Aldinga Washpool:

Macroinvertebrate baseline

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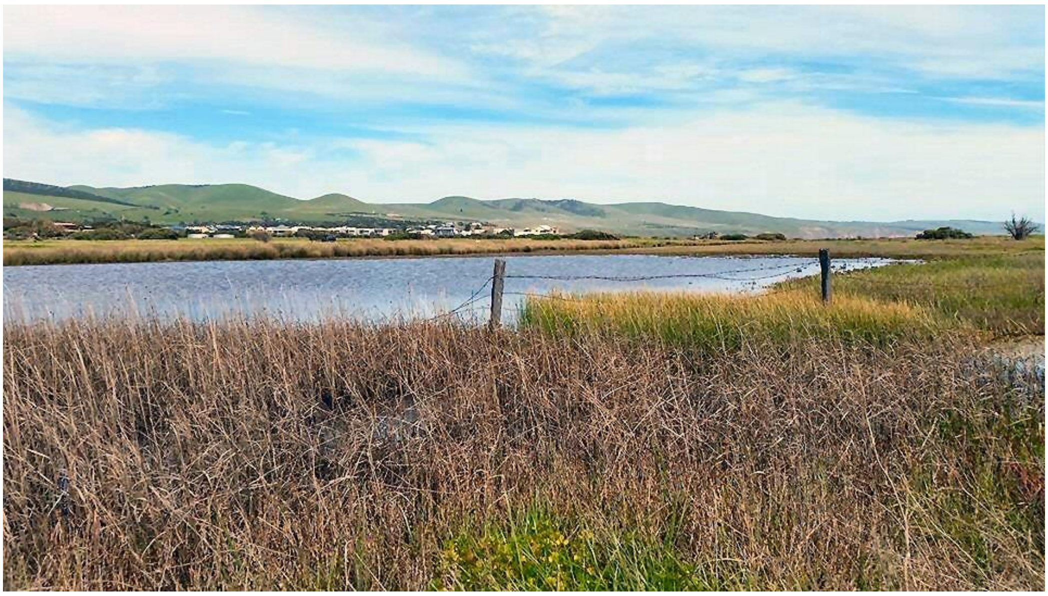

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EXECUTIVE SUMMARY

Aldinga Washpool is a remnant freshwater to brackish near-coastal lagoon south the Aldinga Scrub Conservation Park, adjacent to Gulf St Vincent in South Australia.

Currently the Washpool would be classified as brackish throughout much of its annual hydrological cycle, but the salinity does not appear to increase greatly prior to the evaporation of all the free water in summer. This suggests that the current drainage through the shingles from both the north and south lagoons is exporting much of the salt that gathers in the system. There are indications, from the species collected and the presence of empty shells from *Coxiella* sp, that the lagoon system may have been more saline at some point in the past.

Thirty-eight taxa of macroinvertebrates have been collected from the Aldinga Washpool. The taxa collected in these sampling events come from twenty-three families, and include mites, crustaceans, insects and snails. There are doubtless worms and other groups of macroinvertebrate organisms that escaped detection during this collection.

The majority of the organisms detected were pollution and salinity tolerant species, as would be expected in an ephemeral wetland with a changeable and brackish salinity. While microcrustaceans were the most abundant taxa, a wide diversity of predatory species was recorded, in some abundance, and this may explain the low presence of insect species such as mosquitoes that are considered to be human pests.

The body of the report concentrates on the macroinvertebrates themselves, looking at the diversity that were recorded, the feeding niches they occupy in the wetland and their ability to tolerate the characteristically variable water quality of a freshwater-brackish coastal lagoon.

Macroinvertebrates are part of a larger picture however, and contribute to the feeding resource of local and migratory birdlife. An appendix to this report comprises some compendium tables that illustrate the prey preferences of bird species that have been recorded at the Washpool. The data lend support to Seaman's (2002) assessment that the Washpool Lagoon should be considered regionally a priority wetland.

INTRODUCTION AND PHYSICAL FEATURES OF THE SITE

Macroinvertebrates can be used as biological indicators for determining the health and changes in wetlands. The number of different species of invertebrates (species richness or diversity) and the total number of types of organisms (abundance or dominance) can provide an indicator of water quality. Macroinvertebrates are also an important food resource for a range of wildlife, and measuring their numbers can also provide an understanding of the amount of food available, or productivity, of this seasonal wetland as it fills and dries out. The sampling undertaken for this report provides baseline information on the macroinvertebrates found in the Aldinga Washpool.

Aldinga Washpool is a remnant freshwater to brackish near-coastal lagoon south the Aldinga Scrub Conservation Park, adjacent to Gulf St Vincent in South Australia.

The main lagoon is located north of Button Road. A smaller lagoon south of the road has developed a slightly different character, partly as a result of the presence of the road and partly because of its proximity to the sea outlet. A third small lagoon (the "blue lagoon" is located to the north of the main lagoon and was historically a permanent pool of freshwater, surrounded by lignum, although in recent times it has become ephemeral.

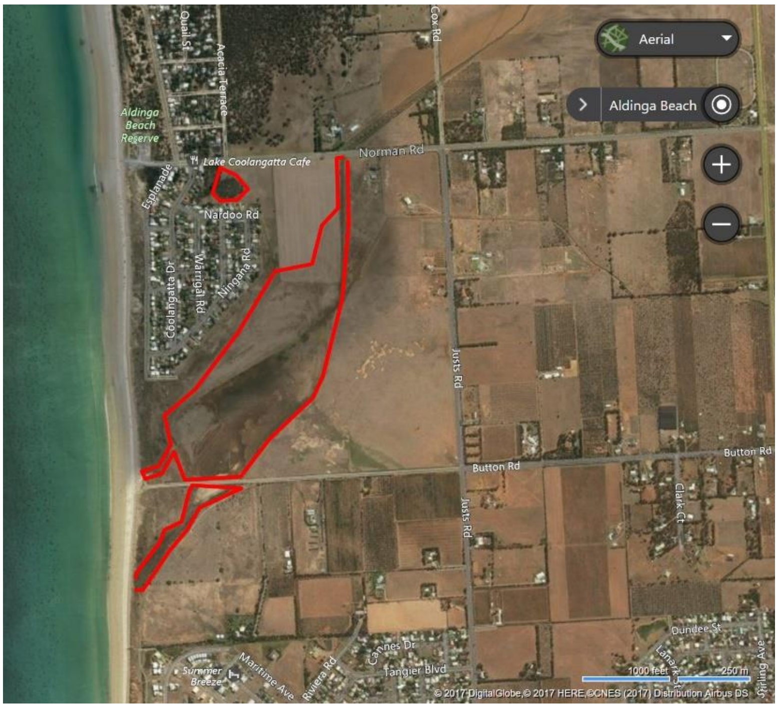


Figure 1 – Main areas of the Aldinga Washpool that are seasonally inundated

The climate is marked by cold, wet winters and hot dry summers. Evaporation exceeds precipitation by a considerable amount. Strong south-westerly winds occur during autumn and spring, with hot northerly winds occurring during summer. The site experiences stronger breezes in the afternoon with calmer conditions in the mornings. Lightning storms occur thoughout the year, but with higher intensity in mid to late spring. As a result of this climate, wetlands in the region tend to be ephemeral.

The wetlands have a central "panne" of *Sarcocornia* (a samphire). Surrounding that (dependent on depth and source of runoff) is a taller vegetated ring that contains saltmarsh grass (*Puccinellia*), salt club-rush (*Bolboschoenus*) and small patches of creeping *Wilsonia* (both *W. rotundifolia* and *W. humilis*). Landward again there is a thick sedgeland of *Gahnia filum* before the cleared land starts.

The Washpool was, and still is an important locality for Kaurna people who called it the "possum place" because skins of small animals were cured on the drying salty muds of the southern parts of the lagoon system.

