immediately after the intense fishing pressures. However, this does not preclude that declines had already occurred prior to surveys beginning in 1998. The existence of two year classes within most cuttlefish populations, including the *S. apama* spawning aggregation (Hall et al. 2007), does provide some buffering capacity against particularly poor years relative to most squid populations that depend entirely on the recruitment success of a single year class (Royer et al. 2006). So it is feasible that the declines in abundance and biomass after 2001 are a delayed response (by gradually declining recruitment success) to the intense fishing pressures between 1993 and 1998. But this would be an unusual finding for a cephalopod population.

Since cephalopod recruitment strengths are generally subject to large fluctuations in response to variations in environmental conditions (e.g. water temperature, food availability and predator abundances), most populations show extreme interannular variation in abundance and biomass that do not relate to preceding spawning biomasses (Rodhouse 2001; Boyle and Rodhouse 2005). The eggs of *S. apama* develop and hatch over a long period (2 to 5 months) and are thus exposed to a wide range of environmental conditions, which could cause considerable natural variation in annual recruitment success and subsequent spawning biomass (Hall and Fowler 2003). So it is equally feasible that some recent changes in environmental conditions since 2001 have produced the declines in population sizes through reduced recruitment success.

Because of this difficulty in separating the relative effects of environmental variation and fishing mortality, there are few documented cases in the literature of declines in cephalopod populations directly attributed to overexploitation (Rodhouse 1991). Even the apparently definitive cases of declines in the abundances of *Todares pacificus* in Japanese waters, *Illex argentinus* in Canadian waters and *S. pharaonis* off the Yemen coast have become dubious in the light of the recent rapid recovery of these populations to previous levels and the strong relationship between their biomasses and fluctuating environmental conditions (Sakurai et al. 2000; Agnew et al. 2005; Boyle and Rodhouse 2005).

The implications of the recent decline for the sustainability of the spawning aggregation population are also difficult to predict. Stock-recruitment relationships are generally weak for cephalopods, owing to the strong influence of environmental variation on recruitment success, but there is usually a threshold level of spawning biomass below which recruitment will be adversely affected (Boyle and Rodhouse 2005). Thus it is generally unknown what proportion of spawning biomass is needed for successful recruitment to occur in any given year. The target adopted for escapement in most cephalopod fisheries is arbitrarily set at 40% of the estimated pre-fishing stock, based on the conventions in other fisheries (but with no particular biological significance for cephalopods) (Beddington et al. 1990). The 2008, 2009 and 2010 spawning biomasses of *S. apama* were estimated to be approximately 44%, 57% and 45%, respectively, of the biomass present in 2001, therefore, further declines could potentially affect future recruitment success.

Without an understanding of the mechanisms behind the apparent recent declines, it is difficult to gauge the current status of the population, i.e. whether it is relatively stable at this reduced biomass level, could decline further or indeed recover to pre-2001 levels with continued protection. The decrease in the size distribution of animals within the population in 2009 and 2010 could indicate a population that is currently below its ideal density that has undergone fishing-induced changes to the population structure (Kiss et al., 2005).

In response to recent concerns regarding the accuracy of the methodology currently used to estimate total abundance and biomass (Payne et al. in press), a discussion of the various limitations as originally outlined in Hall and Fowler (2003) is provided below. The current method assumes that there is not a constant turnover of animals in the aggregation area and that the ‘peak’ spawning period represents a time when most cuttlefish that will visit the aggregation in any year are present. If cuttlefish do have shorter residence times and there is a turnover of animals, the method would most likely underestimate the total number of cuttlefish. In such a case, an area-under-the-curve method (that requires accurate temporal variation in abundances and individual residence times data) would be more appropriate for estimating absolute population sizes, similar to the methods used for spawning aggregations of salmon in Canada (e.g. English et al. 1992, Hilborn et al. 1999). However, justifications for using the current method include: the distinct peak in numbers around the end of May that was consistent across different sites and years (between 1998 and 2000); the results from preliminary passive tagging work that indicated at least some cuttlefish remained within the aggregation area for most of the spawning season; and the noticeable deterioration in the condition of many cuttlefish throughout the season, suggesting that they had been present for an extensive period (Hall and Fowler 2003). However, recent findings from a telemetry study at the aggregation area (Payne et al. in press), suggests that residence times may be shorter than previously assumed, particularly for females. Sample sizes from this study were fairly limited, but the results do suggest that further research is warranted.

Irrespective of the above, the current estimates should provide adequate relative measures for comparison between years to discern interannular trends in population sizes, so long as the ‘peak’ abundance period can be reliably determined and sampled each year. Unfortunately, doubts have been raised about possible temporal variation in the ‘peak’ spawning period in response to environmental variation. For example, anecdotal evidence suggests that warmer water temperatures may have persisted until later in the 2010 spawning season, and caused animals to arrive in the aggregation area later, which might have delayed the ‘peak’ abundance period until later in June or even early July. Certainly the comparison of cuttlefish densities at Stony Pt and WOSBF between early June and early July in the 2010 survey suggests that this could have occurred.

If more cuttlefish did continue to move into all sites during June, with a later ‘peak’ spawning period, a significantly greater overall abundance might have been recorded if the survey were completed in early July compared to that reported here for early June. This would have obvious important implications for the long-term trends in population size, but even if the relative increases in abundances at Stony Point and WOSBF were applied to all sites, the total estimates would still be considerably lower than those recorded from 1998 to 2001.

