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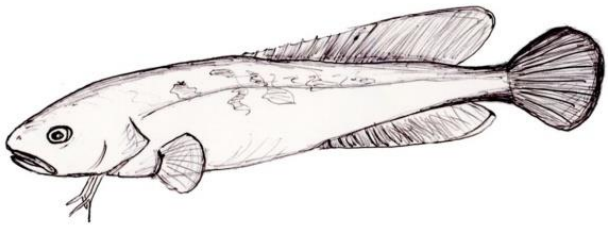
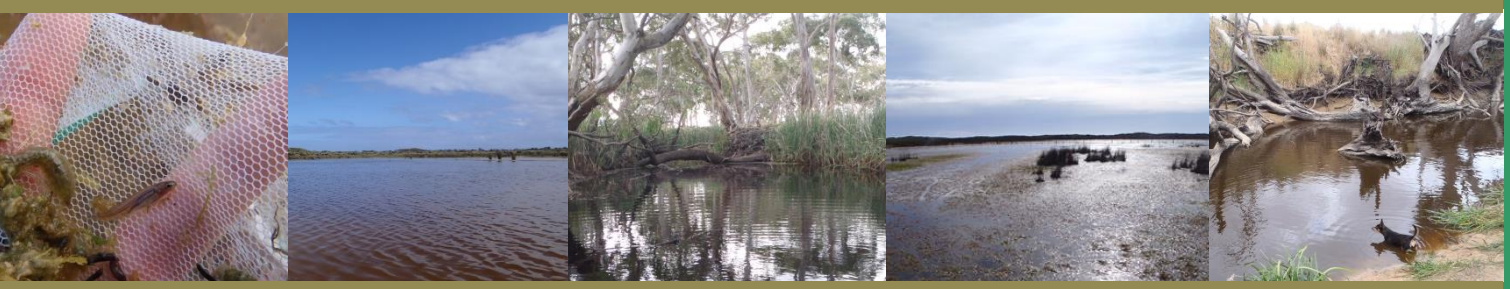


Ecology, Monitoring, Conservation

Regional status update of the dwarf galaxias (*Galaxiella pusilla*) in the South East of South Australia: Spring 2012–14

Mark Bachmann, Nick Whiterod, Dan Anderson and Lauren Veale

A project funded by : Nature Foundation SA



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Correspondence in relation to this report contact

Mark Bachmann
Manager
Aquasave – Nature Glenelg Trust
MOB: 0421 97 8181
mark.bachmann@natureglenelg.org.au

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Executive Summary

A survey for dwarf galaxias, *Galaxiella pusilla*, between 2012 and 2014 detected 627 individuals at 28 out of 57 sites visited. In comparison to records from the 2008 survey, this represented a decline in overall number (vs 1286) but an increase in the number of sites where the species was detected (vs 19). The main findings of the survey were that the species:

- is still widely distributed but patchy and relatively uncommon in the South East;
- was found at the majority of sites where it had been previously recorded;
- presented reduced abundance and detectability in 2012–14, which appears to have been influenced by (and have an inverse relationship with) the increased availability of aquatic habitat at the time of the survey (when compared to drier conditions in 2008);
- is found to have recovered well and be utilising newly reinstated habitats at wetland restoration sites in the Piccaninnie Ponds area (including adjacent Pick Swamp) and Middle Point Swamp; and,
- would significantly benefit from additional wetland restoration works at strategic locations in the South East region; with a focus of securing core populations in each of the different sub-populations, at sites where a desirable level of habitat complexity can be achieved.

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1 Introduction

The dwarf galaxias (*Galaxiella pusilla*) is a tiny, slender, freshwater fish growing to a maximum length of approximately 40 mm for females and 34 mm for males (see Figure 1-1). The species is endemic to south-eastern Australia, where it occurs in Tasmania, South Australia and Victoria (see Figure 1-2). The dwarf galaxias is listed as nationally Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*. The South East of South Australia forms a significant component of the species' national distribution, where it generally occurs in shallow, densely vegetated aquatic habitats across a wide area of the Lower South East.

Figure 1-1. A male (top) and female (bottom) dwarf galaxias [image: Michael Hammer].

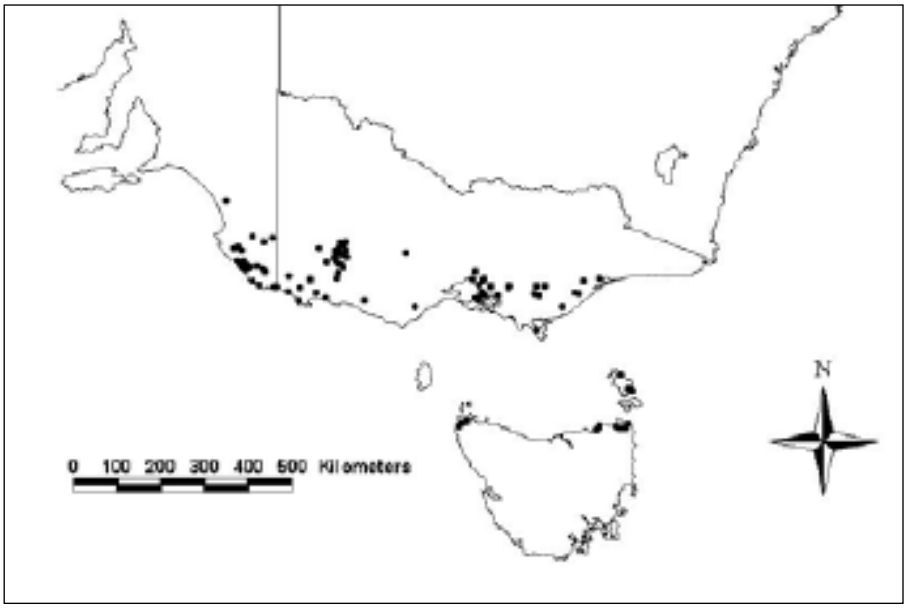

Figure 1-2. The national distribution of the dwarf galaxias (from Saddlier et al. 2010).

2 Biology, threats and background to the 2012-14 survey

Localised dispersal in connected aquatic habitats, combined with a potential to aestivate in Swamp Yabby (*Geocharax* spp.) burrows for up to five months (Beck 1985) enables this species to survive (and recover from) brief periods of drought or dry conditions, however short longevity (1–2 years) leave this species vulnerable to extinction during extended periods of drought (Slater & Hammer 2009). The progressive, comprehensive, artificial drainage of the South East over the past 150 years has also dramatically exacerbated the impact of drought – as observed in the latter part of the last decade (from 2006-2010).

