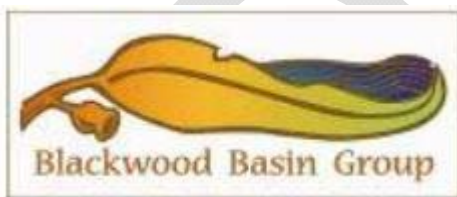


Aquatic fauna of Schwenke's Dam: a rehabilitated mine lake in Greenbushes



Report to:

Blackwood Basin Group



Freshwater Fish Group &
Fish Health Unit

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November 2014



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Front cover photos: (top) Riparian vegetation within Schwenke's Dam, (bottom) Upper Schwenke's Dam.

Executive Summary

The freshwater fishes of south-western Australia are highly endemic (>82%) to the region. Most species have been severely impacted by habitat and water quality decline and introduced species. Freshwater fish and crayfish play important roles in aquatic ecosystems and are useful indicators of the ecological health. In designing and implementing robust ecological management and monitoring programs of aquatic ecosystems, it is important to have a sound understanding of the prevailing aquatic fauna; particularly the resident fish communities. Schwenke's Dam is a historical mining pit located in Greenbushes, ~75km south of Bunbury, Western Australia. The Bittern and Waterbird Biodiversity Enhancement Project aims to create a wetland haven to attract critically endangered waterbirds to inhabit the site. Fishes are an important food source for Bitterns and other waterbirds and would play an important role in attracting them to and sustaining them at a waterbody.

Little was known of the freshwater fishes that occupied the inundated mine pits around Greenbushes, including Schwenke's Dam that maintains a relatively constant water level relative to lotic systems in the region. The current study therefore aimed to provide a comprehensive assessment of the fish and crayfish community of Schwenke's Dam in order to provide important baseline ecological information that would complement other water quality and macroinvertebrate datasets upon which future condition of the Dam may be assessed. It also aimed to provide recommendations on future monitoring that should occur in Schwenke's Dam and others in the Greenbushes area to better assess and monitor their ecological condition, and recommend actions that could be taken to enhance freshwater fish populations in these systems to provide an ecological in terms of Bittern and waterbird biodiversity enhancement.

The ecological survey occurred in October 2014 and employed several different sampling techniques to ensure the full suite of species present was detected. These included fyke netting, gill netting and underwater visual observations throughout the dam.

The survey resulted in one introduced fish, two native fish, two native crayfish, one native shrimp and turtle being recorded from Schwenke's Dam. A total of 1661 fish were captured with the majority being the introduced North American species Eastern Gambusia *Gambusia holbrooki* (previously known as Mosquitofish). The Western Minnow *Galaxias occidentalis* and Western Pygmy Perch *Nannoperca vittata* were also captured but in much lower numbers. The vast majority of Eastern Gambusia and Western Pygmy Perch were recorded in the shallow edges of the dam; probably as a result of the vast beds of macroalgae, and rehabilitated riparian vegetation which they used for cover. The Western Minnow, however, was observed and captured in larger numbers in open water. The Freshwater Shrimp *Palaemonetes australis* made up the vast majority of the 3356 decapods captured, however, the Smooth Marron *Cherax cainii* and Koonac *Cherax preissii* were also captured/observed in reasonable numbers.

The Eastern Gambusia is highly aggressive towards native species of fish. Aside from complete drying of the dam, elimination of Eastern Gambusia would be unlikely. In this situation the best approach for controlling the impacts of this species on native fish would be to maintain and improve habitats of macroalgae, and aquatic vegetation and riparian vegetation to provide continuing cover that was obviously highly beneficial to the native fishes.

Most physicochemical variables of Schwenke's Dam were within the recently established fieldbased tolerance levels of the widespread native fish found within the dam.

Recommendations (see page 18 for expanded recommendations)

1. Survey other remnant inundated mine pits within the Greenbushes to provide a comprehensive baseline ecological dataset of the fish and crayfish in all key reservoirs in the vicinity of Greenbushes. Determining the spatial distribution of all native and introduced aquatic species in the Greenbushes area is crucial prior to any connecting of the water bodies taking place
2. Continue with rehabilitation activities, including ongoing riparian and aquatic re-vegetation around the edges of the lake to serve as cover and provide important breeding habitat.
3. Implement a cost-effective, biennial monitoring program (involving the community) of the waterbodies to detect introductions early to maximise chances of control or eradication.
4. Ongoing education of the Blackwood Basin community should occur regarding the conservation and ecological importance of native freshwater fishes and crayfishes. This will aid in monitoring through 'Citizen Science' and future conservation efforts.



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Background

The Greenbushes Mine, located in Greenbushes 75 km south of Bunbury, is situated on one of the oldest mining tenements in Western Australia and has a long history of mining activities dating back to 1888. The inundation of past open cut mines has created some 24 water bodies varying in size from one to 20 hectares. Schwenke's Dam is one of the former mining pits and is located on Spring Gully Rd. The Blackwood Basin Group (BBG) has been successful in attaining a grant for the Bittern and Waterbird Biodiversity Enhancement Project that aims to create a wetland haven at Schwenke's Dam to attract critically endangered waterbirds to the site.

