Marine Environment and Ecology

Baseline surveys of the marine environment adjacent to the proposed high salinity water discharge from the south lagoon of the Coorong

SARDI Publication No. F2009/000694-1
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January 2010

Prepared for the SA Murray-Darling Basin Natural Resource Management Board

Government of South Australia

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Cover photograph: Aerial view of Coorong adjacent to proposed outfall location (© NatureMaps; SA DEH)

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EXECUTIVE SUMMARY

1. With severely reduced water flows in the Murray River over the last 5 years, freshwater flow from the Lower Lakes to the Murray estuary and Coorong lagoons has been negligible. As a consequence, water in the South Lagoon of the Coorong is, depending on season, four to six times as saline as seawater, leading to substantial ecological changes.

2. It is unlikely that improved freshwater flows will be available to the Coorong over the next 12-24 months, and salinity will continue to increase if there are no other management interventions. A proposed intervention is to pump the hypersaline water out of the South Lagoon into the adjacent ocean, drawing in less saline seawater through the Murray mouth and reducing the salinity of the entire system.

3. If hypersaline water is pumped out of the South Lagoon of the Coorong into the adjacent ocean, it will have potential negative impacts on marine life. The SA MDB NRM board has convened a panel of experts to assess what these consequences might be. One recommendation was to survey the marine environment (including infauna, epifauna and a pelagic assessment) in the likely zone of influence of the hypersaline water plume.

4. The survey included swath bathymetry mapping and video assessment of the benthos in an area 4 km longshore and 2 km offshore from the proposed outfall. Infauna (using a benthic grab) and the epifauna (using a beam trawl) were sampled on three transects, immediately offshore, 1.6 km north west and 1.6 km south east of the proposed outfall.

5. Habitat mapping using swath bathymetry and video drops showed the area adjacent to the proposed high salinity water discharge from the south lagoon of the Coorong was bare soft sediment.

6. In both infauna and epifauna sampling, no EPBC listed species were found. Species composition as a whole was consistent with what would be expected from the high wave energy soft sediment environment along this section of coastline. Some commercially important species, including the pipi *Donax deltoides* and the sand crab *Ovalipes australiensis,* were present.

1. INTRODUCTION

The Coorong, Lower Lakes, and Murray Mouth (CLLAMM) system, to the south-east of Adelaide, South Australia (Figure 1) is one of Australia's largest and most important wetland systems, recognised as a Wetland of International Importance under the Ramsar convention (Phillips and Muller 2006). The Coorong connects to the sea via a narrow channel at the Murray mouth and extends 140km along the coast, separated from the ocean over most of its length by the narrow coastal dunes of the Younghusband Peninsula. A barrage system separates the freshwater Lower Lakes from the Coorong and Murray mouth (MDBC 2006). The Coorong has a strong salinity gradient from north to south, with three distinct regions: The Murray mouth region, where salinity ranges from near fresh to marine depending on flow over the barrages; the North Lagoon, which ranges from estuarine to moderately hypersaline; and the South Lagoon, which connects to the North Lagoon via a narrow and shallow channel at Parnka Point, and is moderately to extremely hypersaline (MDBC 2006; Brookes *et al.* 2009).

Flow over the barrages is regulated based on the water level of the Lower Lakes, and so is determined primarily by inflow from the River Murray (MDBC 2006). With several years of regional drought, flows over the barrages have been greatly reduced since 2002, with no flow since 2006 (CSIRO 2008; Brookes *et al.* 2009). As a consequence, salinity has steadily increased in the Coorong, to the point where, depending on the season, the South Lagoon is four to six times as saline as typical seawater. This in turn has led to substantial ecological changes, with many species formerly common in the South Lagoon now restricted to the North Lagoon. The South Lagoon water also has elevated nutrient and turbidity levels (Brookes *et al.* 2009).

Given the current low water levels in the Lower Lakes, and other upstream storages, it is unlikely that freshwater flows to the Coorong will improve over the next 12-24 months (MDBA 2009), and thus salinity will continue to increase if there are no other management interventions. One intervention being considered is to pump hypersaline water out of the South Lagoon into the adjacent ocean, drawing in less saline sea water through the Murray mouth and reducing the salinity of the entire system (Commonwealth of Australia 2008; Aurecon 2009).

Preliminary hydrodynamic modelling (Aurecon 2009) indicates that the discharge water will rapidly mix with the receiving water, with the plume being diluted to within 1 psu of background values within ~2 km. As well as elevating local salinity, the plume will be turbid and contain high levels of nutrients. The discharge water will potentially have negative impacts on marine life in close proximity to the discharge point; hence, the SA MDB NRM board has convened a panel of experts to assess what these consequences might be. One recommendation was to survey the marine environment (including infauna, epifauna and habitat mapping) of the likely zone of influence of the hypersaline water plume.

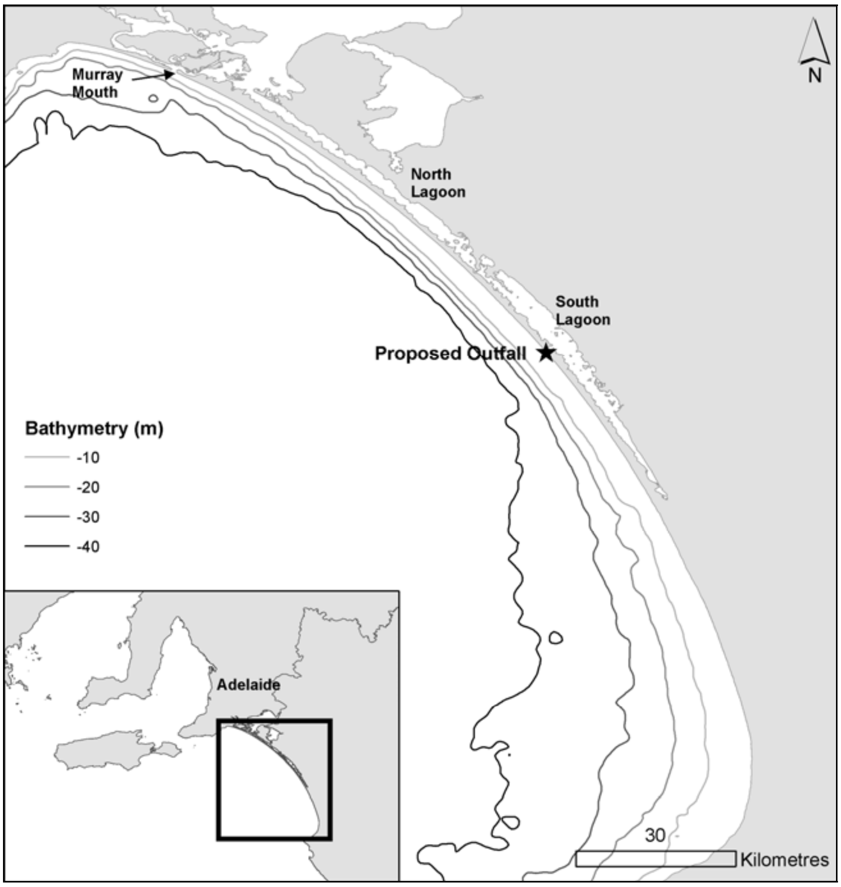

Figure 1. Map of the Coorong indicating the proposed outfall location.