Furthermore, an alternative explanation that could explain the temporal variation observed in 2010 is a net eastward displacement of cuttlefish from False Bay, Black Point and 3rd Dip towards WOSBF and Stony Point as the 2010 season progressed. Unfortunately, no transects were completed in any of the western sites in early July for comparison. The only way to resolve these issues in future surveys is to complete comprehensive temporal sampling over a number of years (like that originally completed during 1998, and to a lesser extent in 1999 and 2000). Given that the original temporal sampling occurred over 10 years ago, and with the possibility of ongoing climate change, it would seem pertinent to update this data in the future.

In the interim, the author firmly believes that the data presented in this report provide the best possible information on the abundances and biomasses of cuttlefish in the aggregation area for the resources that are currently available. The results are considered sufficiently robust to provide a realistic indication of trends in population sizes within acceptable levels of uncertainty. However, the above does not preclude any well considered suggestions to improve the methodology and strengthen future results.

Acknowledgements

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Disclaimer

The author of this report has taken all reasonable care to ensure accuracy and quality; however, this does not guarantee that the information is free from errors or omissions. The author does not accept any liability for the contents of this report or for any consequences arising from its use or any reliance placed upon it.

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Appendix I. Data collected during the 2008 survey of *S. apama* within each habitat at each site, including: reef area (hec ± SD), date surveyed, number of transects completed, density of cuttlefish (number 100 m^{-2} ± SD), abundance (± SD), average weight-per-transect (kg ± SD) and biomass (t ± SD). Data for Backy Point were excluded from 2008 and 2009 totals to facilitate comparisons with estimates from previous years.

Site	Habitat	Reef area	± SD	Date	Transects	Density	± SD	Abundance	± SD	Av sumwt	± SD	Biomass	± SD
OneSteel Wall	Boulders	0.3	0.0										
False Bay	Reef	1.9	0.8	02-Jun-08	4	11.3	14.6	2102	2866	9.6	12.5	1.8	2.5
Black Point	Urchins	7.1	1.7	02-Jun-08	4	16.3	6.1	11543	5142	17.7	7.1	12.5	6.9
Black Point	Algae	2.6	1.1	02-Jun-08	4	6.5	2.6	1680	993	6.6	3.8	1.7	1.3
3rd Dip	Urchins	5.6	1.0	03-Jun-08	4	13.3	7.4	7366	4347	11.9	6.8	6.6	4.4
3rd Dip	Algae	2.1	0.9	03-Jun-08	4	12.3	8.3	2605	2118	12.1	9.1	2.6	2.3
WOSBF	Urchins	5.6	0.6	04-Jun-08	4	25.0	11.4	13978	6524	30.5	11.8	17.1	9.0
WOSBF	Algae	5.8	0.3	04-Jun-08	4	23.5	11.7	13746	6860	25.8	13.7	15.1	9.3
Stony Point	Urchins	6.2	0.4	03-Jun-08	4	18.3	14.8	11289	9175	18.3	15.0	11.3	9.8
Stony Point	Algae	2.5	0.1	03-Jun-08	4	20.5	14.6	5053	3609	23.8	23.4	5.9	6.0
SANTOS Jetty	Urchins	1.8	0.2										
SANTOS Jetty	Algae	0.4	0.1										
SANTOS Tanks	Urchins	3.9	0.3	03-Jun-08	4	4.8	5.6	1855	2178	4.9	6.7	1.9	2.7
SANTOS Tanks	Algae	5.9	0.3										
Point Lowly West	Urchins	2.1	0.6	02-Jun-08	4	0.0	0.0	0	0	0.0	0.0	0.0	0.0
Point Lowly West	Algae	3.2	0.5										
Point Lowly Lighthouse	Urchins	1.4	0.1	03-Jun-08	4	19.3	8.4	2612	1169	20.9	11.7	2.8	1.8
Point Lowly Lighthouse	Algae	0.7	0.4										
Pt Lowly East	Reef	1.2	0.7	05-Jun-08	2	2.0	2.8	244	372	0.9	1.3	0.1	0.2
Fitzgerald Bay	Reef	0.8	0.2	04-Jun-08	4	15.5	14.2	1222	1172	14.0	12.8	1.1	1.1
Backy Point	Reef	2.2	0.4	04-Jun-08	4	40.3	33.4	9000	7646	32.8	29.7	7.3	7.1
Closed-closed								**18197**	**10097**			**19.1**	**11.7**
Open-closed								**53020**	**12192**			**57.4**	**15.7**
Open-open								**4077**	**1697**			**4.0**	**2.1**
Whole aggregation area (excluding Backy Point)								**75295**	**15921**			**80.6**	**19.7**

Appendix II. Data collected during the 2009 survey of *S. apama* within each habitat at each site, including: reef area (hec ± SD), date surveyed, number of transects completed, density of cuttlefish (number 100 m^{-2} ± SD), abundance (± SD), average weight-per-transect (kg ± SD) and biomass (t ± SD). Data for Backy Point were excluded from 2008 and 2009 totals to facilitate comparisons with estimates from previous years.