Seaman (2002), in the Wetland Inventory for the Mount Lofty Ranges recommended that the Aldinga Washpool be monitored, in order to gain a more complete understanding of the current wetland values of the site. While considerable mapping of vegetation and recording of birds has been undertaken around these wetlands little data exists in relation to the aquatic life. This report is intended to provide an initial survey of the common species of macroinvertebrates found in the Washpool

METHODOLOGY

A collection of baseline invertebrate data for northern and southern lagoons was made in September 2017. Additional data collected from the southern lagoon in the previous summer (January 2017) has also been incorporated, to provide a fuller picture of the changing macroinvertebrate assemblages in this ephemeral wetland.

Figure 2 - Working a D-net in the shallows

Sampling was conducted in the shallows and deeper areas of both flooded wetlands, using a D-net, a “sweep-net” used for sampling aquatic life. Discrete samples from the varying habitats being pooled into aggregate samples for each of the north and south lagoons. Netting was conducted for 15 minutes in each lagoon. Samples were placed in white sorting trays and individuals were “picked” for 30 minutes. The dominant species were noted. The subsamples were narcotised using soda water then alcohol was added to preserve the samples for return to the laboratory for later identification and photography.

AQUATIC INVERTEBRATES

A table in *Appendix 1* contains all the taxa recorded for each site, with semi-quantative abundance data. In the table, the stars denote the relative abundance of each species caught, using the semi-log abundance criteria specified in SIGNAL2.iv, established by the National River Health Program (Chessman 2003). As usual, names in italic denote scientific names of individual species, while unitalicized names such as “Oligochaete sp.” simply mean “a species belonging to this class/order/family”. An asterisk after a scientific name denotes the species is introduced.

There were a total of thirty-eight macroinvertebrate taxa recorded over the 2017 summer and spring sampling events. The spring sampling events had a greater diversity than the summer event, and the southern lagoon had a greater diversity than the northern lagoon in the spring sample. Many tadpoles (*Crinia* sp.) were also caught. Additionally, the shells of dead *Coxiella* (salt lake snails) were found in the nets during all of the sampling events, but no live individuals. It is not known if these shells are recent or historic, from a period when the lagoon was saltier.

The most abundant organisms were microcrustaceans. Crustaceans were also diverse, with at least twelve separate taxa from five orders/classes (Amphipoda - scuds, Cladocera - water fleas, Copepoda - cyclops, Isopoda - slaters and Ostracoda - seed shrimps).

Insect numbers were lower, but there was a high diversity, with twenty-one separate taxa from nine families (at least twelve subfamilies) in four orders (Coleoptera - beetles, Diptera - flies, midges and mosquitoes, Hemiptera - true bugs and Odonata - dragonflies and damselflies). Water mites, gastropods, worms and springtails were also captured.

All taxa found were given a pollution tolerance score based on SIGNAL2.iv (Chessman 2003). Most taxa fell into the "very tolerant" category – not surprising as the wetlands are both ephemeral (with resulting water, temperature and salinity stresses) and surrounded by agricultural lands. A small number of "sensitive" and "tolerant" taxa were present in the spring surveys when water salinities and temperature were lower.

	Total	**Washpool South Jan 2017**	**Washpool South Sept 2017**	**Washpool North Sept 2017**
Count of all TAXA collected	**38**	**12**	**28**	**20**
Number of very sensitive taxa	0	0	0	0
Number of sensitive taxa	3	0	1	2
Number of tolerant taxa	6	0	5	3
Number of very tolerant taxa	19	9	14	8
Number of taxa with no sensitivity score	10	3	8	7

Table 1 - Diversity & SIGNAL tolerance

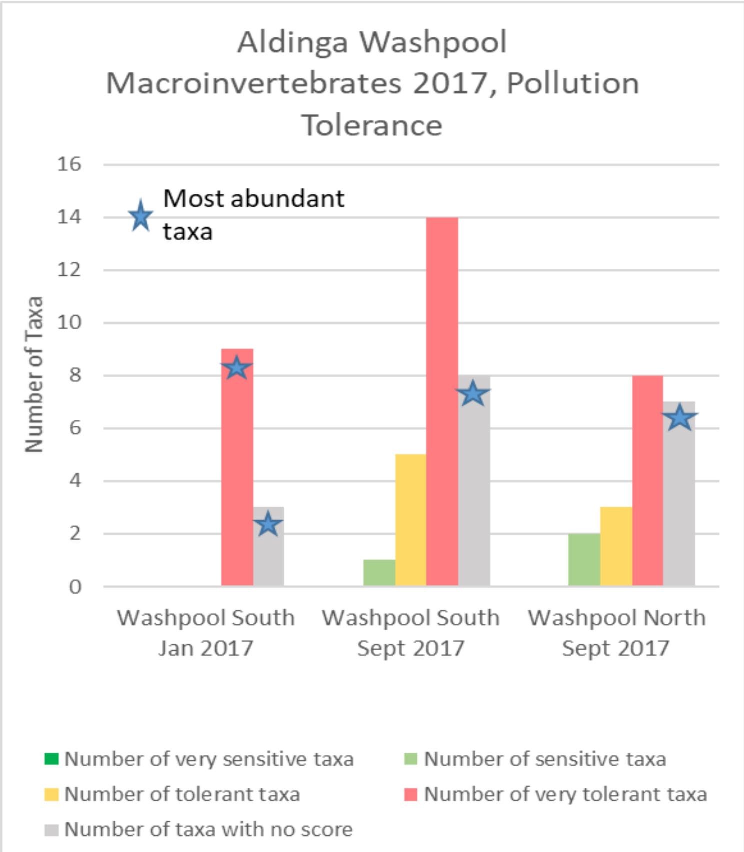


Figure 3 – Many abundant taxa do not have SIGNAL ratings

Figure 3 highlights the fact that the most abundant taxa, the various microcrustaceans, do not have SIGNAL ratings. Microcrustaceans formed clouds of many thousands of individuals in the shallow waters.

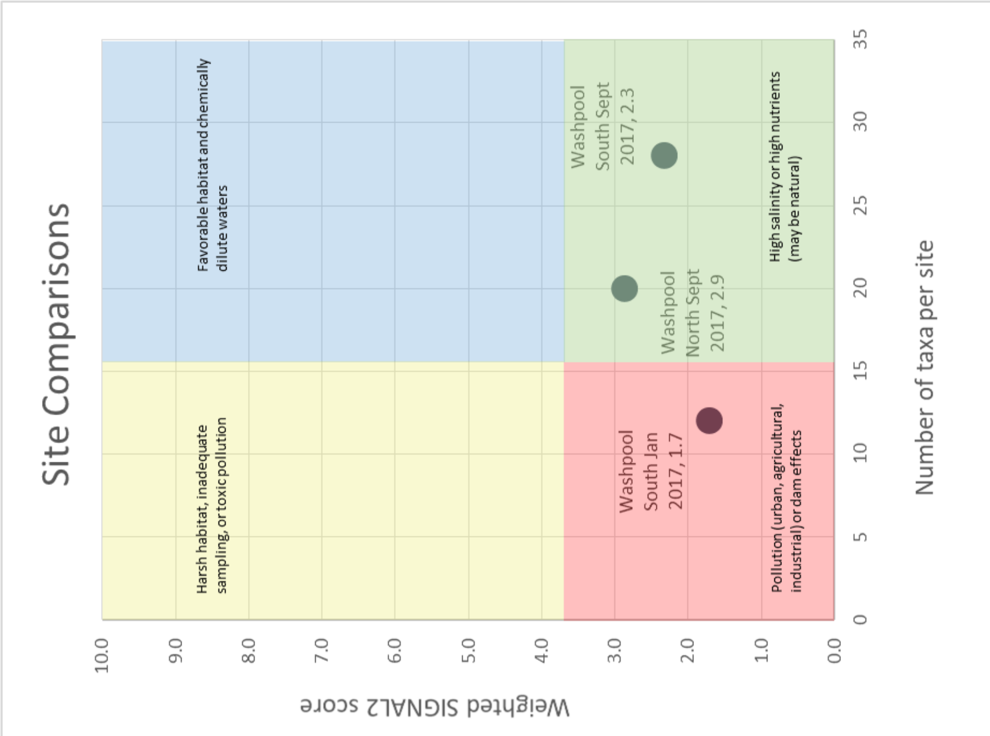
A further limitation of SIGNAL ratings is that they were developed specifically for freshwater rivers and creeks (lotic) conditions. Lentic waterbodies (lakes or ponds) in Australia are infrequently permanent freshwater. They are commonly shallow, ephemeral, with varying salinity and temperature regimes. Some attempts have been made to separate out this natural habitat variability from the effects of “pollution” in order to gain an understanding of what the SIGNAL scores may be telling us about a specific waterbody. The SIGNAL biplots developed by Chessman (2003) are one such approach.