Previous coarse- (Edyvane 1999) and fine- (Haig *et al.* 2006) scale studies of the ocean bordering Younghusband Peninsula have indicated that sand overlying low platform limestone reef is the dominant habitat of the area. It is likely that the high wave energy and constant sand movement prevent the settlement of many sessile species (Edyvane 1999). Interspersed between these sand covered platform reefs are more complex reef formations, suitable for the settlement of sessile biota, particularly in the offshore areas (Haig *et al.* 2006). The area supports a number of marine species that are of importance to commercial and recreational fisheries including abalone (*Haliotis* spp.), southern rock lobster (*Jasus edwardsii*), pipis (formerly Goolwa cockles - *Donax deltoides*) and mulloway (*Argyrosomus hololepidotus*) (Edyvane 1999). The Protected Matters search tool (DEWHA 2009) was used to identify threatened, protected or endangered species that occur in the area. A number of species of syngnathids (Table 1) and marine mammal species were listed, although most of the former only occur in more complex habitats (eg seagrasses, reefs), rather than on sand.

The purpose of this study is to assess the marine environment in the area potentially exposed to hypersaline water from the south lagoon of the Coorong, particularly relating to EPBC listed species and their habitats.

Table 1. Syngnathid species whose distribution encompasses the Coorong offshore area, and which might occur if suitable habitat is present

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

2. METHODS

2.1 Study Site

The proposed outfall point is approximately 75 km south east of the Murray Mouth adjacent to the south lagoon of the Coorong system (Figure 1), and the study was carried out in an area 4 km longshore by 2 km offshore (Figure 2). The survey involved identifying seabed texture using swathe bathymetry with associated remote video ground truthing, investigating infauna using a benthic grab and the epibiota with a beam trawl. The ground truthing and benthic sampling were conducted on three transects, one immediately offshore from the proposed outfall and another two transects approximately 1.6 km north west and 1.6 km south east of the outfall. All transects ran from as close to the proposed outfall as was practically possible, given the prevailing wind and sea conditions at the time, out to a further 2 km offshore. The surveys were carried out on the SARDI research vessel RV *Ngerin*, between the 3rd and 6th November 2009.

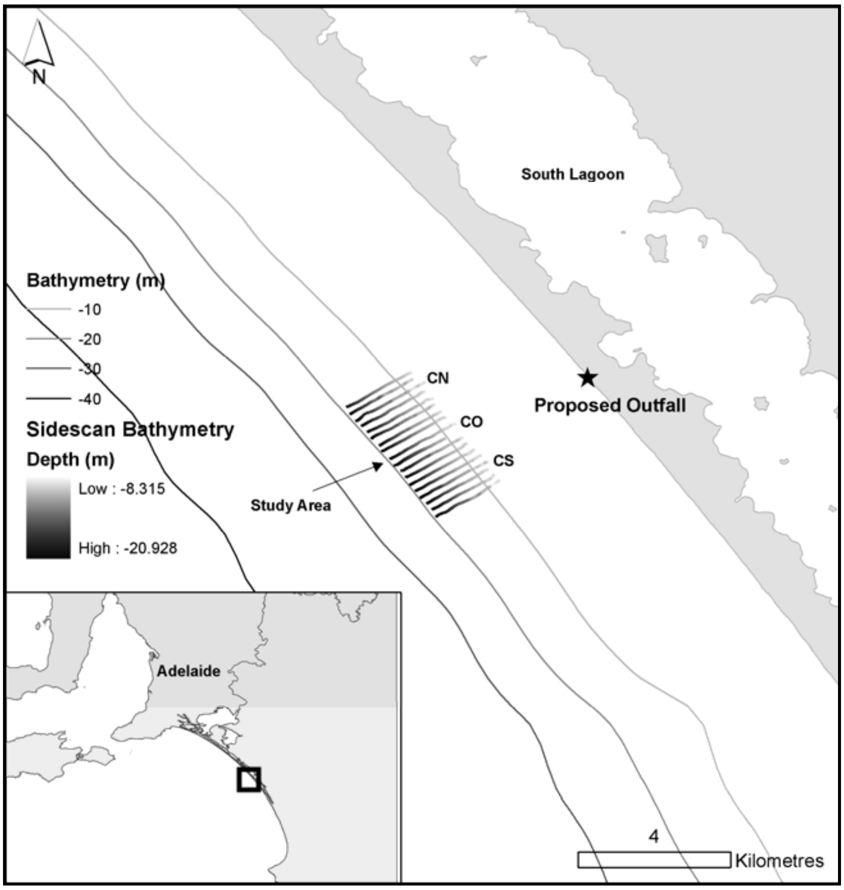

Figure 2. Map of the study area with associated coarse and fine scale bathymetry. Transects used for benthic sampling are indicated by CN, Coorong North; CO, Coorong Outfall; CS, Coorong South.

2.2 Habitat Mapping

A motion-compensated GeoAcoustics 250KHz GeoSwath Plus bathymetric sonar, or swathe bathymetry system, was used to acquire water depth and seabed reflectivity perpendicular to shore at a resolution of 200 m within the survey area. The system is comprised of two separate transducers, port and starboard, an altimeter, Mini Sound Velocity Sensor (MiniSVS), Motion Reference Unit (MRU) and Deck Control Unit

(DCU). The transducers are configured in such a way that a wide swath of bathymetric and backscatter data is collected (up to 10 times the water depth), and it can record co-referenced genuine side-scan sonar data. The altimeter provides a gross error check and the MiniSVS allows for speed of sound corrections at the swathe head. The MRU corrects for vessel motion and is fed with position and heading data to allow it to function fully aided.

Navigation, heading and sound velocity profile (SVP) data are also collected simultaneously to the bathymetric / backscatter data acquisition. The navigation data was collected in DGPS mode (beacon corrections from the Corny Pt Station). SVP data was obtained by lowering a fast-update sound velocity sensor through the water column at appropriate intervals during the survey. The Valeport SVP houses temperature, pressure and sound velocity sensors allowing accurate profiles to be obtained and entered into the GeoSwath software. This allows effective correction of data affected by ray-bending.

Prior to survey operations the GeoSwath system was calibrated for roll, pitch, yaw and latency using an appropriate calibration procedure and calculation methodology. The offsets for the location of all equipment onboard the RV *Ngerin* were measured rigorously.

All the data (bathymetric and backscatter) required post-processing. The bathymetric data needed to be reduced from the tide values, and an important step of filtering was performed in the processing suite GS+ by applying an amplitude filter, limits filter, along track filter and the across track filter. The backscatter data was post-processed in the processing software GeoTexture; a Trace Normalisation Function was extracted from the data collected and applied on all the files. Then, a slant range and horizontal range correction was applied prior to importing the data into the final mosaic.

In order to ground truth the seabed mapping, an underwater 450 line analogue camera (Morphcam) was lowered to about 1 m above the seabed and the vessel was allowed to drift or slowly motor for 2 minutes. Five drops were undertaken on each of the predefined transects, while a further two drops were conducted on transects 800 m north east and south west of the Coorong Outfall transect. Drops were approximately 40-100 m in length, depending on the prevailing sea conditions. Camera footage was recorded on a Sony digital video recorder along with time-stamped positional data from a Garmin GPS.

Data were extracted from videotapes using a Visual Basic program designed in-house at SARDI. The user viewed the videotape on a TV monitor and was able to select from a list of predetermined habitat categories (Table 2), assigning one of the categories whenever a habitat transition occurred. The Visual Basic program combines each selected habitat category with position information that is simultaneously downloaded from the audio track of the tape during viewing, into a text file that can be imported into a Microsoft Access database for processing. Accurate positional data makes it possible to calculate the length of each section of homogeneous habitat. The percent cover of different habitat groups was subsequently mapped using the GIS software package ArcMap (Ver 9.3).

