Benthic Macroinvertebrate Response Monitoring in the Coorong and Murray Mouth, February 2015

Interim Report

for the Department of Environment and Natural Resources

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1. Background

This report presents findings from the fifth year of monitoring the response of macroinvertebrates to the restored freshwater inflows into the Murray Mouth and Coorong since late 2010. The previous survey years gave indications of a recovery, following a slow start in the first year of inflow (Dittmann et al. 2013a). Species not seen in the system during the drought were first found again in the 2012/13 survey (Dittmann et al. 2013a), and their establishment will affect whether benthic communities return to pre-drought conditions, or follow a trajectory into a new state.

The approach and methods used during 2015 monitoring followed previous monitoring protocols, but the design was changed with a reduction to a single sampling event in February 2015, sampling only the intertidal sites and sampling at a slightly different set of sites in the Coorong and Murray Mouth.

2. Materials and Methods

2.1 Study sites and sampling methods

A single sampling event was undertaken during February 2015. Sites in the Murray Mouth region (Monument Road to Pelican Point) were sampled on the 9th February 2015, with sites in the Coorong Lagoons sampled on the 12th February 2015. Sites sampled were those included as part of The Living Murray (TLM) condition monitoring for macroinvertebrates and mudflats (Figure 1). Water quality was measured in the field and samples were taken for macrobenthic communities. All measurements for water quality and samples for macrofauna were taken in the same way as described in previous reports for this monitoring programme (see sections 3.2 and 3.3 in Dittmann et al. 2014a).

Eleven sites were sampled, including five in the Murray Mouth (Monument Road (MR), Hunters Creek (HC), Mundoo Channel (MC), Ewe Island (EI) and Pelican Point (PP)), three in the North Lagoon (Mulbin-Yerrok (MY), Noonameena (NM) and Parnka Point North (PaPN)) and three in the South Lagoon (Villa dei Yumpa (VdY), Jacks Point (JP) and Loop Road (LR); Figure 1). These sites were sampled in previous studies for condition monitoring in the region (TLM; Dittmann et al 2014b), and most sites were sampled in previous water release studies (see Dittmann et al. 2014a). These sites were selected to allow for long term comparisons of macrobenthic communities, with data available back to 2004 for sites sampled as part of the TLM monitoring programme.

2.2 Data Analysis

Total abundance was calculated for each sample and species number and diversity were calculated for each site. A two-factor mixed-model nested PERMANOVA was used to test for differences in univariate measures (e.g. abundance, diversity etc.) and community structure (in terms of both species composition and relative abundances) between Regions (fixed-factor with three levels, Murray Mouth, North Lagoon and South Lagoon) and Sites (nested in Regions). Detailed analysis comparing 2015 to previous sampling events and analysis looking at relationships between biological communities and physical conditions will be included in the final report, draft due August 2015, and so is not included here. All data were analysed using Primer 6 with the + PERMANOVA add-on.

