Inter-tidal infauna of the Younghusband Peninsula: assessing the potential impacts of discharge of hypersaline water

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D. Gorman, G. Ferguson, C. Mathews and T. M. Ward

SARDI Aquatic Sciences
PO BOX 120 Henley Beach SA 5022

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South Australian Research and Development Institute
SARDI Aquatic Sciences
2 Hamra Avenue
West Beach SA 5024

Telephone: (08) 8207 5400
Facsimile: (08) 8207 5406
http://www.sardi.sa.gov.au

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Author(s): D. Gorman, G. Ferguson, C. Mathews and T. M. Ward

Reviewers: Dr Mike Steer and Matthew Hoare

Approved by: Dr Adrian Linnane

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EXECUTIVE SUMMARY

1. This report provides an assessment of the relative abundance and composition of beach infauna across the site of a proposed temporary saline water discharge approximately 80 km south of the Murray River mouth, South Australia.
2. The survey was done in October 2009 and spanned an area of beach 10 km long with sampling intensity (250, 500, 2000m) decreasing with increased distance from the proposed site of saline discharge (i.e. 5 km in either direction).
3. Relative abundances of the Pipi (*Donax deltoides*) were generally low (<5 % compared with estimates from the Coorong Classified Area [CCA]). Although between-site variability was high, there was a detectable increase in average catches in a northwesterly direction.
4. The relative abundance of other intertidal infauna was similarly low, with communities typically dominated by nematodes and polychaetes in the families Glyceridae and Saccocirridae.
5. The mean size of *D. deltoides* collected from the survey area was smaller, and moreover, displayed a bimodal length frequency distribution whereas samples collected from the southern end of the CCA (40-60 km) were unimodal.
6. The low relative abundance of intertidal infauna (in particular, *D. deltoides*) suggests that that the proposed discharge of saline water may be unlikely to have major effects on the biomass or diversity of extant faunal communities along the beach as a whole.
7. Monitoring of longshore dispersal of saline water during pumping operations is recommended due to the close proximity of the commercial fishery for *D. deltoides* on the Younghusband Peninsula. Pumping should be temporarily ceased if extensive northward movement of the hypersaline plume is detected.

1.0 INTRODUCTION

1.1 Background

The Coorong lagoons represent one of the largest and most important wetland systems in Australia (Phillips and Muller 2006; MDBC 2006). Prolonged drought and lack of freshwater inflow have resulted in concerns about increased salinity and the ecological viability of these ecosystems. In an attempt to alleviate further damage to the Coorong ecosystem the Murray-Darling Basin Natural Resource Management Board (MDB NRM) to pump high salinity water from the southern Coorong lagoon, across Younghusband Peninsula, to the adjacent ocean via a pipeline discharge system. Discharge water will be hypersaline (120 - 150 ppt) compared to that of the Southern Ocean (35-36 ppt). The proposed outfall will be near Policeman Point/Woods Well, approximately 80 km south of the Murray River mouth. Preliminary hydrodynamic modeling (Aurecon 2009) predicts that the discharged water will rapidly mix with oceanic water and that the saline plume would be diluted to within 1 ppt of background values within ~ 2 km of the discharge point. As well as elevating local salinity, the plume has the potential to increase turbidity and elevate nutrient concentrations.

1.2 Consequences of saline discharge

Changes to salinity regimes can have dramatic implications for infaunal communities (McLeod & Wing 2008). Biological communities exposed to high salinity/low O_2 regimes can display low species diversity and biomass (Dauer et al. 1992). Information on the community structure and relative abundance on the infauna of the Younghusband Peninsula is needed to assess the potential impacts of saline water discharge. This information is needed because of the close proximity of the proposed discharge point to commercial fishing grounds (i.e. the Coorong Classified Area, CCA) located on the Ocean Beach fishing area of the Lakes and Coorong Fishery (Fig 1.1). There are concerns that hypersaline and potentially hypoxic water masses (i.e. O_2 is less soluble in hypersaline water) may have detrimental effects on extant infaunal communities (e.g. Debelius et al. 2009).

The principle concern is for the potential affects of saline discharge on the commercially important bivalve species *Donax deltoides*, which is marketed as pipi. The recruitment and subsequent development of *D. deltoides* into the fishery may be influenced by elevated salinities from the proposed Coorong outfall (Wiltshire et al. 2009). Previous studies of *D. deltoides* suggest that breeding populations located at the south-eastern end of the Younghusband

Peninsula may provide an important source of eggs and larvae (King 1976; King 1985). This suggestion was based on the seasonal pattern of longshore currents which flow in a north westerly direction during the main spawning period i.e. September/October (King 1985).

