# SEGments

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# Scientific Expedition Group Inc.



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**Cover Photo**: Male Red-capped Plover at the Coorong. Photograph by Tom Hunt

**Rear Cover Photo:** Some of the participants on the Ikara-Flinders Expedition. Photograph Jill Tugwell.

The Scientific Expedition Group is a not-for profit organisation which began in 1984. SEG undertakes several expeditions each year to record scientific information on wildlife and the environment in many parts of South Australia.

A major expedition to conduct a biodiversity survey occurs each year over two weeks. Scientific experts lead volunteers in surveying mammals, reptiles, invertebrates, vegetation, birds and physical geography. The data collected on each survey are archived with the relevant State scientific institutions to ensure they are available to anyone interested in our State's environment.

In addition to the major expedition, a number of trips for the Vulkathunha-Gammon Ranges Scientific Project are organised annually. A long term study of rainfall on the ranges and of water flow in arid-zone creeks is undertaken. All data are supplied to the Department of Environment Water and Natural Resources and to the Bureau of Meteorology and are available for analysis.

SEG conducts four-day biodiversity surveys at eight different sites each autumn and spring in the Heritage Area of scrub on "Minnawarra" farm near Myponga. Data collected are entered into the Biological Data Base of SA. SEG also conducts annual mallee-fowl monitoring over a weekend in the Murraylands.

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# SEGments

## Volume 34 Number 1 March 2019

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## GUEST EDITORIAL

Government investment in Australia's natural environment is declining and this has grave consequences for biodiversity. NGOs contribute taking up some of the slack but they are no substitute. The shift away from conserving nature for future generations is likely driven by a growing disconnect between society and the natural environment. We live, appropriately, in an Epoch of our own-making - the Anthropocene.

More and more Australians live in cities now than ever before, and in this environment people are largely divorced from experiencing nature first hand. I suspect that most, if not all, SEG members can identify childhood experiences that have given rise to a lifelong interest and passion for nature. Opportunities for young Australians to have those same experiences are limited now. Instead, free time for many youngsters is spent indoors playing on a device. At best they might watch a nature documentary, visit a Zoo or a Museum but those experiences are unlikely to yield lifelong interests in natural systems. Difficult to see how this will change in the short- to medium-term. Until society is reconnected and values the natural environment, governments will resist reinvesting in the sector. The challenge is how to turn this around and reconnect society to nature.

A grass roots approach is probably needed. We need to find ways of providing opportunities for more people to experience nature. Volunteering on natural history expeditions is one way of engaging with nature, often with knowledgeable people and often with the purpose of gathering information that informs and helps manage natural systems. In the 1980s, 1990s and 2000s I used Earthwatch volunteers to help with field-based research. This included 7 years of support for work in the Coorong in the early 2000s, where families attended and worked on monitoring waterbirds and their food resources. The idea was that families shared experiences. Liability insurance, however, became an issue and so those family-oriented activities were curtailed. I still take a few volunteers on these trips more than a decade later but my attention focuses on giving university students opportunities. These outings provide at best a small number of people with experiences of nature, but many of these already had an interest to start with but not necessarily a strong connection to nature. So how can this exposure to nature be ramped up, particularly in young people.

Here is my challenge to you. We all have stories of our childhood (and adult) experiences with nature whether that is while fishing, camping, bushwalking, sailing or some other venture. These are our oral histories and we need to pass these experiences on to our children and grandchildren – particularly that sense of adventure, discovery and enjoyment. If you enjoyed camping then why not take the children or grandchildren camping as well. Many people now connect with nature through photography and proudly display their finest images. What we rarely do is talk about them and put the narrative to those images. If provided with an image of a bird, plant, mammal, insect, reptile or marine organism many of us would have an experience we could pass on to future generations, to friends and acquaintances, triggered by that image. We need to be doing this, and doing this frequently. So the first step for those of us who love nature is to communicate this broadly to others and so start the reconnection process.

Associate Professor David Paton
Ecology and Evolutionary Biology
University of Adelaide

# PLANT-INSECT-MICROBE INTERACTIONS
# WAKE UP AND SMELL THE YEAST
# Miguel de Barros Lopes

**Introduction**

A microorganism (microscopic organism or microbe) is a living thing that is too small to be seen with the naked eye. The importance of microorganisms in ecological systems is attracting increasing attention. The focus has been on the human-microbiome, but more recently the importance of interactions between insects and microbes is being realised. Yeast which are unicellular fungi have a special relationship with insects, as many yeast are dependent on insects for colonisation of new habitats. Yeast are just beginning to be studied.

In this review three different systems will be examined to highlight the relationship between yeast, insects and plants: the cactus-insect-yeast tripartite relationship; the leafcutter ant – yeast symbiosis and yeast- plant pollination.

**Classification of Life**

The anthropocentric nature of scientific studies is illustrated in the way we classify all living organisms (Figure 1). For most of us our high school biology textbooks separated all living organisms into 5 kingdoms. Four of these kingdoms correspond to eukaryotes - cells that, like us, possess their genetic material in a nucleus.

Because we can easily see them and relate to them plants and animals each received their own kingdom. The fungi best known to us because of macroscopic forms such as mushrooms, also had a kingdom reserved for them. A large group of very diverse and generally unicellular microorganisms made up the fourth eukaryotic kingdom, the protists. However, recent taxonomy has generally abandoned this level of classification, recognizing that the vast majority of life's diversity exists in the microscopic world. All living organisms have now been divided into 3 domains – the bacteria, archaea and eukarya. The domain eukarya includes the four kingdoms described in Figure 1.

The fifth kingdom, Monera, which included all prokaryotes is now separated into the two bacteria and archaea domains. All organisms in these two domains lack a nucleus and are unicellular. The archaea were only recognised as separate to bacteria in the late 1970s when DNA sequencing demonstrated the unique evolutionary history between the two domains. Archaea are well known for being extremophiles, having been initially isolated from environments with temperatures above 100$^{o}$C: Antarctic oceans; salt lakes; and extreme pH environments. It is now recognised that they are present in almost all habitats, but as none have been shown to cause human disease, research into these organisms has remained relatively limited.

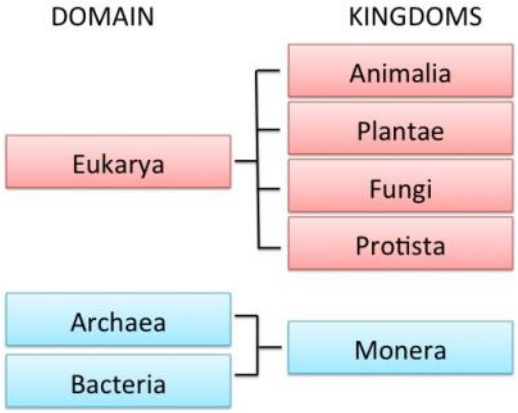


*Figure 1. The classification of all life into kingdoms and domains*

**Microorganisms**

While the focus has been on disease causing microorganisms, the vast majority of microorganisms cause no harm, and many are indeed beneficial. Humans are in fact greater than 50% microbial cells and the microbial genes that we carry outnumber our *Homo sapien* genes one hundred to one. Our microbiome has important consequences to our health, and new studies demonstrate that they modify our behaviour and impact the way we respond to our environment.

An estimate of the number of microorganisms on the earth is $5x10^{30}$, a number too large to fathom. But to give an idea, the total mass present in this very large number of microscopic organisms is greater than that of all plants and animals on earth. In soils, their numbers have been shown to reach 100 million in a single teaspoon and this can consist of greater than 50,000 unique species.

**Yeast – part of Fungi**

Yeast are a relatively small subset of unicellular microorganisms. Together with multicellular moulds and mushrooms, yeast make up the fungi. Yeast are evolutionarily diverse and do not form a single phylogenetic group– so a species can be more closely related to moulds and mushrooms than they are to each other. So being unicellular, yeast is a way of life rather than a taxonomic grouping. Yeast are considered to be of particular importance in insect interactions because while bacteria, archaea and other fungi are able to move by wind or water, many yeast are thought to be exclusively dependent on insects for their transmission to

new habitats. For this reason they are experts at producing volatile chemicals for insect attraction.