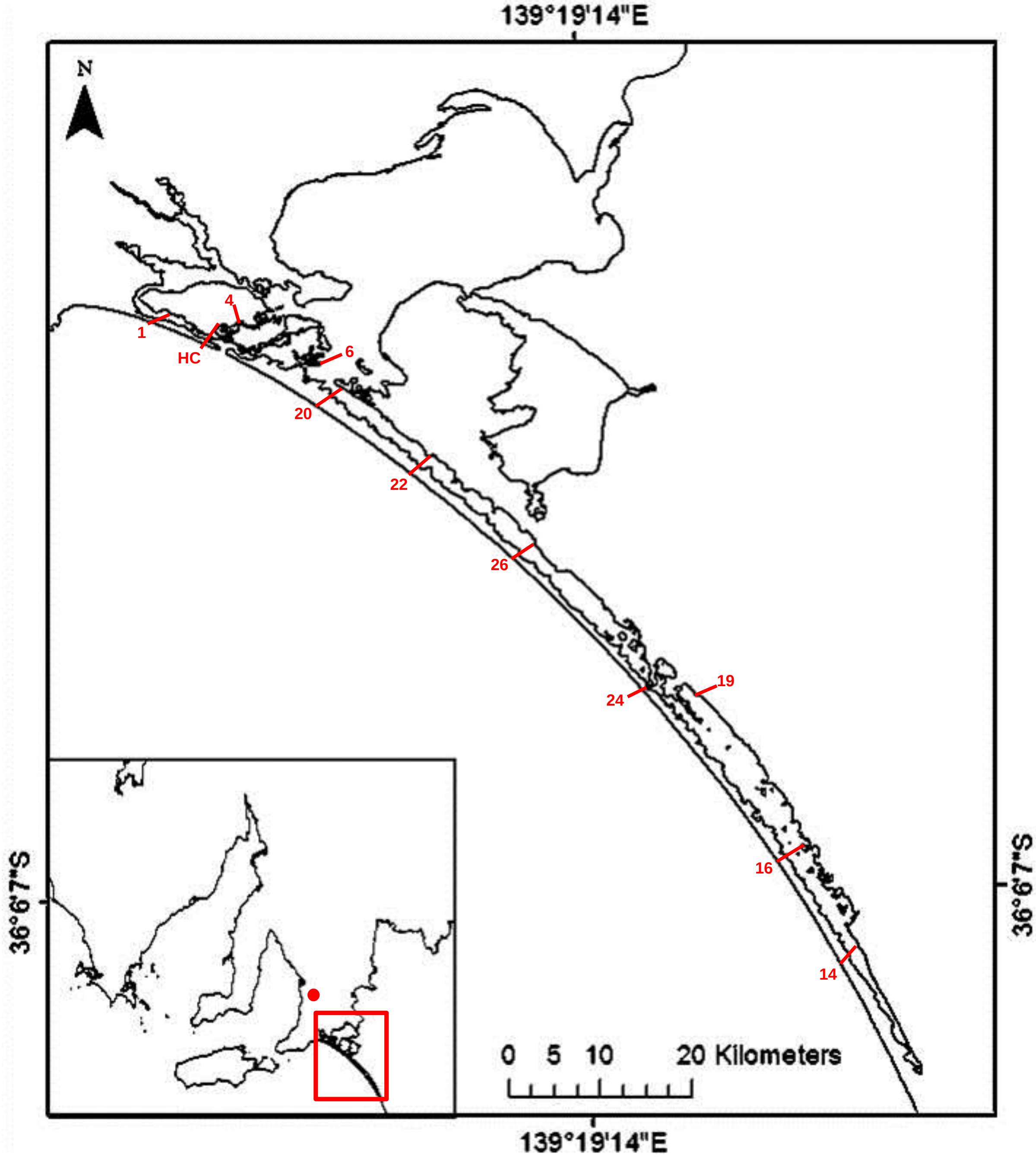


Figure 1. Map of study sites sampled during 2015 monitoring. Sites are Monument Road (MR; site 1), Hunters Creek (HC), Mundoo Channel (MC; site 4), Ewe Island (EI; site 6), Pelican Point (PP; site 20), Mulbin-Yerrok (MY; site 22), Noonameena (NM; site 26), Parnka Point North (PaPN; site 24), Villa dei Yumpa (VdY; site 19), Jacks Point (JP; site 16) and Loop Road (LR; site 14). Inset map shows location of study region (red box) in relation to the CBD of the state capitol of South Australia, Adelaide (red dot).

3. Results and Discussion

3.1 Environmental conditions (Water Quality)

Salinity was polyhaline throughout the Murray Mouth region during February 2015 monitoring, with only a narrow range in values observed, from 15.1 ppt at Pelican Point to 16.6 ppt at Hunters Creek (Figure 2). Salinity rose sharply in the North Lagoon, from euhaline conditions at Mulbin-Yerrok (salinity = 38 ppt) to extreme hyperhaline conditions at Parnka Point North (salinity = 109 ppt; Figure 2). Conditions in the South Lagoon were extremely hyperhaline at all three sites, with salinity ranging from 102 ppt at Jacks Point to 104 ppt at both Villa dei Yumpa and Loop Road (Figure 2).

Water temperature was relatively high at all sites, ranging from 16.5 C at Loop Road to 26.8 C at Pelican Point (Figure 2). These ranges are more reflective of time of day samples were collected rather than regional or site differences in water quality.

Dissolved oxygen percentages and concentrations were very different among sites within each region (Figure 2). Dissolved oxygen (DO) saturation was above the ANZECC lower-limit trigger value of 90% (ANZECC 2000) at all sites at the time of sampling, except at Parnka Point North (DO = 85.9%; site 24; Figure 2). Oxygen over-saturation was observed at most other sites, with the exception of Monument Road (site 1) and Loop Road (site 14; Figure 2), but values for DO% at both of these sites were still close to 100%. Patterns in DO concentration mirrored those for DO %, with lowest values recorded at Parnka Point North (DO = 5.85 mg/L; Site 24) and highest values at Pelican Point (DO = 13.30 mg/L; site 20; Figure 2).

3.2 Macroinvertebrate abundance, diversity and community structure

Macroinvertebrate total abundance was highest at Mundoo Channel (site 4) in the Murray Mouth in February 2015, with high total abundances recorded at all sites between Monument Road (site 1) and Noonameena (site 26) (Figure 3). South of Noonameena, total abundance of macroinvertebrate communities was low (Figure 2). Abundance was significantly different among the regions (Table 1), with significantly higher abundance in the Murray Mouth compared to the South Lagoon (t = 2.596; P(perm) = 0.0001; Figure 1). There was however, no significant difference in abundance between the Murray Mouth and North Lagoon or between the North and South Lagoons (Table 1). In addition to regional differences, there was significant spatial variation in total abundance among sites (Table 1).