We have made bi-plots for the sampling events/locations at Aldinga Washpool, but note that, in addition to the limitations outlined above, when undertaking comparisons between sites it is wise to remember that not all sites provide an identical range of habitats or fauna, although sites are selected to capture at least the most common habitat types.

The SIGNAL bi-plots used in the following analysis may be made with either abundance-weighted data (where numbers of organisms are used to “weight” the different taxa) or with unweighted (presence-absence) data. Both data types have been presented here. The bi-plots are divided into quadrants that may provide some indication of the habitat aspects revealed by plotting the SIGNAL scores and diversity data. The division points between the quadrants are not fixed, Australia-wide. They require calibration based on local conditions, and this calibration is done by sampling well understood reference sites and impact sites repeatedly over a number of seasons.

This has not been done for the Aldinga Washpool. It is cautioned that the division lines provided here, which represent commonly used divisions for South Australian flowing freshwaters, may not represent the lentic (still water) environment and variable salinities of the Aldinga Washpool very well, and should be considered tentative.

Both the abundance-weighted and unweighted plots reveal a similar pattern – the samples fall either into the “high salinity/high nutrient” quadrant or, in the case of the summer sample, just over the boundary into the “polluted/dam effects” quadrant. This reflects the overall shallow brackish nature of the site and the drying state of the water body in summer.



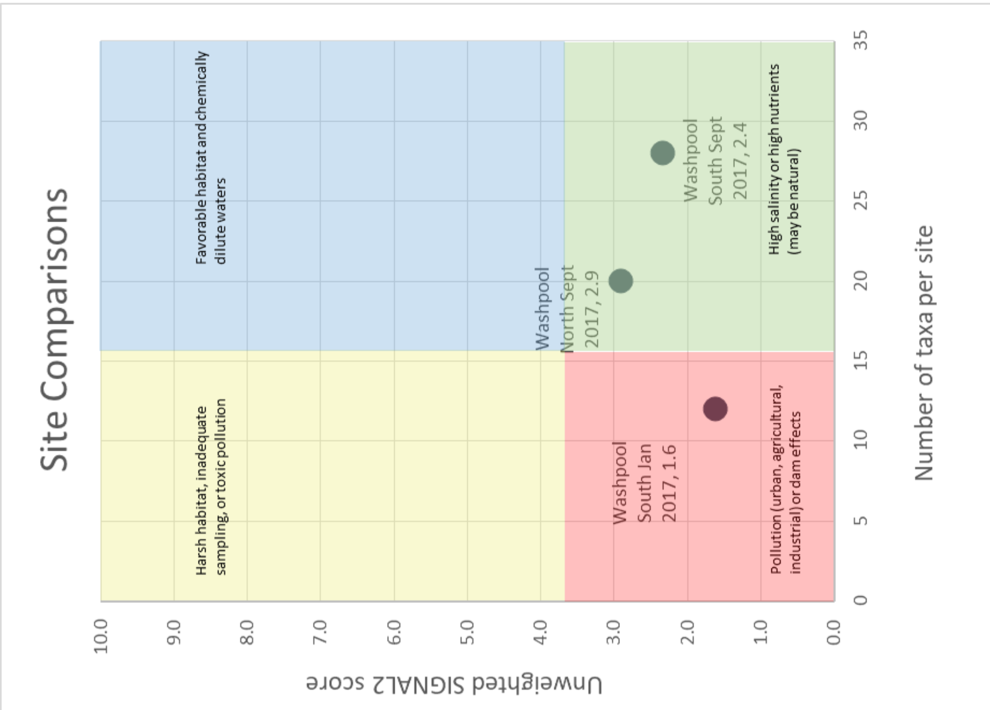


Figure 4 - SIGNAL bi-plots

Another way to look at the macroinvertebrate data is to group the data by the function each species provides within the habitat. This “functional feeding group” approach looks at how the taxa use the feeding resource of the habitat and occupy different niches. In this regard, it is interesting to look at the diversity of taxa found in the different feeding groups. Figure 5 reveals there may be several different taxa that use a particular feeding strategy.

In each sample there was a bigger diversity of predators than other feeding groups. The diversity reflects the wide range of hunting approaches that predators use to partition the feeding resource between them. While predators are the most diverse feeding group they are rarely the most abundant organisms, basically because each predator needs to eat many times their body mass of other organisms. The summer sample, when predators were the most diverse and included one of the two most abundant taxa, indicates the food resource drying up, along with the waterbody. At this point the predators, in a race to reach maturity and leave, may eat themselves out of house and home.

In springtime many varieties of “collectors” utilise the fine particulate matter in the system, while the lush growth of vegetation and its accompanying periphytic algae provides niches for a diversity of scrapers that “scrape” the coating from the submerged surfaces of vegetation and other objects. In the Aldinga Washpool during spring the scrapers contain quite a diversity of taxa. However even in summer when the diversity of scrapers is low, this feeding function in the wetland continues because most abundant organisms, the microcrustaceans, are scrapers.

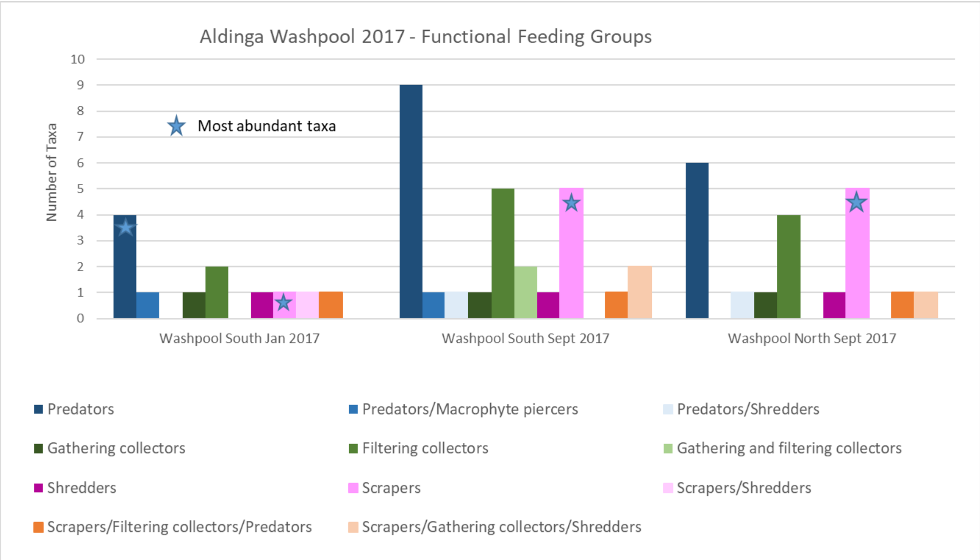


Figure 5 - Functional feeding groups

While the pattern of feeding groups was similar across seasons and locations, the actual species varied. In summer, the Washpool South (Jan 2017) was dominated by a high abundance of the water flea *Moina australiensis* (a scraper), with predatory backswimmers co-dominant, then lesser numbers of water boatmen, larval brine flies (scraper/shredders) and soldier flies (gathering collectors).

In springtime, the diversity of the predators increased markedly, as did the diversity of filtering collectors, although they were of a lower abundance than the ubiquitous scraping water fleas of several varieties. These small scrapers included the dominant (most abundant) species, which varied by location: whereas *Daphnia* sp. was the most common water flea in the south lagoon, *Chydorus sphaericus* and the large *Simocephalu*s sp. were dominant in the north lagoon. Brine flies were absent in the spring collections.

CRUSTACEANS

Five orders/classes of crustacea were present in the lagoons (Amphipoda, Cladocera, Copepoda, Isopoda and Ostracoda).