Monitoring the ecological impacts of human disturbance on beach infauna is a challenge because of uncertainties in the response of organisms to both natural and anthropogenic change (Lucrezi et al. 2009). This report provides a preliminary assessment of the relative abundance and community composition of intertidal infauna in the vicinity of the proposed discharge site. The current project builds on previous descriptions of *D. deltoides* abundance and community structure, obtained through fishery-independent surveys conducted in 2007-08, 2008-09 and October 2009 (PIRSA Fisheries, SARDI Aquatic Sciences and commercial pipi fishery). These surveys involved a coordinated scientific sampling effort and structured commercial fishing, similar to that which currently exists in other South Australian fisheries, such as the Blue Crab Fishery and Spencer Gulf Prawn Fishery. It also builds on the findings of a doctoral research study conducted by Coby Matthews (funded by PIRSA Fisheries, SARDI Aquatic Sciences and Adelaide University) that focuses on aspects of the biology and distribution of pipi along the Younghusband Peninsula and complements a concurrent project "Tolerance of Goolwa cockles to high salinity water from the south lagoon of the Coorong", which was conducted from 1st August to 31st October 2009 by SARDI Aquatic Sciences (Wiltshire et al, 2009).

1.3 Aims

The specific aims of the study were to:

1. Estimate the relative abundance and size structure of the pipi (*Donax deltoides*) at the site of the proposed hypersaline water discharge and compare this with commercial fishing areas located in the Coorong Classified Area to the northwest,
2. Investigate the relative abundance and community structure of other infaunal communities (i.e. primarily nematodes and polychaetes),
3. Use assessments of infaunal abundance and community structure to inform management of the susceptibility of infaunal communities to saline discharge.