Table 2. Video habitat categories and their assigned habitat group used for describing the benthos of the study site.

Habitat Category	Details	Habitat Group
Amphibolis	Any cover of *Amphibolis*	Seagrass
DDD	Missing - not recordable	Excluded
Macroalgae	Any cover of macroalgae	Macroalgae
Posidonia	Can see little substrate between seagrass	Seagrass
Rock	100% reef	Reef
Sand	100% soft sediment cover	Bare
Unknown	Unidentified	Excluded

2.3 Infauna

Replicate samples of infauna were collected from the three transects using a 0.1 m^2 Smith-McIntyre grab. A total of three samples were taken on each transect as close as possible to the shore. All grabs collected were sieved through a 1 mm mesh screen and the fauna retained was preserved in 5% formaldehyde solution. Data recorded at each site included date, time, location (latitude and longitude) and depth (Appendix 1). This fauna was later sorted in the laboratory to the lowest taxonomic level before being counted. Voucher specimens were photographed and stored in 75% ethanol for future reference

2.6 Epifauna

To target small fish and motile invertebrates, a CSIRO designed beam trawl (4 m wide by 0.5 m high) with a 25 mm stretch mesh codend was used. Replicate trawls were conducted on each transect in a direction away from or towards the shore, with all three tows commencing or concluding as close as possible to shore. The trawl was towed for ~ 500 m with the start and end point of the tow defined using a Garmin GPS. Data recorded included date, time, location and depth (Appendix 1). The entire contents of the codend were bagged and frozen on the research vessel. The trawl sample was later sorted and identified to species or putative taxon. For each species a reference sample was photographed and preserved in 75% ethanol.

2.8 Data Analysis

Site-related differences in community structure were examined using Bray-Curtis dissimilarity measures (Bray and Curtis 1957). This dissimilarity measure was chosen because it is not affected by joint absences, and has consistently performed well in preserving 'ecological distance' in a variety of simulations on different types of data (Faith *et al.* 1987; Field *et al.* 1982). Single square-root transformations were applied to the data before calculating the Bray-Curtis dissimilarity measures. These transformations were made to prevent abundant species from influencing the Bray-Curtis dissimilarity measures excessively (Clarke 1993; Clarke and Green 1988). Spatial patterns in dissimilarity were examined using a combination of hierarchical agglomerative clustering (with group average linking) and non-metric multi-dimensional scaling (MDS). The SIMPER routine of PRIMER was subsequently used to identify those species contributing most to observed differences (Clarke and Gorley 2001).

3. RESULTS

3.1 Habitat Mapping

3.1.1 Swath Bathymetry

The results of the GeoSwath survey are shown in Figure 3. The substrate in the survey area is entirely soft sediment, with sand dominating. Closer examination of the inshore section of the north transects indicate the possibility of some habitat variation, including some relief and finer sediment. These observations were supported by the grab sampling which sampled much finer mud than the grabs on the outfall and south transects (K. Rowling unpublished observations).

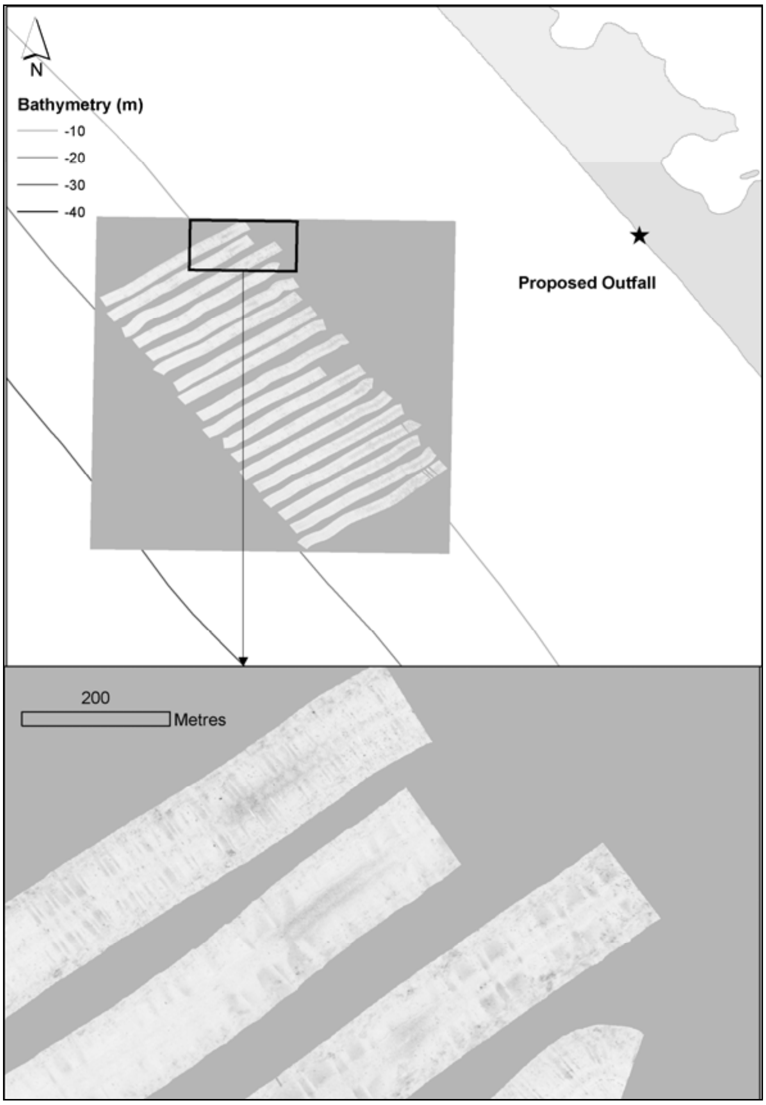

Figure 3. Side scan mosaic of the benthos in the study area off the proposed outfall.

3.1.2 Video Ground Truthing

Observations taken from the video habitat mapping are summarised in Figure 4. Analysis of the video drops confirmed that the benthos in the study area is entirely bare sand (Figure 4). No reef or seagrass habitat was observed on any of the videos, supporting the GeoSwath observations.

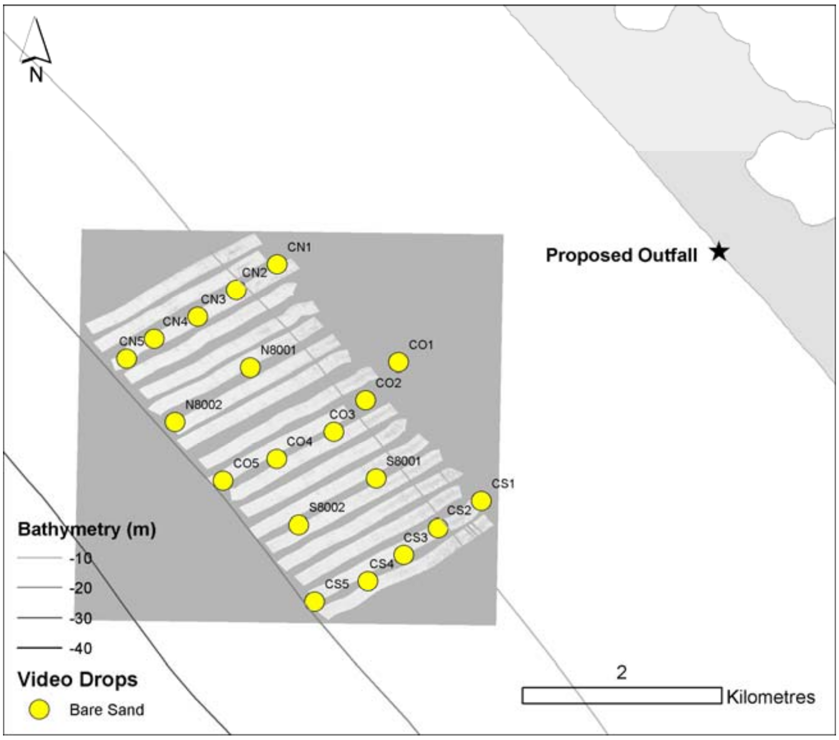

Figure 4. Map of the survey area showing 19 video drops used to ground truth swath bathymetry data.