Four species of cladocerans, or water fleas, from three families (Figure 6) were recorded. The tiny Chydoridae (*Chydorus sphaericus*) and Moinidae (*Moina australiensis*) were found in shallower water. Daphniidae were represented by the easily recognised *Simocephalus acutirostratus* as well as a species of *Daphnia. Simocephalus* was found in the deeper waters of both wetlands while *Daphnia* sp. was found in the south lagoon.

Cladocerans are most common in the sheltered shallows. They feed on bacteria, decaying matter and plant materials that they harvest by scraping from surfaces. These tiny crustaceans are preyed upon by larger macroinvertebrates, some birds and small fish.

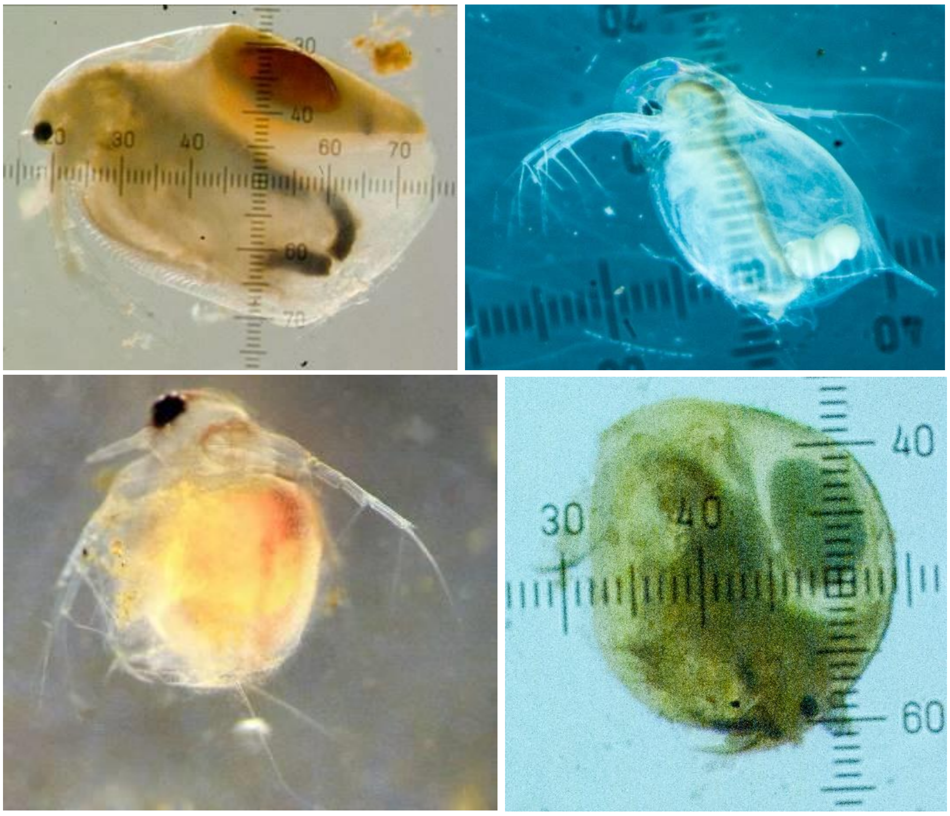


Figure 6 - Water fleas (Clockwise from top left: *Simocephalus acutirostratus* (3mm), *Daphnia* sp. (2.5mm), *Chydorus sphaericus* (0.6mm), *Moina australiensis* (>1mm)) NB: scale in photos varies with magnification

Both calanoid and cyclopoid copepods (cyclops) were recorded, although none were carrying eggs at the time of the spring survey (Figure 7). These two groups of cyclops are free-living planktonic forms that are omnivorous, filtering out phytoplankton as well as nauplii, rotifers and small cladocerans from the water column.

Figure 7 - Calanoid (L) and cyclopoid (R) copepods. Approx. 2mm long, eyepiece scale in photos variable

It is estimated there were four species of small to mid-sized ostracods (seed shrimps) from two families (Cyprididae and Notodromadidae) collected (Figure 8). Ostracods require microscopic dissection to determine species, except for a rare few with shell features that are diagnostic. Some species also change morphology as they age. The small dark heart shaped *Cypretta* sp. is easily recognised. The other species were probably *Heterocypris* and *Eucypris,* which are variable genera undergoing review currently. *Newnhamia* sp. (Notodromadidae) is another that is recognisable from its shell. It is light sensitive, so likely to be found in the vegetated margins of the lagoon and is often found in water with elevated salinities and temperatures.

Seed shrimps use their antennules and antennae for filter feeding organic detritus and algae, as well as for locomotion.

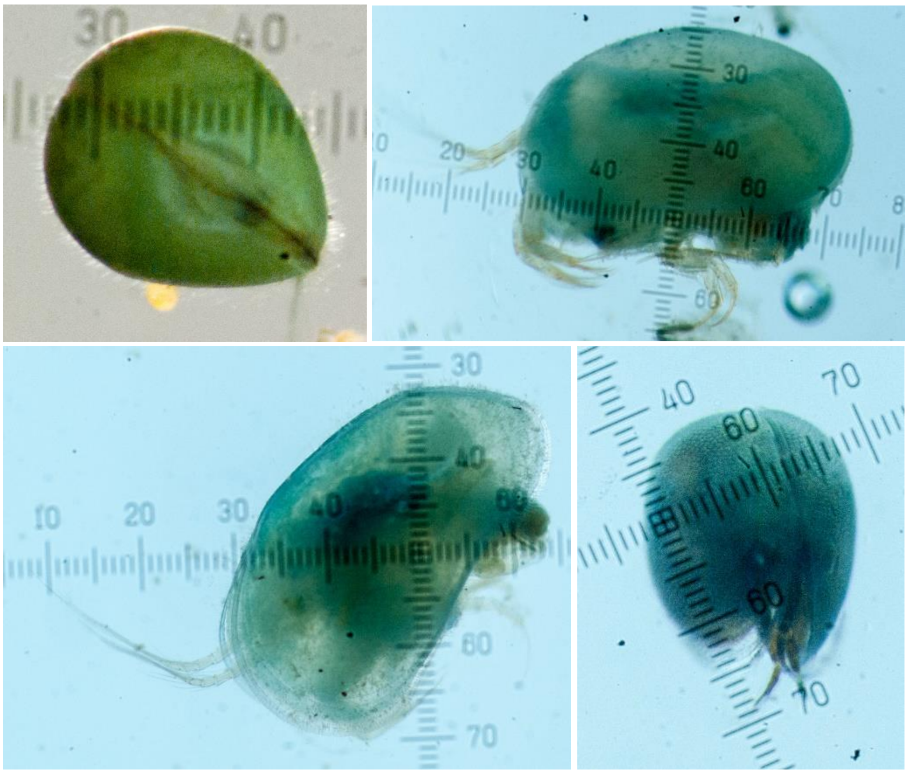


Figure 8 – Ostracods (clockwise from top left) *Cypretta* sp., possibly *Eucypris* sp., *Newnhamia* sp., possibly *Heterocypris* sp. All <1.5mm, eyepiece scale in photos varies with magnification

Larger crustaceans included amphipods – the scuds *Austrochiltonia* sp. (Figure 9), and an isopod species, the salt lake slater *Haloniscus* sp. (Figure 10). This latter species, found only in summer in the southern lagoon, suggests that the Aldinga Washpool may regularly become quite saline or may have been generally more saline at some past time, a theory supported the finding of dead *Coxiella* shells (salt lake snails) as well as the summer presence of brine fly larvae.