**Cactus-insect-yeast tripartite relationship**

Cacti, consisting of approximately 130 genera and 1,500 species that are native to the Americas, have been introduced into many parts of the world. The *Opuntia* cacti (prickly pears) provide a unique story in Australia where they have become a major pest species. The species' management provides a striking example of biological control.

*Opuntia* typically have flat paddle-shaped stem segments called cladodes that grow on top of each other, with large fixed spines and small hair-like spines called glochids that detach from the plant and can cause severe irritation (Figure 2) . The cactus reproduces sexually, with birds and animals eating the fruit and spreading seed. It also reproduces asexually by cladodes breaking off and re-establishing, a characteristic that makes it particularly difficult to eliminate cacti physically. The multiple uses of *Opuntia* also encourage the spread of these plants. As well as being popular pot and garden plants, the fruit, commonly known as cactus fig, is eaten in many parts of the world. The stems are less frequently used as a food.

*Opuntia* were brought to Australia with the first fleet in 1788 with the intention of developing a cochineal dye industry, particularly important for the red coats of British soldiers. The cochineal is a scale insect which feeds on plant nutrients and moisture of *Opuntia*, on which it lives.

The whereabouts of these first cacti brought in 1788, most likely *Opuntia monocantha* (drooping pear) are unknown, and it was the later spread of *Opuntia stricta* (the common prickly pear) that was used as a hedge plant in homesteads and as drought fodder that became the major weed. In 80 years, from a single plant traced back to 1839 in Scone, NSW, *O. stricta* had taken possession of almost 25 million hectares, reaching from West of Sydney to as far north as Mackay, a distance of over 1,423 kilometres. In the late 1900s it was estimated to be increasing at the rate of 400,000 hectares a year. At its most dense, there were as many as 16,000 plants per hectare. (Figure 3)

In 1910 prickly pear was declared a noxious weed and the recognition of the problem led to the establishment of the Commonwealth Prickly Pear Board in 1919. The effort to rid NSW and Queensland of prickly pear has not been matched. Prior to the board's establishment a number of generally ineffective strategies had been used to control the pest species, including the use of 3 million kilograms of arsenic blends.

**Biological control of cactus**

The potential use of biological control had been recognized and between 1920 and 1935 extensive travels to North and South America had identified 150 cactus feeding insect species. Over half a million individual insects, representing 52 species, were imported to Australia and tested for their potential use for biological control. Cactus feeding moths and beetles were the main insects studied, but the collection also included flies and Hemiptera (plant suckers and cochineal), as well as cactus spider mites. Precise data was collected on the insects' life history and habits, acclimatisation to Australian conditions, susceptibility to parasites and predators, and host specificity.

Figure 2. Opuntia cactus in Ikara-Flinders Ranges. Photo Jill Tugwell

Twelve species were finally reared and released with two credited with the immense success, the cochineal *Dactylopius tomentosus* and the more well know *Cactoblastis cactorum* moth. The scale of the release is most likely responsible for the success. Between 1927 and 1930, the board released close to 2 billion egg sticks (each with 50-100 eggs) of *C. cactorum* over an area of 450,000 sq km. Further releases continued until 1936 and over 1 billion egg sticks were also provided directly to landowners. By 1932, 6 years after the initial release, the moth had destroyed most of the major stands of prickly pear. In 10 years, land that had been deemed useless was almost back to normal productivity. This is a success that has not been replicated, and is unlikely to be repeated with current investment into biological control programs. It is predicted that the demise of the prickly pear in Australia owes its success to the close relationship between insects and yeast.

When cacti stems of some species are damaged, for example by the *Cactoblastis* moth, a community of organisms produce a long-lasting necrotic wound called a soft rot. At early stages, *Drosophila* flies (vinegar flies) and yeast dominate the rot and this plant-insect-yeast relationship, a relationship that is envisaged to be more than 50 million years old, has provided a principal model for ecological study.

Importantly, the yeast that inhabit the cactus soft rots show high specificity to this habitat, with very little overlap between

*Figure 3. Phil Ganter, a leading cactus yeast ecologist, with a large prickly pear cactus in a rural suburb north of Adelaide. Interestingly, while cacti in the Flinders Ranges appear to have a typical cactus yeast community, cacti rots closer to Adelaide were found to have a generalist yeast community, much more similar to that found on fruits.*

yeast that are isolated from the fruits and flowers of the same plant. The yeast influences many aspects of fly development and behaviour, including feeding, mating (female chooses mate according to number of yeast on mate's face) and oviposition (laying eggs on rot only when a certain yeast from rot is present). The *Drosophila* in turn are important in vectoring yeast to new sites; this is essential as unlike bacteria and other fungi, yeast are unable to move on their own.

Three cacti clades (clades are a group of organisms believed to comprise all the evolutionary descendants of a common ancestor) have been well studied at the microbial level. Each is chemically distinct and this significantly impacts the *Drosophila* and yeast community that use the host plant, and illustrates the importance of yeast in detoxifying cactus stem chemistry. For example, rots of the Organpipe cactus *(Stenocereus thurberi)* is a preferred substrate for *Drosophila mojavensis* larvae. However, compounds including lipids in the cacti are inhibitory to fly development; only in the presence of a specific yeast, *Didipodascus starmeri*, that can secrete lipases which break down lipids, is the fly able to resist the harmful compounds and utilise them as a sole carbon source. When *D. mojavensis* larvae develop on cacti that lack these toxic lipids, the presence of the yeast is not necessary.

Similarly, yeast of the species *Starmera amethionina* possess a single gene that **minimises** the effect of inhibitory chemicals in Organpipe cacti. Isolates of the same yeast species that grow on cacti without the inhibitory chemical appear to be genetically separated and do not possess the 'resistance' gene. Interestingly, *S. amethionina* isolated from Australian *Opuntia* are sensitive to the Organpipe inhibitory compound, but at the DNA level are much more similar to the resistant isolates from the Americas. Hence this yeast, although originating in Organpipe cacti, appears to have lost resistance since its transport to Australia.

**Leafcutter ant - fungi-bacteria association**

The cultivation of fungi by attine (fungus growing) ants is one of the best studied insect mutualisms (50-60 million years old) and has led to the identification of a complex interaction between insects and microbes. In this symbiosis, which is often described as the earliest example of farming, each ant species cultivates a particular species of fungus. Whilst adult ants feed on leaf sap, the fungus is the sole food source of the ant larvae. Moreover, the fungus is completely dependent on the ant for growth and distribution, as it no longer produces spores for dispersal. When cultivating, the ants collect leaves to feed the fungus and they prune and regulate temperate of the fungus garden.

As with any monoculture weeds are a problem and weed fungi compete with the crop. To combat this the ants like Australian gardeners are obsessive weed removers. If the ants are removed the farm will be overrun by weed fungi in a matter of days. But the ants are not solely dependent on physical means to keep the weeds at bay. They also possess chemical strategies. For this the ants have a mutualistic relationship with bacteria that grow on the ant cuticle. These bacteria produce peptides (short proteins) which act to kill the weed fungus but do not harm the crop fungus.

Over the past few years this amazing tripartite relationship has been shown to be even more complex with the demonstration that a number of other microorganisms, particularly yeast, are present on the fungus garden where a number of potential roles have been described. First, enzymes released by the yeast assist in the digestion of plant polysaccharides, making the nutrients in the leaves more accessible to the crop fungus. Preliminary results also indicate that these yeast can inhibit mycelial growth of the weed fungus as well as fungi that are direct pathogens of the ants.