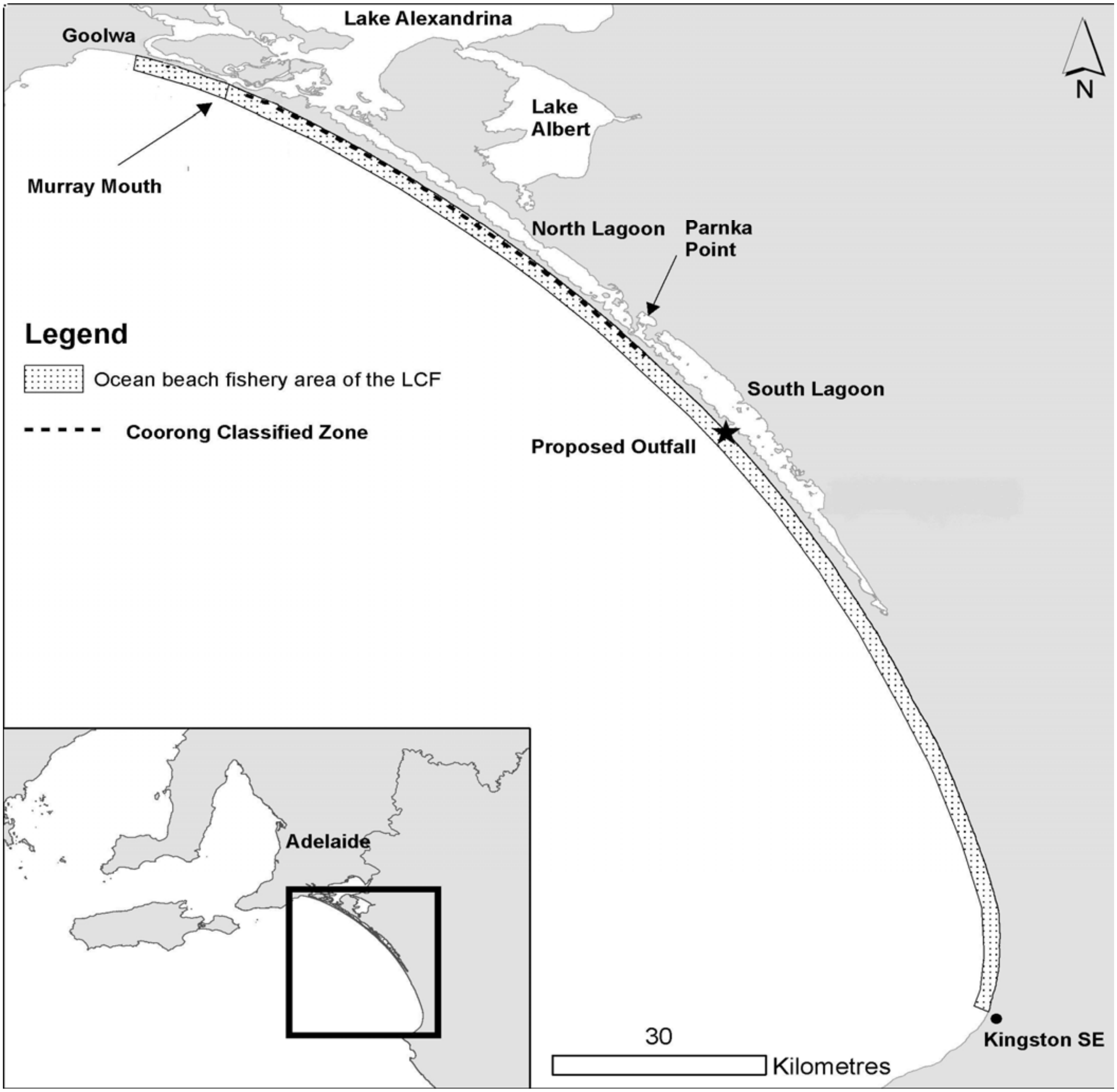

Figure 1.1 The Coorong region showing the location of the Coorong Classified Area (CCA) located within the Lakes and Coorong Fishery (LCF), and the location of the proposed outfall for the Southern Lagoon temporary saline water discharge.

2.0 METHODS

2.1 Study area

The survey area consisted of a 10 km section of Younghusband Peninsula centered on the proposed site of the Coorong temporary saline water outfall (Fig. 2.1). Predetermined sampling sites (*n* = 21) were oriented along the beach in a north-west and south-east direction from the proposed discharge site, with sites separated by 250 m for the first 1.5 km, 500 m up until 3 km and 2000 m up to a distance of 5 km. The location of all sampling sites were marked on the 2nd October 2009 (Appendix, Table S1), with sampling done between the 3rd and 30th of October 2009. During this period, field conditions were generally good with low swell, sea height and wind strength (various directions between west and SE, ≤15 knots).

2.2 Relative abundance and size structure of *Donax deltoides*

The sampling protocol followed that used for previous fishery independent surveys of *Donax deltoides* on Younghusband Peninsula by SARDI. At each site three replicate transects were located along the beach, separated by > 10 m. Each transect was 1.5 m x 3 m (across and along the beach respectively). Sampling was done by commercial fishers using a commercial 'cockle rake' (mesh size 44 mm). Analysis of mean catches obtained during a preliminary standardization revealed no variation in fishing efficiency among individual fishers (ANOVA: $F_{2, 12} = 1.30$; $P = 0.307$). The total catch from each replicate transect was weighed using calibrated spring scales (to the nearest 0.1 of a kilogram) and data recorded along with time of sampling.

At each site an independent sub-sample of *D. deltoides* (up to 100 individuals) was collected for length frequency analysis. Samples were collected adjacent to fishing transects by a SARDI observer using a fine-mesh research net (1 mm mesh size). In the laboratory, the shell length (measured across the widest part of the shell) of all collected samples was recorded to the nearest 0.01 mm using electronic calipers.