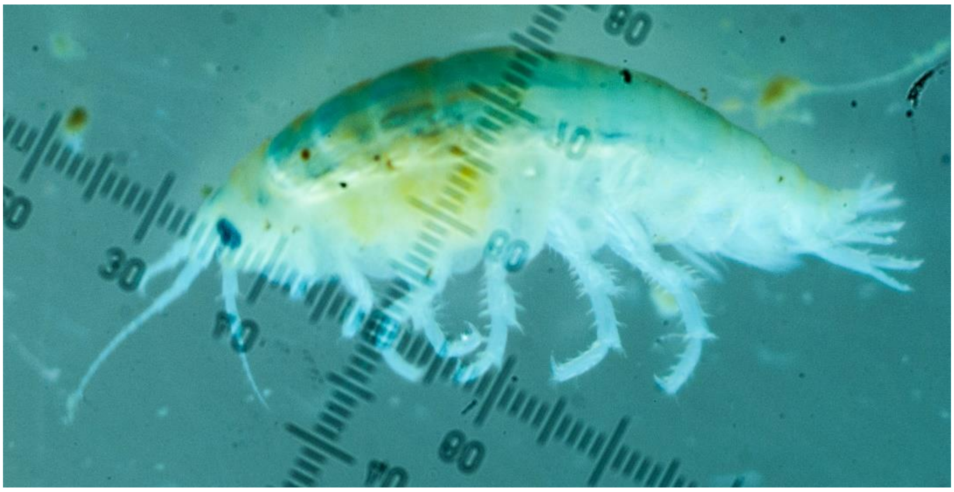


Figure 9 – Amphipoda, a scud, *Austrochiltonia* sp., approx. 6mm long

Figure 10 – Isopoda, a salt lake slater, *Haloniscus* sp., approx. 1cm long

INSECTS

Besides the crustaceans, insects were the most biodiverse members of the Washpool communities. Many insects fly, making it easy for them to utilise ephemeral waterbodies, and so the insect species are mostly common and widespread species. Despite this, only four orders were present – beetles, flies, bugs and damselflies.

Amongst the Coleoptera (beetles) only predacious diving beetles (Dytiscidae) and water scavenger beetles (Hydrophilidae) were encountered.

Figure 11 – Diving beetles, Top L-R *Allodessus bistrigatus,* larval *Allodessus bistrigatus*, larval *Rhantus suturalis,* Middle *Platynectes* sp., Bottom L-R *Lancetes lanceolata, Onchohydrus scutellaris*

There were five species of larval and adult dytiscid beetles (predacious diving beetles). *Allodessus bistrigatus* is a common diving beetle that prefers still water (pools), while *Rhantus suturalis* is one of the most widespread water beetles in Australia. The other dytiscids included *Onchohydrus scutellaris, Lancetes lanceolata* and *Platynecte*s sp. Many diving beetles use mandibular channels to inject digestive enzymes into their prey and then suck up the resulting fluids. Both the larvae and adults are air breathers and the term ‘diving beetle’ comes from the adult behaviour of coming to the water surface to replenish their air supply then returning to swimming well below the surface.

Three species of water scavenging (hydrophilid) beetles were present including *Enochrus* sp., *Berosus* sp. and *Limnoxenos* sp.. Adult water scavenging beetles are scavengers, feeding by shredding plants or decaying plant matter, but the larvae are predators, feeding on snails, worms, small crustaceans and insect larvae. The group are not strong swimmers so are more common in still waters than fast flowing streams.

Figure 12 - Water scavenging beetles, L-R *Berosus* sp., *Limnoxenos* sp., *Enochrus* sp.

Amongst the diptera (flies) the families represented include the Chironomidae (midges), Culicidae (mosquitoes), Ephydridae (brine flies) and large numbers of Statiomydae (soldier flies).

There were numerous larvae of at least five species of non-biting chironomid midge, from the Chironominae, Tanypodinae and Orthocladiinae subfamilies (Figure 13 shows one example). The Chironominae are largely temporary pond specialists, while the others are widespread. Their feeding mechanisms vary from scrapers, to gathering and filtering collectors, shredders and even predators (Tanypodinae).

Figure 13 – A chironomid midge larvae

Amongst the other dipterans (Figure 14) rare mosquito pupae were also recorded, from the Culicidae. Pupae are more difficult to identify than larvae and so this was not attempted. No larvae (wrigglers) were found, possibly reflecting the large numbers of predatory macroinvertebrates. Most mosquito larvae feed on small algae and detritus but the species use differing techniques. Some species are filter feeders and use brushes on either side of the labrum to create a current to pull in food from the water. Other species scrape material from submerged surfaces. A few genera are predators that feed on other smaller mosquito larvae.

Figure 14 - L-R Culicid pupa, larval brine fly, larval soldier fly

Brine fly larvae and pupae (Ephydridae) were collected from the south lagoon in the summer sampling event, when the water was relatively saline, but were not recorded in spring. These flies live in still waters and exposed wet muds, making them well adapted to ephemeral conditions. Little is known about their feeding habits, but they are thought to be scrapers and shredders of vegetation.

Soldier fly (Statiomydae) larvae were present in both summer and spring. They were uniformly abundant in both lagoons. These large larvae can be found in still waters and are tolerant of salinity. They are poor swimmers, mostly crawling along the benthos or floating in the water column. They are gathering collectors that utilise decaying organic matter and micro-algae.

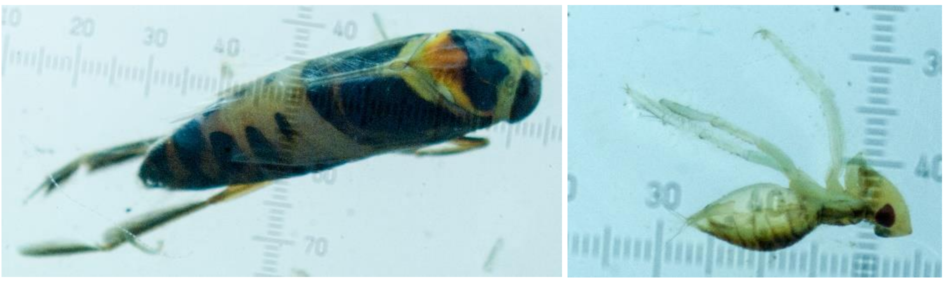


Figure 15 - Backswimmer, *Anisops* sp. and water boatman *Agraptocorixa* sp.

Three hemiptera (true bugs) from two families were recorded (Figure 15). There were two types of Corixidae (the waterboatmen *Micronecta* sp. and *Agraptocorixa* sp.) and a member of the Notonectidae (a backswimmer *Anisops* sp.). Both water boatmen and backswimmer species tend to be predatory, although some are recorded as macrophyte piercers (sap suckers).

Finally, amongst the insects collected the Odonata were represented by two species of *Austrolestes* spp. damselflies. Damselflies are predatory in both their larval and adult stages.

Figure 16 - *Austrolestes* sp.

OTHER INVERTEBRATES

Three taxa of water mites (hydracarina) were recorded in the springtime samples, from two families (two taxa from the Pionidae and one from the Eylaidae). All are predatory.

Molluscs were represented in the springtime samples by two taxa from two gastropod families – a small snail (possibly *Isidorella* sp.) from the Planorbidae and the introduced *Physa acuta* from the Physidae (Figure 18). Both types of snail are scrapers that feed on vegetation and algal periphytes, and several *Isidorella* species can aestivate when conditions become too dry, making them well adapted to ephemeral water bodies.

The empty shells of *Coxiella* sp. (salt lake snails) that were collected in the nets were not recorded in the tabulation of taxa collected, as it was not known if these shells represented recently or historically dead specimens. These snails belong to the family Pomatiopsidae.