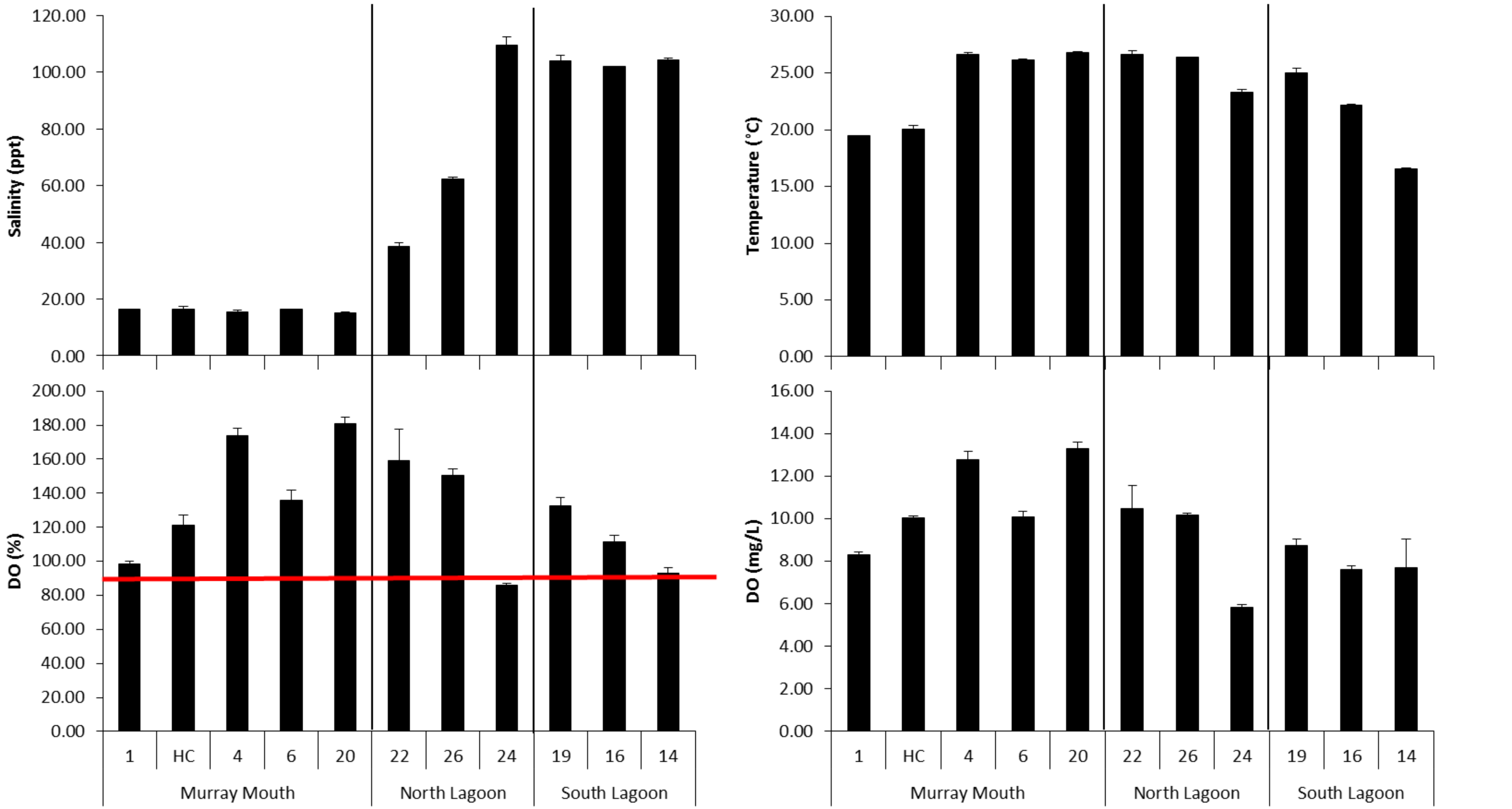


Figure 2. Average (±SD) a) salinity, b) temperature, c) dissolved oxygen saturation, and d) dissolved oxygen concentration for each site sampled during the February 2015 monitoring event. The red horizontal line on the DO% plot indicates the lower threshold value for DO% for estuaries in southern temperate Australia (ANZECC 2000).

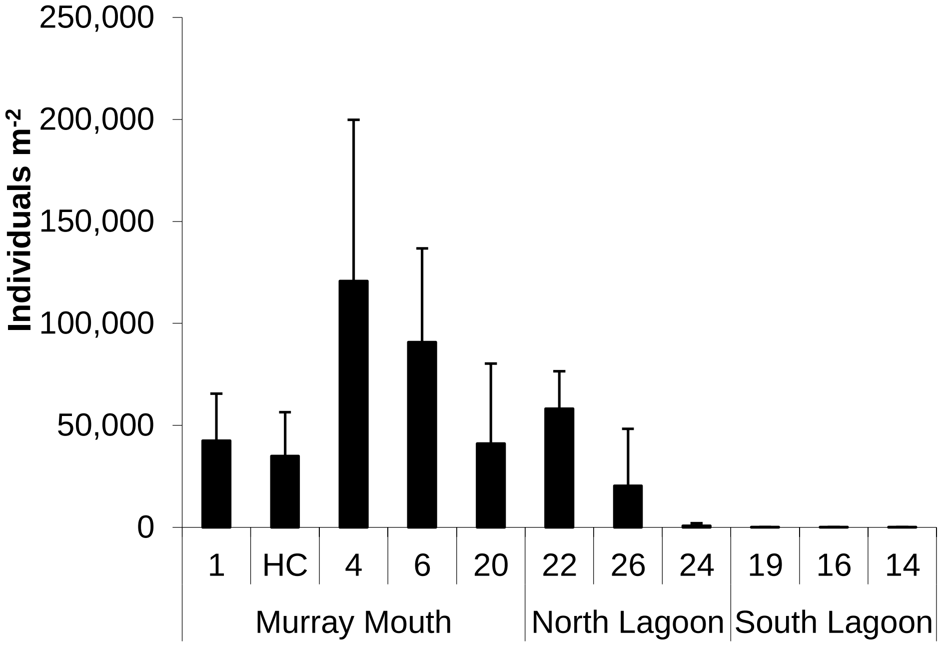


Figure 3. Average of total abundance (ind.m^{-2}; ±SD) of benthic macroinvertebrates at each site sampled during the 2015 survey (see Figure 1 for site numbers).

Table 1. PERMANOVA *P*(permutations-based) statistics for the main test for differences among regions and sites (nested in regions), and for post-hoc pair-wise tests for the factor region, when it was significant, for total abundance, abundance of each phyla represented, species number (S), diversity (H'log$_e$) and multivariate community structure (CS).

Source	Abundance	Annelida	Crustacea	Mollusca	Hexapoda	S	H'(log$_e$)	CS
Region	**0.0034**	**0.0357**	**0.0182**	**0.0068**	0.1269	**0.0030**	**0.0034**	**0.0002**
Site (Region)	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**
MM v NL	0.1201*	0.4087*	0.0596*	**0.0270***	N/A	**0.0146***	**0.0359***	**0.0136***
MM v SL	**0.0001***	**0.0001***	**0.0081***	**0.0006***	N/A	**0.0001***	**0.0002***	**0.0001***
NL v SL	0.0588*	0.1252*	0.3934*	0.3782*	N/A	0.1271*	0.2747*	0.0514*

* Monte Carlo tests done (unique permutations less than 100)

Patterns in total abundance across the different sites were driven by abundances of key taxa. Peaks in abundance at sites between Monument Road (site 1) and Ewe Island (site 6) were driven by high abundances of Crustacea (Figure 4), while patterns in total abundance between Pelican Point (site 20) and Noonameena (site 24) were driven by abundance of Annelida (Figure 4). With the exception of Hexapoda, all taxa were significantly different in abundance among regions and all taxa exhibited significant spatial variation among sites (Table 1). As for total abundance, abundance of individual taxa (except Hexapoda) was significantly greater in the Murray Mouth compared to the South Lagoon (Table 1; Figure 4).Mollusca were also significantly more abundant in the Murray Mouth compared to the North Lagoon (Table 1; Figure 4). There were no significant differences in abundance between the North and South Lagoons of the Coorong (Table 1).