The specificity of the above yeast-ant interactions have not been demonstrated and so their importance has been difficult to establish. There are however a group of yeast (black yeast) that, similar to the weed killing bacteria, inhabit the ant cuticle. (Figure 4a and 4b) These black yeast however, are antagonistic to the ant because they feed on the mutualistic bacteria. This in turn reduces the 'antiweed' peptide produced by the bacteria, encouraging the success of the weed fungus. Thus these complex interactions are likely to keep all populations in check. All these organisms are only found on these attine ants.

**Chemical signalling - yeast and pollination**

It is not unexpected that some yeast and insects have a remarkable association as many species from both groups rely

*Figure 4a). The common wine yeast Saccharomyces cerevisae. The panel on the left shows yeast undergoing normal asexual division by budding. The panel on the right shows yeast forming elongated 'shmoos', in preparation for sexual reproduction.*

*Figure 4b). A number of yeast cultures isolated from ants growing on agar medium. The darker colonies are examples of black yeast discussed in the text.*

on rich sources of sugar for survival. While some sugar sources, such as nectar, advertise their presence by colour and scent, finding most sugar sources in nature would be testing. Having yeast as a beacon to attract insects is not only useful for the insect but is essential for yeast to relocate to new food sources. The cactus system has been the most studied system for understanding the attraction between insects and yeast.

*Drosophila* that live in cacti are able to discriminate between yeast species for food, with each *Drosophila* species having unique preferences. The yeast *Pichia cactophila* which is the most common yeast isolated from cacti is the preferred food for *D. mojavensis* larvae. Preference however is not simply linked to availability – the same larvae ignore the second most common cactus yeast *Candida sonorensis*. It has been shown that the yeast diet affects growth and fecundity of *Drosophila*, with a mixed yeast diet being most beneficial. Moreover, yeast are exchanged between courting flies and the quality of the yeast can impact the mating success of male flies.

More recent studies have emphasised the potential importance of yeast in adding to the attraction of flowers for insect pollinators. Similar to cactus rots, nectar possess a very specific yeast community, frequently dominated by the yeast *Metschikowia reukaufii*.

While avoiding nectar colonised by bacteria, yeast species appear to attract insect pollinators to flowers and **increase** insect foraging time on each flower. This is expected as the ability of yeast to colonise new flowers is completely dependent on the pollinating insects. Nectar is a suitable yeast habitat, as the sugars and amino acids present in the nectar provide an important food source for growth, and for this reason extensive yeast growth on flowers alters the nectar chemistry. Importantly, while the volatiles produced by many yeast appear to attract insects, non-nectar specific yeast and bacteria appear to compromise insect survival by reducing nectar quality. Specific nectar yeast such as *M. reukaufii*, on the other hand, appear to cause no adverse effect on insect longevity and survival.

These results point to the importance of understanding microbial ecosystems. While many studies describe the impact of humans on plants and animals, few have studied the impact of humans on yeast. Preliminary cactus findings suggest that suburban cactus rots have a more generalist yeast community compared to less 'disturbed' plants with more specialised yeast community. It is thus important to consider that if the same is found in flowers of cultivated plants, the presence of more generalist yeast in gardens and fields may affect plant and animal success by decreasing the viability of pollinating insects.

**Conclusion**

It is hoped that the three systems described provide some awareness of the importance of insect-microbe interactions and intimate a special role for yeast. The significance of microorganisms has now been recognised in programs that use insects for biological control of invasive pest species. Long term studies have shown the striking decline in insect numbers and diversity over recent years and have forecast the impact that this will have on pollination, plant survival and ecosystems. It is envisioned that a deeper knowledge of the insect community microbiome is essential if we are going to halt this catastrophe.

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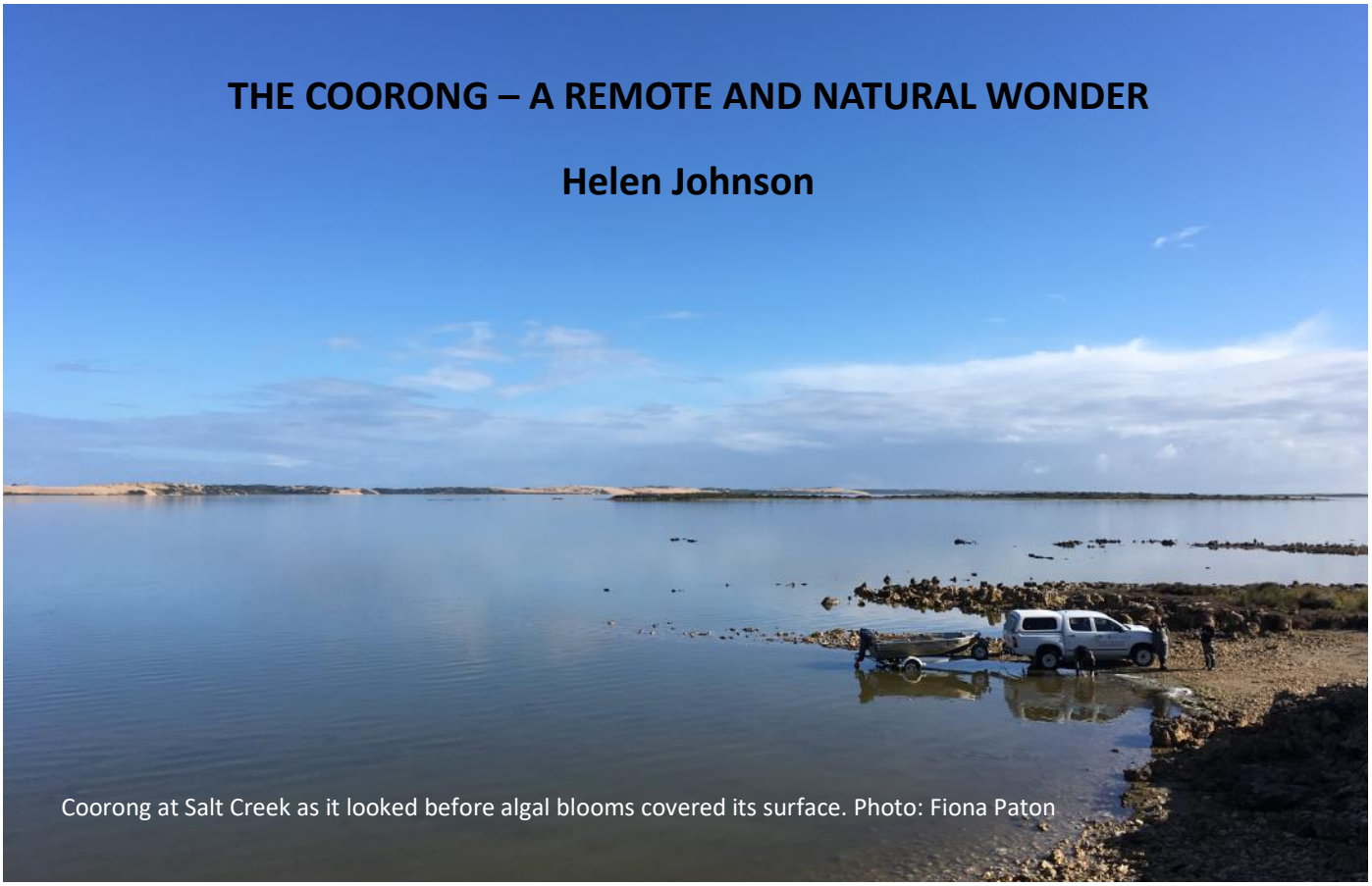
# THE COORONG – A REMOTE AND NATURAL WONDER

## Helen Johnson



Coorong at Salt Creek as it looked before algal blooms covered its surface. Photo: Fiona Paton

**Introduction**

The Coorong has a wildness and uniqueness that you cannot really appreciate by driving along the Meningie to Kingston road occasionally catching a glimpse of shimmering water. Even seeing the Coorong from a light plane does not give you a full sense of the treasure we have. However parts of the Coorong are not functioning as a viable ecosystem and the Ramsar Status as a Wetland of International Importance as a Habitat for Waterbirds may be under threat.