The impact of human-induced landscape change has been two-fold. Specifically, it has caused an immense decline in the availability of:

(1) the broad, shallow seasonal wetland type favoured by the species during the winter/spring peak activity periods, and

(2) deeper more permanent aquatic refuge habitats that sustain the species in intervening drier times.

The first comprehensive regional survey by Hammer (2002) found the species to be widespread, but patchily distributed across the South East. Although this work led to the discovery of the dwarf galaxias at a number of new sites, it also failed to detect the species at a range of previous known locations. This lead Hammer (2002) to propose the connection between comprehensive artificial drainage and habitat loss for the species, causing what was likely to have been a major decline in its historic range.

Another regional analysis of the species' status and distribution occurred in spring 2008 as part of a regional assessment of nationally threatened fish species during the peak of the millennium drought (Hammer 2009). Consistent with the findings of the earlier work, dwarf galaxias were found to remain reasonably widespread, although apparent extinction of outlying populations in the Upper South East and declines from sites within the Dismal Swamp corridor were noted.

A 2012–14 survey for dwarf galaxias, summarised in this report, is the first regional re-assessment of the species since the millennium drought concluded. The following objectives were adopted for the survey within the context of available time and funding:

- to revisit as many of the previously sampled sites to gain a representative insight into the longer term trends.
- to include sampling of as many potential new sites as possible, to determine if the previously assumed (widespread but patchy) distribution remains a correct reflection of the species' current habitat occupancy pattern in the South East.
- to provide a synopsis of the post-drought status of dwarf galaxias populations in the South East of South Australia.

3 Methods

Sampling was conducted between October 2012 and December 2014, with the majority effort during spring 2013 (i.e. September and October 2013). All sampling was undertaken in accordance with PIRSA Fisheries Permits (no. 9902527, 9902631 and ME9902705) and DEWNR Wildlife Research Permit (A26248-1).

The sampling method for this species was consistent with previous studies (Hammer 2009), using a rapid technique (to cover a wide search area at a site and regional scale), that was tailored to suit specific habitats and small fish size.

Adults and juveniles were targeted with a 3 m x 1.5 m seine with 3 mm stretch mesh, operated with three 10 m hauls in small habitats and six to nine hauls in larger wetlands. Juveniles and larvae were targeted with a sweep net (30 cm diameter circular head, 1mm mesh), operated along a 20 m section of bank then tipped into a sorting tray. Scooping water into the sorting tray from near the edges and dense vegetation proved an effective method for targeting larvae and 10 scoops in suitable habitat were undertaken at each site. Categorisation of adults, juveniles and larvae was as follows: adults were reproductively active fish that were large (>25 mm) and displaying nuptial colouration (i.e. clearly last season's cohort), juveniles ranged between 10-25 mm and displayed adult body shape, and larvae were 4-10mm with an uneven body shape (large head and thin body) (Figure 3-1).

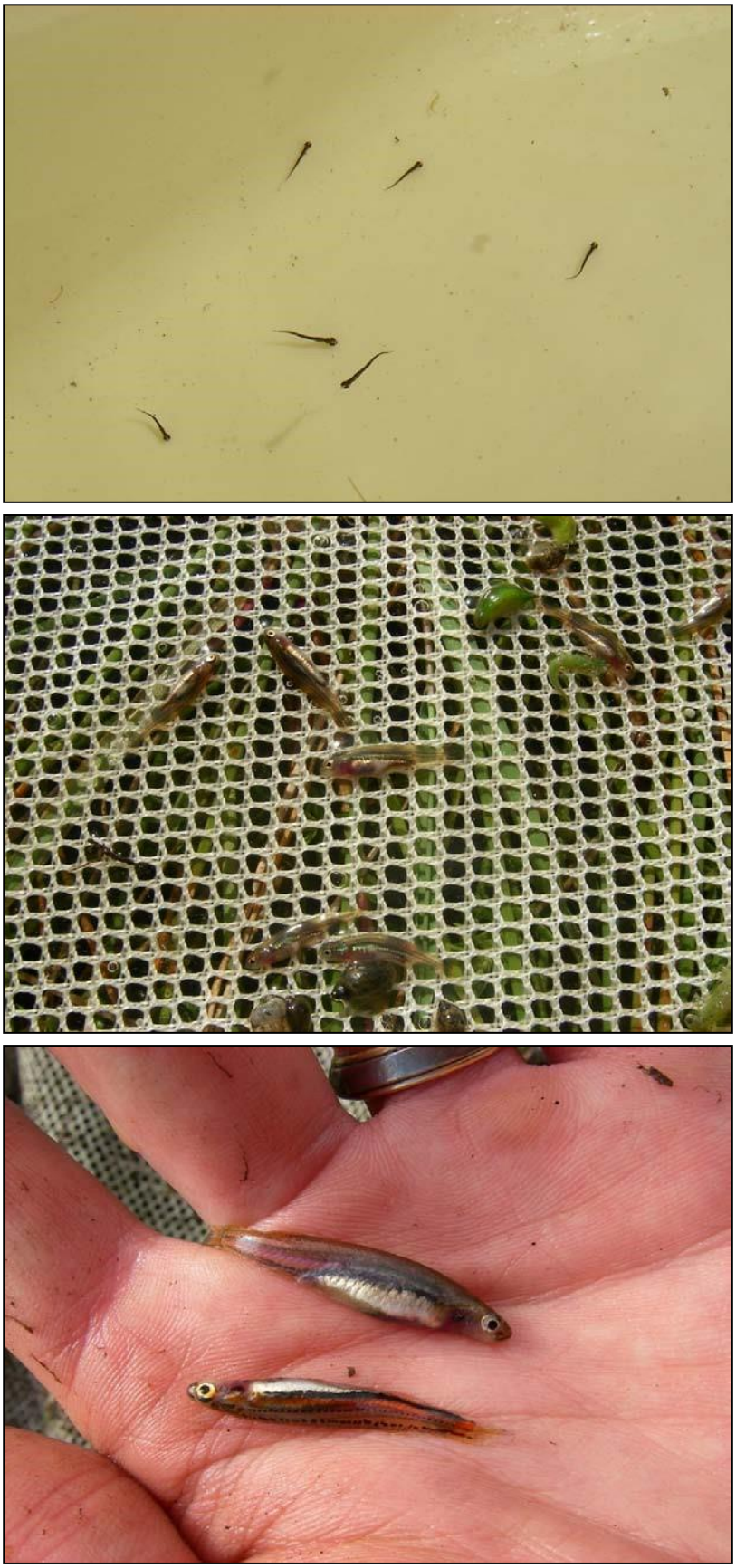

Figure 3-1. Different life stages of dwarf galaxias (top-larvae, middle-juveniles, bottom- adults).