The freshwater fishes of south-western Australia are highly endemic (>82%) and are therefore of broad conservation value, however, they have been severely impacted by habitat and water quality decline (Morgan *et al.* 2011; Beatty *et al.* 2014b). Freshwater fishes play important roles in aquatic ecosystems and, in conjunction with other groups such as macroinvertebrates, are useful indicators of ecological health. Furthermore, the fishes and crayfishes of south-western Australia form part of Bittern diets (Marchant & Higgins 1990). Therefore, freshwater fishes and crayfishes would play an important role in successfully attracting Bitterns and other waterbirds to the site.

There has been a marked increase (~44%) in introduced fishes in freshwater systems of south-western Australian in the past decade (Beatty & Morgan 2013). This rapid increase necessitates ongoing monitoring in order to maximise the probability of controlling or eradicating populations of alien species at the earliest opportunity before they become self-sustaining. Education of the community on the impacts of introducing fishes is also extremely important to help prevent additional introductions.

Anecdotally there is believed to be at least one introduced fish (Redfin Perch *Perca fluviatilis*) in the Greenbushes mine pits; however, intensive fish surveys have not yet been conducted in the area, including in Schwenke's Dam. Given the recent influx of introduced species in south-western Australia, there is a need to conduct a comprehensive survey of the native and introduced fishes and freshwater crayfish fauna in Schwenke's Dam to provide a robust baseline to quantify the current ecological condition of the water body and to help guide its rehabilitation and ongoing management.

Aims of the study

The current study aimed to assess the fish communities of Schwenke's Dam in order to provide baseline ecological information (to complement existing water quality and macroinvertebrate datasets) which can be used to compare against the condition of the dam over time. It also aimed to provide recommendations for improving the ecological condition of Schwenke's Dam, and to outline steps that could be taken to enhance freshwater fish populations in the area; thereby helping to attract critically endangered waterbirds to the site.

The specific aims of this study were to:

1. Determine the aquatic macrofauna (freshwater fishes, crayfishes and mussels) within Schwenke's Dam including native and introduced species.
2. Identify possible control options for any non-native species detected.
3. Broadly identify habitat types associated with resident native and introduced species and identify any habitat enhancement approaches that may improve native fish populations.
4. Provide recommendations for future monitoring and management that could occur to enhance the ecological value of Schwenke's Dam and others around Greenbushes.

Methods

Fish and crayfish communities

Sampling for aquatic macrofauna in Schwenke's Dam occurred in late October 2014 and involved the use of six fyke nets (set for ~16 h to capture the dawn, dusk and nocturnal movement periods of aquatic fauna) (Figure 1). Two types of fyke nets were employed, one net was 11.2 m total width, including two 5 m wings, one 1.2 m wide mouth, a depth of 0.8 m and a length of 5 m, all comprised of 2 mm woven mesh, that was set to fish the entire water column, while the second net was a floating fyke net of 40.8 m total width, including two 20 m wings, one 0.8 m wide mouth, a depth of 0.55 m and a length of 5 m, all comprised of 2 mm woven mesh (Figure 1). As per standard procedure, air hatches were provided within each net to ensure survival of any potential air-breathing animal by-catch (Figure 2).

Three 30 m gill nets (one 1.4 m deep with a stretched mesh size of 50 mm and two that were 1.8 m deep with a stretched mesh size of 75 mm) were deployed in three locations throughout the lake (Figure 1). To minimise the potential for death and injury of aquatic fauna, nets were monitored constantly and checked regularly. Catch per unit effort (CPUE), measured as the number of fish/metre of net/hour, was determined for each species. All aquatic macrofauna captured using these sampling techniques were identified to species (see Morgan *et al.* 2011) and sub-samples of each species were measured to the nearest 1 mm total length (TL, for fishes), orbital carapace length (OCL, for freshwater crayfishes), or carapace length (i.e. shell length) for turtles. Introduced species were euthanased in accordance with Murdoch University's Animal Ethics protocols.

In order to provide estimates of species abundances and densities and to gather additional qualitative data on the presence/absence of more sedentary species, an underwater visual survey was undertaken. This involved a SCUBA diver swimming slowly (~1 km/hr), just above the substrate for a distance of 300 m recording abundances of species to a distance of 2 m each side (i.e. total area of 1200 m²). Finally, a nocturnal visual observational survey was conducted that



involved three persons intensively observing an unbaited area for 30 minutes and recording species abundances.