Site	Habitat	Reef area	± SD	Date	Transects	Density	± SD	Abundance	± SD	Av sumwt	± SD	Biomass	± SD
OneSteel Wall	Boulders	0.3	0.0										
False Bay	Reef	1.9	0.8	31-May-09	4	36.5	20.9	6820	4839	31.2	17.7	5.8	4.5
Black Point	Urchins	7.1	1.7	01-Jun-09	4	42.0	9.8	29834	9934	37.9	7.8	26.9	11.9
Black Point	Algae	2.6	1.1	01-Jun-09	4	8.3	3.3	2132	1251	5.3	2.6	1.4	1.0
3rd Dip	Urchins	5.6	1.0	01-Jun-09	4	37.3	13.8	20707	8628	28.6	10.7	15.9	8.5
3rd Dip	Algae	2.1	0.9	01-Jun-09	4	6.5	2.4	1383	795	3.3	1.4	0.7	0.5
WOSBF	Urchins	5.6	0.6	30-May-09	4	58.3	13.7	32569	8299	52.9	12.9	29.6	12.2
WOSBF	Algae	5.8	0.3	01-Jun-09	4	7.8	2.1	4533	1224	6.3	1.9	3.7	1.6
Stony Point	Urchins	6.2	0.4	30-May-09	4	36.5	15.1	22579	9409	30.8	13.6	19.0	10.5
Stony Point	Algae	2.5	0.1	30-May-09	4	6.0	8.7	1479	2140	3.9	5.4	1.0	1.4
SANTOS Jetty	Urchins	1.8	0.2										
SANTOS Jetty	Algae	0.4	0.1										
SANTOS Tanks	Urchins	3.9	0.3	30-May-09	4	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SANTOS Tanks	Algae	5.9	0.3										
Point Lowly West	Urchins	2.1	0.6	02-Jun-09	4	0.3	0.5	53	107	0.2	0.3	0.0	0.0
Point Lowly West	Algae	3.2	0.5										
Point Lowly Lighthouse	Urchins	1.4	0.1	02-Jun-09	4	1.0	0.0	136	13	0.6	0.0	0.1	0.0
Point Lowly Lighthouse	Algae	0.7	0.4										
Pt Lowly East	Reef	1.2	0.7	02-Jun-09	4	4.8	3.3	579	522	3.1	2.4	0.4	0.4
Fitzgerald Bay	Reef	0.8	0.2	31-May-09	4	4.3	2.9	335	246	3.1	2.6	0.2	0.2
Backy Point	Reef	2.2	0.4	31-May-09	4	45.5	17.3	10174	4275	35.2	13.6	7.9	4.1
Closed-closed								**24111**	**9650**			**20.0**	**10.6**
Open-closed								**97979**	**16405**			**84.0**	**19.7**
Open-open								**1050**	**577**			**0.7**	**0.5**
Whole aggregation area (excluding Backy Point)								**123139**	**19042**			**104.7**	**22.4**

Appendix III. Data collected during the 2010 survey of *S. apama* within each habitat at each site, including: reef area (hec ± SD), date surveyed, number of transects completed, density of cuttlefish (number 100 m^{-2} ± SD), abundance (± SD), average weight-per-transect (kg ± SD) and biomass (t ± SD). Data for Backy Point were excluded from 2008 to 2010 totals to facilitate comparisons with estimates from previous years.