All sampled fish were identified to species level, counted and threatened species (including dwarf galaxias) were measured (total length, TL) to obtain general biological information (size range, snap shot of population structure) with any signs of reproductive condition and external disease or parasites recorded. Threatened species were photographed at each site as identification vouchers. All native species were returned to water at the place of sampling whereas alien (exotic) species were handled in accordance with fisheries regulations. Records of other fauna opportunistically sampled were maintained. Environmental data was collected the same way at each site covering differing aspects of underwater cover, edge vegetation, pool condition, flow and water quality (see full details in Appendix 1).

4 Results

In total, 15,269 fish were recorded across 20 fish species from 57 sites sampled in 2012-14 (see Table 4-1 and 4-2). The estuarine species, the smallmouthed hardyhead (*Atherinosoma microstoma*) accounted for 42% of the total fish catch (n=6353). Site conditions are presented in Table 4-3.

Of the total number of sites visited during the 2012-14 assessment, 627 dwarf galaxias were captured from 28 of the sampled sites (49% of sites). The highest numbers of dwarf galaxias were recorded at two coastal wetlands in the Lower South East (LSE), Bucks Lake Reserve (n=141) and Middle Point Swamp (n=159).

Population structures were observed by looking at trends in the length frequency distributions of dwarf galaxias collected from selected sites. At Middle Point Swamp (SE14-36), dwarf galaxias were represented by both adults and juveniles (Table 4-2 & Figure 4-1). In contrast, populations at Bucks Lake Reserve (SE14-32) and the Connector Drain at Lake Hawdon South (SE14-33) consisted mainly of young-of-year fish, while those at Badmans Pool along Mosquito Creek were primarily adults (SE14-37; Figure 4-1).

Total numbers of dwarf galaxias recorded in 2012-14 were down from 1286 fish, from 19 sites, in 2008. For a summary comparing the relative fish survey results from 2008 to 2012-14, please refer to Tables 4-4 and 4-5.

Table 4-1. Summary of sites targeted for dwarf galaxias in 2012, 2013 and 2014.

Site Code	Region	Waterway	Location
SE12-22	Lower Drain M	Sutherland Drain	Beachport-Penola Rd
SE12-25	Lower Drain M	Sutherland Drain	Burk Island Rd
SE12-30	USE	Cortina Lakes	Log Crossing Bridge
SE12-34	Mosquito Creek	Drain M	ds Bool Lagoon outlet
SE12-42	USE	Katani Park	NW section of wetland
SE13-13	Dismal Swamp	Claypans	Southern edge
SE13-14	Dismal Swamp	Everglades	At fire track
SE13-15	Dismal Swamp	Everglades	West waterhole
SE13-16	Dismal Swamp	Perched Swamp	Mount McIntyre
SE13-17	Dismal Swamp	Blue Teatree Swamp	Mount Burr Rd
SE13-18	Dismal Swamp	Marshes	SW corner
SE13-19	Mosquito Creek	Deadmans swamp,	at reserve
SE13-20	Mosquito Creek	Deadmans swamp	SE waterhole
SE13-21	Mosquito Creek	Mosquito creek	Forestry reserve
SE13-22	Lower South East	Piccaninnie Ponds	NE section
SE13-23	Lower South East	Eight Mile Creek	upstream Drain 5
SE13-24	Lower South East	Eight Mile Creek	edge of Conservation Park
SE13-25	Lower South East	Deep Creek Drain	Deep Creek drain channel
SE13-26	Lower South East	Deep creek spring pool	spring fed pool in paddock
SE13-27	Lakes Frome and	Drain 36	Alleyens Rd, junction 41
SE13-28	Lakes Frome and	Lake Bonney	At track on western end
SE13-29	Lower South East	Spring pond Cape	off Megaws Road
SE13-30	Lakes Frome and	Drain 31B	Sapiatzer Lane
SE13-31	Lower Drain M	Ephemeral drain - mid	Road Bridge Reedy Ck Lane
SE13-32	Dismal Swamp	Isolated wetland 1	off Kangaroo Flat Road
SE13-33	Dismal Swamp	Isolated wetland 2	off Kangaroo Flat Road
SE13-34	Lakes Frome and	Snuggery drain	Top section
SE13-35	Dismal Swamp	Isolated wetland	Honans CR
SE13-36	Dismal Swamp	Isolated wetland	Honans CR
SE13-38	Lower South East	Pick Swamp	Pick fishway, western end
SE13-39	Lower South East	Pick Swamp	Top centre levee
SE13-40	Lower South East	Pick Swamp	Below shed, eastern end
SE13-45	Lower South East	Hammerhead Pond	Hammerhead Pond
SE13-46	Lower South East	Main Ponds wetland	West of Pick Road
SE13-47	Lower South East	Eastern wetland	East of Pick Road
SE13-48	Lower South East	Eastern wetland	Limestone Pool
SE13-49	Lower South East	Eastern wetland	Northeast transect
SE13-50	Lower South East	Eastern wetland	Southeast dune
SE13-51	Lower South East	Eastern wetland	Boundary dune
SE13-51	Lower South East	Main Ponds wetland	Ponds Road
SE13-56	Lower South East	Eight Mile Creek	Interconnecting Channel B
SE13-65	Drain L	Bray Drain	Robe Rd
SE13-66	Drain L	Reedy Creek - Willmott	Naracoorte Rd
SE13-67	Drain L	Drain L	Princess Hwy
SE13-68	Drain L	Drain BR45	Princess Hwy
SE13-69	Lakes Frome and	Bevilaqua Drain	Ford at Canunda CP
SE13-70	Lakes Frome and	Narrow Neck Drain	Rendelsham
SE13-71	Lakes Frome and	Hartherleigh Drain 20B	Princess Hwy
SE14-31	Lakes Frome and	Coastal wetland	Spring-fed freshwater pool
SE14-32	Lower South East	Bucks Lake Game	Downstream of drain
SE14-33	Lake Hawdon	Lake Hawdon South	Connector Drain, DS bridge
SE14-34	Lake Hawdon	Lake Hawdon South	Bradys Drain
SE14-35	Lakes Frome and	Lake Bonney	Near spring-fed pool
SE14-36	Lower South East	Middle Point Swamp	Outlet Drain
SE14-37	Mosquito Creek	Mosquito Creek	Badmans Pool
SE14-38	Mosquito Creek	Mosquito Creek	Elderslie 2
SE14-39	Mosquito Creek	Mosquito Creek	Hateleys Pool

Table 4-2. Summary of catch data at sites targeted for dwarf galaxias. Life stage: A = Adult, J = Juvenile, L = Larvae.

