Cranbrook Salt Lakes

Ecological Investigation of
Tom South Lake, Lehmann Little Lake and Bob's Lake

Report prepared for Green Skills Inc, Denmark WA.

by Steve & Geraldine Janicke

November 2018

This project is supported by

Cranbrook Salt Lakes

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Janicke Environmental Assessments

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For bibliographical purposes this report should be cited as;

Janicke S. and Janicke, G. (2018) *Cranbrook Salt Lakes: Ecological Assessment of Tom South Lake, Lehrman Little Lake and Bobs Lake*. Report prepared for Green Skills Inc., Denmark WA.

Cover photo: Children from the Cranbrook Primary School discovering the invertebrates that live in Bob's Lake 25th October 2018.

Acknowledgements

The authors would like to thank the following for their support: Basil Schur of Green Skills Inc. the Lehmann family, Graham Jones and Cameron Williamson for providing access to Tom South Lake, and for their conservation efforts on these lakes. Thanks also to Karina Bateman of the Gillamii Centre and to Tony Peterson, for his bird survey of the Lake and part of its foreshore. Special thanks also to the students, staff and parents of the Cranbrook Primary School who came out for the day and for their interest and willingness to help.

The event is part of Green Skills' biodiversity conservation and citizen science program and has been supported with funding from The Koorabup Trust and South Coast NRM through the Australian Government's National Landcare Program. It also has received support from the Cranbrook Primary School and the Gillamii Centre as well as Janicke Environmental Assessments.

Disclaimer: The authors have, in good faith, made every effort to ensure the accuracy of the information presented and to acknowledge the sources, subject to the limitations of the methods used and take no responsibility for how this information is used subsequently by others, including implied notions and conclusions drawn. Management implications are not recommendations, but present options for consideration and discussion.

INTRODUCTION

There is a suite of mostly salt lakes to the north of Cranbrook and extending eastward to the north of the Stirling Range, Western Australia. These lakes are in the North Stirling Basin.

Field studies of the Hooded Plover have been made on the salt lakes in this region and indicate they use the lakes for breeding and feeding.[1] With this in mind, the Gillamii Centre and Green Skills Inc. have coordinated with farmers in the region to fence the wetlands and protect the ground nesting birds from stock trampling. Breeding Hooded Plovers were observed in February 2018 in Tom South Lake and Bob's Lake while the many other lakes where Hooded Plovers had been observed were hypersaline or dry.

This ecological investigation was conducted on 25th October 2018 on the three lakes, Tom South Lake, Lehmann Little Lake and Bobs Lake. (See map in Figure 1). The Cranbrook Primary School came out to assist in the macroinvertebrate 'picking' and to learn about the ecology of these salt lakes. Tony Peterson assisted in monitoring the birds present.

Craig Carter of Earthrise productions documented the event with the aim of producing a YouTube video highlighting the value of the North Stirling Cranbrook salt lakes and to indicate their importance for biodiversity especially shorebirds such as the threatened Hooded Plover. It also shows what farming families, community and NRM groups are doing to fence, rehabilitate and manage the lake foreshores. A link to this YouTube video is at https://www.youtube.com/watch?v=DwO5s3XWM8c)

Figure 1: The western half of the North Stirling Basin including the three lakes examined.

[1] Tony Peterson (2018) Hooded Plover and Salt-Lakes Foreshore Conservation, North Stirling, WA. Project Report for Green Skills Inc.

Figure 2: Three lakes visited on 25th October 2018, Toms South Lake, Lehmann Little Lake and Bobs Lake and their catchment.

The soil groups of the wetlands are described as the "North Stirling System" and consists of poorly drained flats with many salt lakes and low dunes. The salt lake soils include deep sandy duplexes, often with alkaline subsoils, with pale deep sand and saline wet soil.[2]

The catchment of Bob's Lake is the longest of the three and extends from the base of the Stirling Range. Lehmann Little Lake appears to have no catchment (Figure 2).