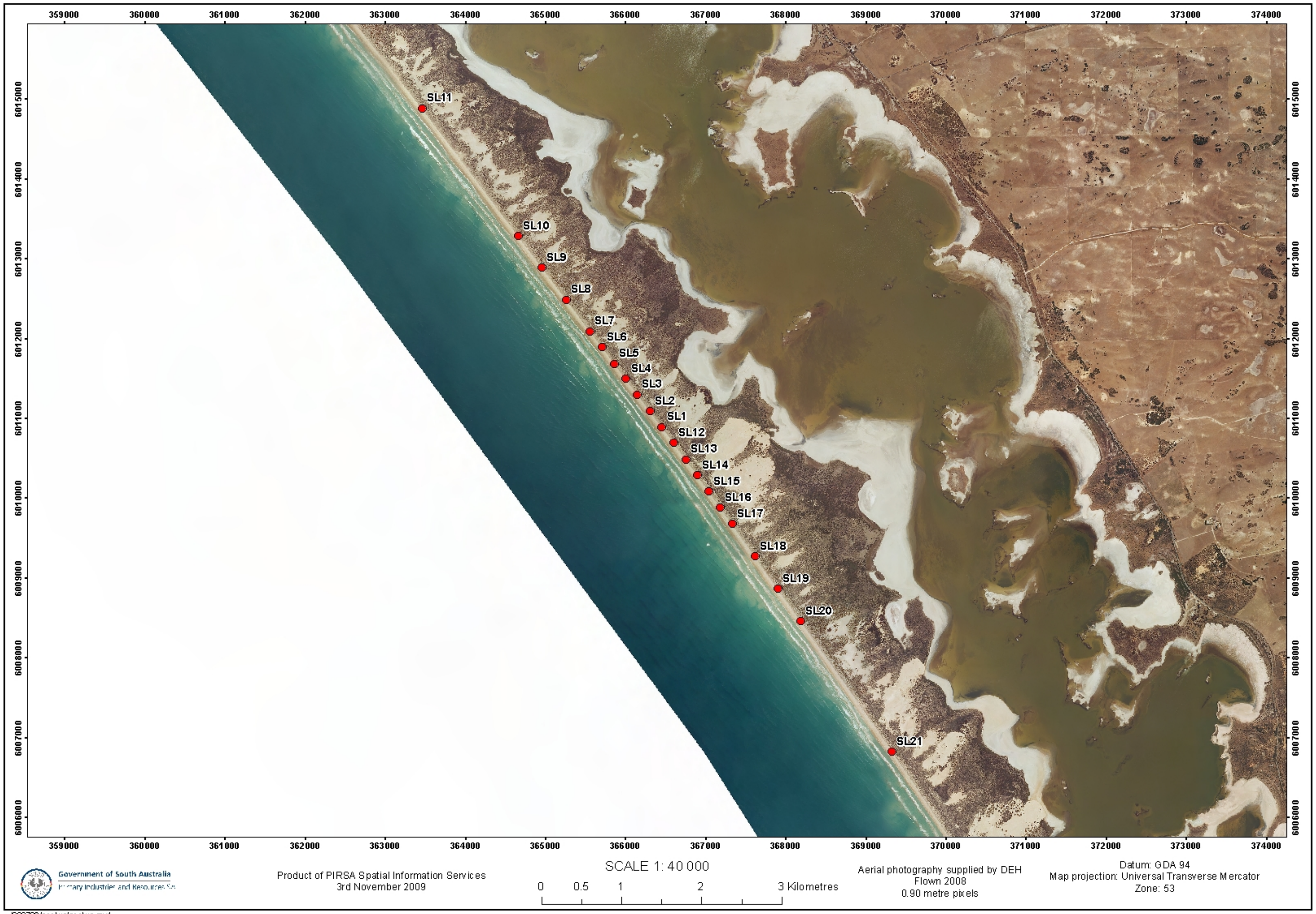

Figure 2.1 Areal photograph of the survey area showing replicate sampling sites (n = 21) centered on the site of the proposed saline outfall (SL1). Survey sites in each direction were separated by 250 m for the first 1.5 km, thereafter 500 m (between 1.5 and 3 km) and 2000m (from 3 km to 5 km).

2.3 Relative abundance and community structure of other intertidal infauna

The abundance and community structure of infauna at each replicate sampling site (*n* = 21; as above) was investigated using a 2 m wide cross-shore transect that extended from the low to high tide marks. Each transect was divided into three zones; high-shore, mid-shore and swash zone (for description of zones see; James & Fairweather 1996). At each site and within each cross-shore transect, five replicate core samples (10 cm diameter × 15 cm depth) were taken at random. Cores were excluded from distances < 1 m from transitional margins defining each zone to account for any gradation. All transects were undertaken at a maximum of two hours either side of low tide. A large plastic zip lock bag was placed on top of the corer and then inverted, to slide the contents of the core into the bag. In the laboratory, three sub-samples were taken from each core. Sub-samples were analysed (without sieving) in a sorting tray under a magnifying lamp. All invertebrates (infauna) were removed and placed into 70% ethanol for further identification. A dissecting microscope was used to identify infauna to the highest practical taxonomic resolution.

2.4 Beach and environmental characteristics

At each transect location the width of each of the three zones was recorded. At seven transects (0, NW and SE 1500, 3000 and 5000) additional information was collected. A theodolite and staff was used to measure the change in beach slope (relative to the base of the sand dunes). A water sample was taken from the surf, with temperature (°C) and salinity (ppt) measured using a TPS WP-84 hand held meter. General conditions were also recorded (surf height, swell, wind strength and direction, air temperature and weather conditions).

2.5 Data Analysis

Analysis of Variance (ANOVA) was used to investigate differences in the relative abundance of infauna across the survey area (i.e. sampling locations). Variation in the abundance of *Donax deltoides* was investigated across sites (single fixed factor), whereas the abundances of other infauna (nematodes and polychaetes) were tested orthogonally with beach zone (swash, mid-shore and high-shore). Pearson's correlation (*r*) was used to investigate any relationship between infaunal abundance and physical parameters.