Site Code	Region	Dwarf galaxias		Aust. mudfish	Carp gudgeons	Common galaxias	Congolli	Flathead gudgeon	Lagoon goby	Shortfinned eel	Smallmouthed hardyhead	Southern pygmy perch	Variegated pygmy perch	Yarra pygmy perch	Yelloweye mullet	Western bluespot goby	No fish	Gambusia *
		All	Life stage															
SE12-22	Lower Drain M	10	2A, 8J					4			3			1				1
SE12-25	Lower Drain M	3	3A	4	4	11		49			4	309		8		4		3
SE12-30	USE										500							
SE12-34	Mosquito Creek																	4
SE12-42	USE				30							2						
SE13-13	Dismal Swamp	13	2A, 11J															
SE13-14	Dismal Swamp	1	1A		1													
SE13-15	Dismal Swamp				2													
SE13-16	Dismal Swamp																x	
SE13-17	Dismal Swamp	9	9J															
SE13-18	Dismal Swamp																x	
SE13-19	Mosquito Creek																x	
SE13-20	Mosquito Creek																x	
SE13-21	Mosquito Creek	1	1J		15												x	1
SE13-22	LSE	16	1A; 15J									14					x	
SE13-23	LSE					8					29	7			12			
SE13-24	LSE					6						8	7					
SE13-25	LSE					11	2					4			2			
SE13-26	LSE											11						
SE13-27	Bonney/Frome	9	4A; 5J									13						
SE13-28	Bonney/Frome								2		39							
SE13-29	LSE	2	2A									4						
SE13-30	Bonney/Frome	20	11A; 9J									5						1
SE13-31	Lower Drain M											1						
SE13-32	Dismal Swamp																x	
SE13-33	Dismal Swamp																x	
SE13-34	Bonney/Frome											21						
SE13-35	Dismal Swamp																x	
SE13-36	Dismal Swamp																x	
SE13-38	LSE	4	4A			827						1365						
SE13-39	LSE	50	43A; 7J			351				1		453						
SE13-40	LSE	10				249						498						
SE13-45	LSE	37	1J									5						
SE13-46	LSE	7	2A; 5J			993						458						
SE13-47	LSE	19	9A; 10J			119				1	1	1445						
SE13-48	LSE																x	
SE13-49	LSE	5	2A; 3J									233						
SE13-50	LSE	32	1A; 31J							1								
SE13-51	LSE																x	
SE13-51	LSE	5	5J															
SE13-56	LSE					41						10	11					
SE13-65	Drain L	1	1A									1						
SE13-66	Drain L	2	2J															
SE13-67	Drain L					9	4				32	28						
SE13-68	Drain L																x	
SE13-69	Bonney/Frome	3	1A; 2J									7						5
SE13-70	Bonney/Frome											1						
SE13-71	Bonney/Frome	3	1A; 2J															
SE14-31	Bonney/Frome																x	
SE14-32	LSE	141	63J			1					5000	1						
SE14-33	Lake Hawdon	45	39J								176	210						
SE14-34	Lake Hawdon										500							
SE14-35	Bonney/Frome								5		69							
SE14-36	LSE	159	11A; 86J									5						
SE14-37	Mosquito Creek	10	8A		97	1						13		3				110
SE14-38	Mosquito Creek	10	7A; 1J		4													
SE14-39	Mosquito Creek				6							5						70

Table 4-3. Summary of environmental descriptors. Dwarf galaxias capture sites are highlighted green.

Site Code	Region	pH	Conductivity (μScm^{-1})	Temperature (oC)	Dissolved oxygen (mgL^{-1})	Transparency (m)
SE12-22	Lower Drain M	8.8	1943	14.7	8.32	>0.9
SE12-25	Lower Drain M	8.5	1864	15.5	12.50	0.6
SE12-30	USE	8.6	11400	19.5	11.60	>0.5
SE12-34	Mosquito Creek	8.8	4500	15.7	12.60	>0.3
SE12-42	USE	8.7	2304	12.2	-	0.1
SE13-13	Dismal Swamp	7.5	445	17.0	-	0.3
SE13-14	Dismal Swamp	7.2	269	14.5	-	0.2
SE13-15	Dismal Swamp	7.2	638	13.8	-	0.3
SE13-16	Dismal Swamp	7.5	263	14.9	-	>0.3
SE13-17	Dismal Swamp	7.3	267	15.7	-	0.3
SE13-18	Dismal Swamp	6.4	321	13.9	-	>0.2
SE13-19	Mosquito Creek	8.2	412	19.0	-	>0.3
SE13-20	Mosquito Creek	-	-	-	-	>0.2
SE13-21	Mosquito Creek	7.8	894	17.1	3.98	0.2
SE13-22	LSE	7.7	826	13.5	8.62	0.5
SE13-23	LSE	8.0	1495	15.9	-	>0.1
SE13-24	LSE	6.2	1888	16.5	-	10.0
SE13-25	LSE	6.2	2217	17.4	-	0.4
SE13-26	LSE	-	-	-	11.05	>0.3
SE13-27	Bonney/Frome	6.3	2058	14.8	11.42	0.5
SE13-28	Bonney/Frome	6.8	9732	17.6	-	-
SE13-29	LSE	-	-	-	-	0.3
SE13-30	Bonney/Frome	7.4	1426	16.9	1.64	0.5
SE13-31	Lower Drain M	8.2	1710	20.0	12.35	0.3
SE13-32	Dismal Swamp	5.8	149	16.0	2.46	0.1
SE13-33	Dismal Swamp	6.3	430	17.0	2.69	0.1
SE13-34	Bonney/Frome	7.2	97	15.3	3.83	0.15
SE13-35	Dismal Swamp	-	-	-	6.14	>0.1
SE13-36	Dismal Swamp	-	-	-	6.05	0.1
SE13-38	LSE	7.9	764	13.3	5.30	1.2
SE13-39	LSE	8.2	826	11.4	7.32	1.4
SE13-40	LSE	8.3	752	13.0	4.34	1.0
SE13-45	LSE	7.6	1076	12.1	3.56	2.0
SE13-46	LSE	7.6	2700	13.7	3.28	3.0
SE13-47	LSE	7.9	2730	12.8	3.45	1.1
SE13-48	LSE	7.4	2400	14.0	2.76	1.0
SE13-49	LSE	7.7	1146	14.7	3.44	0.9
SE13-50	LSE	8.1	1135	14.7	3.90	0.8
SE13-51	LSE	7.6	1829	18.5	1.69	0.8
SE13-52	LSE	7.8	2364	17.6	2.02	0.8
SE13-56	LSE	7.1	758	17.0	8.90	>1.9
SE13-65	Drain L	7.9	1571	13.9	8.92	>0.4
SE13-66	Drain L	8.2	1185	16.5	9.96	0.2
SE13-67	Drain L	8.6	2372	16.3	4.36	0.8
SE13-68	Drain L	7.6	2020	16.7	4.21	0.1
SE13-69	Bonney/Frome	8.0	1653	14.2	3.66	>1.2
SE13-70	Bonney/Frome	8.0	1734	13.4	4.15	>0.8
SE13-71	Bonney/Frome	8.3	1330	14.8	3.05	>0.9
SE14-31	Bonney/Frome	6.8	2089	14.2	6.91	0.4
SE14-32	LSE	9.6	9450	25.3	17.81	0.4
SE14-33	Lake Hawdon South	8.6	1384	25.5	13.27	0.4
SE14-34	Lake Hawdon South	9.4	3128	23.5	14.78	0.3
SE14-35	Bonney/Frome	8.3	1185	20.7	10.16	0.2
SE14-36	LSE	8.9	7731	20.6	13.02	0.5
SE14-37	Mosquito Creek	6.9	1537	19.3	1.50	0.3
SE14-38	Mosquito Creek	6.7	2867	19.0	-	0.2
SE14-39	Mosquito Creek	7.3	5080	17.6	3.95	0.3