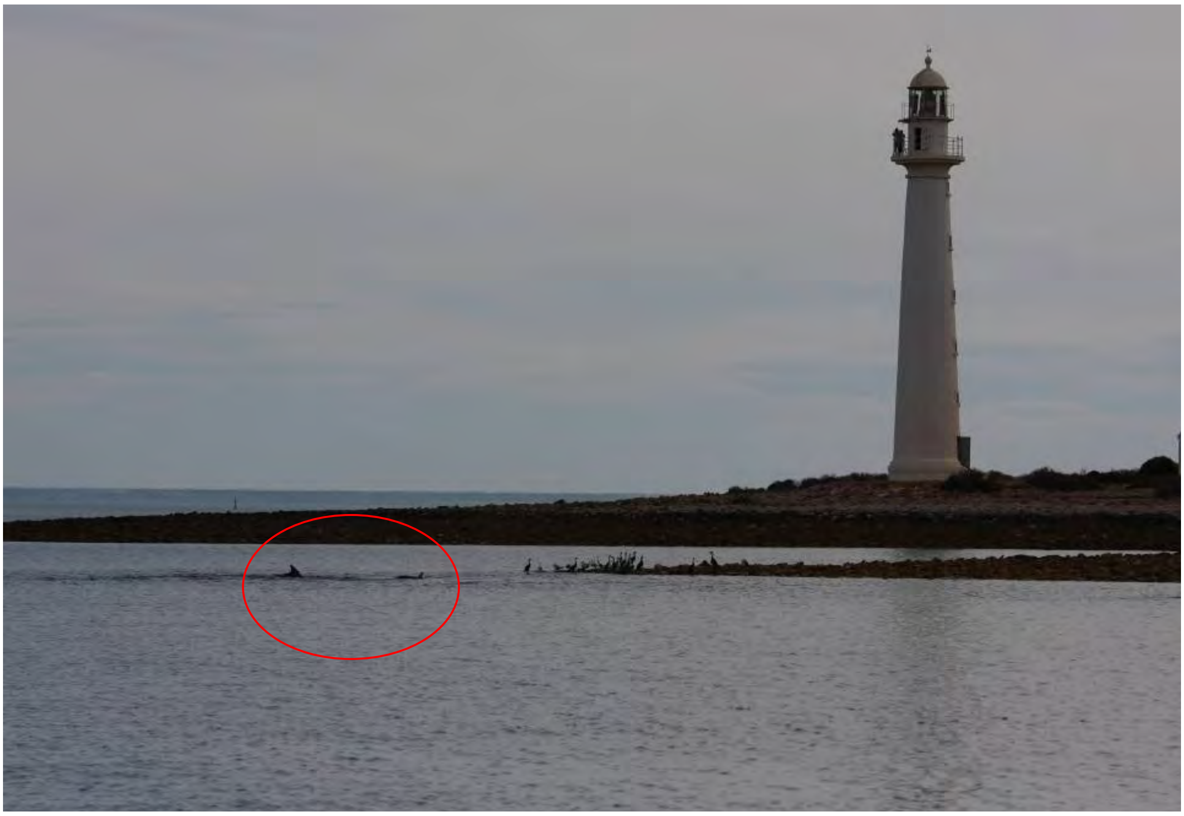
Site	**Habitat**	**Reef area**	**± SD**	**Date**	**Transects**	**Density**	**± SD**	**Abundance**	**± SD**	**Av sumwt (kg)**	**± SD**	**Biomass (t)**	**± SD**
OneSteel Wall	Boulders	0.3	0.0	04-Jun-10	4	36.5	8.2	1222	277	29.9	7.9	1.0	0.4
False Bay	Reef	1.9	0.8	01-Jun-10	4	28.0	17.8	5232	3987	21.3	17.5	4.0	3.9
Black Point	Urchins	7.1	1.7	01-Jun-10	4	28.8	8.1	20422	7538	22.1	8.3	15.7	8.8
Black Point	Algae	2.6	1.1	01-Jun-10	4	10.0	10.4	2584	2913	9.6	9.9	2.5	2.9
3rd Dip	Urchins	5.6	1.0	02-Jun-10	4	66.3	6.9	36829	7645	52.6	5.5	29.2	11.6
3rd Dip	Algae	2.1	0.9	02-Jun-10	4	10.0	6.1	2127	1597	6.8	4.8	1.5	1.3
WOSBF	Urchins	5.6	0.6	02-Jun-10	4	40.5	12.8	22645	7484	33.7	13.6	18.8	9.9
WOSBF	Algae	5.8	0.3	02-Jun-10	4	17.0	9.7	9944	5670	12.9	8.1	7.6	5.4
Stony Point	Urchins	6.2	0.4	01-Jun-10	4	3.5	0.6	2165	378	1.5	0.4	1.0	0.5
Stony Point	Algae	2.5	0.1	01-Jun-10	4	0.0	0.0	0	0	0.0	0.0	0.0	0.0
SANTOS Jetty	Urchins	1.8	0.2										
SANTOS Jetty	Algae	0.4	0.1										
SANTOS Tanks	Urchins	3.9	0.3	01-Jun-10	4	1.5	1.9	586	750	1.2	1.5	0.5	0.6
SANTOS Tanks	Algae	5.9	0.3										
Point Lowly West	Urchins	2.1	0.6	02-Jun-10	4	0.3	0.5	53	107	0.1	0.2	0.0	0.0
Point Lowly West	Algae	3.2	0.5										
Point Lowly Lighthouse	Urchins	1.4	0.1	31-May-10	4	8.5	3.1	1153	436	6.2	2.9	0.8	0.5
Point Lowly Lighthouse	Algae	0.7	0.4										
Pt Lowly East	Reef	1.2	0.7	31-May-10	4	5.5	4.7	671	692	5.0	4.7	0.6	0.7
Fitzgerald Bay	Reef	0.8	0.2	31-May-10	4	5.0	2.2	394	204	3.1	1.9	0.2	0.2
Backy Point	Reef	2.2	0.4	03-Jun-10	4	93.0	25.6	20795	6856	75.8	27.0	16.9	8.8
Closed-closed								**4026**	**891**			**2.5**	**0.9**
Open-closed								**99782**	**15330**			**79.2**	**19.1**
Open-open								**2218**	**843**			**1.7**	**0.9**
Whole aggregation area (excluding Backy Point)								**106027**	**15379**			**83.4**	**19.1**

APPENDIX H9.4

Point Lowly dolphin survey

Point Lowly Dolphin Survey Progress Report
January and May 2010 Surveys

Prepared for BHP Billiton



Prepared by S E Gibbs

29 July 2010

CONTENTS

1 BACKGROUND

Surveys of dolphin activity in the Point Lowly area, approximately 20km north of Whyalla, are being conducted for the purpose of informing the BHP Billiton expansion project, which includes a seawater desalination plant in this area. It is likely that the intake for the desalination plant will be located within Fitzgerald Bay and the outfall off the tip of Point Lowly. The surveys are ongoing and the present report is a progress report.

The region supports a population of bottlenose dolphins that is increasingly attracting tourists to the area. The taxonomy of these bottlenose dolphins is uncertain. Kemper (2004) demonstrated that it has affinities with *Tursiops aduncus* but based on molecular evidence, Möller et al. (2008) refer to it as *Tursiops* sp. and suggest that it may be an undescribed species whose distribution is limited to south-eastern Australia. A second dolphin species also occurs in the area, the common dolphin, *Delphinus delphis*.

Bottlenose dolphins around Point Lowly have become habituated to fishing boats and often approach boats and take food. They are frequent visitors to the Yellow-tail Kingfish aquaculture cages in Fitzgerald Bay. During winter Australian Giant Cuttlefish aggregate in the shallow reef habitat off Point Lowly to breed and the dolphins utilize this food source.

In the Draft EIS it was proposed to construct both the intake and outfall pipelines via trenching and blasting. BHP Billiton has since decided to tunnel the outfall pipeline. Therefore, only the intake pipeline will be constructed by open trenching.