3.0 RESULTS

3.1 Relative abundance and size structure of *Donax deltoides*

Relative catches of *Donax deltoides* were generally low across the survey area (range: 0 – 0.5 kg per 4.5 m^2; Fig. 3.1) although considerable variation was evident among sampling sites (ANOVA: $F_{20, 42} = 11.73$; $P < 0.001$). The mean abundance of *D. deltoides* increased in a northwest direction (Pearson's correlation, $r = -0.51$, $P = 0.019$), with sampling sites 6 and 10 having significantly greater catches than all other transects (Student-Newman-Keuls [SNK] tests).

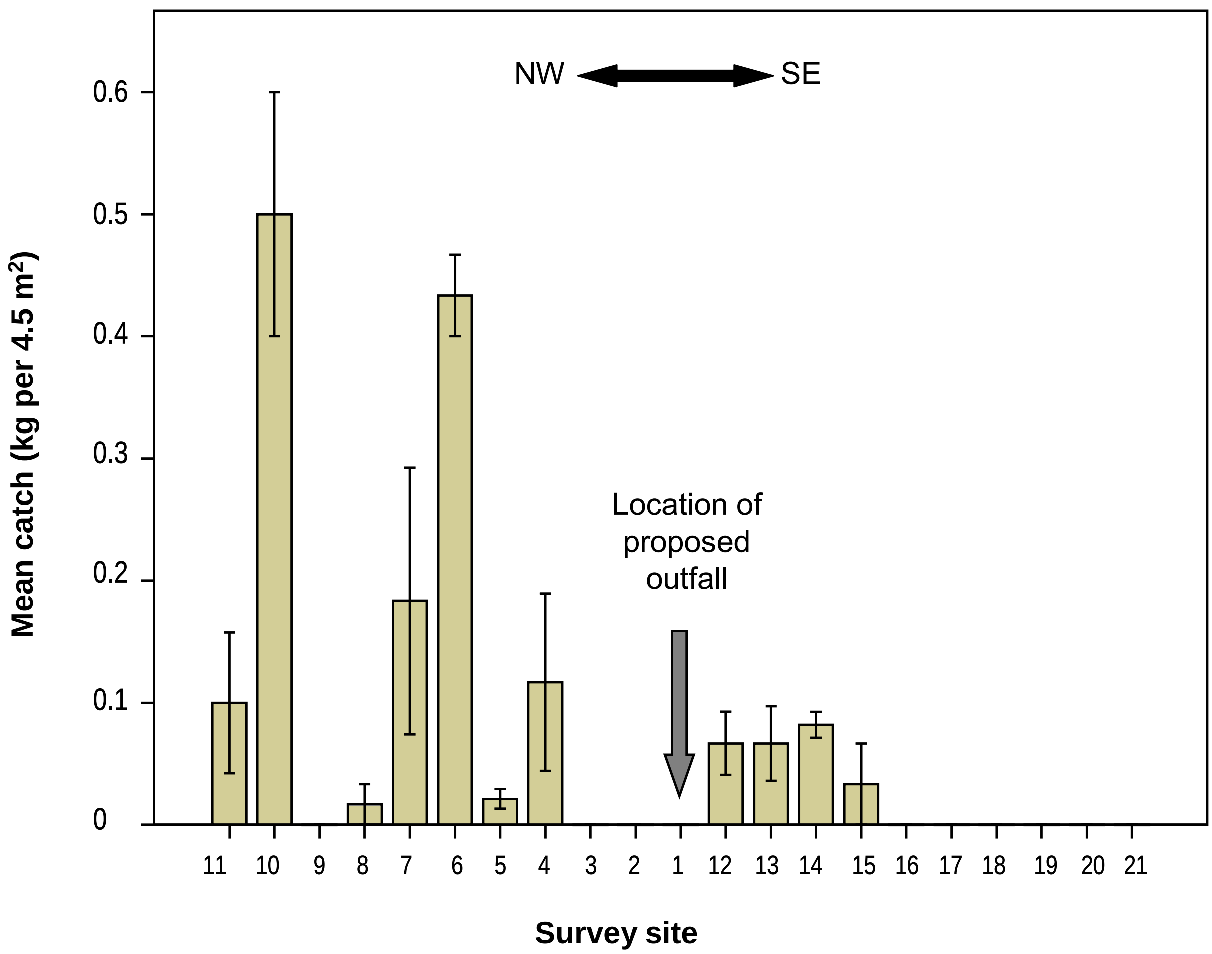

Figure 3.1 Relative catch weights (± SE) of *D. deltoides* sampled from survey sites (n = 3 replicate transects per site) across the proposed saline discharge area during October 2009.