Table 4-4. Dwarf galaxias capture results in 2008 and 2012-14 (sites grouped according to capture region).

Waterway	Location	Region	Dwarf galaxias	
			2008	2012-14
Drain 36	Alleyens Rd, junction 41	Bonney/Frome	21	9
Drain 31B	Sapiatzer Lane	Bonney/Frome		20
Bevilaqua Drain	Ford at Canunda CP boundary	Bonney/Frome	116	3
Narrow Neck Drain	Rendelsham	Bonney/Frome	329	0
Hatherleigh Drain 20B	Princess Hwy	Bonney/Frome	1	3
Bucks Lake	Near Carpenter Rocks	Bonney/Frome		141
Claypans	Southern edge	Dismal Swamp	103	13
Everglades	At fire track	Dismal Swamp	20	1
Blue Teatree Swamp	Mount Burr Rd	Dismal Swamp	0	9
Marshes	SW corner	Dismal Swamp	1	0
Bray Drain	Robe Rd	Drain L	21	1
Reedy Creek - Willmott Drain	Naracoorte Rd	Drain L	42	2
Lake Hawdon	Lake Hawdon South	Drain L		45
Sutherland Drain	Burk Island Rd	Lower Drain M		3
Sutherland Drain	Beachport-Penola Rd	Lower Drain M	6	10
Spring pond Cape Douglas	property off Megaws road Cape Douglas	LSE		2
Winterfield Creek	Cape Douglas wetland	LSE	14	
Middle Point Swamp	Inland of Middle Point	LSE		159
Eight Mile Creek	Ewens Ponds - 2nd connecting stream	LSE	16	0
Pick Swamp	Top centre levee	LSE		50
Pick Swamp	Pick fishway, western end	LSE		4
Pick Swamp	Donovans Drain	LSE	67	
Pick Swamp	Below shed, eastern end	LSE	163	10
Piccaninnie Ponds	Hammerhead Pond	LSE		37
Piccaninnie Ponds	NE section	LSE		16
Piccaninnie Ponds, main wetland 1	West of Piccaninnie Ponds Road	LSE		7
Piccaninnie Ponds, eastern wetland 1	East of Piccaninnie Ponds Road (new swale)	LSE		19
Piccaninnie Ponds, eastern wetland 3	Northeast transect	LSE		5
Piccaninnie Ponds, eastern wetland 4	Southeast dune	LSE		32
Piccaninnie Ponds, main wetland 2	Ponds Road	LSE		5
Deadmans swamp, southern end	at reserve	Mosquito Creek	15	0
Mosquito creek	Mosquito creek accessed via forestry reserve	Mosquito Creek		1
Mosquito Creek	Badmans DS crossing	Mosquito Creek	7	10
Mosquito Creek	Hateleys property	Mosquito Creek	26	0
Mosquito Creek	Elderslie Pools (P1 & P2)*	Mosquito Creek	318 (P1)	10 (P2)
		TOTAL fish	**1286**	**627**
		# detection sites	19	28

**Since Elderslie Pool 1 was dry during a visit in 2014, Elderslie Pool 2 (which had water) was sampled and used for comparison.*

Note: a **black** box indicates sites that were not visited in 2008; a **red** box indicates previous capture sites from 2008, not specifically visited in 2012-14; boxes shaded in other colours are grouped to indicate sites that are within the same general area and are treated as a single site for comparative purposes in Table 4-5.

Table 4-5. Comparing dwarf galaxias capture sites visited in both 2008 and 2012-14.

Waterway	Location	Region	Dwarf galaxias	
			2008	2012-14
Drain 36	Alleyens Rd, junction 41	Bonney/Frome	21	9
Bevilaqua Drain	Ford at Canunda CP boundary	Bonney/Frome	116	3
Narrow Neck Drain	Rendelsham	Bonney/Frome	329	0
Hatherleigh Drain 20B	Princess Hwy	Bonney/Frome	1	3
Claypans	Southern edge	Dismal Swamp	103	13
Everglades	At fire track	Dismal Swamp	20	1
Blue Teatree Swamp	Mount Burr Rd	Dismal Swamp	0	9
Marshes	SW corner	Dismal Swamp	1	0
Reedy Creek - Willmott Drain	Naracoorte Rd	Drain L	42	2
Sutherland Drain	Beachport-Penola Rd	Lower Drain M	6	10
Winterfield Creek	Cape Douglas wetland	LSE	14	2
Pick Swamp	Below shed, eastern end	LSE	163	10
Pick Swamp	Drain/fishway	LSE	67	4
Eight Mile Creek	Connecting channel B	LSE	16	0
Deadmans swamp, southern end	at reserve	Mosquito Creek	15	0
Mosquito Creek	Badmans DS crossing	Mosquito Creek	7	10
Mosquito Creek	Hateleys property	Mosquito Creek	26	0
Mosquito Creek	Elderslie Pools (P1 & P2)	Mosquito Creek	318 (P1)	10 (P2)
		TOTAL fish	**1265**	**86**
		Relative Abundance Ratio	14.7	1

Note: boxes shaded are for grouped sites (highlighted in Table 4-4) that are within the same general area and are being treated as representative of a single site for comparative purposes.