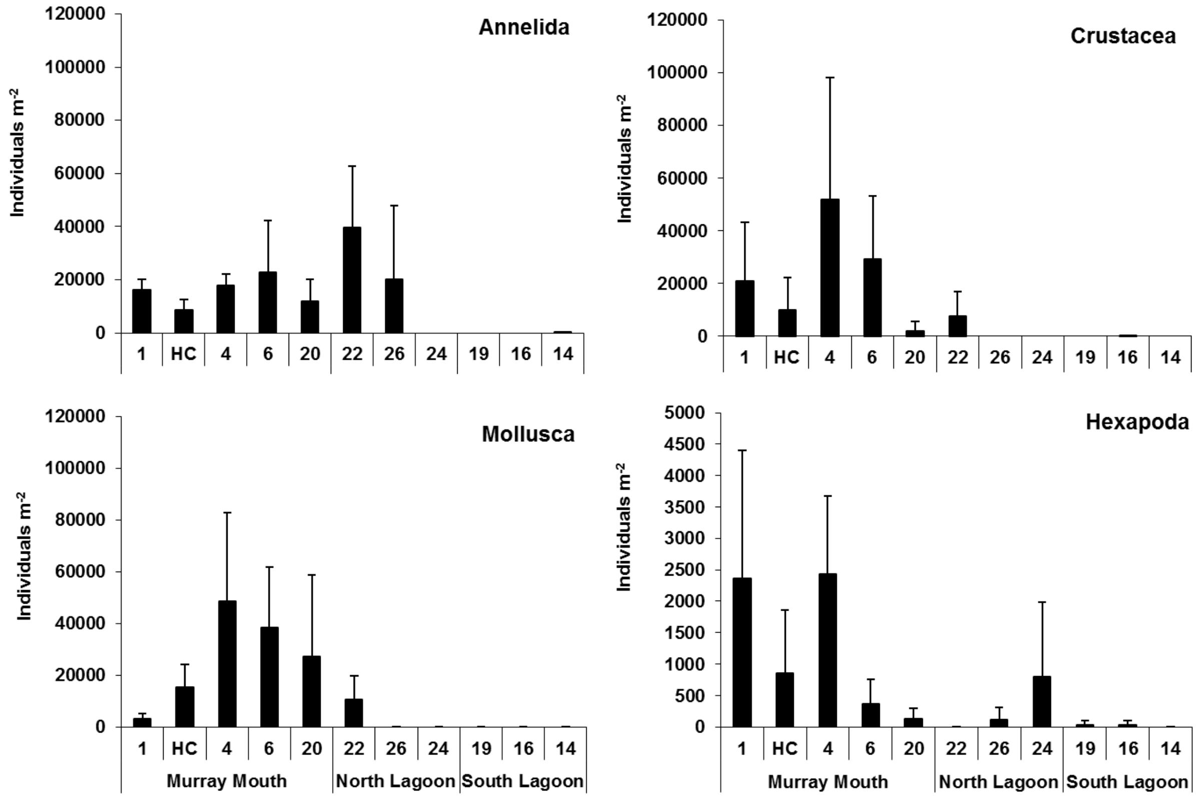


Figure 4. Average abundance (ind.m^{-2}; ±SD) of a) Annelida, b) Crustacea, c) Mollusca, and d) Hexapoda at each site sampled during the 2015 survey (see Figure 1 for site numbers). Note that Hexapoda are plotted on a different scale for the y-axis than other taxa.

Species diversity was high in the Murray Mouth region, even though species numbers had remained unchanged or decreased in comparison to previous years (Figure 5). This indicates an increase in evenness, with less dominance by single species. The total number of species (S) and species diversity (H'log$_e$) were both significantly different among the three regions, and exhibited significant spatial variation among sites (Table 1). For both measures, diversity was significantly greater in the Murray Mouth relative to the North and South Coorong Lagoons, but there was no significant difference in diversity between the two Coorong Lagoons (Table 1).

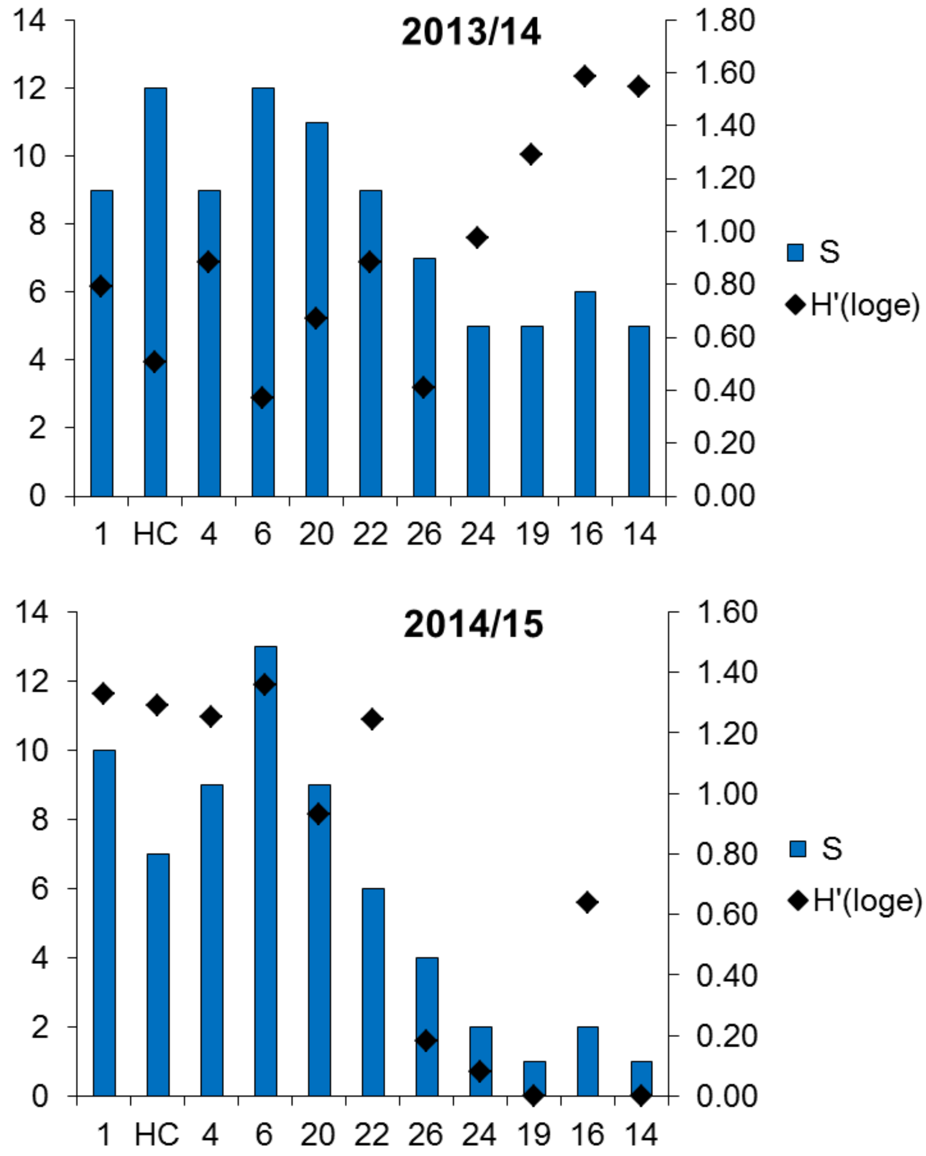


Figure 5. Species number (left y-axis; blue bars) and diversity (right y-axis; H'(log_e); black diamonds) for each site sampled during the 2015 survey (see Figure 1 for site names) during a) 2013/14 (previous years monitoring event) and, b) 2014/15 (current monitoring event).