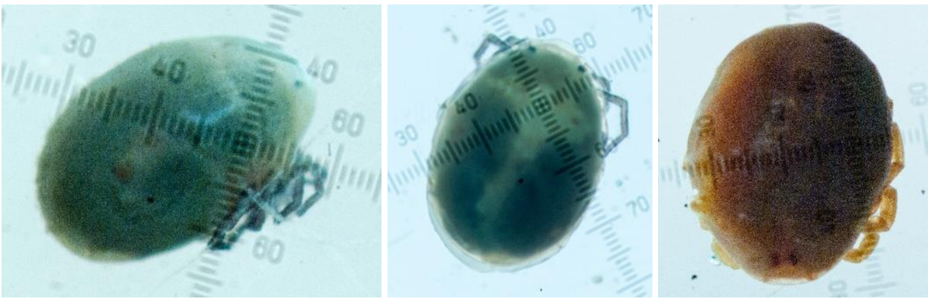


Figure 17 - Water mites, L-R Two species of Pionidae & *Eylais* sp. (water mites vary from 2-5mm)

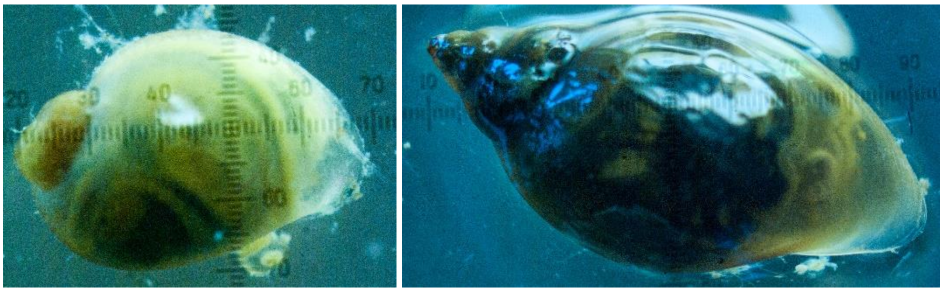


Figure 18 - L: Planorbid snail, R: *Physa acuta*, an introduced water snail

WATER QUALITY IN THE WASHPOOL

Water quality was assessed in-situ during the springtime survey, using a Horiba U-10 Water Checker, while the earlier summer sampling included a water sample that was salinity checked on return to the laboratory.

Parameter	Washpool South Jan 2017	Washpool South Sept 2017	Washpool North Sept 2017
pH		9.52	8.98
Salinity (EC mS/cm)	5	3.11	1.63
Turbidity (NTU)		53	40
Dissolved oxygen (mg/L)		10.22	10.59
Temperature (°C)		16.2	16.5

Table 2 - Water quality

The lagoons are clearly brackish, but the salinity does not appear to increase greatly prior to the evaporation of all the free water in summer. This suggests that the current drainage through the shingles from both the north and south lagoons is exporting much of the salt that gathers in the system. While the presence of salt tolerant organisms is expected in such a situation, it might be that halo-tolerators (freshwater species that tolerate salinity) would be expected, rather than halophiles (either marine or salt lake species). The presence of the empty shells of salt lake snails, and the summer time presence of salt lake slaters and brine flies all point to the lagoon having greater salinities at some time in the past. Its reputation in Aboriginal knowledge as a place to wash and preserve possum skins may also point to this.

DISCUSSION

Seaman (2002) reported that the Aldinga environs contained several wetlands with high conservation value, and that the Washpool Lagoon was one of those wetlands. The Washpool was recorded as having reasonable water quality. The Washpool appears to be brackish throughout much of its annual hydrological cycle. There are indications, from the species collected and the presence of empty shells from *Coxiella* sp., that the lagoon system may have been more saline at some point in the past.

The Washpool was one of only seven (out of eighty-five) sites in Seaman's study with a high aquatic fauna presence. It was one of only four wetlands that were assessed to have both high values for flora and aquatic flora. As a result, it was recommended that the Washpool be one of four priority wetlands to monitor (the others being the Parafield vernal pools, Englebrook Reserve and Eurilla Bog).

This baseline survey of aquatic macroinvertebrate has recorded thirty-eight taxa of macroinvertebrates from the Aldinga Washpool. The taxa collected come from twenty-three families, and include mites, crustaceans, insects and snails. There are doubtless worms and other groups of macroinvertebrate organisms that escaped detection during this collection.

While some attempt to analyse the results of this monitoring are included in this report (SIGNAL and functional feeding group analysis) it has not been possible to validly compare the macroinvertebrate assemblages of the Washpool Lagoon with other similar wetlands. While some monitoring of the other wetlands nominated by Seaman has occurred, particularly of the Parafield vernal pools, the wetlands themselves are of significantly different types, making direct comparisons between them invalid. It is possible that some of the Greenfields Stage III Wetlands and Barker Inlet Wetlands South may function similarly, as fresh to brackish coastal lagoons, but the input water into these man-made stormwater wetlands is likely to be of a much more polluted character, making them poor choices to use as comparative sites.

Even without using a reference or comparison site the macroinvertebrates collected can be informative. The majority of the organisms detected were pollution and salinity tolerant species, as would be expected in an ephemeral wetland with a changeable and brackish salinity.

While microcrustaceans were the most abundant taxa, a wide diversity of predatory species was recorded, in some abundance, and this may explain the low numbers of insect species such as mosquitoes that are considered to be human pests.

The body of this report has concentrated on the macroinvertebrates themselves, and has looked at the feeding niches they occupy in the wetland and their ability to tolerate the characteristically variable water quality of a freshwater-brackish coastal lagoon. However, the macroinvertebrate populations also form part of a larger trophic picture. These small organisms are the food source for numerous birds, including migratory and resident shorebirds, water birds and even some bird species more often considered marine.

Compendium tables have been assembled in *Appendix 2* that present what is known about the feeding habits of birds that have been recorded (Birdlife 2017) at the Aldinga Washpool Lagoon. The bird list used in the compendium tables does not include ubiquitous urban birds, the small reed dwelling and neighbouring grassland dwelling species or raptors, although these birds also make use of the Washpool habitat. The list targets those birds that may utilise the macroinvertebrate population of the Washpool as a primary, or even as an accidental, source of food. Therefore, the list includes shorebirds, herons & egrets, ducks and geese, and some fish-eating species like cormorants and terns.

The prey data has been garnered from arrange of sources, as detailed in *Appendix 2*. The data are of varying resolution, but the tables highlight that even birds often considered herbivorous (for example geese and their relatives) frequently have a measurable intake of macroinvertebrates in their diet.

Macroinvertebrates found in the Washpool that have widespread appeal to birds include aquatic beetles and beetle larvae, the water bugs including water boatmen, and chironomid midges. The microcrustaceans are utilised by shorebirds, especially the stilts and avocets, the larger dragonfly and damselfly larvae are harvested mainly by ducks. Birds considered to be preferentially fish-eaters do also harvest macroinvertebrates, although larger fish-eating birds choose larger invertebrate forms such as freshwater crayfish. Terns, in particular, harvest swimming macroinvertebrates from open areas of water, using the same swoop and dive technique they use to capture small fish or to capture flying insects.

These general comments highlight the significance of the macroinvertebrate fauna of the Aldinga Washpool to regional birdlife and lend support Seaman's (2002) assessment that the Washpool Lagoon should be considered regionally a priority wetland.

REFERENCES

Birdlife Australia (undated) *NRAMLR Birdlife shorebird habitat matrix GM.xlsx* A spreadsheet tabulation of shorebird abundance and habitat use in the Dry Creek Saltfields.

Birds SA (2017) *Checklist for the Washpool Lagoon, Aldinga Beach*. Rev 24 August 2017.

Carpenter G (2001) *Habitat use by waterbirds at the Washpool wetland, Aldinga, 1999-2000.* A report prepared for the Friends of Aldinga Scrub Conservation Park.

Chessman B (2003) *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra.

Frith HJ (1967) *Waterfowl in Australia*. Angus & Robertson Ltd. Sydney.

Gooderham J & E Tsyrlin (2002) *The Waterbug Book*. CSIRO Publishing. Collingwood.

Hawking JH, Smith LM, LeBusque K, Davey C (editors) (2013) *Identification and Ecology of Australian Freshwater Invertebrates*. Murray-Darling Freshwater Research Centre. http://www.mdfrc.org.au/bugguide

Marchant S & PJ Higgins Eds. (1993) *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings*. Oxford University Press Melbourne.

McKilligan N (2005) *Herons, egrets and bitterns: Their biology and conservation in Australia*. CSIRO Publishing. Collingwood.

Paton JB & K Beasley (1993) "Analysis of pellets disgorged by White-faced Herons" in *South Australian Ornithologist* **31:** 141-142

Seaman RL (2002) *Wetland Inventory for the Mount Lofty Ranges*. Department for Environment and Heritage. Adelaide.

Williams WD (1980) 2nd ed. *Australian freshwater life: the invertebrates of Australian inland waters.* Macmillan Education Australia. South Melbourne.