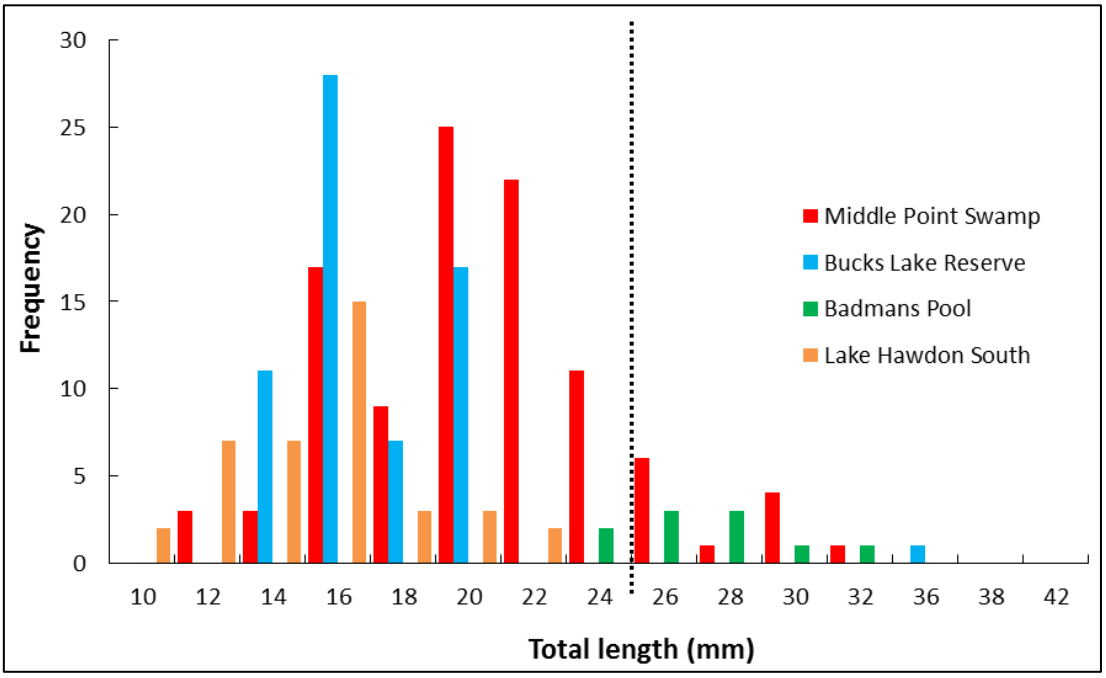

Figure 4-1. Population structures of dwarf galaxias at selected locations that were visited in November and December 2014. Black line represents the distinction between juvenile (10-25 mm) and adult (>25) proportions of the populations.

The key summary statistics apparent in Tables 4-2 to 4-5 include:

- Twenty-eight sites were visited in 2008, with captures recorded from 19 sites.
- Fifty-seven sites were visited in 2012–14, with captures recorded from 28 sites.
- Including the grouped sites in Tables 4.4 and 4.5, 27 of the 28 sites surveyed in 2008 were revisited, with 16 of those sites resulting in dwarf galaxias captures in either survey (15 in both 2008 and 2012–14).
- Of the sites that were revisited:
    - Fourteen sites resulted in dwarf galaxias captures in both 2008 and 2012–14 (including the 3 grouped sites)
    - One site (Blue tea tree swamp) did not have captures in 2008 but did in 2013
    - Three sites (Marshes, Deadmans swamp and Narrowneck drain) had captures in 2008 but not in 2013
- The abundance of dwarf galaxias at sites where the species was detected in either survey was significantly higher in 2008 than the revisited sites; resulting in an abundance ratio of 14.7 fish captured in 2008 for every 1 fish captured in 2012–14.
- The conductivity (salinity) of dwarf galaxias detection sites was typically less than 3000 μScm^{-1}, and hence restricted to southern portion of the region (the mid and lower South East) where fresher wetland salinities predominate. Two exceptions to this trend in the lower South East were Bucks Lake and Middle Point Swamp, where more elevation salinities were recorded at capture sites – noting that the survey timing (November) and seasonal conditions after a dry spring in 2014 are likely to have caused a sharp increase in site salinity in both instances through evapoconcentration.
- Sampling in 2012-14 detected two additional wetland sites in the LSE which were shown to support the largest populations of dwarf galaxias in South Australia (Bucks Lake and Middle Point Swamp).

5 Discussion

5.1 Survey coverage

Every effort was made to revisit capture sites from 2008 – while maximising opportunities to assess potential new sites for the species – to assist in forming a clearer understanding of the updated status of dwarf galaxias populations in South Australia. The result of this approach was greater site coverage that included some new locations where the species was detected for the first time, but also a higher total number of sites where the species was not detected when compared to the 2008 survey results.

5.2 Geographic range of the species

The results of the recent review confirm that the geographic range of the species in South Australia has been maintained over the past 5 years (see Figure 5-1).