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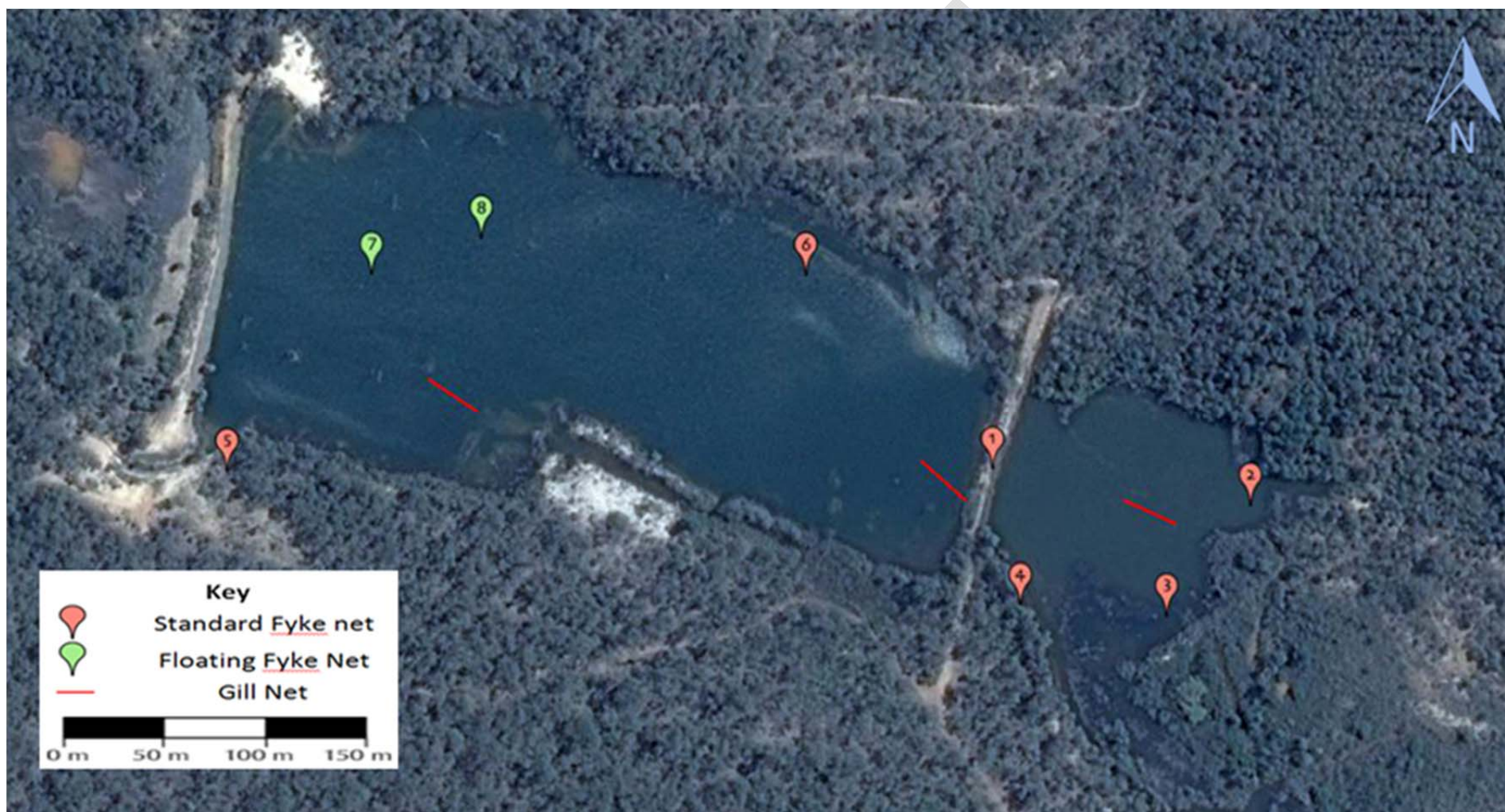


Figure 1: Sites sampled for aquatic macrofauna in Schwenke's Dam in October 2014 using netting methods.



Figure 2: Clockwise from top left: Gill net deployment, standard fyke net set, SCUBA survey, *Litoria moorei* in re-planted sedges, east side of Schwenke's Dam and a floating fyke net set.

Physicochemical variables

To obtain physicochemical variables a YSI™ Professional Plus multimeter (YSI Inc., Yellow Springs, Ohio 45387, USA) was used. Mean (± 1 S.E.) water quality variables (i.e. temperature, pH, conductivity, salinity, dissolved oxygen (% and ppm) and oxidation reduction potential (ORP)) were determined.

Results and Discussion

Freshwater fish and crayfish communities

No listed or threatened species of fishes or crayfishes were recorded during the current sampling. Two common native fish species (i.e. Western Minnow *Galaxias occidentalis* and Western Pygmy Perch *Nannoperca vittata*) and one introduced freshwater fish species (*Gambusia holbrooki*) were recorded from Schwenke's Dam. Three freshwater crayfish species (i.e. Smooth Marron *Cherax cainii*, Koonac *Cherax preissii* and Southwest Glass Shrimp *Palaemonetes australis*) were also recorded. A total of 1661 fish, 3356 freshwater crayfish and 17 Oblong Turtles (*Chelodina colliei*) were captured using fyke nets during the survey (Table 1), with zero captures made in the gillnets. Koonacs were observed during night spotting and seven were captured with a dip-net to obtain length-frequency data.