Over three summers beginning in 2010, I joined the University of Adelaide's annual summer Coorong survey collecting data on the number and behaviour of waterbirds and their food sources. The experiences of walking kilometres a day along the eastern shores counting birds; motoring slowly in a small boat doing bird counts along the western shore and around islands; dragging a seine net (usually in leaky waders) to capture fish; and doing benthic surveys along the shoreline has given me a strong connection to the Coorong. Associate Professor David Paton (University of Adelaide) has been surveying the Coorong for decades during summer.

The Coorong and Lower Lakes are extremely important havens for large concentrations of waterbirds (waterfowl, fish-eaters, resident waders, migratory waders) and threatened fish species. However the ecology of the Coorong is changing and bird numbers have been plummeting, especially in the southern region of the Coorong. Over much of the last decade (since 2010) low water levels, high salinities and, in recent years, algal blooms have been the causes of the change.

**Ecology of the Coorong**

Within the wider Australian community there seems to be very little understanding of the ecological importance of the Coorong. Dr Paton's seminal book "At the End of the River. The Coorong and Lower Lakes" is essential reading for those responsible for making decisions about **how much water flows down the river system** (Ref 1). In **2010**, David Paton wrote "the purpose of the book is to describe the ecology of the Coorong and document its changing ecological character" and to discuss "any notion that this is a dying wetland and thus not worth preserving and managing for its natural assets. The Coorong and Lower Lakes have changed dramatically in the last few years [up to 2010], but even in their current degraded state they remain the standout wetland system of the Murray-Darling Basin, still comfortably meeting the criteria of a Wetland of International Importance under the Ramsar Convention. They are neither dead nor dying, but they are changing and deteriorating". The Coorong and Lower Lakes were listed under the Ramsar Convention in 1985, and thus Australia has committed to conserve them through "wise use and management".

The Coorong is a long shallow coastal lagoon that runs south-east along the coast from the Murray River Estuary for about 110km. Parnka Point juts out from the mainland side narrowing the Coorong to around 100 m at The Narrows, dividing the Coorong in half into two lagoons, North and South. Elsewhere the water is much wider being around 4km at its widest in the South Lagoon. The Coorong is a mostly shallow body of water with maximum depths approaching 4m

in some years in a few places, but more commonly around 1m. In summer and autumn when water levels are lower extensive areas of mudflats covered by only a few centimetres of water provide important habitat for migratory wading sandpipers as well as endemic wading birds like stilts and avocets.

On the western side of the Coorong are the magnificent coastal dunes of the Younghusband Peninsula which separate the quiet Coorong waters from the breakers of the Southern Ocean. On the eastern/mainland side, mallee and sheoak woodland, coastal scrubs and grasslands support many terrestrial birds, mammals and reptiles.

The Coorong is ecologically different to other wetlands of the Murray-Darling Basin which have fresh and occasionally brackish water. The Coorong is a saltwater system with the South Lagoon typically ranging from 1.5 to 3 times saltier than seawater; a hyper-saline system. It is a **reverse estuary** with salinity levels increasing with distance from the Murray Mouth. Salinity levels also vary seasonally; lowest in early spring highest in early autumn.

Based on counts during the 1980's, the Coorong was ranked amongst the top 10 Australian sites for 6 migratory waders and 5 Australian waders. Over the summer, 2000-2009, 71 species of birds were counted in the Coorong (Ref 1).

Crested Tern, Fairy Tern, Caspian Tern, Silver Gull and the Australian Pelican breed on islands in the South Lagoon. The Coorong is a special place for pelicans as it has the only permanent breeding location in South Australia. It is also an important summer and drought refuge for many other Australian waterbird species that breed in fresh or brackish wetlands in other parts of Australia. These wetlands tend to dry out in summer and birds then shift to more permanent wetlands like the Coorong for summer and autumn. Amongst the abundant birds using the Coorong in summer but breeding elsewhere are Australasian Shelduck, Grey Teal, Hoary-headed Grebe and Whiskered Tern.

Migratory shorebirds that breed in the Palaearctic and fly 12,000 km along the East Asian-Australasian Flyway to southern Australia arrive at the Coorong and other parts of SE Australia from September onwards. Wading birds such as Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Common Greenshank and Pacific Golden Plover are just some of these migratory shorebirds that visit. Over about three months of summer the birds replace their feathers and then fatten up for the return journey to the Northern Hemisphere where they breed during our winter.

**Water flow in the Coorong**

With no water extraction for human use and no impediments such as barrages, weirs, and dams the annual long term average flow through the Murray Mouth over the 100 year period 1900-2000 was estimated by the Murray-Darling Basin Authority (MDBA) to be 12,000 GL per annum (GL/a). In the

Pelicans on the Coorong shore. Photo: Fiona Paton

1980s and 1990s as a result of extraction, less than half the water (4000-6000 GL/a) on average was reaching the Mouth and in the 2000s, the decade of the millennium drought, only 1000-2000 GL/a, on average. For a period of years in the latter part of that decade no water reached the Mouth at all (Ref 1). Dredging of the Murray Mouth was required for much of that decade and has continued for most years since.

Barrages built in the 1940's cut off the northern end of the Coorong and the Murray Estuary from Lake Alexandrina preventing seawater from entering the Lakes. During periods of low river flow, gates in the Barrages are closed to help maintain water levels in Lakes Alexandrina and Albert, but they can be opened when high flows arrive.

When water is released through the Barrages most goes out to sea with only a very small amount of those releases flowing into the Coorong. However, when sufficient water is released the water levels rise inside the Mouth. This water acts like a plug and prevents water from leaving the South Lagoon thus maintaining water levels in this Lagoon. Once the flows via the Barrages stop, water levels drop near the Mouth and within days, water from the southern Coorong moves northward no longer prevented from leaving and water levels in the South Lagoon quickly drop by around 0.3m. This drop now occurs regularly in spring, while with the extended flows prior to extraction the water levels in the southern Coorong would not have dropped until late summer.

**Coorong ecology with low water flows and high salinities**

The annual aquatic plant *Ruppia tuberosa* is a **key food resource** (seeds, turions and foliage) for ducks, swans and other waterfowl, as well as an **important habitat** for aquatic organisms (small-mouthed hardyhead fish, midge larvae (chironomids), and crustaceans (ostracods). These form the key food chains that support many of the birds using the southern Coorong.

*Ruppia tuberosa* grows best in the South Lagoon on shallow mudflats in waters that are 0.4 to 0.7m deep, flowering in

spring. When water levels drop in spring many of the plants dry out disrupting their capacity to reproduce. This has dire consequences for this essentially annual plant and all the other organisms that depend on it.

When water is not being released from Lake Alexandrina more marine water enters the Coorong. If the lack of freshwater flows continues for an extended period the Coorong becomes more saline particularly the southern Coorong. In the decade 2000-2009 the summer salinities in the South Lagoon gradually increased, and reached 4 to 5 times that of seawater in 2007, with winter salinities twice that of seawater. From 2006-2010 salt levels in the southern Coorong exceeded the salinity thresholds of the key aquatic organisms (chironomids and fish) in the South Lagoon and these organisms disappeared from this region and few if any aquatic plants were present. However the extremely high salinities allowed brine shrimps to prosper.

With the loss of key food resources abundances of waterbirds declined in the southern Coorong over the ten years to 2009-10 for 15 of the 22 species of waterbirds regularly counted. Banded Stilts, however, prospered as they thrive on brine shrimp. Even in the middle of the millennium drought there were nearly 250,000 banded stilts counted in the South Lagoon of the Coorong alone. In the years since the millennium drought (late 2010-2019), and with more regular but still truncated releases of freshwater over the barrages the typical key food resources started to re-establish in the southern Coorong, albeit taking one to two years or longer in the case of *Ruppia tuberosa*. With the resource base re-established many of the waterbirds excluded during the latter half of the millennium drought returned as well, but for many not to the same extent, with numbers fluctuating. Over the decades the birds have continued to decline.