Catches of *Donax deltoides* within the survey area were low when compared to those within the Coorong Classified Area (Fig. 3.2; ANOVA: $F_{3, 146} = 47.95$; $P < 0.001$; SNK-tests: section A = B > C > survey area). Overall, mean catches from the survey area were less than 5 % of those across the entire CCA. Pooling survey data with data from the fishery-independent surveys, provides further evidence for a general increase in relative catch (and hence biomass) with distance (NW, measured in km) along the Younghusband Peninsula (Pearson's correlation, $r = -0.66$, $P < 0.001$).

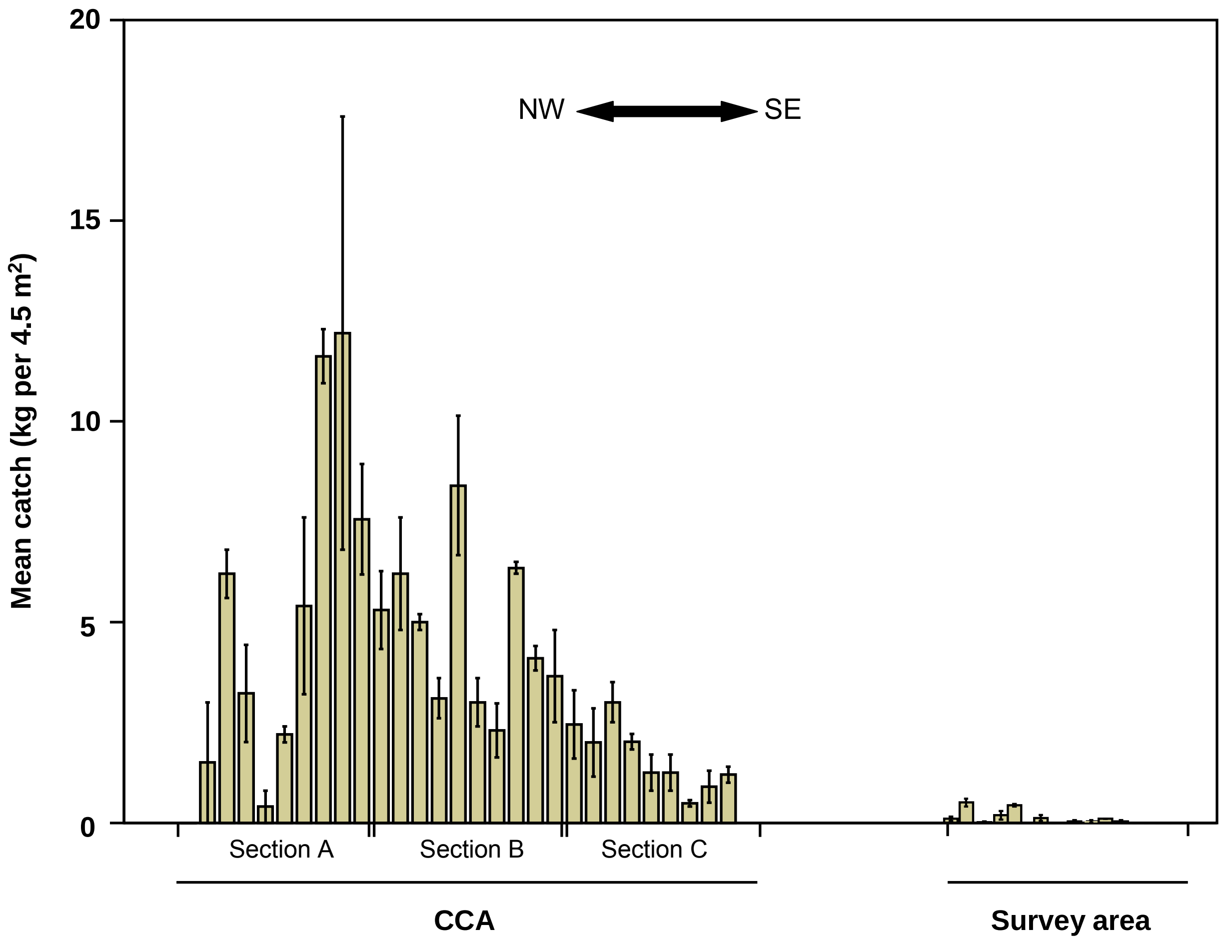

Figure 3.2 Comparison of the relative catch weights of *D. deltoides* sampled from three sections of the Coorong Classified Area (CCA) and the proposed hypersaline water discharge area (Survey area) during October 2009. Data for each site are means ± SE derived from replicate transects (n = 2 or 3 for CCA; n = 3 for all survey sites).