The introduced Eastern Gambusia made up 86.6% of the total captures and had an average density of 0.67 (± 0.33) individuals/m² in shallow waters (Table 1). Eastern Gambusia numbers in south-western Australian systems typically fluctuate seasonally and this density can be expected to rise as sampling coincided with the early part of the prolonged breeding period (spring to autumn). Eastern Gambusia densities usually peak in late summer/early autumn before crashing over winter, and as water levels decline (Beatty *et al.* 2014c). Western Pygmy Perch and Western Minnows comprised 11.3% and 2.1% of total captures, respectively, and occurred in much lower densities compared to Eastern Gambusia (Table 1); however, large schools of up to 300 Western Minnows were observed while setting nets (Figure 3).

Examination of the length-frequency distributions of the Eastern Gambusia, Western Minnows and Western Pygmy Perch revealed that multiple age classes were present, indicating that populations of each of the species are self-maintaining (Figure 4). The lack of any Redfin Perch captured during the survey suggests that this species is not currently present within Schwenke's Dam which is fortunate given it is known to predate heavily on native freshwater fishes and crayfishes of the region (Morgan *et al.* 2002; 2004) (see below).



Figure 3: Clockwise from top left: Western Pygmy Perch, Western Minnow, Oblong Turtle, large school of Western Minnows observed, macroalgae bed and berried Marron.

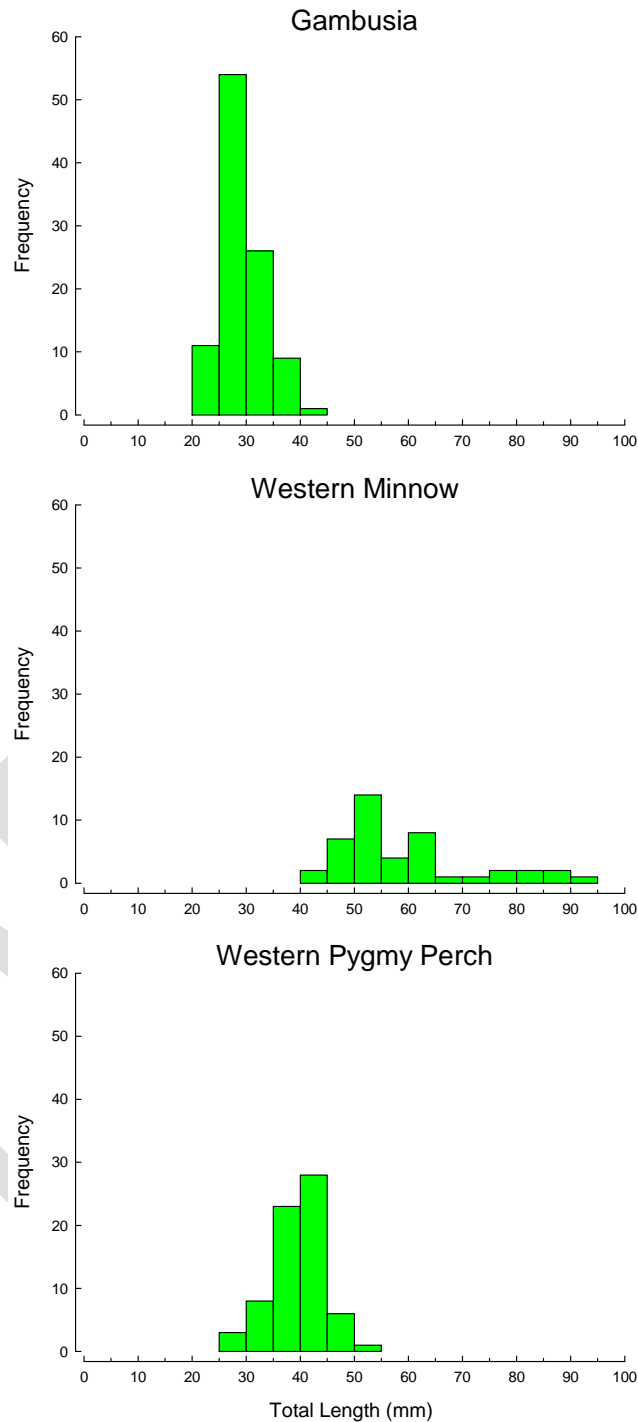


Figure 4: Length-frequency distribution of Eastern Gambusia, Western Minnows and Western Pygmy Perch caught in fyke nets in Schwenke's Dam in October 2014.



Freshwater crayfish communities were numerically dominated by Southwest Glass Shrimp, which accounted for 99.3% of all crayfish captured, while Koonacs and Smooth Marron accounted for 0.2% and 0.5%, respectively. When compared to previous sampling events at other dams in south-western Australia, the capture rates of freshwater crayfish species recorded during this survey were somewhat similar (e.g. Beatty *et al.* 2014a). There is evidence of recruitment (i.e. presence of multiple age cohorts) for Smooth Marron and Koonacs indicating that populations of both species are viable (Figure 5). There was also evidence of Smooth Marron breeding with one individual female berried with eggs (Figure 3). As with the fishes and crayfishes, the length-frequency distributions of the Oblong Turtle (Figure 6) revealed that multiple age classes were present, indicating successful recruitment and a self-maintaining population.