This document is a preliminary report, intended to provide a brief overview of the progress of ongoing dolphin surveys in the Point Lowly area and describe some general early indications. Surveys are not yet complete and thus data has not been fully analysed. This document reports only on the progress of surveys, it does not attempt to address potential effects of construction activities on the dolphins, nor mitigation of potential impacts. This document is intended only to provide information on the progress of surveys. Caution should therefore be used if third-parties are drawing conclusions from this preliminary work.

2 OBJECTIVES

The key objectives in relation to the survey of the dolphin population at Point Lowly are to:

- Undertake field surveys in spring, summer and autumn to determine the usage made of the Point Lowly area (and in particular the sites of the intake and outfall pipelines) by dolphins
- Determine the usage made of the Point Lowly area by dolphins
- Determine whether the vicinity of the intake and outfall pipelines is of specific importance to dolphins as habitat (i.e. do they feed or rest in the area, transit the area or behave in any other discernable way)
- Determine the number of dolphins (including size of pods) that pass the construction sites for the intake and outfall pipelines

- Determine the frequency with which (and time of day) single dolphins or pods pass the construction sites for the intake and outfall pipelines
- Provide sufficient information from the above objectives to enable BHP Billiton to determine the likelihood that a dolphin would enter an area within 1,000 m of the pipeline construction sites
- Provide advice on the certainty of determining when dolphins are within 1,000 m of the construction area
- Produce statistical data showing the frequency of usage of the 1,000m area by dolphins and the number of dolphins transiting or using the area.

3 SURVEYS UNDERTAKEN

To date, observations have been conducted from the Point Lowly lighthouse to indicate dolphin activity in the area of the outflow pipe. Thus far, a summer survey has been undertaken over six days in January 2010 and an autumn survey over nine days in May 2010. No surveys have been conducted in the vicinity of the proposed inflow pipe as yet, the proposed location of the inflow pipe cannot be effectively observed from the lighthouse and a second observation site has been proposed.

4 PRELIMINARY RESULTS AND DISCUSSION

4.1 Habitat usage

The Point Lowly, Fitzgerald Bay and adjacent waters are an area with high dolphin activity (Figures 1 and 2). Multiple dolphins were observed within 1000m of the proposed outflow pipe for several hours on each day that the survey was conducted. Both species were present within 1000m of the proposed outflow pipe. Repeated sightings of identified dolphins are indicative that the dolphins are resident.

The vicinity of the outflow pipe is heavily utilized by dolphins of all life stages (i.e. adult, juvenile and calves). The dolphins have been observed using the area for all behaviours, including resting, feeding, socializing, milling and transit. Dolphins were present on many days at sunrise and sunset, and throughout the day on numerous occasions, indicating that they remain in the area. Furthermore, the sheltered waters of the bay adjacent to and west of the lighthouse point appears to be an important nursery area, with cow and calf pairs (Figure 3) frequently in attendance during both surveys. Behaviour included nursing, resting, socialising with other dolphins and traveling, including around the lighthouse point. As very young dolphins (i.e. with neonatal folds still present), have been present during both surveys. As the gestation period for bottlenose dolphins is around 12 months (Cornell et al. 2005), it can be assumed that pregnant dolphins were also present. We have also observed adults hunting with juveniles in the bay, suggesting this area is used to teach young to hunt. The presence of a nursery area is particularly important to consider as calves may be more susceptible to injury or hearing loss due to noise/vibration related construction activity (e.g. the impacts of temporary hearing loss may render them unable to find mothers, particularly if scared apart by intense noise or vibration). The area is also frequented by groups of adults (Figure 4), which were observed engaging in all behavioral activities including socialising with mothers and calves.

The proposed location of the inflow pipe could not be effectively observed from the lighthouse (Figure 2). Due to the steep slope of the coast near the intake, areas close to the shore are obscured. Early indications suggest that dolphins travel very close to the coast. Furthermore, dolphins have been observed traveling directly toward the observers on the lighthouse platform, which is the most difficult direction from which to detect dolphins. When detecting dolphins, observers look for the dorsal fin breaking the sea surface when the dolphin surfaces to breathe. When a dolphin is heading directly toward the observer, only the grey leading edge of the dorsal fin (approximately 2cm wide) is presented and as such is very difficult to detect in the waves (Figure 5). To overcome these difficulties as noted during the first survey, a second observation site near the proposed inflow pipe was proposed. To increase sightability of the dolphins and accuracy of the theodolite used to track dolphins a platform would be engaged. Since dolphins have been observed transiting close to the coast, the second observation site would provide observers with a clear view of the coast to track dolphins between the lighthouse and the proposed inflow pipe. It would also provide a side view of dolphins traveling toward the lighthouse to and from the direction of the fish farms where anecdotal evidence from workers at the farms indicates that dolphins are often found. The second site near the intake is likely to be used during the next survey.