In an ABC Background Briefing Report recorded April 2018 (updated 4 May 2018) Dr Paton said in the last two years, during the implementation of the Basin Plan, the numbers of the shorebirds which make this place so special have hit a record low ."If this was a healthy system, we would be typically getting 30-50,000 Red-necked Stints, 20-30,000 Sharp-tailed Sandpipers, and 5-10,000 Curlew Sandpiper... Last summer's bird count only registered 968 [of the critically endangered] Curlew Sandpiper … I think we've seen 10-20,000 [waders] in total in the Coorong in the last couple of years, and that's across all species, not just the few common ones" (Ref 2). However, excessive salinities and low flows were not the only perturbation driving change in the southern Lagoon.

**Consequences of releasing water drained from adjacent agricultural regions into the southern Coorong**

An extensive drainage scheme across the Upper South East of South Australia was established in 2000 to help solve dryland salinization and local flooding that was restricting agricultural production. This scheme drained this relatively freshwater into the hyper-saline southern Coorong but the water also carried nutrients.

When agricultural water enters the southern Coorong it freshens the water and changes the salinity gradient away from being a reverse estuary, which is not ideal. However, lowering the salinity and adding nutrients favour filamentous algal blooms. In the last three or four years, the southern Coorong has experienced massive algal blooms with the algae attaching to *Ruppia tuberosa*, filling the water column and even covering the surface. The algae attaches to the flower-heads of Ruppia and the extra drag catches on and rips them from the plant, preventing seed production (Ref 2). The algae also prevent chironomid larvae (immature midges) from hatching, dampening their abundances, reducing the food resources for shorebirds. But more significantly the algae makes it nearly impossible for shorebirds to be able wade through shallow water to secure the food they need and so effectively excludes them at a critical time in their annual cycle.

The situation is about to get a lot worse. The SA and Australian Governments' $60m South East Flows Restoration Project aims to provide salinity management in the southern Coorong; enhance flows to wetlands in the Upper South East; and reduce drainage outflow at Kingston Beach. This has involved building a 94 km drain with the aim to allow more water from agricultural land to enter the Coorong at Salt Creek (and into other wetlands along the route). The annual volume of water to flow into the Coorong is expected to be between 5 and 45.3 GL (median 26.5 GL) (Ref 3).

The SA Government really needs to reconsider releases of water drained from agriculture into the southern Coorong given the obvious consequences to the birds, and particularly so given its status as a Ramsar-listed wetland. . "The broad aims of the Ramsar Convention are to halt and where possible, reverse the worldwide loss of wetlands and to conserve those that remain through wise use and management" (Ref 1).

Algal bloom in the Southern Coorong. Photo: Fiona Paton

**What is needed to secure a healthy resilient Coorong**

The Murray Darling Basin Plan has a commitment to deliver 2,750 GL of water and if required a further 450 GL back to the river and the environment. This needs to be actual water back in the river and not some figure estimated or assumed to have been returned. If the modelling is correct then this should be sufficient to maintain water levels in the Lower Lakes and allow sufficient water to be released over the barrages to prevent the excessively high salinities that established during the millennium drought from re-establishing in the Coorong. Fail to deliver that water and the Coorong's ecology is challenged. But equally if the water is delivered as promised then the modelling suggests that releases of water into southern Coorong should not be needed for salinity management, so why are we releasing water at Salt Creek? The challenge now facing South Australia is how to remove the nutrients and the algae from the southern Coorong and in a timely fashion to allow the food resources and birds to recover. This is not an easy task nor will this alone return the southern Coorong to a healthy state, since the return of even 3,200 GL to the river will be insufficient to prevent water levels falling in spring in most years in the southern Coorong. The maintenance of adequate water levels over spring is critical if vigorous populations of *Ruppia tuberosa* are to be secured and sustained. The well-being of the Coorong and Lower Lakes and its status as a wetland of international significance is now management dependent and needs innovative solutions. Governments need to step up, invest in science and use that knowledge to manage it wisely.

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Acknowledgement: The author wishes to thank Dr David Paton for his valuable assistance in the preparation of this article.

Younghusband Peninsula from the Coorong

# THE MURRAY-DARLING BASIN

## BOB NEWMAN HEALTHY RIVERS AMBASSADOR

### *Exploitation to ecological realisation and perhaps recovery?*


Fig 1. Murray-Darling Basin Map (source MDBA)

**Where to start?**

By 1890 the river ports of Bourke and Wilcannia, Menindee and Wentworth were amongst the busiest ports in Australia. It was around that time that the Chaffey brothers attempted large scale irrigation in Mildura but being regarded by the Victorian Parliament as "cute Yankee land grabbers" moved on to Renmark.

Sharing the waters of the Murray became an important driver for federation; droughts had already impacted on shipping transport. A Royal Commission was held and The River Murray Waters Agreement was in place by 1914. This provided for water sharing rules and the construction of Hume Dam on the Murray at Albury together with 26 weirs, locks and barrages for navigation. That's why they are called 'Locks'!

**River Murray Waters Agreement**

The 'Agreement' confirmed that water abstraction rights belong to the States in which the in-flows originate but importantly provided for a guaranteed supply to South Australia sufficient to meet demands, and maintain a flow to the sea in all but extreme droughts (SA Entitlement). The 1969 decision to construct Dartmouth Dam in lieu of the proposed Chowilla Dam provided for an increase in the SA entitlement from 1,550 GL/a to 1,850 GL/a. *(A story for another time!)* Nevertheless, SA kept to its moratorium on new irrigation allocations which had been declared in 1967. Allocations to SA urban users and country towns continued to increase. In past years Adelaide has been 95% dependant on the Murray. The Adelaide desalinisation plant has provided increased security (an expensive insurance policy), but as yet it has not changed Adelaide's allowance from the Murray. An extensive network of pipelines across SA was initiated in the Playford era. It was expanded with the Murray Bridge- Onkaparinga 66" pipeline to Adelaide being completed in the '70s.

**River Operations Infrastructure**

Following Hume Dam, the River Murray Commission increased tri-state storage by 'capturing' Lake Victoria, raising the banks around the Menindee Lakes (near Broken Hill) and later building Dartmouth Dam (in the Victorian Highland above Lake Hume). The operation


Fig 2. Sir Ronald East astride the Murray at Nyah in 1923


Fig 3. Murray Mouth open in 1981 after a flood.

of these facilities is a joint enterprise. Salinity control infrastructure was added after 1989. The management of these resources, the ownership of the structures and the employment of field staff remained State responsibilities under the individual jurisdiction's laws.

In 1981, the Murray Mouth closed for the first time in recorded history. Fortunately a flood came along and re-opened it until it closed again in 2000. Dredging has now become commonplace and has involved many $millions. Another notable emergency occurred in 1996 when the Hume dam wall 'moved'. The decision was made to drop the water storage level by one third. It never recovered before the millennium drought. Lake Victoria operations have been affected by the acknowledgement of its aboriginal history.

There are many other State controlled dams and regulating structures throughout the Basin.

**Irrigation**

Navigation had given way to rail, so irrigation became the main purpose for the river control structures and the number of weirs was cut back during the 1930s depression. The irrigation industry has had a chequered history. Many of the schemes were originated by governments as social ventures. Soldiers returning from the world wars were granted small parcels of land, generally sufficient for one family and one horse. Other early schemes included cultural or religious communities. Supply infrastructure was provided, mostly by gravity open channels, while community pumps were used in situations like the SA Riverland due to the incised topography of the river channel. Irrigation farmers were locked into crops such as the dairies, the early wine industry, dried and canned fruits and these sometimes failed through diseases such as phylloxera and market failures. Governments came to the rescue often, but not always.