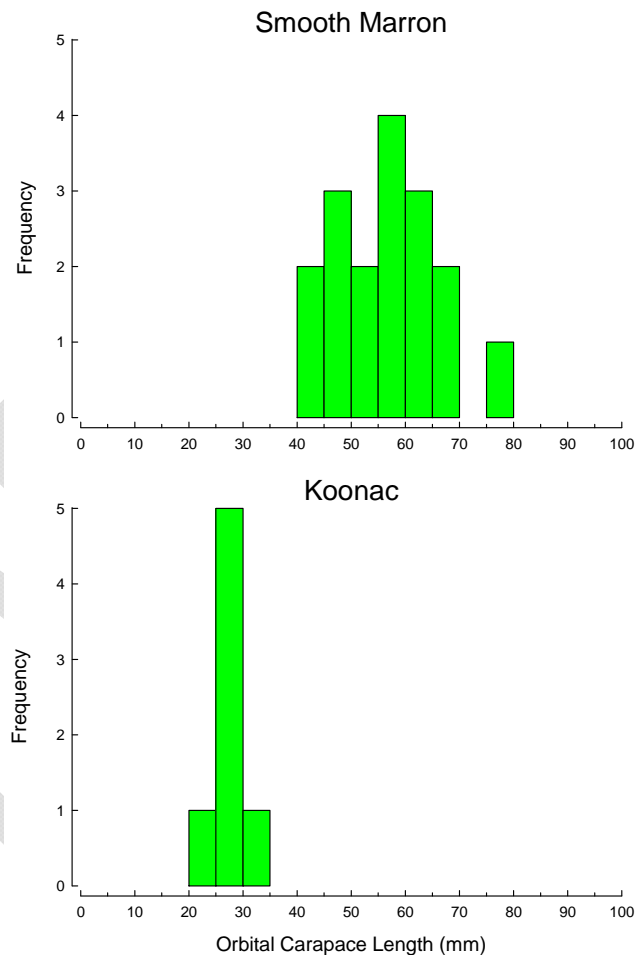


Figure 5: Length-frequency distribution of Smooth Marron and Koonacs captured in Schwenke's Dam in October 2014.

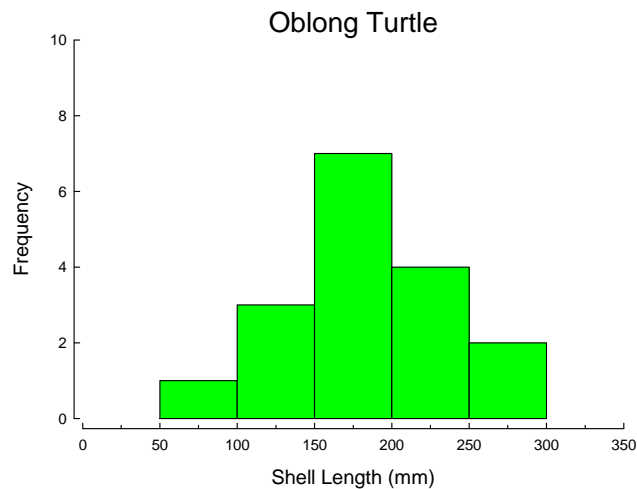


Figure 6: Length-frequency distribution of Oblong Turtles caught in fyke nets in Schwenke's Dam in October 2014.

	Native fishes		Intro. fishes	Freshwater crayfishes			Turtles
SITE	Go	Nv	Gh	Pa	Cc	Cp	Ccol
FYKE NETTING (CAPTURES)							
1	7	127	485	40	1	0	4
2	1	11	15	147	0	0	7
3	6	30	195	1285	4	0	3
4	1	1	280	280	1	0	0
5	0	13	450	477	9	0	3
6	3	6	5	1000	2	0	0
7 (Floating)	13	0	8	70	0	0	0
8 (Floating)	4	0	0	40	0	0	0
Total fykes	35	188	1438	3339	17	0	17
VISUAL OBSERVATIONS (DENSITY)							
scuba	0.033	0.125	0.333	1.666	0.003	0	0.003
Night spot	0.300	0	1.000	2.000	0.050	0.250	0
Mean (SE)	0.17 (0.13)	0.06 (0.06)	0.67 (0.33)	1.83 (0.17)	0.03 (0.02)	0.13 (0.13)	0.002 (0.002)
Total number	50	75	300	1200	7	25	2

Table 1: Capture summaries from Fyke netting, underwater and night visual observations undertaken in Schwenke's Dam in October 2014. N.B. densities are individuals per m² (± 1 S.E.). Species codes: Go = Western Minnow, Nv = Western Pygmy Perch, Gh = Eastern Gambusia, Pa = Southwest Glass Shrimp, Cc = Smooth Marron, Cp = Koonac and Ccol = Oblong Turtle (see text for details).