3.2 Infauna

In total, 1079 individuals from 27 taxa representing 3 phyla were collected from the 9 grab samples (Figure 5). The total number of individuals on each transect ranged from a high of 556 on the south transect to 183 on the north, Crustaceans accounted for more than 53% of the individuals collected, with molluscs accounting for 43%. The most abundant individuals collected were the pipi *Donax deltoides* (463 individuals, 43% of total), followed by the crustacean families Urohaustoriidae (370 individuals, 34% of total) and Platyischnopidae (100 individuals, 9% of total). No EPBC listed species were taken in the grabs.

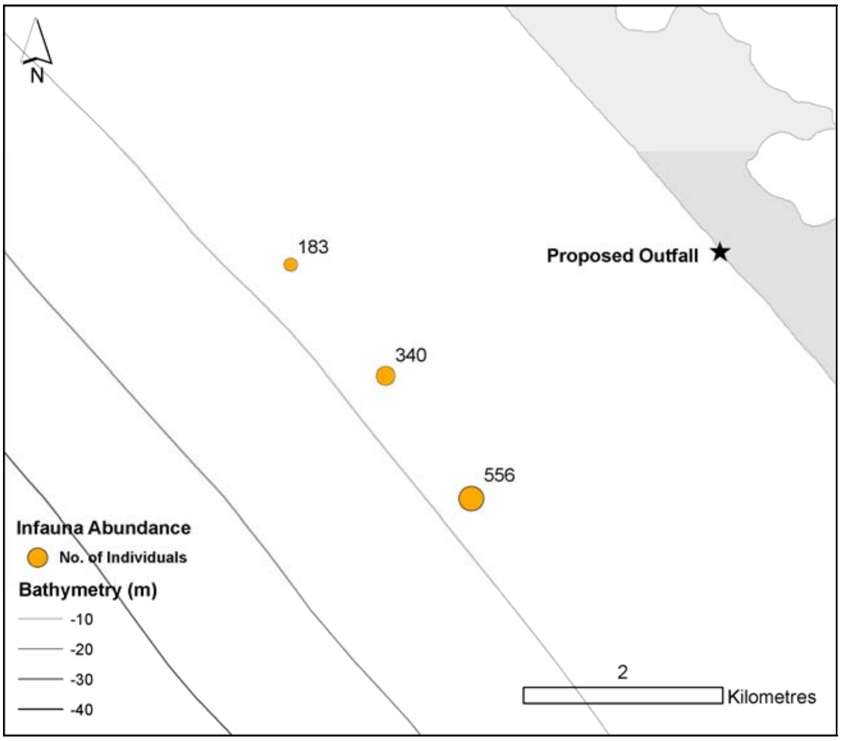

Figure 5. Bubble plot showing the total abundance of infauna found in 3x0.1 m^2 replicate grab samples taken at the three transects off the proposed Coorong Outfall. Numerals next to each bubble represent total numbers of individuals.

Patterns in infaunal species richness differed from the patterns in abundance, with the outfall transect the richest site (21 species), although the north transect had a lower species richness (14 species) as well as fewer individuals (Figure 6). The crustacean Urohaustoriidae was found in all grabs, with other crustaceans (Platyischnopidae, Phoxocephalidae and Oedicerotidae) found in 8 grabs. The pipi *Donax deltoides* was found in 7 grabs, but only one individual was found in the three northern replicates, with >99% coming from the south and outfall replicates.

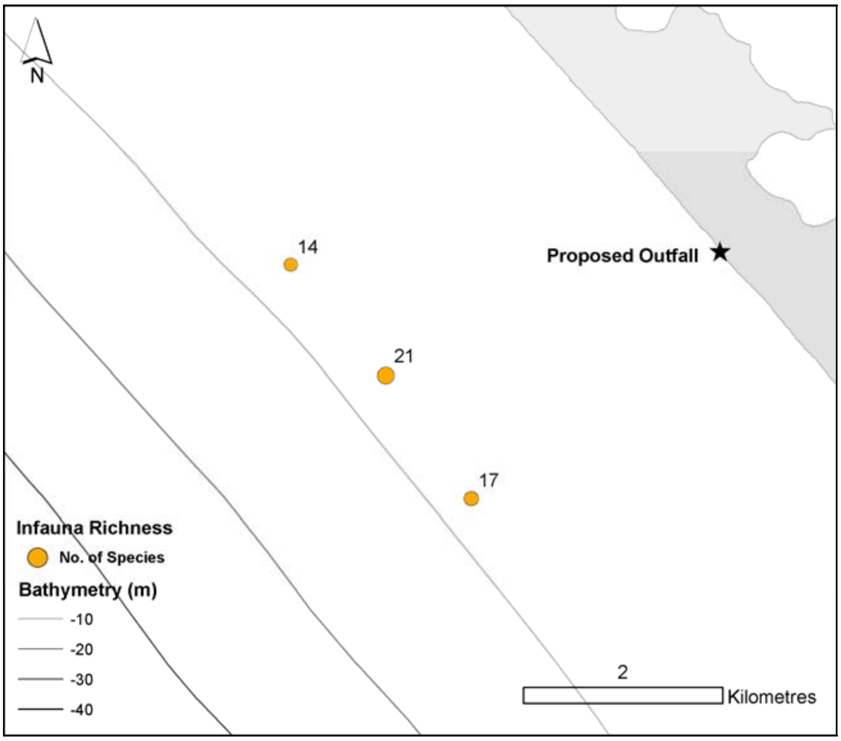

Figure 6. Bubble plot showing the total number of infauna species found 3x0.1 m^2 replicate grab samples taken at the three transects off the proposed Coorong Outfall. Numerals next to each bubble represent total species number**.**

Patterns in infaunal species composition were investigated using cluster analysis (Figure 7) and non-metric multidimensional scaling (MDS) (Figure 8). Two discrete groupings were separated at the 55% Bray-Curtis dissimilarity level on the cluster analysis, and were also evident in the ordination. The groups recognised are characterised by their locations and are; (i) north transect and (ii) outfall and south transects.