The early soldier settlement 'irrigation farmers' generally had poor skills, but agricultural research and advisory facilities were on offer. The selection of crops and irrigation systems was strongly 'directed'. Flood irrigation was the only practical method until farm scale pumps and overhead sprinklers became available. Rostered water supplies constrained efficient water management until rehabilitated irrigation systems provided for 'water on order' at short notice. Water use efficiency was very poor, often less than 50%. It was only with access to systems of plastic drippers and high tech moisture measuring equipment that efficiencies became 'respectable'. Poor irrigation efficiencies had lead to damaging salt mobilisation. Irrigated land was being lost to rising water tables. Irrigation drainage schemes were constructed throughout the Basin to reduce water-logging; most extensively throughout northern Victoria. Irrigation induced accessions to the regional groundwater were devastating the floodplains and increasing saline accessions to the river itself.

**Water Reform: Salinity, Algal Blooms, the Cap on Diversions, Water Trading, The Living Murray, Healthy Rivers Audit**

Downstream of Swan Hill, the Murray Basin overlies highly saline groundwater regimes. High in-stream salinity concentrations became commonplace causing damage to crops and urban facilities. South Australia began to construct salinity control schemes to divert salt away from the river to remote evaporation basins (the Noora scheme). At the same

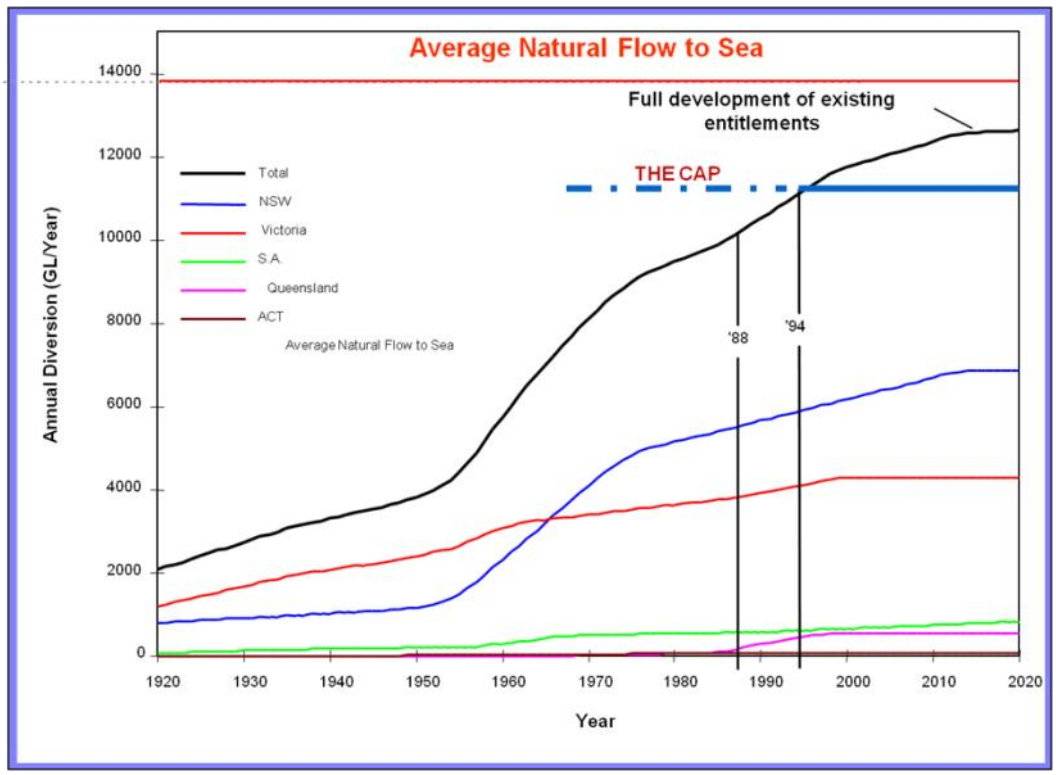



Fig 4. The Diversion CAP Murray Darling Basin Commission 1997

time the Victorian and NSW drainage schemes continued to discharge directly to the river; as did many schemes in SA! Ultimately, this nonsense led to the 1989 Salinity & Drainage Strategy. *(S&DS - Another story for another time!)*

Until 1985 the Southern Basin rivers were managed by the River Murray Commission, involving the three southern States and the Commonwealth. However, an environmental condition review, together with the negotiations around the S&DS, led to the formation of the first Murray-Darling Basin Ministerial Council and M-DB Commission. Now there were six governments involved including ACT and Queensland (perhaps reluctantly?). Ministers were directly at the table instead of just public servants. The notion of a connected Basin became widely accepted. Basin scale maps became a norm rather than maps that stopped at state boundaries. The bureaucracy became complex but not really cumbersome.

Interestingly, the six governments were able to make important decisions in relation to water management, albeit perhaps somewhat piecemeal. The issue of over-allocation, pollution and water use efficiency were on the agenda. Prime Minister Bob Hawke had declared the 'Decade of Landcare' in 1989. That was the first time that environmental investments involved budgets in the '$billions'! Water reform became the name of the game (CoAG 1994).

The 1991 1,000km algal bloom along the Darling River led to the Algal Management Strategy. Irrigation had expanded to around 1,000,000ha and the 1995 audit of water consumption indicated diversions were reaching 75% of the annual net flow to the sea and increasing at 1% per year! This realisation led to the 1997 CAP on 'diversions'. The Diversion Cap decision triggered expanded water trading rules with the first inter-state water trading trial initiated in 1998. Water rights rapidly became a tradeable commodity. But it wasn't just the rivers that were at risk; Integrated Catchment Management became the way forward in 2000. The basin-wide Salinity Audit (1999) raised the concern that dryland salinisation could expand dramatically influencing in-stream salinity. The Salinity and Drainage Strategy was extended to become the Basin Salinity Management Strategy in 2001.

A first step in water recovery came with The Living Murray 500GL/a buy-back and complementary works (2003). The National Water Initiative (2004) provided for much needed independent science. The Healthy Rivers Audit provided baseline conditions for the ecological systems across the Basin. Those early water reform decisions were generally hard won, but not too contentious and were widely supported. Technically, they involved complex analyses to actually confirm any baseline assumptions.

**Drought: The Feds to the Rescue: The Water Act 2007 and the Basin Plan 2012**

However the 'millennium drought' which had started around 1996 was biting hard. By 2006 the inflows to the basin had hit an all-time low. There was not enough water to maintain flow and the Lower Lakes began to drop below sea level. Prime Minister John Howard called for federal intervention and passed the 2007 Water Act calling for a Basin Plan. The Murray-Darling Basin Commission became the Basin Authority. However, many of the responsibilities remained in State's hands. The Water Act forces the recalcitrant States to prepare catchment scale water management plans. Negotiations, mostly behind closed doors, took until 2011 when the guide to the plan was released. All hell broke loose in the NSW Riverina! The plan was publicly burnt and a media campaign was started. Scientists had claimed that a reduction in 'long term take' of 4,000 to 7,000 GL/a would be necessary to restore the Basin's river to health.

Nevertheless, the political process was able to reinterpret the science. The agreed Plan provided for 3,200 GL/a water recovery. Albeit that the last 450GL/a recovery demanded by SA would be subject to further justification and review. A so-called 'science based plan' with some obscure ecological targets.

The Plan is actually an Act of Parliament (https://www.legislation.gov.au/Series/F2012L02240 ) and being written in legal language can be hard to interpret by the lay person. There is practically no statement, paragraph or sentence that does not refer the reader to some other part of the document. Getting to grips with the Plan is daunting! Most importantly those rules that reduce the level of water recovery needed to achieve the Sustainable Diversion Limits (SDLs) for each valley or catchment. Note the Basin Plan also provides for limits on groundwater extraction which are not discussed here *(Yet another story for another time!)*

The SDLs relate to the Baseline Diversion Limits (BDLs) which are the long run modelled diversion history under the level of development current at 2009. The hydrologic models are supposedly based on a 114 year scenario from 1896 to 2009. However the validity of such models is very dependent upon the availability of data, for both flow and diversions and the rules. The Southern basin is quite data rich and the models have been developed over decades. However, in the Northern Basin the data is very scarce and the rivers are more complex.