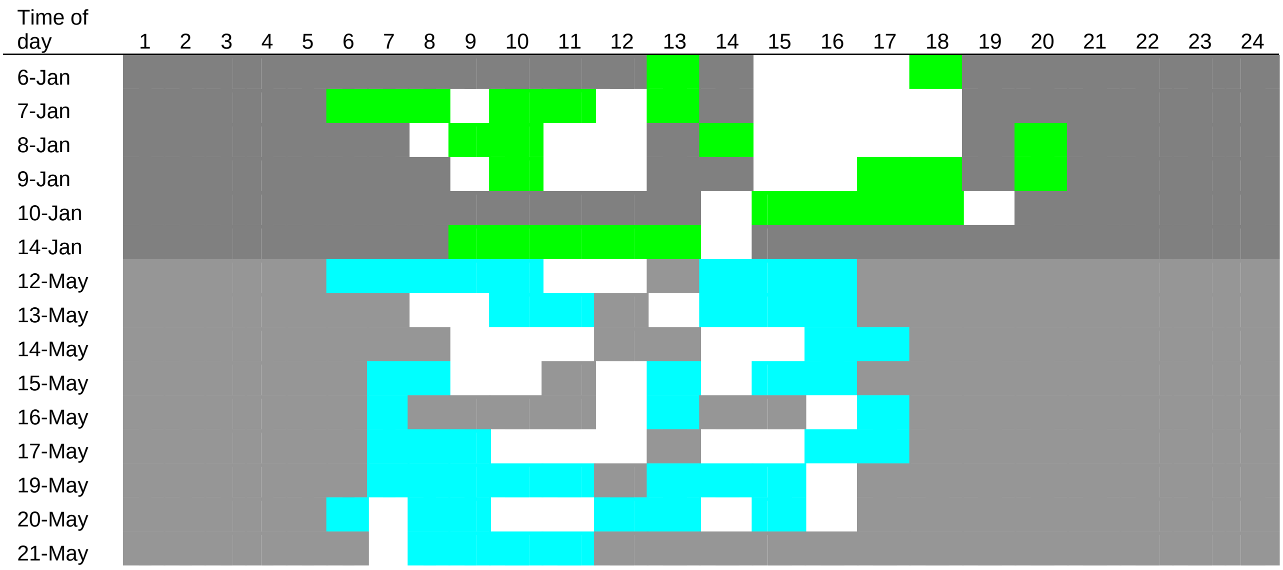


Figure 1. Times when at least one dolphin was within 1000 m of the outfall pipeline alignment. Map (top) shows 1000m survey zone around outflow pipe. The table indicates one hour blocks of time. If dolphins were observed in the 1000m zone for all or part of an hour the block is marked as present. Observations of tracked dolphins are included with opportunistically sighted dolphins (e.g. dolphins sighted from accommodation before/after observation periods). Green= summer, blue = autumn. Grey = no observations conducted; white = no dolphins detected in 1000m zone.

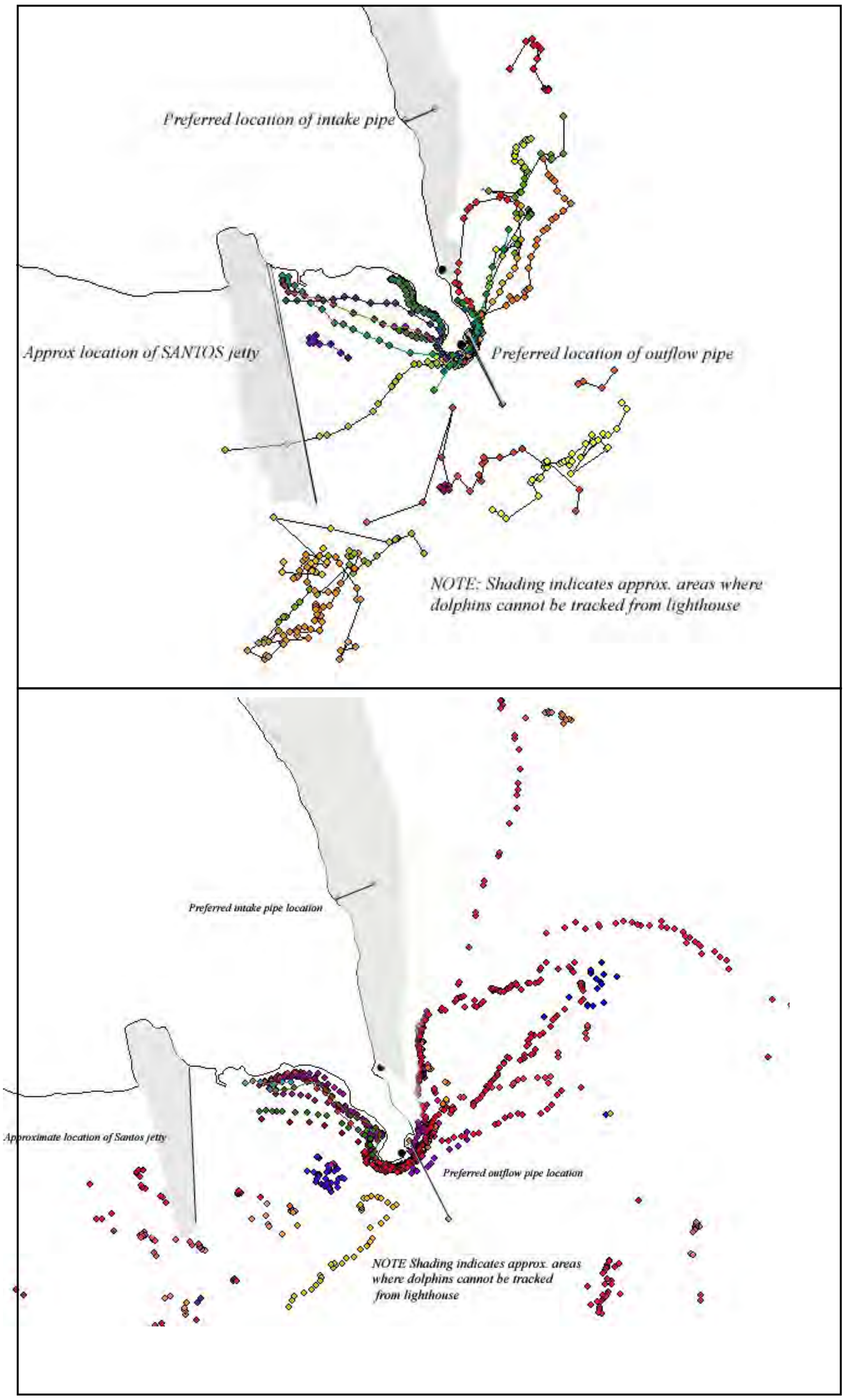


Figure 2. (top) Dolphin tracks observed over 6 days between January 6 and 15; (bottom) Dolphin tracks over 9 days between May 11 and 21.