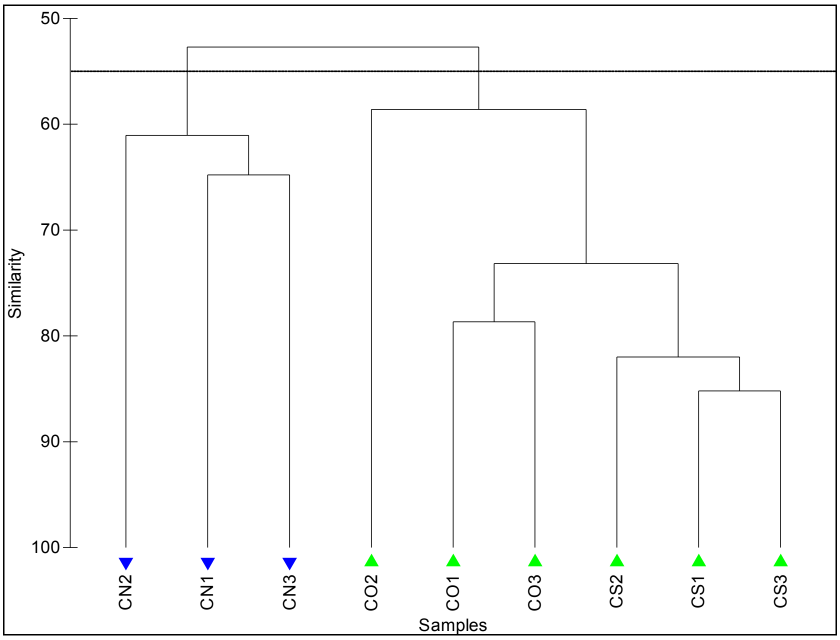

Figure 7. Cluster analysis of community structure in 9 grab samples taken off the south east. Two groups are identified at a Bray-Curtis dissimilarity level of 55 percent; north transect (blue triangles) and outfall and south transects (green triangles).

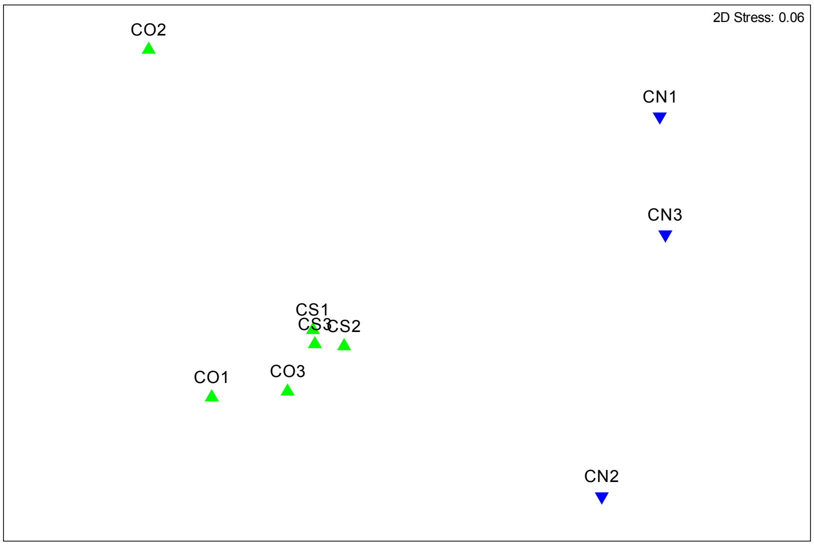

Figure 8. Non-metric MDS plot of community structure in 9 grab samples taken off the south east. Two groups are identified at a Bray-Curtis dissimilarity level of 55 percent; north transect (blue triangles) and outfall and south transects (green triangles).

SIMPER analysis was undertaken to determine which species contributed most to similarities within and differences between the two spatial groupings. Abundances of the 7 taxa contributing ≥ 5% to within-group similarity or between-group dissimilarity for at least one of the two groupings are given in Table 3. Results from the SIMPER analysis indicate that the north group is characterised by high numbers of the crustacean families Urohaustoriidae and Platyischnopidae. The Outfall/South group shares characteristically high numbers of the crustacean Urohaustoriidae with the north transect, but also has high abundance of the pipi *Donax deltoides.*

Table 3. Mean abundance of (n per 0.1 m^2) infauna collected from 9 grab samples off the proposed Coorong Outfall. Species listed were identified from SIMPER analysis as contributing ≥ 5% to the similarity within and/or dissimilarity between groupings. Species indicative of each sediment characteristic (contributing ≥ 10% to the total similarity within an assemblage type) are highlighted in bold.

Phylum	Species/Family	North (n=3)	Outfall/South (n=6)
Crustacea	Urohaustoriidae	**36.33**	**43.5**
Mollusca	*Donax deltoides*	0.33	**77**
Crustacea	Platyischnopidae	**9.33**	12
Crustacea	Phoxocephalidae	5.66	4.33
Crustacea	Oedicerotidae	1.33	3
Crustacea	Gammaridea	2.33	
Crustacea	Cumacea	1	0.33

3.3 Epifauna

A total of 482 fish and motile invertebrates weighing 31.1 kg were recorded from the 9 trawl shots (Figure 9). The highest number of individuals recorded from a transect was 225 at the outfall, with the south transect having 200 and the north only 57 individuals. The most abundant species collected was the prickly toadfish *Contusus brevicaudus* with 298 individuals, with the ornate cowfish *Aracana ornata* and the sand crab *Ovalipes australiensis* having 53 and 51 individuals respectively. No EPBC listed species were taken in the beam trawls.

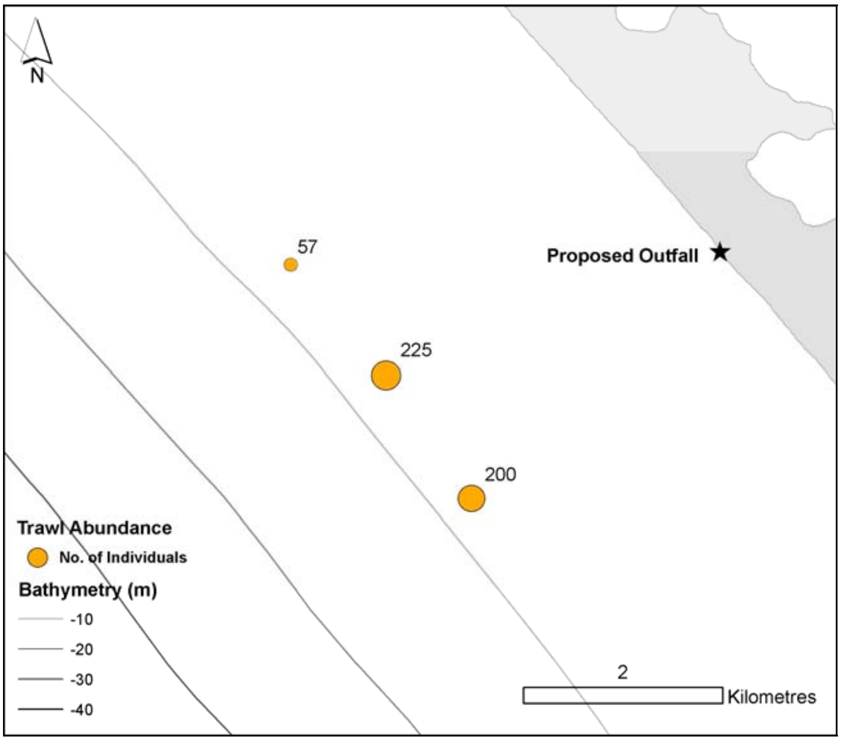

Figure 9. Bubble plot showing the total abundance of live epibenthos collected in 3x500 m beam trawls taken at the three transects off the proposed Coorong Outfall. Numerals next to each bubble represent total numbers of individuals.

A total of 21 species were recorded in the 9 trawl shots (Figure 10). The south transect supported the highest species richness, with 16 species present. Although it had the highest abundance, the outfall transect had only nine species, with the less abundant north transect having 10 species in the three trawls. The most widespread species was the sand crab *Ovalipes australiensis*, found in all nine trawls. The ornate cowfish *Aracana ornata* and the prickly toadfish *Contusus brevicaudus* were found in 8 of the trawls, with the pipi *Donax deltoides* found in 7.