SALINE LAKES

Secondary salinization is well known in the West Australian wheatbelt. However, what is not so well known is that many inland lakes and river systems in the southwest of Western Australia are naturally saline. As a result, Western Australia has a particularly high diversity of salt loving (halobiont) aquatic fauna that are endemic to these salt lakes.

These natural or primary saline lakes are also subject to secondary salinization (i.e. increases in salinity, changes to the ionic composition, and loss of fringing vegetation). Secondary salinization has impacted many wetlands and lakes in the basin, shifting formerly fresh systems to saline. This is most strikingly demonstrated by the presence of dead trees in the bed of some lakes. Nevertheless, numerous wetlands appear to have been highly saline in varying degrees prior to land clearing.

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[2] Stuart-Street, A. and Marold, R. 2008. "Soil-landscape map of the Tambellup-Borden area (Scale 1:100,000). Department of Agriculture Western Australia Land Resource Map. To accompany "Tambellup-Borden area land resources survey", 2008.

The lakes in the North Stirling Basin are endorheic, i.e. drainage is normally retained in the lakes and there is no outflow, only evaporation and in some cases groundwater recharge. These lakes generally receive brackish water from seasonal rainfall run-off, but it is the episodic heavy thunderstorms that dump large quantities of fresh water into the lakes that give them a fresh flush and perhaps allow them to overflow. The balance between in-fill, groundwater discharge/recharge and evaporation will determine the water levels and salinity.

Several factors contribute to the quality of the water that may be encountered at any place and at any one time. These include; proximity to the groundwater table, annual rainfall, seasonal rainfall variability, the extent of the surface catchment, geological setting, soil type, prevailing winds, the intensity of storm events, local land-use, artificial drainage, riparian vegetation cover and the size of the wetland. Thus, neighbouring lakes within a basin can have very different levels of salinity. For example, the salinity of nearby Jebajup Lake was measured at more than 250 ppt at the in February 2017, compared with Bob's Lake which was between 15 to 20 ppt at the same time. Sea water, by way of comparison, is approximately 35 ppt.

“The ultimate cause of increased salinity in wetlands is rising groundwater, although sometimes wetlands are more directly affected by the increased surface run-off that results from high water tables in the catchment than by groundwater beneath the wetland.” [3] Isolated lakes low in the landscape may be ground water fed with usually saline water. Salt accumulates in lakes through evaporation. The lack of an outlet for many lakes means that salt remains in the basin.

Ruhi Ferdowsian [4] explained the hydrological balance as follows. “*Saline lakes are windows to groundwater. Saline groundwater discharges into these lakes and maintains their high salinity levels. In very wet years, surface runoff tops up the salt lakes and dilutes their water. If their water levels rise above piezometric levels of the aquifer, limited saline water may recharge the aquifer and reduce the salt storage of the lakes.*”

WATER QUALITY

The investigation of three small lakes north of the town of Cranbrook on the 25th October 2018 highlighted the dramatic differences in water quality that define the numerous wetlands systems found along the South Coast region of WA. Although these wetlands exist in a naturally saline groundwater environment the salinity of the surface waters can vary from fresh to hypersaline, i.e. from less than one part per thousand to greater than 250 parts per thousand. This in turn determines what aquatic and fringing flora and fauna can exist there.

Table 1: Water quality at the three Cranbrook Lakes. Instruments used: Optical salinometer, pH strips, thermometer, turbidity tube.

	Salinity (ppt)	Temp (C)	pH	Turbidity (NTU)	Comment
Toms South Lake 25th October 2018	230	29	8.5	100	Shallow, pink tinge
Lehmann’s Little Lake 25th October 2018	> 260	28	-	150	Suspended salt crystals implied salinity at saturation. (c 360 ppt)
Bobs Lake 25th October 2018	39	28	10	50	Phyto plankton, Depth board datum 0.35 m.
Bobs Lake 22nd February 2017	16-20	19	8.8		Cloudy Depth board datum 0.25 m

[3] D.J. Cale, S.A. Halse and C.D. Walker (2004) *Wetland monitoring in the Wheatbelt of south-west Western Australia* Conservation Science W. Aust. 5 (1): 20-135 (2004)