The length frequency distribution of *D. deltoides* from the study site was bimodal, with the dominant mode of 14 mm and a second mode of 36 mm. In contrast, the adjacent section of beach (40 to 60 km) had few small individuals and was unimodal with a mode of 33 mm. The northern sections of Younghusband Peninsula (0 to 20km, 20 to 40 km) appeared to have three modes (~15, 30, and 45 mm).

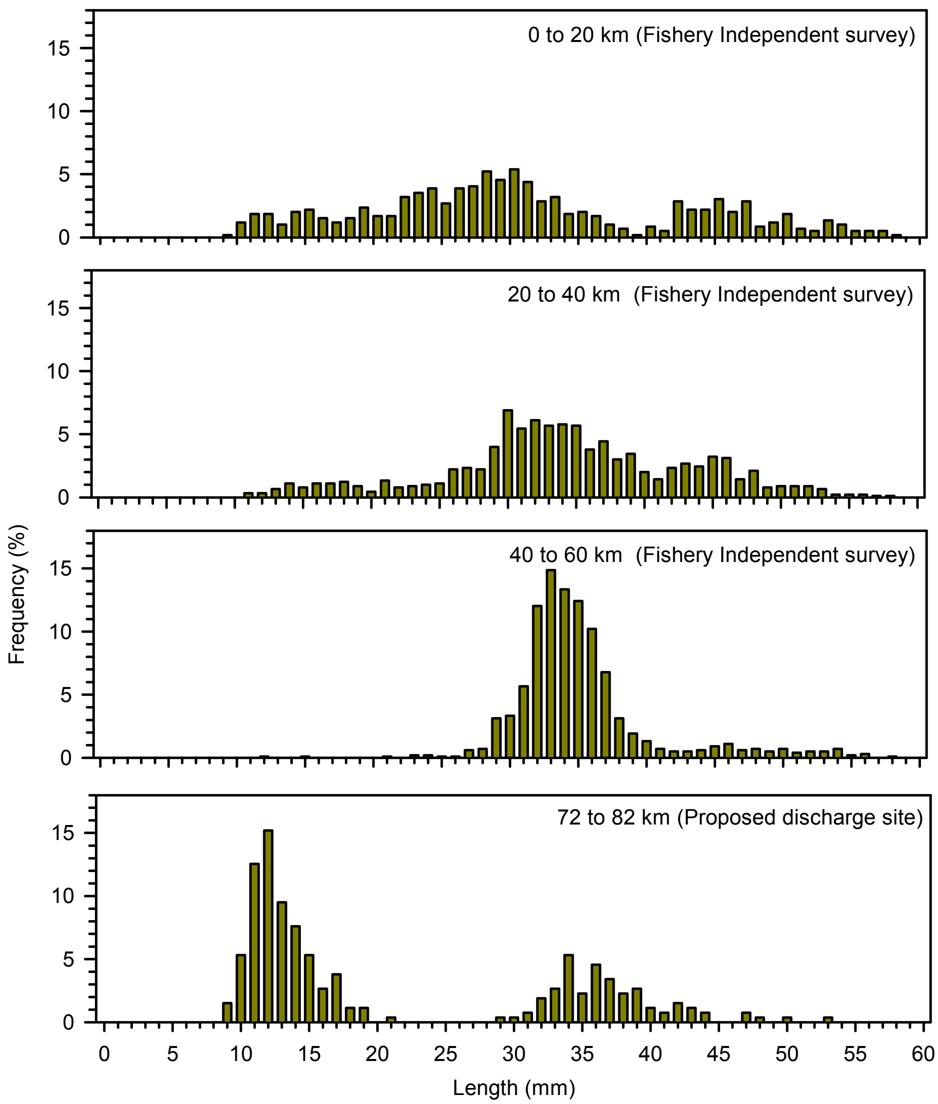

Figure 3.3 Length frequency distributions are shown for *D. deltoides*, from four sections of the Younghusband Peninsula in October 2009. Sections 0 to 20, 20 to 40, and 40 to 60 km from the Murray River mouth occur within the Coorong Classified Area and 72 to 82 km is the area of the proposed hypersaline water discharge site.