Dolphin behaviour can be affected by many factors (e.g. temporal patterns, seasonal patterns, sea temperature, tides, salinity etc). Therefore in order to detect possible association patterns many observations are required. Also the ability of observers to sight dolphins is affected by environmental conditions including weather (e.g wind and rain), light conditions (e.g. sun glare and heavy cloud), sea surface conditions (e.g. affected by currents, tides etc) and these factors must be considered in data analysis. As this brief report has been prepared while surveys are proceeding and is intended to provide progress information, analysis is not presented here.

No observations of the inflow pipe area have been conducted as yet (see above).

4.2 Dolphin numbers

Group size of dolphins in the 1000m survey zone ranged from single dolphins to more than 12 (outside the zone were larger groups). Multiple groups were present in the area on any one day of observations. Groups were dynamic and individual dolphins entered and left the area multiple times as groups formed and disbanded.

No observations of the inflow pipe area have been conducted as yet (see above).

4.3 Frequency and timing of passage or residence

The frequency and time of day dolphins entered the 1000m zone varied each day (Figure 1). No daily trend was detected. Dolphins were observed in the 1000m zone for up to eight hours in a single day, but were probably present longer as observers were not on duty during all daylight hours. One cow/calf pair was present from daylight and did not move out of the zone for at least five hours after sunrise. During this five hour period the pair were often joined by other dolphins. Dolphins were often present at sunrise and sunset, suggesting they had been present during the night.

Dolphin tracks are shown in Figure 2. Indicators represent where dolphins were observed, with the start of tracks indicating where the dolphins were detected by observers and the end, where the dolphins were lost by observers. It is noted that indicators represent only where the dolphins were detected but absence of indicators does not indicate absence of dolphins (i.e. dolphin detection by observers depends on environmental conditions and direction of dolphin travel) (see above limitations). Shaded areas indicate approximate regions that cannot be seen from the lighthouse viewing point at low tide. To the west, the jetty prevents accurate observations beyond the jetty, and to the north the sloping coastline and coastal shape, obscures the sea surface. However, it is noted that dolphins have been observed in these areas, but not from the lighthouse vantage point. Therefore, dolphins do use the shaded areas but a second vantage point is required and we have not attempted to track them in these areas to date. Furthermore, the data presented in the above figures are preliminary and have not been corrected for factors affecting detection of dolphins (e.g. weather, sea state, glare, distance from observer etc). The following details are noted:

- the tracks represent different periods of time, from minutes to many hours
- dolphins do not just transit through the area, but rest, feed and socialize as shown by circling and zig zagging
- tracks represent different group sizes from 1 to 12+

- groups are dynamic, forming and dispanding frequently.

Figure 3. Cow and calf pairs have been sighted during both surveys. Photograph was taken from the Point Lowly lighthouse, May 2010.

4.4 Potential scavenging behaviour

We have observed dolphins feeding around boats and the dolphins also take dead fish from occupants of boats. The habituation of the dolphins to provisioning may make them more likely to be attracted to feed on dead fish resulting from blasting. Being highly intelligent, dolphins may quickly learn that blasting results in dead fish and an “easy feed”, and therefore be attracted to blast locations.

4.5 Fin matching

Where possible, dorsal fin photographs were taken for the purpose of fin identification. The purpose is to determine if the same dolphins are seen between surveys by cross matching fins (e.g. Figure 6). Photo-matching is ongoing. Preliminary indications are that at least some dolphins are resident, with multiple sightings during both surveys.

4.6 Acoustic detection trial

Acoustic recordings were trialed over two days during the January survey using a simple hydrophone from a small boat. Recordings indicated that the dolphins do not vocalize all of the time and when vocalizing they may only be detected by the hydrophone over a limited distance (i.e. about 100-200 m to date). Dolphins were often observed travelling slowly in small groups. In this type of formation and activity, it may not be necessary for the dolphins to vocalize in order to communicate movements.

Dolphins echolocate when hunting for prey. While this can be detected by hydrophone, echolocation is very directional and the dolphins were often engaged in activities other than feeding. The pilot hydrophone trial indicated that using simple recording equipment was not an effective way of detecting dolphins. If acoustic detection was to be considered, further trials using more sophisticated equipment would need to be explored. Acoustic methods can only detect presence but do not indicate absence (i.e. no noise may be that the dolphins are not vocalizing).

Figure 4. The bay west and adjacent to the lighthouse point is frequently attended by dolphins. Initial indications suggest this bay may be a nursery area. Photograph was taken from the beach indicating the closeness of the dolphins to the coast.

Figure 5. Dolphin orientation to observer affects detectability. Red circle shows a dolphin traveling toward observer contrasted with dolphin traveling across view.

Figure 6. Examples of fin photographs for the purpose of fin identification to cross match a proportion of dolphins between surveys.