[4] Ruhi Ferdowsian (2012) Wetland Assessment in the Upper Kent Catchment: Report No 1 Attributes of the Wetlands

Bob's Lake was sampled in February 2017 and again in October 2018. Since the 2017 sampling, the salinity level had increased from 20ppt to 39ppt. Cranbrook had received 40% above average rainfall for the previous 14 months leading up to the February 2017 sampling event. However, in the 14 months leading to the October 2018 sampling event, Cranbrook had received 22% below the average rainfall for that period. As a result, Bob's Lake, and all the lakes in the region were generally drier and saltier than they would have been in February 2017.

Table 2: Rainfall anomaly over previous 14 months to sampling date for Cranbrook. [5]

Sampling date	Rainfall for previous 14 months	Rainfall anomaly over previous 14 months
22/02/2017	749mm	215.8mm i.e. 40% more than average
25/10/2018	461.9mm	-134mm i.e. 22% less than average

The extent of the catchments of Toms South and Bobs Lake is difficult to estimate in the flat landscape, but both receive storm runoff with Bobs Lake having the larger catchment (See Figure 2). Lehmann's Little Lake appears to have no significant surface water input. The lower salinity of Bobs Lake compared with the others is likely to be due to fresher storm water flowing from the catchment to the south. Ground water inputs to the wetlands will also influence water conditions.

Wetland salinity categories (Pinder et al, 2005).

- <3 ppt, freshwater
- 3 to 12 ppt, sub-saline or brackish
- 12 to 35 ppt, saline
- >35 ppt, hypersaline.

Note: seawater is usually 35 ppt (52ms/cm).

It is interesting that although the water level was higher in 2018, the lake was saltier than 2017, suggesting the surface water inflow in that time has been saline. A pertinent question to ask is "Is Bob's Lake steadily becoming saltier through secondary salinization?"

It is suggested that the flow paths between the catchment of Bobs lake and a large saline lake to the immediate north warrants some investigation regarding the flow dynamics, as this may have a significant influence on the future of Bobs Lake. If an end-point wetland continues to receive even slightly saline water over time it will tend to become saltier since the salt is not removed by evaporation. If the lake can overflow during very high rainfall events, then the runoff can ameliorate the salt concentration, effectively flushing salt northward.

The pH of Bob's Lake had increased from 8.8 in 2017 to 10 in 2018. Some variation in instrument error may occur but cannot account fully for the difference in pH between the two sampling events. Although the sub-soil is alkaline, an increase in groundwater entering the lake is unlikely to be the cause of the increase in pH since Tom South Lake is under-lain by the same alkaline soils but was not so high in pH. Photosynthetic consumption of carbon dioxide can drive pH to high levels.

In 2017 the bed of Bob's Lake had an even low covering of the green algae *Lamprothamnium papulosum* (Charales) and a micro-algal bloom. However, in 2018 there was a distinct increase in aquatic vegetation biomass with water mat and annual swan grass, (*Althenia (Lepilaena*) sp. and *Ruppia tuberosa*) present. There was also a microalgae bloom and the water temperature was fairly high. This aquatic vegetation and microalgae actively photosynthesis on warm sunny days, consuming carbon dioxide which is known to diurnally increase the pH of a wetland by up to 2 pH units[6].

[5] Calculated from BoM website (http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=2017&p_c=-22386281&p_stn_num=010537) accessed November 2018.

[6] https://ozcoasts.org.au/indicators/biophysical-indicators/ph_coastal_waterways/ Accessed November 2018

AQUATIC PLANTS AND MACROINVERTEBRATES

Toms South Lake, Lehmann Little Lake and Bobs Lake were sampled for macroinvertebrates on 25th October 2018 using a 250µm mesh net to sweep around the edge and up to 25m into the lake. The contents of the net were split between two trays and animals were 'live-picked' with the help of students from the Cranbrook Primary School. All picked animals were placed into sample containers with 70% ethanol and returned to the laboratory where all specimens were identified to the lowest taxonomic level possible.