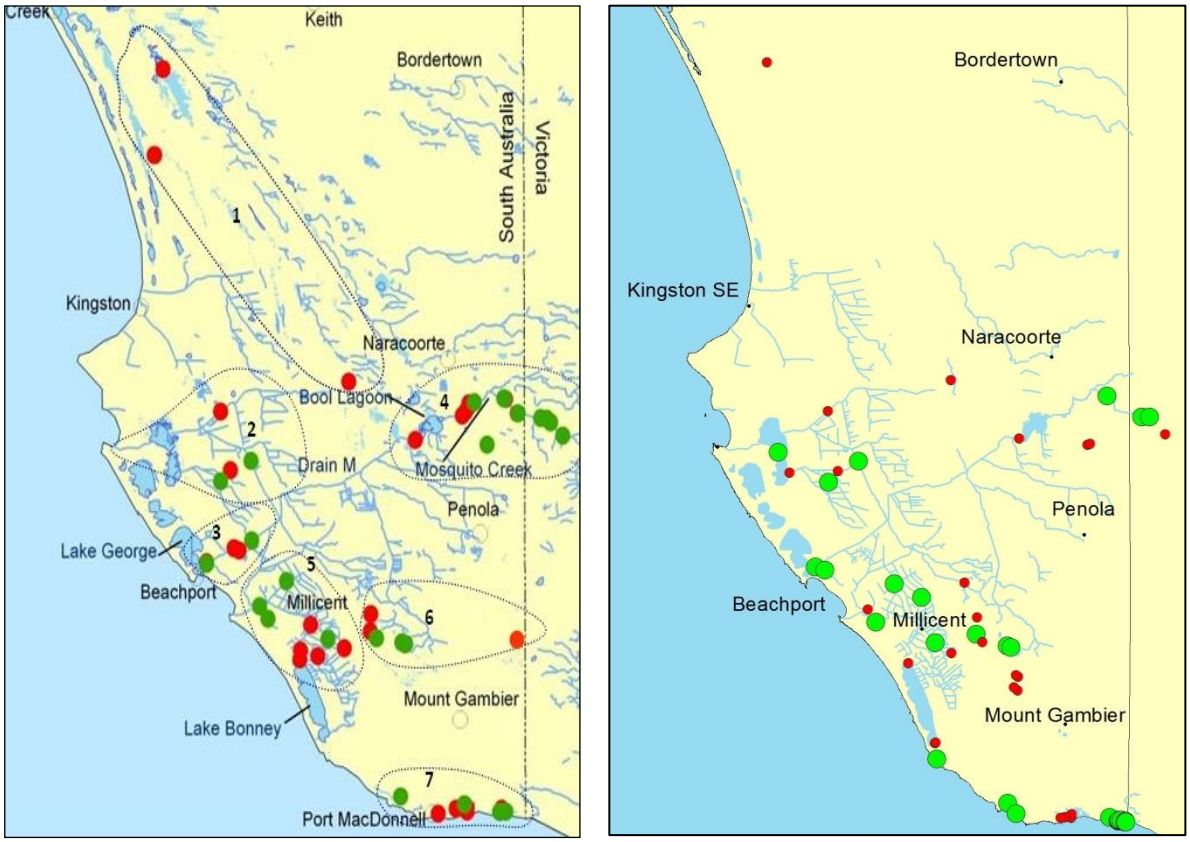

Figure 5-1. Dwarf galaxias 2008 survey results (which included sites targeted for other species and groupings according to sub-region, from Hammer 2009) – LEFT; and, 2012-14 survey results – RIGHT.

Green indicates presence, **red** indicates absence.

[Sub-regions: 1 - Upper South East, 2 – Drain L, 3 – Lower Drain M, 4 – Mosquito Creek, 5 – Bonney/Frome Drains, 6 – Dismal Swamp, 7 – Lower South East.**]**

At the finer scale, there were a small number of additional sites highlighted as priorities for follow-up evaluation. Three sites (Marshes, Deadmans swamp and Narrowneck drain) were positive detection sites (with numbers varying from one to 329) in 2008 but failed to produce any captures in 2013. Of these, Narrowneck Drain is hydrologically connected (on a seasonal basis) to other existing sites where the species was detected and for that reason is of least concern. The other two sites in particular are identified as a priority for future evaluation, something that Nature Glenelg Trust will endeavour to undertake in future years. However, in a positive finding contrary to this trend, Blue Tea-tree Swamp in The Marshes Native Forest Reserve resulted in the re-detection of the species (nine fish) after not being found at this site in 2008. Furthermore, Middle Point Swamp (which underwent restoration works several years ago to increase its depth and duration of inundation) and Bucks Lake Game Reserve (enhanced by seasonal flow restoration from Lake Bonney), both located in the LSE, produced large numbers of dwarf galaxias with evidence of strong recruitment occurring in 2014. In fact, juveniles were detected at 21 of the 28 sites where dwarf galaxias were recorded during the 2012-14 assessments, confirming that recent recruitment had occurred at 75% of sites.

Although the species still occurs at a number of sites, across a range of land systems in the South East, widespread available wetland habitat (such as would have historically existed) is clearly lacking. In this way, the current extent of the species within its known geographic range should be considered to be “relictual” (a fraction of its historic extent) and on the basis of its current fragmented distribution, the species clearly remains a conservation priority in this western-most portion of its national range.

5.3 Abundance of captures and detectability

The site specific results (as previously described in Section 5.2 and presented in Tables 4-3 and 4-4) also indicate a significant reduction in the relative abundance of the dwarf galaxias from sites where the species was detected using the standard methodology for the study. However, caution is required before making any immediate conclusions on the basis of such raw data, given that the results are directly related (sometimes inversely) to site conditions and habitat availability. For example, when water resources are restricted or wetland habitat at a site is concentrated after seasonal drying, fish will often be found in higher abundances in smaller areas of any remaining open water habitat for a limited period of time – and this can make the species significantly more detectable (and appear more numerous per unit of survey effort) than when habitat is widespread and populations less concentrated.

For instance, near the peak of the drought in 2008, spring environmental conditions were relatively dry across the region (making surface water resources more limited in the landscape) in comparison to the relatively wet conditions experienced in the winter/spring of 2013 (less so in 2012 and 2014). Hence, it is not possible to make any significant conclusions on the basis of the capture abundance figures alone for dwarf galaxias in the region. Additionally, this reduction in the probability of detection during a time of increased seasonal habitat availability could be a major factor responsible for three previous capture sites not returning any captures in 2013, and clearly does not mean that species is truly absent from these sites. As such, further sampling is required to confirm the status of populations at these locations.

A recommendation born out of this observation is that future quantitative monitoring needs to compensate reduced probabilities of detection during wetter climatic phases by either waiting until later in the season when aquatic habitat has become more restricted and concentrated, or to undertake sampling frequency according to habitat size. While this will required a larger amount of effort in wet years, it will allow sampling to be undertaken and in a standardised way during spring, when recruitment monitoring is best undertaken.

A final discussion point worth considering, which may influence species abundance and detectability, is the ecology of the species itself. As an effective early colonist of shallow wetland habitats (which tend to be more ephemeral in nature), the dwarf galaxias is able to exploit short term changes in habitat availability that give it a competitive advantage under these circumstances. However more stable, permanent habitats, as are often associated with key refuge sites, while still suitable, may give rise to competitors gaining an advantage under these conditions. More intensive monitoring of a handful of study sites, as part of an honours or other post-graduate research program, would be an effective way of helping to inform this knowledge gap. It is not hard to imagine a time prior to drainage (i.e. pre 1860s) when, with widespread, highly connected shallow wetlands covering expansive portions of the South east NRM region, the dwarf galaxias would have been a much more ubiquitous species, well suited to taking advantage of the available habitats and dynamic changing seasonal conditions (Hammer *et al* 2009).

5.4 Impacts of restoration activities

One of the most positive findings of the status review is additional evidence to support the value of hydrological works to restore, enhance or recreate wetland habitats suitable for dwarf galaxias population recovery. The success of the Pick Swamp restoration site for a range of species, including dwarf galaxias, was described in the *Drought Response Plan for Nationally Listed Freshwater Fishes of South East South Australia* (Slater and Hammer 2009). At that time it was clear that (during a time of high stress for native freshwater fish in the region generally), the only site where a positive trajectory and population recovery was occurring was in the restored, rising spring-fed habitat at Pick Swamp (see Figure 5-2).