3.2 Relative abundance and community structure of other intertidal infauna

A total of 138 invertebrates were identified from 866 sub-samples. This result highlights the low relative abundance of infauna across the survey area. Infauna was dominated by nematodes (79%), followed by polychaetes (17%) from the families Glyceridae and Saccocirridae. The remaining infauna comprised of insects (4%) and isopods (< 1%). Among beach zones, the abundance of nematodes differed with sampling site (Table 3.1a; 'site × zone' interaction). The abundance of polychaetes differed among sampling sites and with beach zone (Table 3.1b). Abundances were consistently greater in the mid and swash zone than they were in the high-shore zone (SNK-tests).

Table 3.1 Results of two-factor ANOVA testing for differences in the abundance of (a) nematodes and (b) polychaetes estimated across sampling 'site' and 'zone' (high-shore, mid-shore and swash zone).

Treatment	*df*	MS	*F*	*P*
(a) *Nematodes*				
Site	20	1.506	3.949	***
Zone	2	14.649	38.417	***
Site × Zone	40	1.407	3.690	***
Residual	803	0.381		
(b) *Polychaetes*				
Site	20	0.064	2.226	***
Zone	2	0.231	7.974	***
Site × Zone	40	0.039	1.333	NS
Residual	803	0.029		

Notes: NS = $P > 0.05$, *** = $P < 0.001$.

4.0 DISCUSSION

Results from this study suggest that the relative abundance of *Donax deltoides* and other beach infauna were very low in the area of the proposed discharge site during October 2009. The high spatial variability seen among replicate sampling sites is typical of high-energy (dissipative) beaches where infauna are regularly redistributed by swash action (James 1999). Estimates of relative abundance of *D. deltoides* in the study area were less than 5% those for the Coorong Classified Area (CCA), which begins approximately 10 km to the northwest. Although previous studies of *D. deltoides* (1970's and 1980's) suggested that the south-eastern end of Younghusband Peninsula may provide an important pool of breeding animals (King 1976; King 1985), the relatively low abundances of *D. deltoides* observed in this study did not support this suggestion.

The size structures of *D. deltoides* differed between the proposed discharge area and the CCA. The length-frequency distribution of *D. deltoides* in the study area comprised higher frequencies of small individuals and fewer larger individuals than in the CCA, suggesting that this growth and/or survival rates may be low in this area.

Across Australia, there has been recent concern about the affects of terrestrial inputs on coastal resources (e.g. Gorman et al. 2009). These concerns, however, typically involve persistent 'non-point' discharges along developed coastlines (see, Carpenter et al. 1998). Whilst prolonged changes to coastal salinity have been shown to affect infauna communities (Dauer et al. 1992, McLeod & Wing 2008) this may not be a major concern with the current proposal. Both adult and juvenile *D. deltoides* are able to tolerate short periods of exposure to salinities up to 50 ppt with few negative effects (Wiltshire et al. 2009). However, prolonged exposure to salinities within this range during or soon after spawning events appear to pose a significant risk (Wiltshire et al. 2009). The constrained temporal and spatial nature of the proposed discharge, coupled with the low extant faunal abundance, suggests that detrimental effects are likely to be limited. The major concern is the potential for hypersaline water plumes to travel northwards into the Coorong Classified Area during conditions of low dissipation. It is therefore recommended that the dispersal of the hypersaline water is monitored and that pumping is temporarily ceased if extensive northward movement of the hypersaline plume is detected.

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APPENDIX

Table S1. Distance from proposed saline discharge point and latitude/longitude positions for survey sampling sites.

Survey site	Distance (m)	Position
SL11	5000	S36.00090 E139.48499
SL10	3000	S36.01552 E139.49804
SL9	2500	S36.01912 E139.50129
SL8	2000	S36.02280 E139.50453
SL7	1500	S36.02641 E139.50778
SL6	1250	S36.02820 E139.50947
SL5	1000	S36.03012 E139.51110
SL4	750	S36.03184 E139.51268
SL3	500	S36.03365 E139.51420
SL2	250	S36.03555 E139.51597
SL1 (proposed discharge point)	0	S36.03733 E139.51755
SL12	250	S36.03915 E139.51914
SL13	500	S36.04104 E139.52077
SL14	750	S36.04287 E139.52232
SL15	1000	S36.04470 E139.52389
SL16	1250	S36.04655 E139.52549
SL17	1500	S36.04842 E139.52709
SL18	2000	S36.05212 E139.53020
SL19	2500	S36.05582 E139.53330
SL20	3000	S36.05953 E139.53641
SL21	5000	S36.07444 E139.54878