APPENDIX 1 – MACROINVERTEBRATE DATA

Family	**Subfamily**	**Genus/species**	**Common name**	**South Jan 2017**	**South Sept 2017**	**North Sept 2017**
Pionidae		Pionid sp. 1	Water mite			*
Pionidae		Pionid sp. 2	Water mite		*	
Eylaidae		possibly *Eylais* sp.	Water mite			***
Ceinidae (now Chiltonidae)		*Austrochiltonia* sp.	Scud		*****	*****
Chydoridae		*Chydorus sphaericus*	Water flea		**	*****
Daphniidae		*Daphnia* sp.	Water flea		*****	
Daphniidae		*Simocephalus* sp.	Water flea		*	*****
Moinidae		*Moina australiensis*	Water flea	*****		*****
Centropagidae		Calanoid copepod sp.	Calanoid cyclops		*	**
Cyclopoidae		Cyclopoid copepod sp.	Cyclops	**	*****	*****
Oniscoidea (now Scyphacidae)		*Haloniscus* sp.	Salt lake slater	**		
Cyprididae		*Cypretta* sp.	Seed shrimp		*	*
Cyprididae		possibly *Eucypris* sp.	Seed shrimp	**	****	
Cyprididae		possibly *Heterocypris* sp.	Seed shrimp			****
Notodromadidae		possibly *Newnhamia* sp.	Seed shrimp		**	
Dytiscidae	Tribe Bidessini	*Allodessus* sp.	Diving beetle adult		***	
Dytiscidae	Tribe Bidessini	*Allodessus bistrigatus*	Diving beetle larva	***	**	
Dytiscidae		*Lancetes lanceolata*	Diving beetle larva		*	
Dytiscidae		*Onchohydrus scutellaris*	Diving beetle larva		***	
Dytiscidae		*Playnectes* sp.	Diving beetle larva		*	*
Dytiscidae		*Rhantus suturalis*	Diving beetle larva			**
Hydrophilidae		*Berosus* sp.	Water scavenger beetle adult		*****	***
Hydrophilidae		*Berosus* sp.	Water scavenger beetle larva		*****	

Family	Subfamily	Genus/species	Common name	South Jan 2017	South Sept 2017	North Sept 2017
Hydrophilidae		*Enochrus* sp.	Water scavenger beetle larva	***		
Hydrophilidae		*Limnoxenus* sp.	Water scavenger beetle larva		***	***
Chironomidae	Chironominae	Chironomid sp. 1	Non biting midge larva		*	
Chironomidae	Chironominae	Chironomid sp. 2	Non biting midge larva		*	
Chironomidae	Orthocladiinae	possibly *Corynoneura* sp.	Non biting midge larva		*****	*****
Chironomidae	Orthocladiinae	Orthocladinid sp. 2	Non biting midge larva		**	
Chironomidae	Tanypodinae	Tanypodinid sp.	Non biting midge larva			*
Culicidae	Culicinae	Culicid sp.	Mosquito pupae	*	**	*
Ephydridae		Ephydrid sp.	Brine fly larva	*****		
Ephydridae		Ephydrid sp.	Brine fly pupa	*****		
Stratiomydae	Stratiomyinae	*Odontomyia* sp.	Soldier fly larvae	*****	*****	*****
Corixidae		*Agraptocorixa* sp.	Water boatman		**	
Corixidae		*Micronecta* sp.	Water boatman	*****		
Notonectidae		*Anisops* sp.	Backswimmer	*****	**	
Lestidae		*Austrolestes* sp. 1	Damselfly larva	***	*	
Lestidae		*Austrolestes* sp. 2	Damselfly larva		***	
Planorbidae		poss *Isidorella* sp.	Freshwater snail		*****	****
Physidae		*Physa acuta**	Introduced freshwater snail		****	****
Count of individuals	**Symbol**					
1-2	*					
3-5	**					
6-10	***					
11-20	****					
>20	*****					

APPENDIX 2 – WATERBIRD & SHOREBIRD FOOD SOURCES

Water/shorebirds recorded at the Washpool	Prey Species
Australian Crake	Invertebrates: varied, mostly those that live on the mud surface; Plants: seeds
Australian Pelican	Mainly fish. Small quantities of Crustaceans: crabs, shrimps; Vertebrates: small turtles, frogs, and rarely, other birds
Australian Painted Snipe	Plants: small seeds; Invertebrates: varied
Australian Shelduck	Plants: grazers on grasses and seeds, submerged algae, charophytes and macrophytes; Insects: chironomid midge larvae & adults, water boatmen, dragonfly larvae, beetles, mayflies; Crustaceans: seed shrimps, brine shrimps, Molluscs: bivalves
Australian White Ibis	Invertebrates: varied, including worms and terrestrial crickets; Fish; Frogs
Australasian Bittern	Fish: up to 60cm long; Crustaceans: freshwater crayfish; Other Invertebrates, Small vertebrates including Frogs; Rats; Birds
Australasian Grebe	Aquatic Insects, Crustaceans: freshwater crayfish; Molluscs: snails; Fish
Australasian Shoveler	Insects: beetles especially *Berosus*, water boatmen; Molluscs: small snails & small bivalves mostly less than 4mm, rarely Crustaceans: seed shrimps; Plants: floating seeds strained from the water
Baillon's Crake	Plants: floating algal rafts; Invertebrates: possibly only those caught in the algae
Banded Lapwing	Mainly Insects: beetles, ants; Other prey includes Molluscs: snails; Arachnids: spiders; Annelids: worms
Banded Stilt	Mainly Crustaceans: brine shrimp, shield shrimp, seed shrimp, aquatic slaters & other isopods; Other prey includes Molluscs: small snails; Insects: chironomid midges - adult and larvae; Arachnidae: spiders; Fish: hardyheads; Plants: some *Ruppia*
Black-fronted Dotterel	Annelids: earthworms; Molluscs: snails; Insects: chironomids, bugs, beetles, ants, rarely grass seeds
Black Swan	Plants: aquatic plants. Invertebrates only eaten when caught up in vegetation
Black-tailed Nativehen	Plants: Grazers on grasses
Black-winged Stilt	Mainly Molluscs: snails; Annelids: worms; Crustaceans: seed shrimp; Insects: beetles, chironomids, water boatmen; Plants a minor component: seeds of samphires & *Ruppia*
Buff-banded Rail	Crustaceans; Molluscs; Insects; Vertebrates: frogs; Plants: seeds, fruit; Carrion and refuse
Bush Stone-curlew	Varied Insects; Molluscs; Vertebrates: small lizards & occasional small mammals; Plants: seeds
Cape Barren Goose	Plants: grazers on grasses, seeds including grasses and samphire
Caspian Tern	Fish
Cattle Egret	Insects: terrestrial grasshoppers, crickets &locusts, Arachnids: ticks; Vertebrates including frogs & reptiles
Chestnut Teal	Plants: largely amphibious plants like *Polygonum,* sedges, grasses, aquatic seeds; Insects: beetles, water boatmen, chironomid midges & mosquitoes, caddis, dragon & damselflies; Molluscs: small bivalves; Crustaceans: freshwater crayfish, microcrustaceans