Multivariate community structure (in terms of species composition and relative abundance) was significantly different among the regions and also exhibited significant spatial variation among sites (Table 1). As for total abundance, community structure was significantly different in the Murray Mouth compared to both the North and South Coorong Lagoons, but the two Lagoon regions were not significantly different to each other (Table 1). A non-metric multidimensional scaling (nMDS) plot shows clearly that there is a distinct separation between communities at sites in the Murray Mouth region (green triangles), and sites in the Coorong Lagoons (blue triangles and dark blue squares; Figure 6). The community at Parnka Point North (site 24) was more similar to communities observed at sites in the South Lagoon, particularly Jacks Point (site 16) and Villa dei Yumpa (site 19; points plotted closely together; Figure 6). Communities at sites in the North Lagoon were more variable in structure than those in the Murray Mouth or South Lagoon (Figure 6), and there was a significant difference in dispersion of samples among the regions, with the North Lagoon being significantly more variable in community structure than those in the Murray Mouth (t = 12.59; P(perm) = 0.0004) or South Lagoon (t = 7.05; P(perm) = 0.0004). The North and South Lagoons were not significantly different to each other.

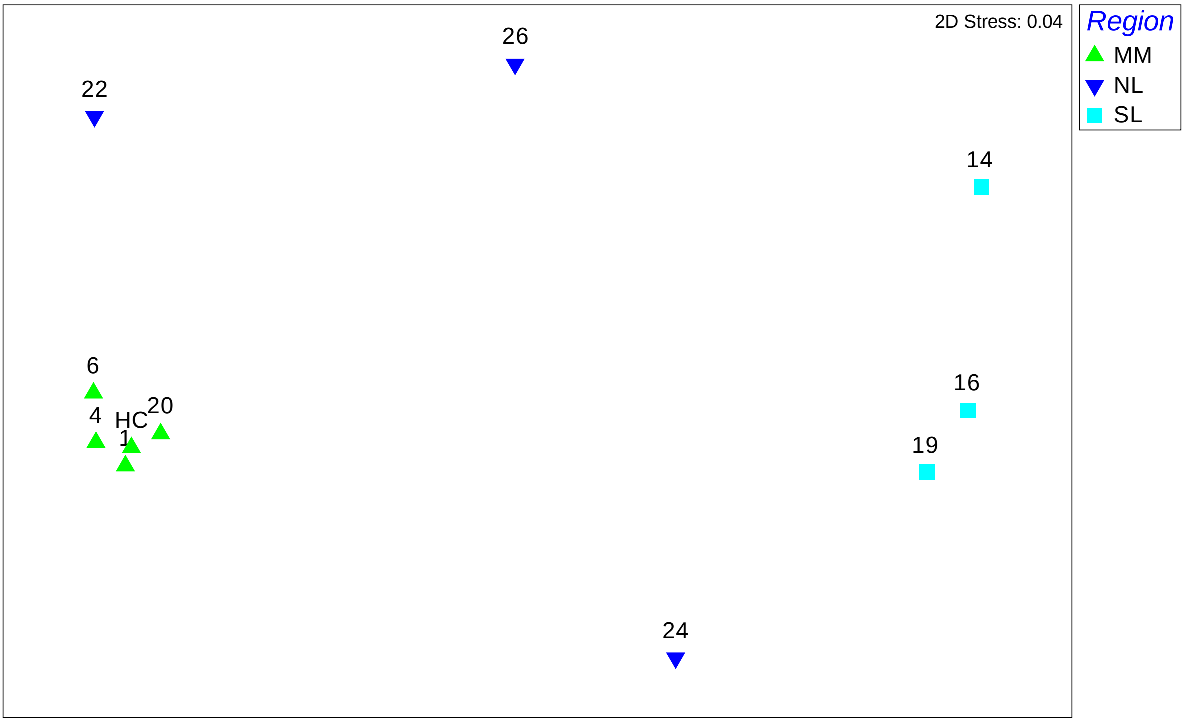


Figure 6. Non-metric multidimensional scaling (nMDS) plot of community structure at each site (data averaged by sites), with symbols and colours representing the different regions. See Figure 1 for details of site numbers.

4.3 Recovery of macroinvertebrate communities in the fifth year of continued flows

A highly detailed statistical analysis of temporal and spatial changes in total abundance, abundance of key species and taxa, species diversity and community structure in this system since flows were restored in 2010 will be provided in the final report for 2015, and so will not yet be provided here. Instead, this section will discuss the general observations made when comparing data from February 2015 to those collected for the 2010/11 to 2013/14 monitoring events.

Total abundance of benthic macroinvertebrates rose in 2011/12, the year following the restoration of flows in 2010. Since that time, benthic macroinvertebrate abundances have remained high at most sites, in the Murray Mouth, a trend which has continued into 2015 (Figure 7). In comparison, abundances at sites in the northern Coorong, Mulbin-Yerrock (site 22) and Noonameena (site 26) have fluctuated since flows were restored (Figure 7), presumably as communities undergo changes as they recover from drought conditions experienced prior to 2010. Sites in the southern Coorong

Lagoons, south of Parnka Point (site 24) have experienced little or no apparent change in abundance. since flows were restored in 2010 (Figure 7).