The presence of these species in the inundated mining pit may be attributed to the dam's connectivity with the Blackwood River and surrounding tributaries through Spring Gully Creek, which connects the dam in periods of flow (Figure 8). These periods of flow also coincide with the upstream migration of many native species. At some point in history or at present the flow



conditions may have been appropriate for upstream migration, however, further onground examination of downstream connectivity and migration barriers is needed to determine this.

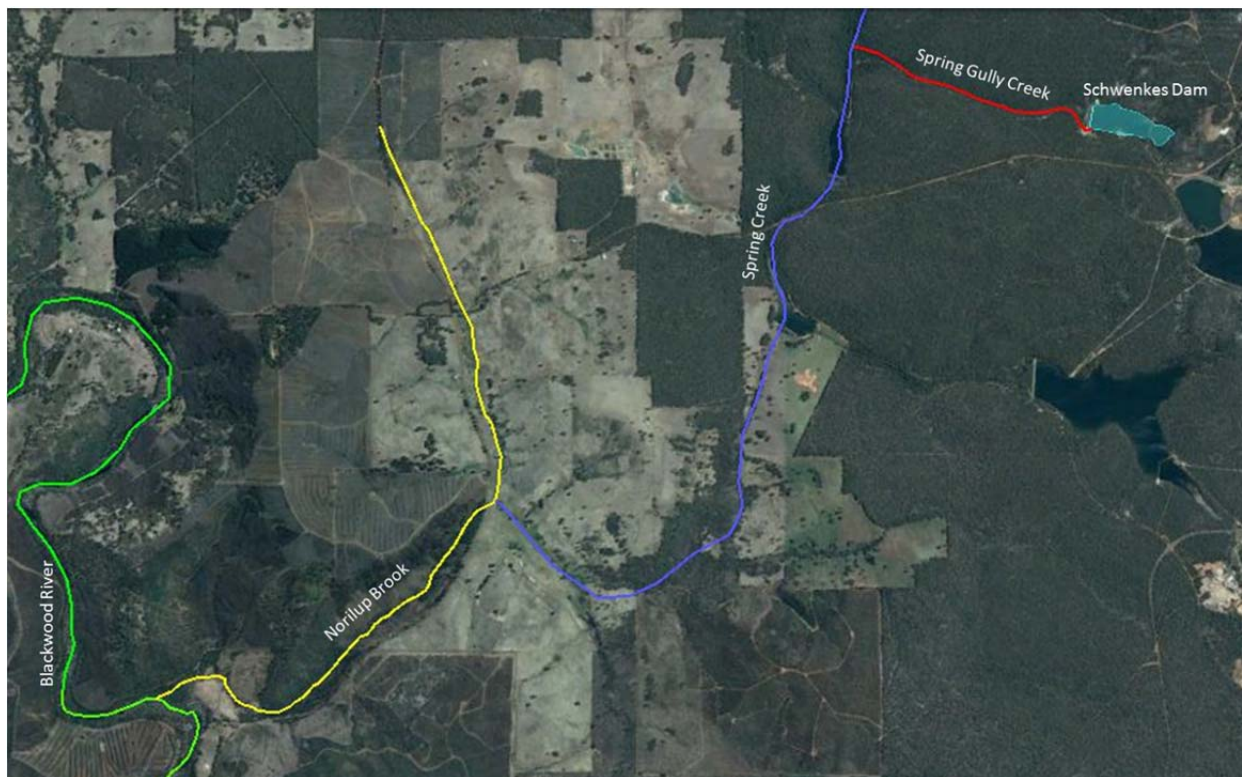


Figure 7: Connectivity of Schwenke's Dam to the Blackwood River and surrounding tributaries.

This survey has alluded to the number of aquatic fish and crayfish species present and highlights the efficacy of deploying a number of survey techniques rather than relying on a single technique that can produce inconclusive and biased results. In combination, these methods have produced a solid baseline dataset of the fish and crayfish communities in Schwenke's Dam.

Physicochemical variables

The authors have recently undertaken a field threshold analysis of south-western Australian freshwater fishes that has characterised the water quality within their sites of occupation (see Beatty *et al.* 2013). Water quality variables within Schwenke's Dam at the time of sampling were all within the range known to be tolerable to the native freshwater fishes of south-western Australia as well as the Eastern Gambusia (Table 2).

Table 2: Mean (± 1 S.E.) environmental variables taken Schwenke's Dam in October 2014

Schwenke's Dam	Conductivity ($\mu\text{S}\cdot\text{cm}^{-1}$)	DO (ppm)	DO%	ORP	pH	Salinity (ppt)	TDS (ppm)	Temp ($^{\circ}\text{C}$)
Boat Ramp	655.33 (1.86)	7.28 (0.12)	80.17 (1.51)	140.33 (0.72)	7.55 (0.02)	0.36 (0)	474 (0)	19.7 (0.06)

Non-native species and control methods

Small-bodied (20-40 mm) Eastern Gambusia are known to be aggressive; their agonistic behaviour often causes physical injury to the fins or body parts of other fishes and tadpoles (Gill *et al.* 1999, Hamer *et al.* 2002). They are also known to predate upon and compete with native species (Mieiro *et al.* 2001). However, the native fishes captured in Schwenke's Dam appeared to be injury free and in reasonable numbers (*cf* Beatty *et al.* 2014c who surveyed the rivers of the Vasse-Wonnerup). We strongly suspect that this would be due to the vast macroalgae beds and fringing vegetation present in the dam. Gill *et al.* (1999) investigated field evidence of fin damage caused by Eastern Gambusia in wild populations of native fishes and found that the incidence of this agonistic behavior was reduced in more complex habitats.

