Wetland Biodiversity Monitoring Program

Towerrining Lake
Fauna and Water Chemistry Datasets

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INTRODUCTION

This spreadsheet-based report is part of a series of such reports that will each comprise a Microsoft Excel workbook and a companion document summarising results of monitoring at individual wetlands. The reports provide:

1) A quality assured dataset for analysis by those with specific questions or interests.
2) Some exploratory analyses of temporal patterns in the wetland's fauna in relation to measured environmental variables.

In this report on Towerrining Lake, spreadsheets for invertebrate, waterbird and water chemistry data collected between 1997 and 2012 are presented. They include a raw dataset and a number of spreadsheets that have taxonomy standardised for analysis within date, within the wetland or across a set of wetlands. The full report includes two files *Towerrining to 2012 text.pdf* (this document) and *Towerrining 1997_2012.xlsx*

PROJECT BACKGROUND

The Western Australian Salinity Action Plan (Government of Western Australia 1996) was developed as a blue print for government action, in partnership with the community, to address the problems of landscape salinisation. The plan included strategies to manage the impact of salinity on natural (biological and physical) diversity. With respect to wetlands, the plan recognised that: 1) "*changes in flora and fauna due to salinisation will be most pronounced, in the short term, in valley flats and their* *wetlands*", and 2) "*wetland monitoring will provide a basis for evaluating achievement of biodiversity conservation goals and will focus on both physical and biotic characteristics*".

To this end, the Department of Parks and Wildlife (DPaW, as its predecessor CALM) was charged with the responsibility to "*...monitor a sample of wetlands, and their associated flora and fauna throughout the south-west to determine long-term trends in natural diversity and provide a sound basis for corrective action.*"

In response, DPaW's Natural Resources Management Branch and Science Division developed a wetland monitoring project (Science Project Plan 1998-018) with two components:

1. DPaW (and its predecessors) had been monitoring salinity and depth in up to 100 wetlands since the 1970s (Lane and Munro 1983) and this program was revitalised as the South West Wetland Monitoring Program (SWWMP - Lane *et al.* 2013) to partially meet the requirements of the Salinity Action Plan.
2. The Wetland Biodiversity Monitoring Program commenced in 1997 to monitor waterbirds, invertebrates, flora, water chemistry and groundwater in a sub-set of SWWMP wetlands. This intensive program commenced in 1997 with a pilot study of 5 wetlands (Halse *et al.* 2002) and over the course of 1998 and 1999 a further twenty wetlands were added. These wetlands were selected according to a number of criteria (listed in Cale *et al.* 2004) enabling the relatively small sample of wetlands to be representative of the wide range of wetland types occurring in the region and to make best use of pre-existing knowledge. Wetlands present in the Warden, Muir-Byenup, Toolibin and Bryde Natural Diversity Recovery Catchments were included.

Towerrining Lake was included in the program because it is an example of a secondarily salinised wetland with considerable historical data for lake depth and waterbirds and a recent history of lake and catchment management including modification of the inflow and outflow structure which has resulted in increased depth and decreased salinity. Historically, the waterbird community was relatively species rich with moderate abundance and a large number of species bred on the lake (Jaensch *et al*. 1988).

PREVIOUS PUBLICATIONS

Several publications have arisen from the data , including a summary of the selected wetlands and of data from the first few years of monitoring (Cale *et al.* 2004), a paper on changes in biodiversity at two wetlands (Lyons *et al.* 2007) and detailed reports of results from a number of individual wetlands (Cale *et al*. 2010, Cale *et al*. 2011). In order to make results and analyses available on a more timely basis, spreadsheet-based reports will be produced for selected wetlands. These will not be as detailed as the above mentioned reports, but can be quickly updated as new data becomes available.

METHODS

Each wetland in the program is sampled every second year to determine the composition of invertebrate and waterbird communities and every third year to assess the health and composition of vegetation communities. These biodiversity data are comprehensive. Invertebrates from a very broad suite of taxa are identified to species level and complete counts of waterbirds are conducted three times in a monitoring year (late winter, spring and autumn). Vegetation is monitored in set quadrats enabling the assessment of health in marked specimens of a wide range of species. To aid interpretation of biological data, data are also collected for surface water chemistry, shallow monitoring bores, and salinity of riparian soils. A detailed description of the monitoring protocol is given by Cale *et al.* (2004) and Gurner *et al.* (1999) and an analysis of the efficacy of the invertebrate sampling protocols was presented by Halse *et al.* (2000). The sampling regime is ongoing and the earliest sampled wetlands (i.e. those commenced in 1997) have now been sampled at least six times. Lake Towerrining has been sampled eight times, however some data are still being processed, consequently six years data for invertebrates and eight years data for waterbirds are presented.

THE DATASETS

SITE

Lake Towerrining is located in the Shire of West Arthur, approximately 32km south of Darkan (33^{o} 35'S 116^{o}47' E). Part of the 182 ha wetland lies within the Towerrining Nature Reserve (Reserve No. 24917), and the remainder within Shire or private land.