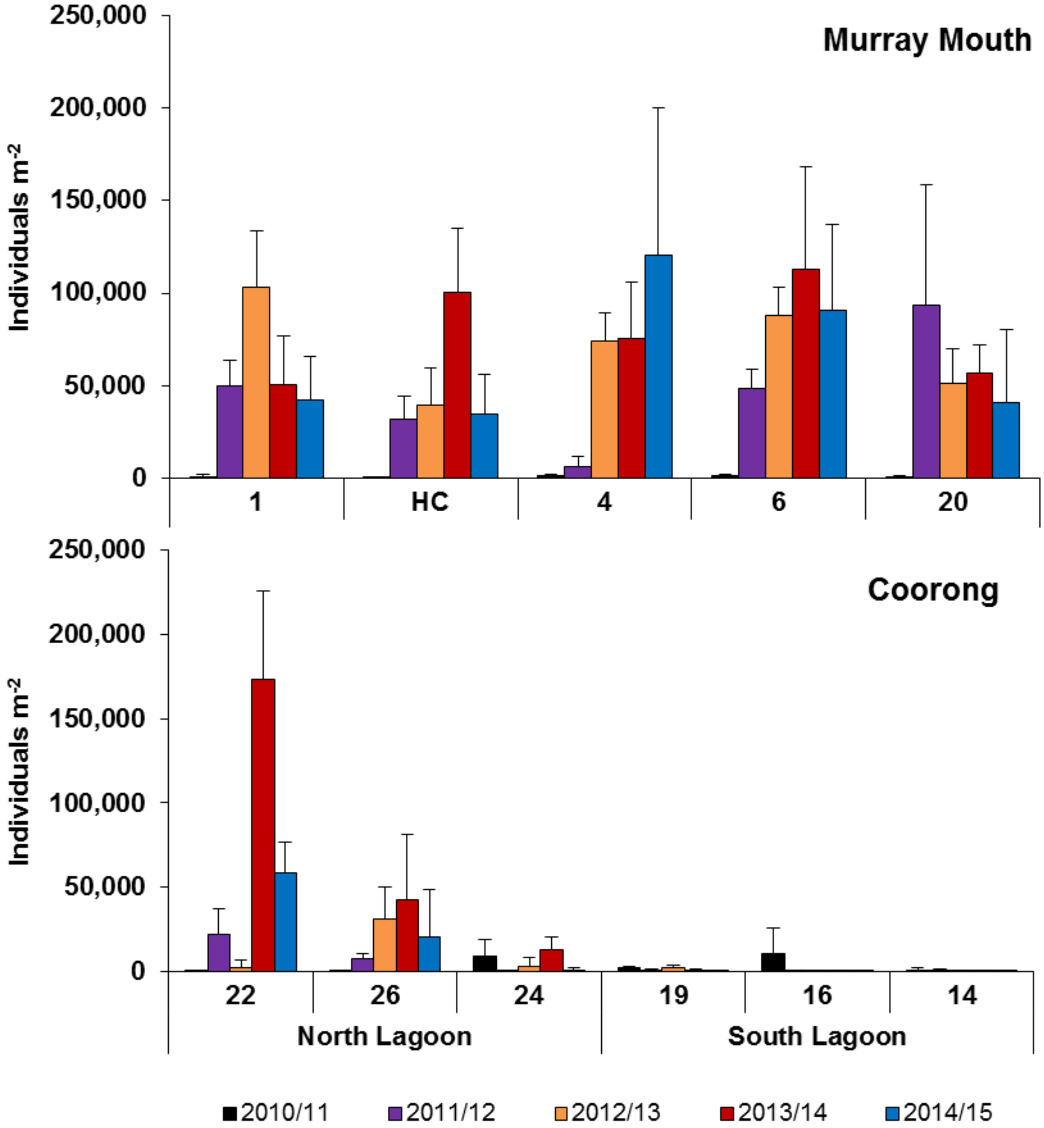


Figure 7. Average abundance (ind.m^{-2}; ±SD) for benthic macroinvertebrates in intertidal habitats in the Murray Mouth and Coorong Lagoons for the five years of monitoring since flows recommenced in 2010.

The abundance of some species, particularly Amphipoda, *Capitella sp.* and Chironomidae, has decreased during 2015 compared to earlier monitoring years (Figure 8). Other species, especially *Arthritica helmsi* and *Simplisetia aequisetis* have increased in abundance during 2015 (Figure 8).