Table 3: Macroinvertebrates in samples from Tom South Lake and Bob's Lake (Lehmann Little Lake was not sampled for macroinvertebrates).

CLASSIFICATION Taxon	Common name	Tom South Lake	Bob's Lake
Crustacea			
Cladocera Daphniidae *Daphniopsis pusila*	water fleas		abundant
Copepoda Calanoida *Calamoecia* sp. (pink metallic)	pink copepod		many
Copepoda Calanoida Calanoid sp.	Copepods		some
Copepoda Cyclopoidea Cyclopoid sp.	Copepods		some
Ostracoda Cyprididae *Diacypris* sp.	Seed shrimp		some
Ostracoda Cyprididae *Mytilocypris mytiloides*	Giant Ostracod		abundant
Ostracoda Cyprididae *Platycypris baueri*	Seed shrimp		some
Ostracoda Cyprididae *Reticypris* sp.	Seed shrimp		some
Ostracoda Cyprididae *Sarcypridopsis aculeata*	Seed shrimp		abundant
Insecta			
Diptera Ephydridae Undetermined larvae	Fly larvae		1
Diptera Tanypodinae *Procladius paludicola*	Midge larvae		2
Diptera Orthocladiinae sp.	Midge larvae	2	
Mollusca			
Gastropoda Pomatiopsidae *Coxiella* sp.	salt-lake snails		some
Gastropoda Pomatiopsidae Unknown sp. or juveniles	salt-lake snails		many
Nemetoda			
Nemetoda Undetermined sp.		some	
Plants			
Charales *Lamprothamnium papulosum*	foxtail stonewort		some
Potamogetonaceae Althenia *(Lepilaena*) sp.	Water Mat	spores	many
Ruppiacaea Ruppia *tuberosa*	Annual swan grass		Abundant

Tom South Lake

Tom South Lake was hypersaline and pink. There was no aquatic vegetation present however, spores of Water Mat grass were observed in the detritus. The pink colour is due mainly to the green algae, *Dunaliella salina.* At higher salinities and water temperatures *Dunaliella salina* produces a red pigment, β-carotene (which also gives carrots their colour). The β-carotene seems to protect the algae from long-term UV radiation and the high light intensities that it is exposed to in the hypersaline environment.

Dunaliella salina is not the only organism that produces β-carotene in salt lakes. There are several bacteria species (*Halobacterium* and *Salinibacter ruber*) that grow within the salt crust on the bottom of lakes and that can give a lake a ruby colour. However, it is likely that bacteria were not the main source of pink in Tom South Lake.

Tom South Lake was turbid (cloudy) indicating the presence of microalgae. Microalgae are a primary food source for macroinvertebrates which then become a food source for birds.

Amazingly there were two midge larvae observed. Also present in the lake were nematodes. Both the midges and nematodes would be feeding on the microalgae and bacteria.

Lehmann's Little Lake

This lake was at saline saturation and was not sampled for macroinvertebrates.

Bob's Lake

Bob's Lake had been sampled on 22 February 2017 and on this occasion, 25 October 2018. The overall species diversity for Bob's Lake between the two sampling events was similar with 12 species identified in 2018 and 15 species in 2017. However, the macroinvertebrate composition was distinctly different with crustaceans dominating the more saline sampling event in 2018 and insects dominating the fresher sampling event in 2017 (see Figure 3).