INVERTEBRATES

Invertebrate samples were processed to retrieve as many species as possible and specimens were identified to species level where possible. Several dipteran families (Dolichopodae, Tabanidae, Tipulidae and Muscidae) were identified to family level only and Turbellaria, Nematoda, Mestostigmata and Oribatida were not determined beyond these nominal taxa. The maturity or gender of specimens sometimes prevented identification to species level. Within a sample identifications of taxa above species level do not impair the calculation of species richness for comparison between samples. However, when multiple samples (dates) are to be compared, e.g. during multivariate analyses, it is necessary to adjust species lists so that identifications at different taxonomic levels do not add spurious taxa to the analysis. This is achieved by deleting or combining taxa so as to lose as little information from the dataset as possible. For example to calculate species richness the presence of *Berosus* sp. (larvae) and adults identified as *Berosus munitipennis* in different samples would be resolved to *Berosus* sp. by combining the two taxa.

The Invertebrate datasets presented have been adjusted at several levels to maximise the information they contain for analyses.

1) Invertebrate richness: adjustments in this sheet are aimed at achieving the best count of total richness on each date. Consequently, only differences of determination between sub-sites on the same date are modified.
2) Invertebrate occurrence: adjustments are aimed at ensuring consistent determination of taxon identity across sampling dates and to remove species which are not obligate aquatic species (i.e. at best semi-aquatic). This dataset is most appropriate for multivariate analyses of samples from the wetland over time.
3) Invertebrate Community Structure: corrections in this sheet have been made to match taxa between the monitored wetland and a series of 'marker wetlands' which have been sampled

with the same protocol and are representative of particular wetland types (see Cale *et al*. 2004). This dataset is derived in order to present a brief analysis of community data in relation to diversity elsewhere in the Wheatbelt.

WATER BIRDS

The water bird datasets presented have not been adjusted for taxonomic resolution except to remove "un-identified species". Un-identified species may be suitable for inclusion in calculations of species richness, but because they are often seen briefly or poorly it cannot be discounted that they are individuals of species properly identified later in a survey.

1) Waterbird Occurrence: lists species abundance for individual surveys and species occurrence by monitoring year (i.e. consecutive late winter (LW), spring (Sp) and autumn (Au) surveys; see Cale *et al*. 2004).
2) Waterbird richness: presents species richness by category, i.e. total, breeding and guild
3) Waterbird Community Structure: lists the presence or absence of species by monitoring year for the monitored wetland and for five marker wetlands.

WATER CHEMISTRY

Two spreadsheets are presented for water chemistry

1) Water Chemistry: data as measured (including units).
2) Environmental Variables: data from Water Chemistry which has been transformed to approach normal. In this context, transformations are aimed at reducing the influence of extreme values and increasing the central tendency of the dataset. The resulting environmental variables are suitable for ordination analyses. Prior to transformation concentrations of anions and cations were converted to milli-equivalents. All variables were examined individually and transformed (by log or square root) as required to give the best approximation of a normal distribution. Variables with two or fewer value levels or with grossly skewed distributions were removed from the dataset. Where single data points were missing from a variable the datum was imputed to be the median of the remaining data (and highlighted red). Where data were missing for more than one sampling date no imputation of values was performed.

ANALYSES AND STATISTICS

Pinder *et al*. (2004) classified Wheatbelt invertebrates into a number of assemblages (groups of taxa which co-occur in wetlands with similar physicochemical characteristics). Waterbird guilds are based on a broad food category (animal or vegetable) and foraging technique. These guilds were developed by Halse (1987) and modified by Cale *et al*. (2004). These assemblages and guilds are used to characterise changes in invertebrate and waterbird communities through time.

Constrained ordinations were performed in R (version 3.0.0, R Development Core Team 2009) using function rda() from the vegan package (version 2.0-7, Oksanen et al. 2009). This analysis investigates relationships between community composition and environmental variables. Both response (species presence/absence) and predictor (environmental) matrices were scaled and the latter was centred. Abundance data were transformed using the Helliger transformation (Legendre & Legendre 1998). Reduced models including only: 1) electrical conductivity (Ec), pH and chlorophyll concentration (Chll) and 2) Ec, Total filtered Nitrogen (TFN), Temperature and Chll were used for invertebrate and waterbird data respectively. Function anova()(Oksanen *et al*. 2009) was used to separately test the significance of axes and terms for the resulting ordination. Vectors for statistically significant terms ($p < 0.05$) are displayed in red, terms displayed in black are not significant but are included for descriptive purposes.

Ordination by non-metric multidimensional scaling (n-MDS) was performed in R (R Development Core Team 2009) using function metaMDS() (vegan version 2.0-7, Oksanen *et al*. 2009), presence/absence data and the Bray-Curtis dissimilarity measure.