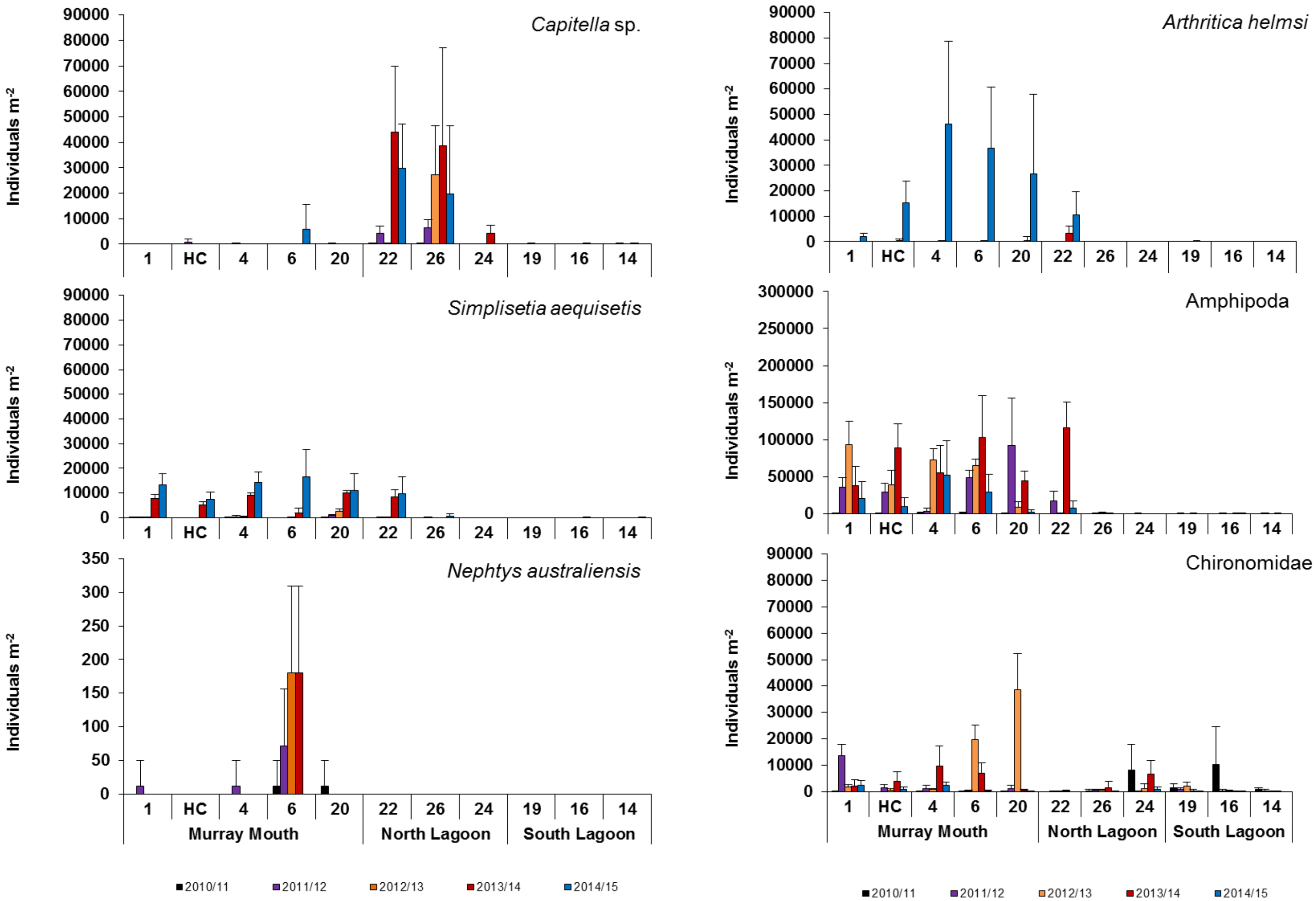


Figure 8. Average abundance (ind.m^{-2}; ±SD) for key species of benthic macroinvertebrates in intertidal habitats in the Murray Mouth and Coorong Lagoons for the five years of monitoring since flows recommenced in 2010. Note that *Nephtys australiensis* and Amphipoda are plotted on different scales for the y-axis than other taxa.

Species numbers have generally increased in each region since flows were restored during 2010, and remained relatively high during 2015 monitoring except in the North Lagoon, where species number declined in 2015 relative to 2013/14 (Figure 9).

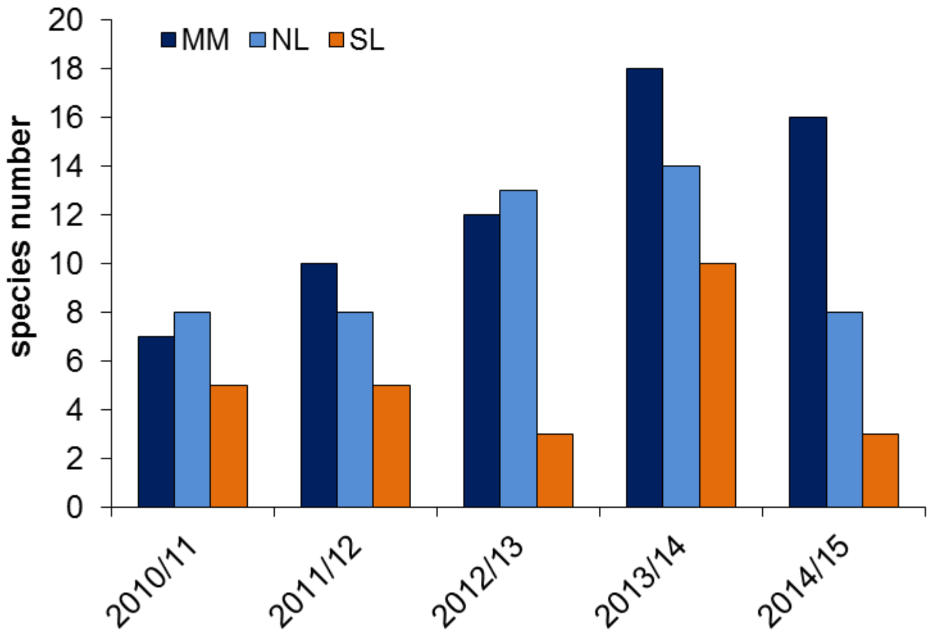
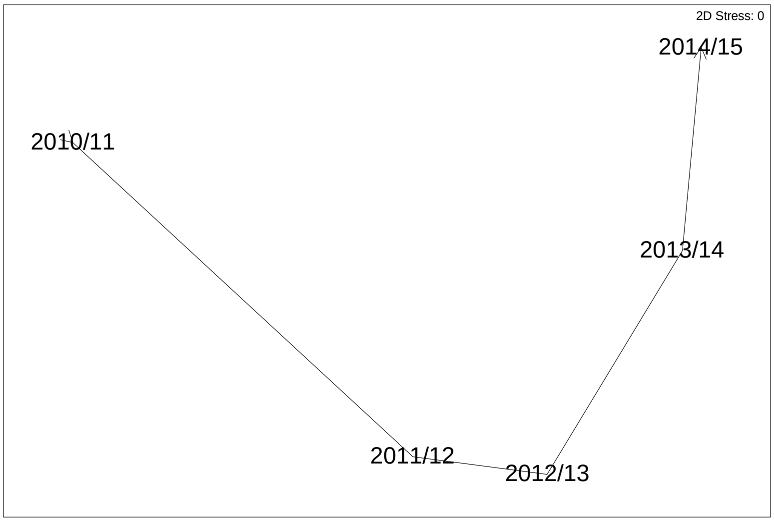