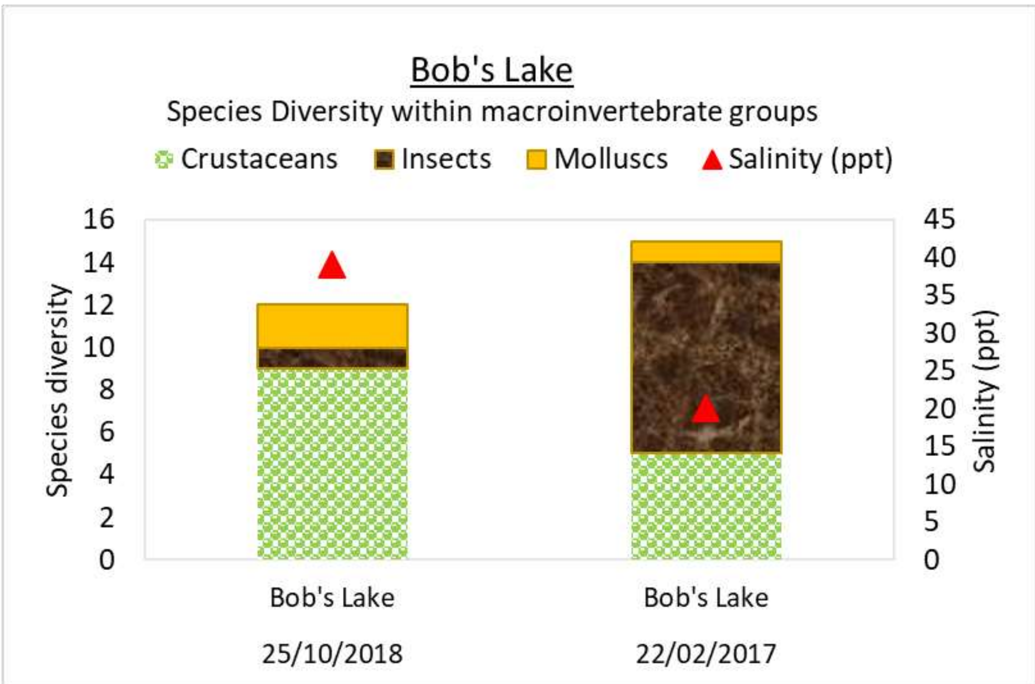

Figure 3: Species diversity within macroinvertebrate groups for the two sampling occasions at Bob's Lake.

The most abundant species were a small green ostracod (*Sarcypridopsis aculeata*), the 'Giant' ostracod (*Mytilocypris mytiloides*), and waterfleas (*Daphniopsis pusila*). The giant ostracod and the water flea are endemic to Australia however the small green ostracod is cosmopolitan. The other species of ostracod identified in Bob's Lake are endemic to Western Australia and are commonly found in ephemeral salt lakes.[7]

'Giant' ostracods are defined as those species greater than 3 mm in length. The common salt loving Giant' ostracod that was named *Mytilocypris tasmanica chapmanii* has recently been determined as being the same as *Mytilocypris mytiloides* and is endemic to Australia. They are filter feeders that feed on plankton and can be found throughout the whole water column. They are highly salt tolerant and produce drought resistant eggs. Juveniles can also 'hitch' a ride on the feathers of waterbirds. There is a high level of endemicity of 'giant' ostracods in the south-west. The high richness and endemism of crustacean groups

[7] DeDeckker, P. (1983) Notes on the ecology and distribution of non-marine ostracods in Australia. Hydrobiologia 106, 223-234.

in south-west Western Australia is usually attributed to the antiquity and geological stability of the landscape, with a long history of saline waterbodies.[8]

There were good numbers of salt-lake snails in Bob's Lake. The salt-lake snail, *Coxiella* sp. is endemic to saline wetlands of Australia. Their shells are thick, often with a tall spire and can be found in huge numbers on the 'beaches' of many saline lakes. They feed on detritus and benthic algae. They can block the opening of the shell with an operculum to avoid desiccation when the lake is too saline or dry. It is uncertain whether there are two species present or whether one is a juvenile form of the other. The Coxiella snail has been observed as the main diet for Hooded Plovers on inland West Australian salt lakes,

Saline lakes from the region

Lakes and wetlands in the North Stirling Region (Plantagenet, Cranbrook and Ongerup shires) have been variously sampled since 2014. Macroinvertebrate species diversity within groups from the brackish to hyper-saline lakes sampled are represented in Figure 4.

Although each lake had a macroinvertebrate species diversity ranging from 0 to 18, there were 59 species in total found in all the lakes.