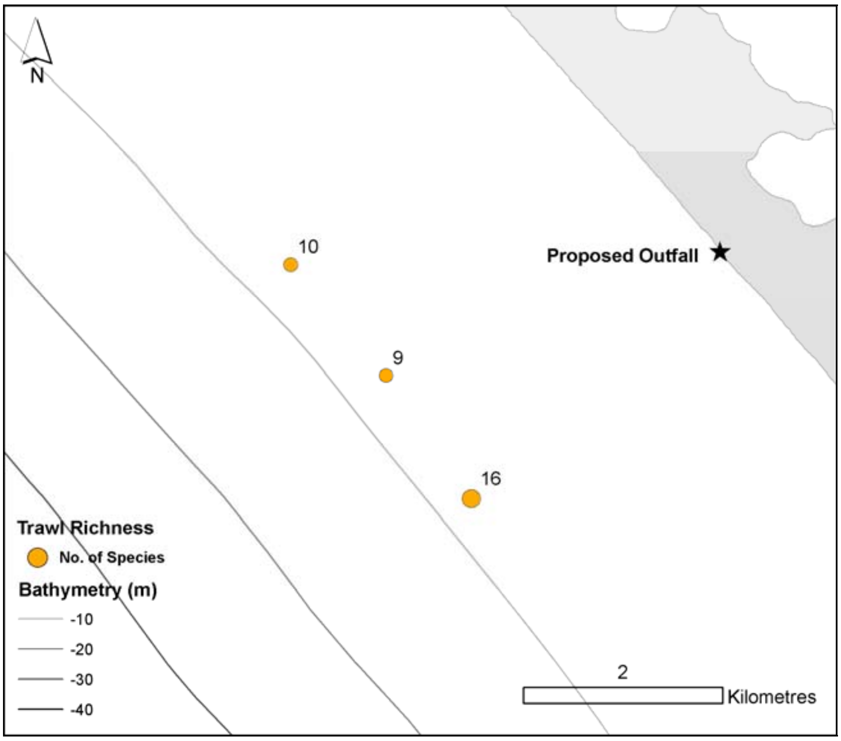

Figure 10. Bubble plot showing the total number of epibiota species found 3x500 m beam trawls taken at the three transects off the proposed Coorong Outfall. Numerals next to each bubble represent total species number**.**

Patterns in species composition were compared using cluster analysis (Figure 11) and MDS analysis (Figure 12). Three assemblage types are identified at a Bray-Curtis dissimilarity level of 55 percent; (i) the north transect; (ii) outfall and south transects (towed out); (iii) outfall and south transects (towed in).

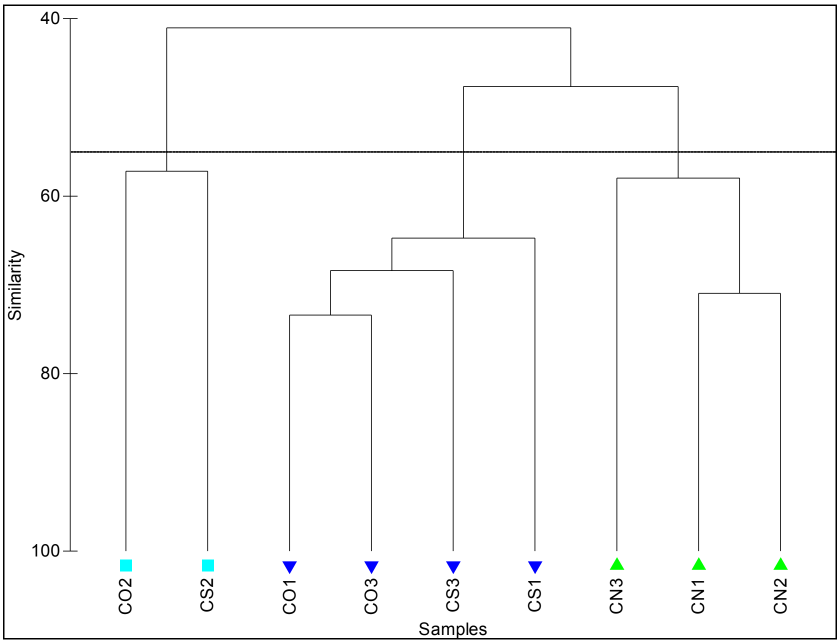

Figure 11. Cluster analysis of community structure from 9 trawl shots off the potential Coorong outfall. Three assemblage types are identified at a Bray-Curtis dissimilarity level of 55 percent; north transect (green triangles), outfall/south transects (towed in) (blue squares), outfall/south transects (towed out) (blue triangles).

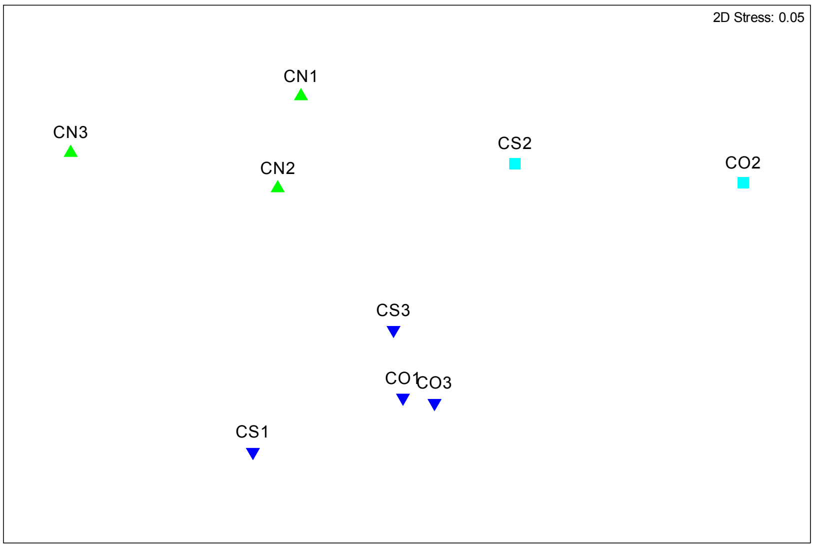

Figure 12. Non-metric MDS plot of community structure from 9 trawl shots off the potential Coorong outfall. Three assemblage types are identified at a Bray-Curtis dissimilarity level of 55 percent; north transect (green triangles), outfall/south transects (towed in) (blue squares), outfall/south transects (towed out) (blue triangles).

Similarity percentage (SIMPER) analyses were employed to identify the 8 species contributing ≥ 5% to within group similarity or between group dissimilarity for the three assemblage types (Table 4). The north group was characterised by high numbers of the prickly toadfish *Contusus brevicaudus*, sand crab *Ovalipes australiensis* and Derwent flounder *Taratretis derwentensis*. The outfall/south trawls that were towed away from shore also had high numbers of the prickly toadfish *Contusus brevicaudus* and sand crab *Ovalipes australiensis*, but also had many ornate cowfish *Aracana ornata.* The outfall/south trawls that were towed towards shore were characterised by high numbers of the ornate cowfish *Aracana ornate*, the pipi *Donax deltoides* and the sand crab *Ovalipes australiensis.*

Table 4. Mean abundance (n per 500 m^2) of epibenthos species collected from 9 sled shots taken off the south east. Species listed were identified from SIMPER analysis as contributing ≥ 5% to the similarity within and/or dissimilarity between groupings. Species indicative of each assemblage type (contributing ≥ 10% to the total similarity within an assemblage type) are highlighted in bold.