Water/shorebirds recorded at the Washpool	Prey Species
Common Greenshank	Molluscs: snails; Crustaceans: shrimps, seed shrimps, water fleas; Insects: beetles, ants, bees & wasps; Amphibians: frogs; Fish
Common Sandpiper	Molluscs: bivalves; Crustaceans: seed shrimp, crabs; Insects: beetles, flies, mosquitoes and midges
Curlew Sandpiper	Plants: *Ruppia* seeds; Annelids: marine worms; Molluscs: bivalves, snails; Crustaceans: seed shrimps, crabs; Insects: flies, mosquitos & midges, beetles
Eurasian Coot	In Australia Coots feed almost entirely on vegetable matter, with Insects, Worms and Fish a minor dietary component
Glossy Ibis	Insects: beetles, dragonflies, damselflies, grasshoppers, crickets, flies and caddisflies; Annelids; Molluscs: snails and bivalves, Crustaceans: freshwater crayfish; Occasional vertebrates including fish, frogs, reptiles and bird chicks
Great Cormorant	Fish, supplemented in freshwater by Crustaceans; Insects and Frogs
Great Egret	Mainly Fish but also other small vertebrates; Insects: Flies
Greater Crested Tern	Mainly Fish but also Insects; Crustaceans
Grey Teal	Plants: largely amphibious plants like *Polygonum*, sedges, grasses, aquatic seeds; Insects: beetles, water boatmen, chironomid midges & mosquitoes, caddis, dragon & damselflies; Molluscs: small bivalves; Crustaceans: freshwater crayfish, microcrustaceans
Hardhead	Mostly Plant material: seeds & flowers of sedges & grasses, waterlilies (northern Australia) & *Polygonum*. This species can dive in permanent waters to harvest pondweeds; Insects: beetles & waterbugs; Molluscs: bivalves, Crustaceans: yabbies
Hoary-headed Grebe	Fish
Latham's Snipe	Plant seeds sometimes fibres make up almost half the diet: *Poa, Juncus,* Cypraceae, Ranuculaceae. Prey items include Annelids: worms; Arachnids: spiders; Insects: flies, mosquitoes & midges, beetles
Little Egret	Fish; Aquatic insects, Crustaceans and Arachnids: spiders
Little Black Cormorant	Fish; Crustaceans and aquatic Insects
Little Pied Cormorant	Crustaceans: freshwater crayfish; Insects; Fish
Maned Duck (Wood Duck)	Plants: grazers on grasses and herbs. Very little seed intake, negligible animal matter
Masked Lapwing	Mainly Insects: beetles; Annelids: earthworms; Molluscs: snails; Centipedes, Millipedes; Plants
Pacific Black Duck	Aquatic plants and their seeds, varied invertebrates
Pacific Gull	Crustaceans: crabs; Molluscs: chitons; Fish
Pacific Golden Plover	Annelids: marine worms; Molluscs: snails; Crustaceans; Arachnids; Insects: bugs, beetles, ants, bees & wasps
Pied Cormorant	Fish
Pink-eared Duck	Insects: especially chironomid midge larvae; Crustaceans: water fleas, seed shrimps, cyclops; Plants: freshwater algae, seeds of *Polygonum*
Purple Swamphen	Plants: soft shoots of reeds and rushes; Molluscs: snails; Vertebrates: frogs, bird eggs, and ducklings
Red-capped Plover	Annelids; Molluscs: snails; Crustaceans: seed shrimp, slaters and other isopods, scuds, small crabs; Insects: beetles, Chironomid midges, flies, mosquitoes, ants, bees & wasps; Fish

Water/shorebirds recorded at the Washpool	Prey Species
Red-kneed Dotterel	Molluscs: aquatic freshwater snails; Insects: mayflies, beetles, flies, mosquitoes & midges, wasps, bees & ants, beetles
Red-necked Avocet	Annelids: worms; Molluscs: small snails/bivalves; Crustaceans: brine shrimp, seed shrimp, fairy shrimp, Insects: beetles; chironomid midges; Fish; Seeds
Red-necked Stint	Plants: *Ruppia* Seeds, Fabaceae; Animals: Molluscs: aquatic snails; Crustaceans: scuds, seed shrimp; Insects: flies & mosquitoes, chironomid midges, beetles
Royal Spoonbill	Fish; Crustaceans; Insects
Ruddy Turnstone	Molluscs: snails & bivalves; Crustaceans: barnacles, slaters & other isopods, crabs; Annelids: worms; Insects: beetles, ants, wasps & bees; Echinoderms; Fish
Sharp-tailed Sandpiper	Plants: *Poa* seeds, Fabaceae; Animals: Molluscs: snails & bivalves; Crustaceans: seed shrimps, scuds; Insects terrestrial & aquatic: dragonflies & damselflies, grasshoppers, bugs, beetles, moths & butterflies, flies, mosquitoes & chironomid midges
Silver Gull	Varied small prey from open water, occasional plant material
Spotless Crake	Plants: seeds; Molluscs; Insects; Crustaceans; and Arachnids: spiders
Straw-necked Ibis	Invertebrates: varied, including worms and terrestrial crickets; Fish; Frogs
Whiskered Tern	Invertebrates: larger swimming species in open water, Fish: small fish like hardyheads
White-faced Heron	Insects: beetles; Frogs & tadpoles
White-necked Heron	Molluscs: bivalves, Crustaceans: freshwater crayfish; Insects: beetles; Frogs & tadpoles
Wood Sandpiper	Molluscs; Insects, terrestrial & aquatic: grasshoppers, bugs, beetles, flies, mosquitoes & midges, ants, wasps & bees
Yellow-billed Spoonbill	Varied aquatic Insects

Additional shorebirds that may occur	Prey Species
Bar-tailed Godwit	Mainly Annelids: marine worms, but also earthworms; Crustaceans: crabs; Insects: moths & butterflies
Black-tailed Godwit	Quite variable. In European saltfields it has been found to feed overwhelmingly on chironomid midges. In Northern Australia it mainly feeds on bivalve Molluscs. In Africa it utilises plant foodstuffs especially rice seeds, but also Annelids: marine worms
Broad-billed Sandpiper	Crustaceans: brine shrimp; gammarid shrimps; Annelids: marine worms
Common Redshank	Annelids: marine worms; Molluscs; Insects: chironomid midges
Double-banded Plover	Annelids: earthworms; Molluscs: snails; Crustaceans: scuds; Insects: mayflies, chironomid midges, beetles; Arachnids: spiders
Eastern Curlew	Mainly a great variety of large Crustaceans: prawns & shrimps, crabs; Molluscs: snails; Insects: grasshoppers
Great Knot	Mainly Molluscs: bivalves; Crustaceans: prawns, crabs and shrimps; Annelids: marine worms; Echinoderms; Foraminifera; Fish

Additional shorebirds that may occur	Prey Species
Grey Plover	Annelids: worms; Molluscs: sea snails; Crustaceans; Insects: termites, ants, wasps & bees
Grey-tailed Tattler	Annelids: marine worms; Molluscs; Crustaceans: scuds, slaters & other isopods, crabs; Fish
Lesser Sand Plover	Molluscs: snails; Annelids: worms; Crustaceans; Insects
Long-toed Stint	Australian prey & food source not known: Plants: Seeds; Molluscs; Insects; Crustaceans
Marsh Sandpiper	Molluscs; Insects: Dragonflies & damselflies, bees, wasps & ants, beetles
Pectoral Sandpiper	Plants: Seeds; Insects: beetles, bugs; Crustaceans; Algae
Pied Oystercatcher	Annelids; Molluscs: Aquatic snails including air breathers, large bivalves like pipi & cockles, small bivalves; Crustaceans: prawns, crabs; Rarely fish and Insects.
Red Knot	Mainly Molluscs: bivalves & snails; Also Annelids: marine worms; Crustaceans; Echinoderms.
Ruff	Plants: grains; Animals: Molluscs; Annelids; Crustaceans; Insects; Spiders; Fish; Amphibians
Sanderling	Annelids: worms; Arachnids: spiders; Insects: beetles, butterflies & moths, ants, wasps & bees; Crustaceans; Rarely Fish and Molluscs.
Terek Sandpiper	Crustaceans: scuds, crabs; Insects: beetles, flies, midges & mosquitoes
Whimbrel	Mainly Crustaceans: shrimps, crabs; Also Annelids: marine worms; Fish; Bird Chicks

Data for these compendium tables were sourced from:

Birdlife Australia (undated) *NRAMLR Birdlife shorebird habitat matrix GM.xlsx* A spreadsheet tabulation of shorebird abundance and habitat use in the Dry Creek Saltfields.

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Carpenter G (2001) *Habitat use by waterbirds at the Washpool wetland, Aldinga, 1999-2000.* A report prepared for the Friends of Aldinga Scrub Conservation Park.

Frith HJ (1967) *Waterfowl in Australia*. Angus & Robertson Ltd. Sydney.

Marchant S & PJ Higgins Eds. (1993) *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings*. Oxford University Press Melbourne.

McKilligan N (2005) *Herons, egrets and bitterns: Their biology and conservation in Australia*. CSIRO Publishing. Collingwood.

Paton JB & K Beasley (1993) "Analysis of pellets disgorged by White-faced Herons" in *South Australian Ornithologist* **31:** 141-142