Diversity was calculated for invertebrate samples using the Shannon Weiner index:

$$H=-\Sigma p_i \ln p_i$$

From this index of diversity, D or the 'effective number of species' is calculated as exp(H) and conceptually is equivalent to the number of equally abundant species which would give rise to the same value of H (Jost 2007). Unlike the raw diversity index, D is comparable across different samples despite changes in species richness.

SUMMARY OF RESULTS

The analyses presented in the spreadsheets indicate that:

1) Salinity (Ec) was not significantly correlated with lake depth across all years, however within a year (i.e. hydroperiod) they appeared closely and negatively coupled. It is likely this is a result of inter annual variability in the salinity of lake inflow and the extent of outflow and flushing of the wetland. Most water chemistry parameters were stable within relatively small ranges.
2) Total phosphorus concentrations (spring mean = 10.6 μg/L) during the monitoring period were lower than the 79.5 μg/L recorded in September 1986 (Froend and McComb 1991), however, total nitrogen concentrations were similar.
3) Spring measurements of depth and turbidity were negatively correlated. Increased turbidity was implicated in the failure of benthic macrophyte beds to regenerate following an extended dry period in the 1980s (Froend and McComb 1991).
4) The invertebrate species present would generally be considered at least ubiquitous if not abundant species in the region. However, as indicated by ordination of community structure (see below) these species may not commonly co-occur.
5) There was no evidence of a declining trend in total invertebrate species richness or the richness of invertebrate assemblages over the monitoring period. Annual invertebrate species richness varied within the range 35-55 taxa, resulting in the collection of 114 taxa between 1997 and 2007. Fifty four taxa (47%) were collected in one year only and accounted

for a large portion of the annual species turnover (i.e. an average of 19.8% of annual richness).

6) Invertebrate species richness was not correlated with salinity despite a range of 7200 -16880 μS/cm for Ec. Salinity and richness are typically negatively correlated across wheatbelt wetlands with salinity > 4 g/L (Pinder et al. 2005). At Towerrining Lake, species richness is not correlated with Ec, because some species can persist across the salinity range and where species are lost, there are sufficient species tolerant of the conditions at Towerrining for species turnover to maintain richness. Species of typically freshwater assemblages (eg. A and B) were only present in 2005 at the lowest salinity recorded. In contrast, the more salinity tolerant assemblages (eg. E, H and I) were species rich and occurred in all sampling years.
7) Micro-crustacea were numerically dominant in most years, with some species occurring at very high abundances. In 1999 rotifers of the genera *Brachionus* and *Lecane* were even more abundant than micro-crustaceans. Insects, which are larger in body size, were of much lower abundance than either of these groups, but were species rich.
8) Invertebrate community composition, while most similar to the saline 'marker' wetlands, was substantially different from all 'marker' wetlands. This contrasts with the high similarity between years within Towerrining Lake.
9) While Invertebrate species richness was poorly correlated with salinity, community composition varied along a significant salinity gradient. Primary productivity (measured by photosynthetic pigment concentration) and pH were also important correlates of community composition.
10) A total of 39 species of waterbird have been recorded on Towerrining Lake of which 35 were recorded on more than one occasion. Richness of individual surveys varied in the range 14 – 26 species. There was a trend for species richness to decrease with increasing water depth during the monitoring period.
11) The Australian shelduck, grey teal, hoary-headed grebe and silver gull were present in all surveys and Australian shelduck, grey teal, blue-billed duck and hoary-headed grebe were, on average, the most abundant species in a survey. Blue-billed ducks had a maximum abundance of 535 individuals which can be compared with a maximum abundance of 370 of this species observed in the 1980s (Jaensch *et al.* 1988). In late-winter 1997, 849 hardhead were observed; a high abundance for this species (maximum abundance in the 1980s was 200).
12) Five species of water bird were recorded breeding; Australian shelduck, grey teal, black swan, Pacific black duck, pink-eared duck and Australasian grebe. This is substantially fewer than the 14 species recorded in the 1980s (Jaensch et al. 1988) but may reflect differences in methodology (in this study, cases of breeding were collected opportunistically; rather than searched for) rather than a change in character of water bird communities.
13) Comparison of waterbird community structure over the monitored period indicates that, while annual species composition was variable, there was no directional trend that would suggest an ongoing change in the waterbird community using Towerrining Lake. Indeed, compared to the 'marker wetlands', the communities surveyed at Towerrining Lake were very similar. The stable annual composition was comprised of seasonal communities which were also similar across years but different from each other. Spring and late-winter seasonal communities were the most internally similar, most distinct from each other and separated at the ends of gradients of nutrient concentration, temperature and productivity

(chlorophyll). Autumn communities were most variable and spread across the middle range of environmental gradients. There was a tendency (not statistically significant) for seasonal communities to vary along a salinity gradient.

14) The species composition of Towerrining Lake waterbirds was most similar to the brackish/ secondarily saline marker wetlands; Toolibin and Pinjarrega.

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