Eastern Gambusia has established a self-maintaining population in Schwenke's Dam and it will be difficult, if not impossible, to eliminate them from this site (see also Lowe *et al.* 2000). Approaches to controlling their numbers or eradicate them may include physically removing them either through netting or electrofishing. Another approach could involve dewatering the lake as this has previously removed the species from systems (Hamer *et al.* 2002) but the large storage capacity of the impoundment would make this approach logistically challenging to say the least. In this situation the best method for limiting the impacts of this species on native fishes is to maintain and improve habitat complexity (i.e. macroalgae beds, aquatic macrophytes, riparian vegetation, large woody debris) so as to provide adequate cover. This would tie in directly with the Bittern and Waterbird Biodiversity Enhancement Project revegetation activities.

The Bittern and Waterbird Biodiversity Enhancement Project also intends to create an interconnected group of fresh water wetlands in the Greenbushes area. This will be achieved by elevating water levels by means of shallow excavations, construction of dykes and other earthworks to create a network of waterways between water bodies. However, the proposed linking of water bodies has the potential to provide a pathway for introduced species to colonise water bodies that presently do not contain them. In regards to Schwenke's Dam there are plans to create more wetland reed-beds between the dam and Greenbushes Pool to the north-east and a series of chutes and pools at the spillway flowing into Spring Gully Creek which flows into Mt Jones Dam in the west to deal with erosion. This survey has found Eastern Gambusia in Schwenke's Dam, so linking it to Greenbushes pool through a wetland may result in the spread of this species; however, it is not known if this species has already established a population in the pool.

There is also anecdotal evidence that Redfin Perch reside in Greenbushes Pool and Mt Jones Dam. This species would have the potential to invade Schwenke's Dam via Greenbushes Pool if the two were linked by a wetland. There is also the potential for Redfin Perch to invade Schwenke's Dam via Mt Jones Dam if a series of chutes and pools were constructed at the spillway, as the current design may be preventing them from moving upstream into the



Schwenke's Dam. Either scenario would likely result in the decimation of native freshwater fish and crayfish populations in Schwenke's Dam as has occurred elsewhere in south-western Australia, including the nearby Big Brook Dam (Morgan *et al.* 2002; 2004). To prevent such movements between the pool and dam, if the wetland was constructed, there would need to be an appropriate barrier or buffer zone in place which would remain effective in the event of extremely elevated water levels. Given that there is a need to prevent erosion on the spillway, to prevent the upstream movement of Redfin Perch into Schwenke's Dam from Mt Jones Dam, the construction of an appropriate weir among the chutes and pools on the spillway would prevent the upstream passage of all fish species. However, before such measures are put in place, we recommend that Greenbushes Pool and Mt Jones Dam be surveyed for aquatic macrofauna to determine the most appropriate course of action in regards to the proposed hydrological alterations.

To further aid in the control and prevention of introduced species becoming established, community engagement components of the Bittern and Waterbird Biodiversity Enhancement Project can play an important role and can be conducted at the site. Community members can be informed of the native freshwater fish and crayfish species and catastrophic impacts introduced species can have on the aquatic environment, and the importance of native fishes and crayfishes in the ecosystem. This may discourage the translocation and introduction of alien species into freshwater systems around Greenbushes and Schwenke's Dam as they usually occur when people attempt to enhance recreational angling opportunities or dispose of unwanted aquarium pets without knowledge of the consequences. Informed community members may also provide surveillance by reporting introduced species, thus aiding in monitoring through 'Citizen Science'.

Table of recommendations for management

Survey other inundated mine lakes	<p>This study represents an important template for conducting other aquatic macrofauna surveys in the Greenbushes area. These surveys should be conducted in order to:</p> <ol style="list-style-type: none"> 1) Provide baseline ecological information of native/introduced fishes to complement water quality and macroinvertebrate datasets, which can be used to compare against conditions of these water bodies over time. 2) Determine the spatial distribution of all native and introduced aquatic species in the Greenbushes area which is crucial prior to any connecting of the water bodies taking place. 3) Inform effective rehabilitation strategies to improve existing native populations or aid in the potential establishment of stocked populations of native fishes.
Continue rehabilitation of riparian and aquatic vegetation	<p>Continue with rehabilitation activities, including ongoing riparian and aquatic re-vegetation around the edges of the lake to serve as cover and provide important breeding habitat. Native emergent sedges and large woody debris provided by the riparian overstorey represent ideal habitats for native south-western Australian fish and crayfish species. Re-snagging of barren sections of bank with large woody debris would provide additional important habitat for native species, particularly Smooth Marron. Old car tyres have been used in providing Marron habitat in aquaculture projects in the south-west. However, managers would also need to consider the aesthetics of this course of action and whether leaching of contaminants could occur.</p>
Continued monitoring/introduced fish control	<p>Following the initial survey, a cost-effective biennial sampling program should be designed and implemented to monitor native populations, and detect introductions early, before a self-sustaining population is established.</p>
Education	<p>Ongoing education of the Blackwood Basin community should occur about the conservation and ecological importance of native freshwater fish and crayfish species and the catastrophic impacts that introduced species have, in order to:</p> <ol style="list-style-type: none"> 1) Reduce the risk of future introduction/translocation of alien species. 2) Aid in monitoring and detection of introduced species by 'Citizen Scientists'. 3) Improve overall ecological understanding of the Blackwood community that will aid in conservation efforts.