5 LIMITATIONS

Some limitations that are inherent with studies such as the present study are worthy of note. These include the following:

- When a group of dolphins is detected and subsequently tracked by observers, observers cannot search the area of interest for other groups that enter the area. Therefore, groups may be missed.
- Environmental condition can affect detection of dolphins, including sun glare and sea state (e.g. a dolphin swimming in a flat calm sea may not need to breach the surface much to breathe, conversely, in waves, a dolphin may clear the water but be obscured by waves).
- Orientation of observer to dolphin. If a dolphin is traveling directly toward or away from an observer, the leading/trailing edge of the dorsal fin is only ~2cm wide and cannot be easily detected.
- Group size and behaviour. Single dolphins are more difficult to detect than multiples, particularly when the dolphins are not active on the surface.

As a consequence of the limitations above (and others), presence of a dolphin(s) indicates it/they were present, but the reverse is not true (i.e. absence does not indicate that dolphins were not present; they may have been present but were undetected by observers).

6 LITERATURE CITED

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Appendix 1. Effort observing with theodolite

Date	Start time	Stop time	Hours	notes
06-Jan-10	14:00:00	19:00:00	05:00:00	
07-Jan-10	08:05:00	13:45:00	05:40:00	
07-Jan-10	14:15:00	18:30:00	04:15:00	
08-Jan-10	08:00:00	11:30:00	03:30:00	
08-Jan-10	14:00:00	19:00:00	05:00:00	
09-Jan-10	09:20:00	12:40:00	03:20:00	
09-Jan-10	14:00:00	19:00:00	05:00:00	
10-Jan-10				boat – acoustic obs
10-Jan-10	14:20:00	19:30:00	05:10:00	
11-Jan-10				rain, wind - no obs
12-Jan-10				rain, wind - no obs
13-Jan-10				rain, wind - no obs
14-Jan-10	09:35:00	15:10:00	05:35:00	
12-May-10	09:20:00	13:10:00	03:50:00	
12-May-10	14:30:00	16:50:00	02:20:00	
13-May-10	08:30:00	12:10:00	03:40:00	
13-May-10	13:30:00	17:15:00	03:45:00	
14-May-10	09:30:00	12:00:00	02:30:00	issue with theodolite am
14-May-10	13:50:00	17:40:00	03:50:00	
15-May-10	07:40:00	10:30:00	02:50:00	
15-May-10	12:00:00	16:40:00	04:40:00	
16-May-10	12:20:00	13:38:00	01:20:00	raining
16-May-10	15:45:00	17:45:00	02:00:00	showers
17-May-10	07:30:00	12:45:00	05:15:00	
17-May-10	14:40:00	17:30:00	02:50:00	
18-May-10				on boat - GPS positions
19-May-10	07:20:00	12:00:00	04:40:00	
19-May-10	13:30:00	16:30:00	03:00:00	
20-May-10	07:30:00	11:00:00	03:30:00	
20-May-10	11:00:00	15:30:00	04:30:00	sea state deteriorated pm
21-May-10	07:40:00	10:20:00	02:40:00	

APPENDIX H9.5

Habitat requirements of commercial and recreational species near Point Lowly

H9.5 HABITAT REQUIREMENTS OF COMMERCIAL AND RECREATIONAL SPECIES NEAR POINT LOWLY

This appendix supports a response in Section 17.11.1 of the Supplementary EIS.

The habitat requirements of 26 commercial or recreational species (by life cycle stages) are listed in Table H9.1. Habitats and species were derived from three fisheries habitat areas (False Bay, Far Northern Spencer Gulf and Germein Bay) as defined by Bryars (2003). This information supplements the list of fisheries species and their habitats provided in Table 16.5 of the Draft EIS and provides contextual information used to clarify impacts of the proposed desalination plant on species that use Upper Spencer Gulf for feeding, breeding or as nursery habitat.

Table H9.1: The occurrence of commercial and recreational species in marine habitats at Point Lowly

Habitats are as described by Bryars (2003) (a=adults/recruits, s=spawners, e=eggs, l=larvae, pl=post larvae, j=juveniles).

Species	Reef	Seagrass	Unvegetated soft bottom
Southern Calamary	a, s, e	a, s, e	a
Giant Cuttlefish	a, s, e		
Blue Swimmer Crab		a, s, e, l, j	a, s, e, l, j
Western King Prawn			a, j
King Scallop		a, s, pl, j	a, s, pl, j
Queen Scallop		a, s, pl, j	a, s, pl, j
Razorfish		a, s, pl, j	a, s, pl, j
Purple Sea Urchin	a, s, e, l, pl, j		
King George Whiting	a, j	a, j	a, j
Yellowfin Whiting			a, s, pl, j
Snapper	a, j	a, j	a, j
Western Australian Salmon	a, j	a, j	a, j
Tommy Ruff	a, j	a, j	a, j
Southern Sea Garfish	a	a, s, l, j	a, l
Red Mullet		a, j	a, j
Flathead		a, j	a, j
Yelloweye Mullet	a		a, j
Trevally	a, j	a, j	a, j
Yellowtail Kingfish	a	a	a
Leatherjacket	a	a, j	
Wrasse	a		
Snook	a	a, s	a, s
Flounder			a, j
Silver Drummer	a		
Gummy Shark	a		
Whaler Shark	a	a, j	a, j

REFERENCE

Bryars, S, 2003, 'An inventory of important coastal fisheries habitats in South Australia', Fish Habitat Program, Department of Primary Industries and Resources South Australia.