**ABC 4 Corners Investigation July 2017 – "Pumped"**

https://www.abc.net.au/news/2017-07-24/murray-darling-basin-water-pumped-by-irrigators/8732702

Alarm Bells regarding the effectiveness of the Plan were raised dramatically by the ABC. Evidence of water theft and underhand government dealing was revealed during a drought in the Northern Basin. Casual observers began to realise that the Plan was not what we had thought. Questions arose as to whether the Plan was flawed. Have a look at the video. Other media outlets began to take up the story. In particular, the Guardian provided some good visual coverage which is still available. https://www.theguardian.com/environment/ng-interactive/2018/apr/05/murray-darling-when-the-river-runs-dry

Later, South Australia initiated a Royal Commission. The NSW Government and the MDBA responded by dramatically beefing up the compliance regime. There is now much more transparency from the MDBA with press releases coming weekly. Previously communication had been through the release of massive complex scientific style reports.

**Sustainable Diversion Limit Adjustments:**

Now, there is some debate about whether the Plan is for a 3,200 GL/a reduction in surface water take, or 2,750 or some other number! That depends upon whether your understanding comes from reading the actual Plan or media around it and where you accessed that media. So, here in SA we lay people thought we had a 3,200 GL/a plan and whilst we might have wished for better we relaxed! Whereas, if you speak to someone much further upstream, eg in Shepparton, they might perceive the Plan as being 2,000GL/a reduction.

How can that be? Well it comes down to the 'adjustments' that were incorporated in the Plan. If actions can be envisaged which achieve the same ecological outcomes with less water, then the required recovery volumes can be reduced. That's referred to as 'Down Water'. That's all very sensible isn't it? But, how confident are we that the proposed actions will achieve these ecologically equivalent outcomes?

Overall there are some 39 individual projects that have been put forward by the States to achieve a 70 GL/a reduction in the Northern basin and 605 GL/a reduction in the Southern Basin (Down Water). On top of that, the 450 GL/a required to get to the 3,200 can only be delivered by water savings initiatives rather than buy backs. That's referred to as 'Up Water'. A recent decision of the Ministerial Council set "a zero social or economic impact on upstream communities" clause on the water savings initiatives that will practically exclude delivering that outcome.

The Plan allows for the Down Water adjustments to be made with very little information about whether those projects can actually deliver the stated outcomes or have been committed. That matter became political in November 2017 when the Northern Basin Review was released for public consultation. Initially the Greens succeeded in having that adjustment disallowed in parliament with the support of Labor. However, ultimately after some side deal negotiations both the Down Water adjustments passed into law. So we now have a 2,075 GL/a water recovery plan. The question arises 'will the environmental equivalence from these tradeoffs be delivered'?

The upstream States began talking of abandoning the Plan.

**SA Royal Commission and the Productivity Commission**

**https://www.mdbrc.sa.gov.au/sites/default/files/murray-darling-basin-royal-commission-report.pdf?v=1548898371**

**https://www.pc.gov.au/inquiries/completed/basin-plan/report/basin-plan-overview.pdf**

The Wetherill Labor Government initiated a Royal Commission but then lost Government. The Commissioner was hampered by the early lack of cooperation from the federal government. Nevertheless, many independent scientists and observers came forward. The report was released in February 2019 and has been mostly disregarded at the federal level. It questioned the legality of the Plan itself and made 44 detailed recommendations. Concern around the extent to which communities are actually being affected by the Plan versus the affects of drought and commodity market circumstances were raised.

As we approach an election the M-DB issues are becoming critical. The recent Darling River fish kills have caused alarm. Independent reports have acknowledged the Northern Basin drought but also laid blame of the increased interception of floodplain inflows in Northern NSW and Southern Queensland. Some notice is being taken and Labor Policy speaks of rescinding the cap on buy-backs, changing compliance responsibilities and making socio-economic test less stringent. The Liberals are suggesting that that could put the whole plan at risk. The minor parties are raising broader concerns around climate change and implications for communities.

The Plan is subject to routine five-yearly impartial performance reviews. Initially this was assigned to the National Water Commission but that was disbanded by the incoming Abbott Government in 2012. The Productivity Commission (PC) was given the task. It is known for providing forthright advice to Governments. Given the heat of debate at the time, the PC undertook a thorough consultation resulting in severe criticisms of the process. The report (February 2019) made many important recommendations with an emphasis on compliance, roles and responsibilities, transparency and resourcing.

**What Next? Restore the Rigour!**

The Basin Plan remains a well funded and courageous public policy initiative, despite many observers being disappointed. We must face the realisation that the Plan will be unlikely to deliver the outcomes that we would have liked. Nevertheless, abandoning the Plan would be a disaster. It is promoted as an adaptive Plan, albeit enshrined in complex law. No doubt the Plan and its implementation can be honed through careful scrutiny of its many components.

I would urge the Adelaide community to maintain a strong interest in how the Plan is implemented.

A small Adelaide group of 'Concerned Citizens for the Murray-Darling Basin' has formed and is sharing information.

Contact Bob.Newman@McCloudHouse.com.au for further details.

# IKARA-FLINDERS EXPEDITION – STUDENT REPORT
## Tamika Nash-Hahn

Lately I've been one to make rash decisions. An attitude of 'why not?' has tempted me. An opportunity arose to jet off to Fiji for a month with a group of strangers and work with a social enterprise. I gobbled it up and a couple weeks later I left. Upon my return and the resurrection of my travel bug, I saw a post for SEG. Once again I decided 'Why not? How else would I fill my university holidays? Plus, I've never seen the Flinders'. Boy, am I glad for rash decision making!

At first I was a little concerned with the fact that a large proportion of the other participants were older than my grandparents. However, I soon realised I was more like these folk than those of my own age! I soon felt like I had 30 grandparents ensuring I was drinking water, sleeping well and scolding me for not wearing a hat. I initially embarked upon SEG to learn more about ecology and our red centre. This was certainly achieved! However, I learnt so much more and had a blast doing so!

Many, many myths were busted. I discovered life does not end at 40. Seeing the hard work, the laughter and the love everyone shared was truly breathtaking. Whilst this may seem obvious to some, it was not to me. All the adults who I've known growing up have not had this amount of life in them. Maybe there is something they need to ignite them, as the environment does for those who I spent time with at Oraparinna. Maybe in fact our retirement years are the best ones?

I really connected with people through our shared passion for learning. As Andrew shared with me, 'I've never stopped being a student'. As I heard this, I looked around. My roommate Helen stood papers in hand attentively listening to Garry describing the geology of the ground beneath our feet. Others sat flicking through pages attempting to locate the plants, reptiles or birds they'd seen earlier that day.

Being a country girl at heart, I loved the practical aspect that this SEG experience provided. It is great learning the content at uni, but it is not until you are out in the field sweating, after digging a million pitfalls, that you truly appreciate the content. Secretly, I loved digging the holes. I will admit I had it easy, working on digging out the lines and then disappearing to look for lizards.

I discovered that I am extremely interested in reptiles, and in particular lizards. I was reminded of my early childhood where I spent every evening after school searching under rocks and up in trees for geckos. It is quite interesting that your passions, as you grow up, stem from something that you enjoyed at a very young age.

As a student studying advanced science, I can choose my major and the majority of my electives. This SEG experience has confirmed that ecology is the path that I really desire to take. So many people take nature for granted and don't truly appreciate the importance of our green world. In whatever career I do end up in, I really hope that I can achieve what I believe is my calling; helping others appreciate nature. Current predictions of the future of our world are all doom and gloom: as the Lorax once said, 'unless someone like you cares a whole awful lot, nothing is going to get better'. I hope that all of us can continue to spread the importance of looking after our world and do our bit.