References

- Beatty, S.J., Keleher, J., Morgan, D., Allen, M. & Strehlow, K. (2014a). *Aquatic Fauna Survey of Denmark Dam*. Report to the Water Corporation of Western Australia. Freshwater Fish Group and Fish Health Unit, Murdoch University, Perth, Western Australia.
- Beatty, S.J. & Morgan, D.L. (2013). Introduced freshwater fishes in a global endemic hotspot and implications of habitat and climatic change. *BioInvasions Records* 2, 1-9.
- Beatty, S.J., Morgan, D.L., Keleher, J.J., Lymbery, A., Close, P., Speldewinde, P., Storer, T. & Kitsios, A. (2013). *Adapting to climate change: A risk assessment and decision making framework for managing groundwater dependent ecosystems with declining water levels, Supporting Document 4: Environmental variables in the habitats of southwestern Australian freshwater fishes: An approach for setting threshold indicator values*. National Climate Change Adaptation Research Facility, Gold Coast, 33 pp. ISBN: 978-1-925039-38-2
- Beatty, S.J., Morgan, D.L. & Lymbery, A.J. (2014b). Implications of climate change for potamodromous fishes. *Global Change Biology* 20. 1794-1807.
- Beatty, S.J., Morgan, D.L. & Gill, H.S. (2005). Life history and reproductive biology of the gilgie *Cherax quinquecarinatus*, a freshwater crayfish endemic to south-western Australia. *Journal of Crustacean Biology* 25, 251-262.
- Beatty, S.J., Morgan, D.L. & Torre, A. (2007). Restoring ecological connectivity in the Margaret River: Western Australia's first rock-ramp fishways. *Ecological Management & Restoration* 8, 225-229.
- Beatty, S.J., Tweedley, J.R., Allen, M.G., Allen, J. & Lymbery, A.J. (2014c). Control of introduced fish and crayfish in the Vasse-Wonnerup Ramsar Wetland. Report to Commonwealth Government of Australia. Freshwater Fish Group and Fish Health Unit, Murdoch University 160 pp.
- Gill, H.S., Hambleton, S.J. & Morgan, D.L. (1999) Is the mosquitofish, *Gambusia holbrooki* (Poeciliidae), a major threat to the native freshwater fishes of south-western Australia. *Proc. 5th Indo-Pac. Fish Conf., Noumea. Séret, B. & j.-Y. Sire. eds. Paris: Soc. Fr. Ichtyol: 393-403.*
- Hamer, A., Lane, S., & Mahony, M. (2002). The role of introduced mosquitofish (*Gambusia holbrooki*) in excluding the native green and golden bell frog (*Litoria aurea*) from original habitats in south-eastern Australia. *Oecologia*, 132, 445-452.
- Lowe, S., Browne, M., Boudjelas, S., & De Poorter, M. (2000). *100 of the world's worst invasive alien species: a selection from the global invasive species database* (p. 12). Species Survival Commission, World Conservation Union (IUCN), Auckland, New Zealand: Invasive Species Specialist Group.

Marchant, S. & Higgins, P.J. eds. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks*. Melbourne, Victoria: Oxford University Press

Mieiro, C. L., Cabral, J. A., & Marques, J. C. (2001). Predation pressure of introduced mosquitofish (*Gambusia holbrooki* Girard), on the native zooplankton community. A case study from representative habitats in the lower Mondego river Valley (Portugal). *Limnetica*, 20, 279-292

Morgan, D.L., Beatty, S.J., Klunzinger M.W., Allen M.G., and Burnham, Q.E. (2011). *A Field Guide to Freshwater Fishes, Crayfishes and Mussels of South-Western Australia*. SERCUL/ Freshwater Fish Group and Fish Health Unit (Murdoch University), Murdoch, Western Australia.

Morgan, D.L., Gill, H.S., Maddern, M.G. & Beatty, S.J. (2004). Distribution and impacts of introduced freshwater fishes in Western Australia. *New Zealand Journal of Marine and Freshwater Research*, 38, 511-523.

Morgan, D.L., Hambleton, S.J., Gill, H.S. & Beatty, S.J. (2002) Distribution, biology and impacts of the introduced redfin perch (*Perca fluviatilis*) (Percidae) in Western Australia. *Marine and Freshwater Research*, 53, 1211–1221