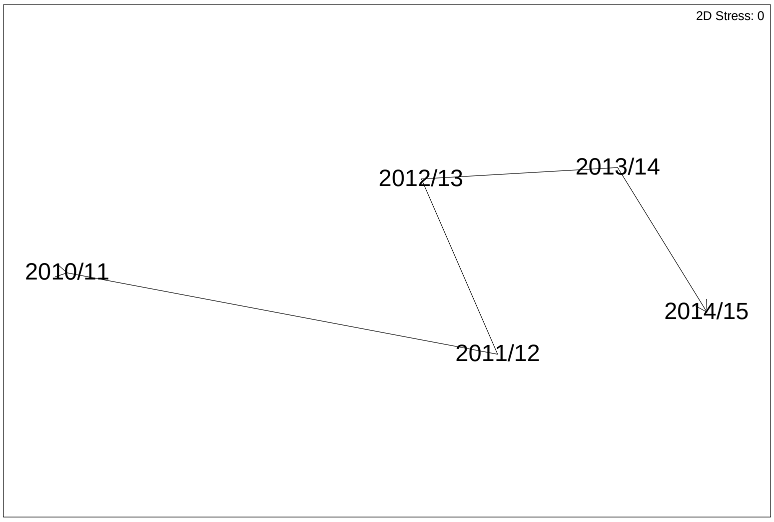
Figure 9. Total number of species of benthic macroinvertebrates in intertidal habitats in each region (MM: Murray Mouth; NL: North Lagoon and SL: South Lagoon) for the five years of monitoring since flows recommenced in 2010.

Each region showed a shift in community structure across the five years of monitoring, with a large shift in community structure between 2010/11 and 2011/12 for both the Murray Mouth and North Lagoon regions, but a large shift not seen in the South Lagoon until 2015 (Figure 10). The Murray Mouth has shown a continual change in community structure over the five years of monitoring since flows were restored in 2010 (Figure 10a). The Coorong Lagoons have responded to continued flows in different ways to one another and to the Murray Mouth region. The North Lagoon showed a large initial shift in community structure in the year after flows were restored (2011/12) compared to 2010/11, with only small shifts over the following years (Figure 10). This area of the Coorong is a highly dynamic transition zone between the Murray Mouth region and the hyperhaline South Lagoon, and variation across years in community structure may reflect more variable environmental conditions in this region. The South Lagoon showed little change initially, with a cross-over of trajectory between 2011/12 and 2013/14, but there was a large shift in community structure between 2013/14 and the most recent event in 2015. This difference was driven by a reduction in the average abundance of Chironomid fly larvae and pupae in the South Lagoon during 2015 (ave. abundance = 20.0 ind.m^{-2}) compared to earlier monitoring years (ave. abundance range 629.3ind.m^{-2} in 2013/14 to 4292.7 ind.m^{-2} in 2010/11; SIMPER analysis).

a) Murray Mouth



b) North Lagoon



c) South Lagoon

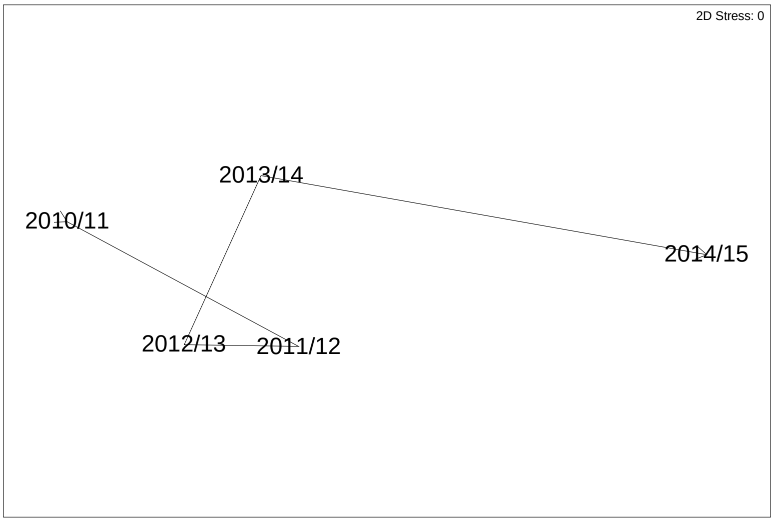


Figure 10. nMDS trajectory plots for the a) Murray Mouth, b) North Lagoon and, c) South Lagoon regions, with data averaged across regions for each year. Arrows linking years show trajectory of change along the annual time series.

4. Summary and Recommendations

Estuarine conditions that were not unusual for late summer were observed throughout the Murray Mouth region during February 2015. A steep gradient in salinity was observed in the North Lagoon, with extreme hyperhaline conditions south of Parnka Point. Dissolved oxygen saturation were mostly above thresholds, with over-saturation observed at most sites. Benthic macroinvertebrate communities in the Murray Mouth region were abundant, diverse and have continued to change in 2015, with an increase in abundance of species that were rare after the Millennium Drought and flood, especially the micro-bivalve, *Arthritica helmsi*. Changes in other regions are more difficult to distinguish, especially in the North Lagoon, which represents a highly variable transition zone between the estuarine Murray Mouth and hyperhaline South Lagoon. Conditions in the South Lagoon continue to be extreme, with depauperate macroinvertebrate communities persisting south of Hells Gate.

The apparent decrease in abundances and species numbers compared to earlier monitoring may be an artefact of the single monitoring event during 2015, undertaken at the end of summer, when predation pressure from migratory shorebirds and stress from environmental conditions experienced over summer months may have affected intertidal species abundances and distributions. Although the information obtained from the single monitoring event is highly useful for informing recovery and the long term management of the system, future monitoring events preferably should monitor conditions over the summer months, with multiple sampling events. Should they be only one-off events each year, then these should be timed in the early summer period of November/December, to make results more comparable across years of this study and other related studies, such as annual monitoring for The Living Murray (TLM), and avoid the compounding effects of predation on macroinvertebrate abundances and diversities by migratory shorebirds.

Future monitoring should also consider the importance of subtidal monitoring, and monitoring at sites on the Younghusband Peninsula (i.e. Tauwitchere and Long Point Peninsula) which was not undertaken in 2015. These sites were some of the first to exhibit recovery, and species, such as *Arthritica helmsi* were recorded first in these sites, before recolonising intertidal sediments. Other species, such as the large bivalves *Soletellina alba* and *Notospisula* and the large predatory polychaete *Nephtys australiensis*, which were rare in intertidal samples during February 2015, may be in recovery stages in subtidal populations, but without subtidal sampling, it is not possible to assess the true abundance and distribution of these and other species in the system.

5. Acknowledgements

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6. References

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