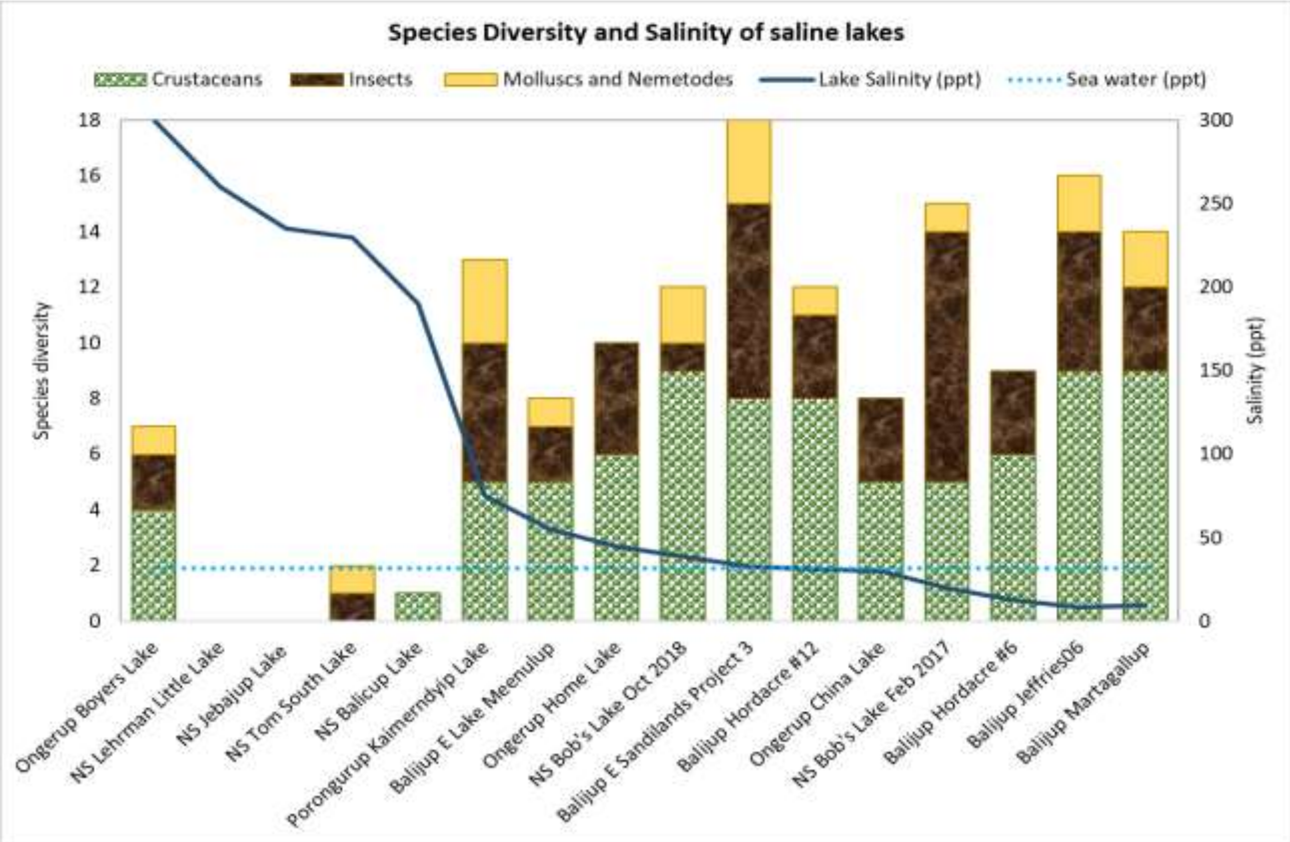

Figure 4: Species diversity and salinity of saline lakes sampled in Plantagenet, Cranbrook and Ongerup region of SW of Western Australia.

BIRD OBSERVATIONS.

Several lakes in the North Stirling region have been part of a Hooded Plover and Salt-Lakes Foreshore Conservation project managed by Green Skills Inc. As part of this project, Tom South Lake, Lehmann Little

[8] S.A. Halse & J.M. McRae (2004) New genera and species of _giant_ ostracods (Crustacea: Cyprididae) from Australia Hydrobiologia 524: 1–52, 2004.