I thank you all for the amazing memories we made. I look forward to seeing you all again. I'm always looking for opportunities to learn and to get out there, so if you hear of any experiences (or want someone to take your pet snake or lizard for a walk), feel free to flick me an email.

a1741135@student.adelaide.edu.au

Tamika with a skink

Helen and Tamika bagging a skink

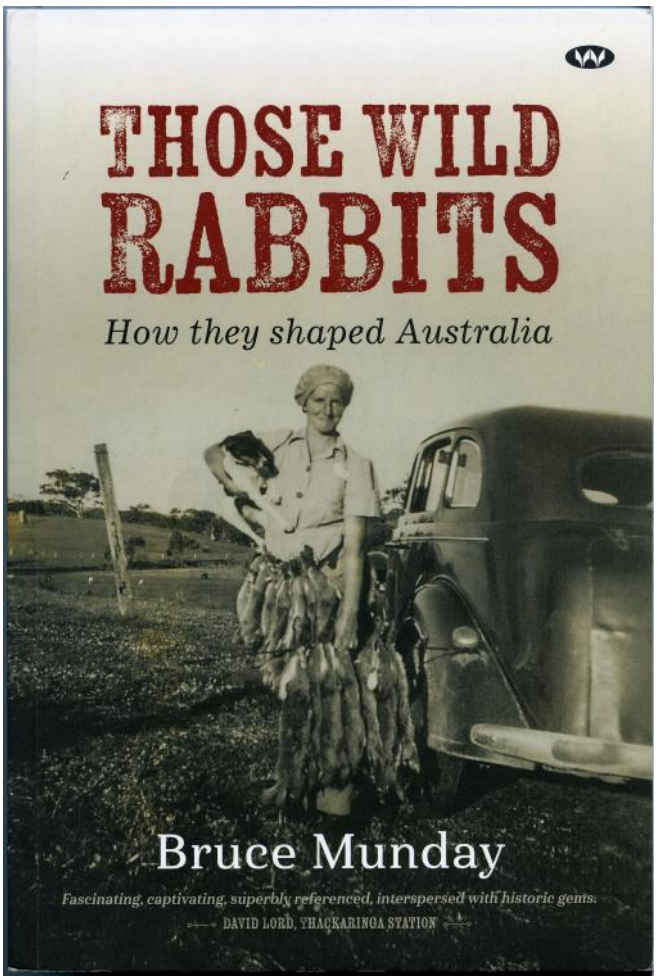
# BOOK REVIEW

***Those Wild Rabbits. How They Shaped Australia*. By Bruce Munday.**

**Reviewed by John Love**

*Those Wild Rabbits. How They Shaped Australia*. By Bruce Munday. (Adelaide, Wakefield Press, 2017)

The State Library of South Australia on-line catalogue has 197 entries under the subject heading 'rabbits'. (The catalogue says so – I did not count them!) Included are papers by Robert Henzell and Brendan Lay, known to some SEG members. Bruce Munday has set out to produce a comprehensive history of rabbits in Australia. He has obviously spent many hours accumulating a large amount of interesting information. Here are some examples.




Rabbits came with the first settlers in the eighteenth century, along with other European animals and plants. The man most commonly blamed for the rabbit problem is Thomas Austin, who turned them loose on his property, with hares and partridges, in 1859. Austin killed eagles, hawks, quolls and cats to protect his rabbits. Within ten years graziers were trying to get rid of them. In the 1870s colonial governments became involved, loading responsibility for control on local government councils. In the 1890s Western Australia and Queensland believed they were safe and began making protective fences - too late: the rabbits bypassed them before the fences were complete. Methods of control included poison, fumigation, digging, wire netting, stone walls and ripping warrens, while some bizarre methods were proposed.

On the other hand, a significant industry grew up, supplying meat, skins, fur for felt, pig food; with related industries making netting, machinery and chemicals, and exporting canned and chilled meat.

Biological control was considered as early as 1885, even attracting the attention of Louis Pasteur, but the risk of infecting other animals was considered unacceptable. Research on myxomatosis in the 1930s included field trials on Wardang Island, South Australia. Its release in 1951 led some to believe that here was a miracle solution to the problem, while scientists warned that its effectiveness would decline. Calici virus controversially escaped from Wardang Island before scientists were ready to release it. Munday favours the theory that the escape was caused by infected insects being blown to the mainland by strong winds.

A recurring theme in the book is the paralysing effect of conflicting interests and opinions. Munday blames responsible people in earlier times for not seizing opportunities presented by severe droughts to exterminate the pests while their numbers were low. He does not point out that extermination was no more possible then than now. It only needs a few escapees to begin the resurgence of one of the most fecund animal species on earth. The last two chapters elaborate on present conflicts, which are more complex than ever.

Historical research inevitably turns up snippets of information, interesting, amusing, quirky, more or less relevant but not essential. Munday could not resist putting them in, the text set on a grey background, distinguishing them from the main body of the book. The grey pages pop up here and there, sometimes annoyingly in the middle of a sentence. This reviewer suggests reading a chapter right through, ignoring the grey pages, and then going back to them.

The author's style is informal and fluent but inclined to be rather wordy, even repetitious, going back over ground already covered. So the impact of the story is softened somewhat by the flow of words. However, the book is well worth reading, containing masses of information, reflections on human behaviour and praise for the scientists and others who spend so much of their lives in the never-ending struggle to control one of our worst animal pests.

John Love.

# GLUEPOT WINS AWARD

## DUNCAN MACKENZIE

Successful partnerships have always been one of the key elements in the operation of both SEG and Gluepot Reserve.

Members of both organisations are represented on each others management committees, and have been for a number of years. Back in the year 2000, SEG ran one of it's most successful expeditions on Gluepot, and 64 SEG members over a two week period conducted a myriad of biodiversity studies, surveys and established monitoring areas that are still utilised today across the 54,000 hectare reserve.

Just like SEG, Gluepot is managed and operated entirely by volunteers who have carefully structured and developed the Reserve into a land management model that is recognised as a world leader. Many SEG members have had a vital hand in this development.

The Reserve has been recognised by a wide variety of organisations for its work in the fields of the environment, conservation, scientific research and monitoring, climate change, ecotourism, health and the built environment. Gluepot is the recipient of 47 awards in these categories.

At the recent National Landcare Awards held in Brisbane, Gluepot was the winner (from 9 nine finalists) of the "Fairfax Landcare Community Group Award"'

At the same time in South Australia, Gluepot was a finalist in the "Premier's Climate Change Council – 2018 SA Climate Leaders Awards" in the 'Community' category.

Gluepot is one of the most highly accredited environmental organisations in Australia and was instrumental in helping develop the Ecotourism Australia 'Climate Action' accreditation.

dmackenzie@iname.com

Checking a pitfall line during the 2000 SEG expedition to Gluepot

## MINNAWARRA BIODIVERSITY SURVEY DATES FOR 2019

**Wednesday 24th to Sunday 28th April 2019, in the last week of school and uni holidays.**

**Saturday 28th September to Wednesday 2nd October 2019, in the first week of school holidays, and the last week of uni holidays.**

Come for half a day, one day or several days.
Minnawarra is situated on the southern Fleurieu Peninsula

For further information and registration forms, contact:
Janet Furler on 0419 842 667 or thefurlers@gmail.com
Richard Willing on 0408 807 517 or rwilling01@gmail.com

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**SOME OF THE ATTENDEES ON THE IKARA– FLINDERS RANGES EXPEDITION**

Back row left to right. Bob Sharrad, Brian Swann, Justin Jay, Tamika Nash-Hahn, Joel Schiller, Paul Rogers, Jeanette Ralston, Rick Porter, Andrew Barr, Jess Swann, Bob Vincent, Russell Porter.
Front row, left to right. Anette Vincent, Carolyn Bishop, Trent Porter, John Love, Kevin Burrett, Helen Johnson, Jill Tugwell