Phylum	Scientific Name	Common Name	North (n=3)	Outfall/South (towed out) (n=4)	Outfall/South (towed in) (n=2)
Chordata	*Contusus brevicaudus*	Prickly toadfish	**7.66**	**65.5**	6.5
Chordata	*Aracana ornata*	Ornate Cowfish	1	**9.25**	**6.5**
Crustacea	*Ovalipes australiensis*	Sand Crab	**5**	**8.5**	**1**
Mollusca	*Donax deltoides*	Pipi	0.33	3.25	**2**
Chordata	*Arripis georgianus*	Australian herring		3	
Chordata	*Lesueurina platycephala*	Flathead Sandfish	0.66	2	
Mollusca	*Uroteuthis noctiluca*	Luminous Bay Squid	1.66	1	
Chordata	*Taratretis derwentensis*	Derwent flounder	**1.33**	0.75	

4. DISCUSSION

Habitat mapping using swath bathymetry and video drops showed a 4 km longshore by 2 km offshore area adjacent to the proposed high salinity water discharge from the south lagoon of the Coorong was bare soft sediment. This is consistent with observations made in coarse (Edyvane 1999) and fine (Haig *et al.* 2006) scale studies of the ocean side of the Coorong which have indicated that sand overlying low platform limestone reef is the dominant habitat of the area.

In both infauna (benthic grab) and epifauna (beam trawl) sampling, no EPBC listed species were found. Some commercially important species, including the pipi *Donax deltoides* and the sand crab *Ovalipes australiensis,* were present. Pipi larvae, and subsequent recruitment of juveniles to the fishery, may be influenced by elevated salinities from the proposed Coorong outfall (Wiltshire *et al.* 2009). Fine scale habitat variation, which may relate to sediment size, meant that there was some variability in the numbers of these species, even over the 8 km^2 of this study. Of the three transects sampled, the north transect had a lower abundance of both infauna and epifauna and significantly fewer pipis.

Species composition as a whole was consistent with what would be expected from the high wave energy, soft sediment environment along this section of coastline where a continuous section of surf beach occurs from the Murray Mouth almost 150 km along the coast (Bryars 2003). The site had no attached epifauna (sponges, ascidians) or flora (seagrasses and alga). The fauna that was sampled tended to be specialised to this environment (e.g. *Donax deltoides,* Murray-Jones and Steffe 2000) or highly mobile (e.g. *Ovalipes australiensis,* various fish; Bryars 2003).

One shortfall of this study is that sampling took place approximately 2 km off shore from the proposed outfall due to prevailing sea conditions including heavy swell. The ideal situation would be to sample at the site and away from it at similar distances and depths. Unfortunately this area is an extremely high energy coastline which precludes getting close to shore on all but a few days each year, and we were unable to sample closer to shore in this study. However, shallow wave exposed soft sediment habitats are typically depauperate in fauna, and it is considered that the species found further offshore are likely to be typical of what is found closer inshore, with the possibility that some species might be missing from this more disturbed environment.

REFERENCES

Aurecon (2009) Data collation, review and preliminary hydrodynamic modelling Coorong temporary saline water discharge. SA Murray Darling Basin NRM Board. Aurecon Australia Pty Ltd, Adelaide.

Bray JR, Curtis JT (1957) An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs* 27, 325-349.

Brookes JD, Lamontagne S, Aldridge KT, Benger S, Bissett A, Bucater L, Cheshire AC, Cook PLM, Deegan BM, Dittmann S, Fairweather PG, Fernandes MB, Ford PW, Geddes MC, Gillanders BM, Grigg NJ, Haese RR, Krull E, Langely RA, Lester RE, Loo M, Munro AR, Noell CJ, Nayar S, Paton DC, Revill AT, Rogers DJ, Rolston A, Sharma SK, Short DA, Tanner JE, Webster IT, Wellman NR, Ye Q (2009) An ecosystem assessment framework to guide management of the Coorong. Final report of the CLLAMMecology research cluster. CSIRO: Water for a Healthy Country National Research Flagship, Canberra.

Bryars S (2003) 'An Inventory of Important Coastal Fisheries Habitats in South Australia. Fish Habitat Program, Primary Industries and Resources South Australia.'

Clarke KR (1993) Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* 18, 117-143.

Clarke KR, Gorley RN (2001) 'PRIMER v5 Users Manual / Tutorial.' (PRIMER-E, Plymouth)

Clarke KR, Green RH (1988) Statistical design and analysis for a 'biological effects' study. *Marine Ecology Progress Series* 46, 213-226.

CSIRO (2008) Water availability in the Murray-Darling Basin. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia.

DEWHA (2009) Protected matters search tool.
http://www.environment.gov.au/erin/ert/epbc/index.html.

Edyvane KS (1999) 'Conserving Marine Biodiversity in South Australia. Part 2. Identification of areas of high conservation value in South Australia. South Australia Research and Development Institute, Adelaide.'

Faith DP, Minchin PR, Belbin L (1987) Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio* 69, 57-68.

Field JG, Clarke KR, Warwick RM (1982) A practical strategy for analysing multispecies distribution patterns. *Marine Ecology Progress Series* 8, 37-52.

Haig J, Russel B and Murray-Jones S (2006) Offshore marine habitat mapping and near-shore marine biodiversity within the Coorong bioregion. A report for the SA MDB NRM Board. Department for Environment and Heritage, Adelaide.

MDBA (2009) River Murray System drought update. Issue 20: August 2009. Murray Darling Basin Authority, Canberra. MDBC (2006) The Lower Lakes, Coorong and Murray Mouth Icon Site Environmental Management Plan 2006-2007. Murray-Darling Basin Commission, Canberra.

Murray-Jones S, Steffe AS (2000) A comparison between the commercial and recreational fisheries of the surf clam, *Donax deltoides*. *Fisheries Research* 44, 219-233.

Phillips W, Muller K (2006) Ecological character of the Coorong, Lakes Alexandrina and Albert Wetland of International Importance. South Australian Department for Environment and Heritage, Adelaide.

Sinclair Knight Merz (2001) Technical Investigations Report for the Amendment Report Relating to Marine Aquaculture in Kingston/Cape Jaffa. Prepared for Planning SA.

Wiltshire K, Gluis M, and Tanner J (2009) Tolerances of juveniles and early life stages of the pipi, *Donax deltoides*, to elevated salinity produced by mixing of Coorong and seawater. 21pp. SARDI Aquatic Sciences, Adelaide.

APPENDICES

Appendix 1. Location, date and depth of all sampling undertaken during the baseline survey off the proposed Coorong outfall. Note that the WGS84 datum is employed for all position fixes.