Lake and Bob's Lake have been fenced and variously revegetated with the purpose goal of protecting breeding Hooded Plovers and other wading birds.

Table 4: Bird List from Thursday 25th October 2019, Tom South Lake, Cranbrook – by Tony Peterson,

Waterbirds and waders					
Red-necked Avocet	27	Australian Shelduck	39	Red-capped Plover	3
Other birds					
White winged triller	3	Magpie Lark	5	Yellow-rumped Thornbill	5
Australasian Pipit	1	Willy Wagtail	2	Elegant Parrot	2
Brown Honeyeater	7	Horsefield's Bronze-Cuckoo		White-browed Babbler	5
Australian Ringneck	7	White-fronted Chat	4	Grey Butcherbird	2
Black-faced woodswallow	5	Nankeen Kestrel	2	Magpie	4

Birdlife Australia describe Red-necked Avocets (*Recurvirostra novaehollandiae*) as "*having long and slender bills that are elegantly and unusually upcurved, and which are used to forage in the water of shallow wetlands. By sweeping the bill back and forth through the water in a scything motion, tiny aquatic invertebrates are caught with each sweep of the bill. The avocet apparently locates these insects and crustaceans by using its sense of touch*.[9]" There appeared to be little in Tom South Lake at the sampling site for these avocets to feed on.

The birds may have been feeding at a different lake such as Bob's Lake and were only resting at Tom South Lake. The distribution of macroinvertebrates within a lake may not have been homogenous. Wind driven currents within a lake might push macroinvertebrates to the down-wind side of a lake. Alternatively, they could congregate in the shallows. However, their distribution can only be confirmed by sampling at different locations around a lake.

The Australian Shelduck (*Tadorna tadornoides*) grazes on green grass on land or in shallow water. It also eats algae, insects and molluscs. The 39 Shelduck observed on Tom South Lake had no food available from within the lake.

Red-capped Plovers forage for molluscs, small crustaceans and some vegetation, on mudflats, sandy beaches and salt-marsh. [10]

It is interesting that some waterbirds can use brackish to hypersaline water bodies[11]. Salinity is not the only cause of changes in the biodiversity values of Wheatbelt wetlands. Clearing of fringing vegetation, eutrophication and other factors have probably affected waterbird and invertebrate use of many Wheatbelt wetlands.[12] These changes can also be influenced by climate change and variability.

Cale *et al* (2004)[13] described are three kinds of climatic variability impacting wetlands and waterbird communities. "*Firstly, small scale annual variability, principally in rainfall, causes annual variation in wetland depth and conditions that will affect waterbird and invertebrate communities. A second, more significant kind of variability is caused by extreme rainfall years (either drought or flood) that cause pronounced short-term natural changes in the depth and ecology of a wetland that are greater than likely anthropogenic change. The third kind of variability is long-term change in climate.*"

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[9] http://www.birdlife.org.au/bird-profile/red-necked-avocet Accessed November 2018
[10] http://www.birdsinbackyards.net/species/Charadrius-ruficapillus Accessed November 2018
[11] Halse, S. A., Williams, M. R., Jaensch, R. P. and Lane, J. A. K. (1993c). *Wetland characteristics and waterbird use of wetlands in South-western Australia.* Wildlife Research 20, 103-126
[12] Cale, DJ et al (2004) *Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data.* Conservation Science W. Aust. 5 (1) : 20–135 (2004)
[13] Cale, DJ et al (2004) *Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data.* Conservation Science W. Aust. 5 (1) : 20–135 (2004)

APPENDIX: SELECTED PHOTOS

Sampling for macroinvertebrates in Tom South Lake and showing the students from Cranbrook School (Years 4/5/6). Craig Carter of Earthrise productions filming the event.

Students from Cranbrook School being updated on the revegetation planting they had been involved in earlier in the year.

Students from Cranbrook Primary School learning about the diversity of aquatic life in Bob's Lake.

Craig Carter of Earthrise Productions filming Geraldine Janicke.