					Start		End	
Transect	Date	Site	Method	Depth	Latitude	Longitude	Latitude	Longitude
Outflow	4/11/2009	CO1	GRAB	10	-36.04917	139.48696		
Outflow	4/11/2009	CO2	GRAB	10	-36.04850	139.48724		
Outflow	4/11/2009	CO3	GRAB	10	-36.04810	139.48757		
Outflow	4/11/2009	CO1	VIDEO	10	-36.04742	139.48849		
Outflow	4/11/2009	CO2	VIDEO	10	-36.05084	139.48550		
Outflow	4/11/2009	CO1	TRAWL	10	-36.05044	139.48778	-36.05388	139.48452
Outflow	4/11/2009	CO2	TRAWL	10	-36.05420	139.48435	-36.05069	139.48761
Outflow	4/11/2009	CO3	TRAWL	10	-36.04875	139.48821	-36.05075	139.48578
Outflow	4/11/2009	CO3	VIDEO	12	-36.05369	139.48263		
Outflow	4/11/2009	CO4	VIDEO	14	-36.05618	139.47748		
Outflow	4/11/2009	CO5	VIDEO	19	-36.05814	139.47266		
South	4/11/2009	CS5	VIDEO	20	-36.06908	139.48092		
South	4/11/2009	CS4	VIDEO	15	-36.06721	139.48573		
South	4/11/2009	CS3	VIDEO	12	-36.06484	139.48897		
South	4/11/2009	CS2	VIDEO	11	-36.06241	139.49206		
South	4/11/2009	CS1	VIDEO	9	-36.05998	139.49597		
South	5/11/2009	CS1	TRAWL	10	-36.06008	139.49602	-36.06297	139.49182
South	5/11/2009	CS2	TRAWL	10	-36.06229	139.49221	-36.05964	139.49650
South	5/11/2009	CS3	TRAWL	10	-36.05988	139.49652	-36.06260	139.49219
South	5/11/2009	CS1	GRAB	10	-36.06022	139.49560		
South	5/11/2009	CS2	GRAB	10	-36.05952	139.49465		
South	5/11/2009	CS3	GRAB	10	-36.05952	139.49465		
South800	5/11/2009	S8001	VIDEO	11	-36.05794	139.48646		
South800	5/11/2009	S8002	VIDEO	17	-36.06213	139.47947		
North800	5/11/2009	N8001	VIDEO	12	-36.04791	139.47511		
North800	5/11/2009	N8002	VIDEO	18	-36.05282	139.46832		
North	5/11/2009	CN1	VIDEO	9	-36.03857	139.47753		
North	5/11/2009	CN1	GRAB	9	-36.03857	139.47861		
North	5/11/2009	CN2	GRAB	9	-36.03854	139.47866		
North	5/11/2009	CN3	GRAB	9	-36.03852	139.47868		
North	5/11/2009	CN1	TRAWL	9	-36.03857	139.47825	-36.04112	139.47373
North	5/11/2009	CN2	TRAWL	9	-36.04031	139.47365	-36.03790	139.47829
North	5/11/2009	CN3	TRAWL	9	-36.03707	139.47909	-36.04026	139.47470
North	5/11/2009	CN2	VIDEO	11	-36.04086	139.47383		
North	5/11/2009	CN3	VIDEO	15	-36.04331	139.47037		
North	5/11/2009	CN4	VIDEO	16	-36.04532	139.46644		
North	5/11/2009	CN5	VIDEO	19	-36.04711	139.46396		

Appendix 2. Taxonomic classification and abundances of 27 infaunal species collected from three replicate Smith-McIntyre grabs at 3 transects off the proposed Coorong Outfall. A reference collection is maintained at SARDI Aquatic Sciences

Phylum/Family	Species	Coorong North			Coorong Outfall			Coorong South		
		CN1	CN2	CN3	CO1	CO2	CO3	CS1	CS2	CS3
Crustacea										
Gammaridea	Gammaridea	2	-	5	-	-	-	-	-	-
Urohaustoriidae	Urohaustoriidae	21	35	53	54	26	53	49	46	33
Phoxocephalidae	Phoxocephalidae	7	-	10	2	2	3	5	7	7
Apseudidae	Apseudidae	-	-	-	1	-	-	-	-	-
Platyischnopidae	Platyischnopidae	3	14	11	4	-	14	14	24	16
Cumacea	Cumacea	1	1	1	-	-	-	1	1	-
Melitidae	Ceradocus	1	-	-	-	-	-	-	-	-
Pontogeneiidae	Pontogeneiidae	-	-	-	1	-	1	-	-	-
Oedicerotidae	Oedicerotidae	1	3	-	3	1	6	2	2	4
Cirolanidae	Cirolana	-	-	-	-	-	-	1	-	-
Alpheidae	Alpheidae	-	-	-	1	-	-	-	-	-
Anthuridea	Anthuridea	2	2	-	2	-	3	1	2	1
Nebaliidae	Nebalia	-	-	-	1	1	1	-	1	-
Mysidacea	Mysidacea	-	-	-	2	-	-	-	-	-
Bodotriidae	Glyphocuma	-	-	-	-	-	1	1	-	2
Mollusca										
Donacidae	*Donax deltoides*	-	1	-	59	29	56	126	89	103
Annelida										
Sigalionidae	Sigalionidae	-	1	1	-	-	-	-	1	-
Opheliidae	Opheliidae	-	-	2	-	-	-	2	1	1
Spionidae	Prionospio	1	-	1	2	2	-	1	3	1
Nepthyidae	*Nephtys longipes*	-	-	-	1	-	-	-	-	-
Dorvilleidae	Dorvilleidae	-	-	-	1	-	-	-	-	-
Syllidae	Syllidae	-	-	-	-	1	-	1	-	-
Paraonidae	Paraonidae	-	-	-	-	1	-	1	-	-
Maldanidae	Maldanidae	-	1	1	1	-	1	1	-	2
Nereididae	Nereididae	-	-	-	1	-	-	-	-	-
Phyllodocidae	Phyllodoce	-	-	1	-	-	1	-	2	1
Glyceridae	Glyceridae	-	-	-	-	1	-	-	-	-

Appendix 3. Taxonomic classification and abundance of 21 epibiota species collected from 9 trawl shots off the proposed Coorong outfall.

Scientific Name	Common Name	Coorong North			Coorong Outfall			Coorong South		
		CN1	CN2	CN3	CO1	CO2	CO3	CS1	CS2	CS3
Thamnaconus degeni	Degens Leatherjacket	-	-	-	-	-	-	2	-	1
Aracana ornata	Ornate Cowfish	-	2	1	7	9	8	5	4	17
Platycephalus bassensis	Southern Sand Flathead	-	-	-	-	-	-	1	-	-
Lesueurina platycephala	Flathead Sandfish	1	1	-	3	-	-	1	-	4
Urolophus paucimaculatus	Sparsely-Spotted Stingaree	-	-	-	-	-	-	1	-	-
Contusus brevicaudus	Prickly toadfish	7	13	3	67	-	88	69	13	38
Arripis georgianus	Australian herring	-	-	-	10	-	2	-	-	-
Taratretis derwentensis	Derwent flounder	2	1	1	1	-	-	1	-	1
Callorhinchus milii	Elephantfish	-	-	-	-	-	-	1	1	-
Myliobatis australis	Southern eagle ray	-	-	-	-	-	-	-	1	1
Neosebastes scorpaenoides	Common gurnard perch	-	-	-	1	-	-	-	-	-
Cyttus traversi	King Dory	-	-	-	-	-	-	-	-	1
Engraulis australis	Anchovy	-	-	-	-	-	-	7	-	-
Sardinops sagax	Australian pilchard	-	-	-	-	-	-	1	-	-
Scomber australasicus	Blue mackerel	-	-	-	-	-	-	1	-	-
Rhombosolea tapirina	Greenback flounder	-	-	2	-	-	-	-	-	-
Ovalipes australiensis	Sand Crab	4	5	6	14	1	4	10	1	6
Donax deltoides	Pipi	1	-	-	1	2	6	1	2	5
Uroteuthis noctiluca	Luminous Bay Squid	-	2	3	-	-	1	2	-	1
Oedicerotidae	Amphipod	-	-	1	-	-	-	-	-	-
Scaberia agardhii	Scaberia	-	-	1	-	-	-	-	-	-