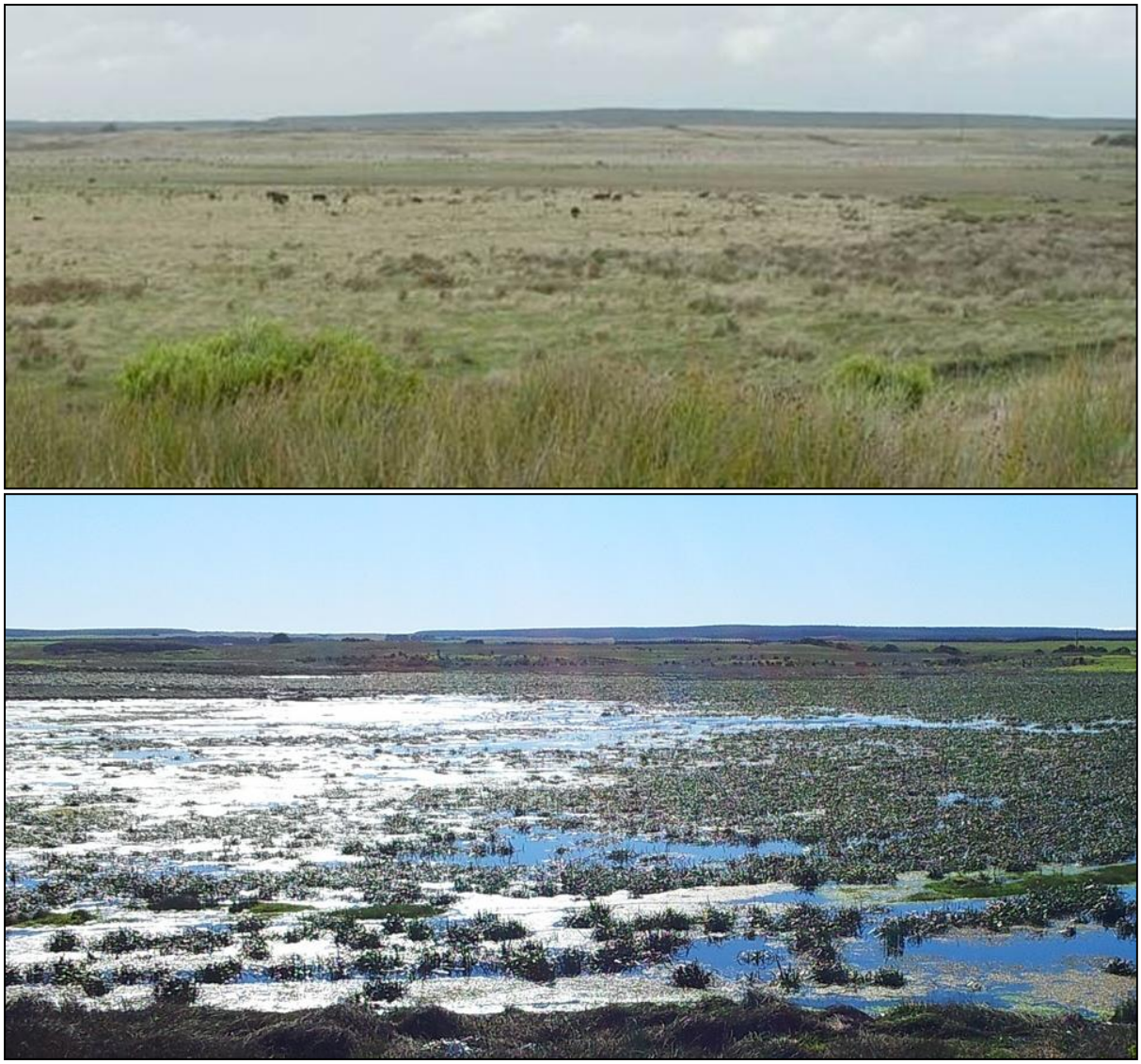

Figure 5-2. Dwarf galaxias habitat at Pick Swamp in 2012 (below), created from what were drained cow paddocks in May 2007 (above), after restoration works (blocking of drains) commenced in June 2007.

Since that time, the next phase of restoration works in the Piccaninnie Ponds Karst Wetlands (a part of the same wetland system situated to the east of Pick Swamp) has also occurred. This work has resulted in the recreation of additional shallow seasonal wetland habitat through (a) increasing water levels at the artificial outlet drain to the sea, and (b) increasing connectivity of flows between wetlands either side of the Piccaninnie Ponds Road; hydrological outcomes that have been found to benefit the fish community in the reserve (Veale & Whiterod, 2014). In fact, several new detection sites for dwarf galaxias in 2013 and 2014 were from wetlands either created or enhanced by recent restoration works, and where dwarf galaxias have colonised extremely effectively, e.g. Piccaninnie Ponds, Middle Point Swamp (see Figure 5-3).

Figure 5-3. Newly inundated habitat within the Piccaninnie Ponds system (above; SITE: Southeast dune – Eastern Wetland, SE13-50) and the change in upstream wetland water level at Middle Point Swamp (SE14-36) following the construction of a regulator in the outlet channel (below).

These examples demonstrate the crucial role of wetland restoration activities in enabling natural aquatic species recovery, and reversing the wider trend of decline in wetland specialist species such as the dwarf galaxias. Restoration works that create habitat mosaics consistent with site topography and a variety of micro-hydrological regimes that recreate or mimic natural conditions, are more likely to benefit a wide suite of wetland species,

including threatened fish. Works associated with more uniform landforms or habitats in situations such as drains, while important, do not provide directly comparable restoration outcomes. One of the key ecological benefits of works throughout the Piccaninnie Ponds wetland complex has been the relatively quick achievement of a desirable level of habitat complexity and ecosystem function.

Although historic data of the species' original area of occupancy in the region is scant, these restoration sites also provide insight into the likely historical use of broad-acre shallow, seasonal wetland habitats in the South East, prior to the drainage and development activities of the past 150 years.

6 Conclusions

In summary and conclusion, the survey found that the dwarf galaxias:

- is still widely distributed but patchy and relatively uncommon in the South East;
- was found at the majority of sites where it had been previously recorded;
- presented reduced abundance and detectability in 2012-14, which appears to have been influenced by (and have an inverse relationship with) the increased availability of aquatic habitat at the time of the survey (when compared to drier conditions in 2008);
- is found to have recovered well and be utilising newly reinstated habitats at wetland restoration sites in the Piccaninnie Ponds area (including adjacent Pick Swamp) and Middle Point Swamp; and,
- would significantly benefit from additional wetland restoration works at strategic locations in the South East region; with a focus of securing core populations in the different sub-populations, at sites where a desirable level of habitat complexity can be achieved.

7 References

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8 Appendices

***Appendix 1*:** Environmental descriptors recorded

Location (description and GPS-WGS 84 datum, zone 54H), waterway, weather, land use, potential impacts and environmental characteristics were recorded for each sampling site to assist with the interpretation of results and future replication. Digital photos were taken of all sites. Environmental characteristics included details of aquatic and interlinked riparian condition under the following categories:

General descriptors: Habitat type (i.e. stream, wetland, in-stream dam).

- Pool size as an estimation of surface area.
- Bank slope (e.g. steep = 45º, vertical 90º).
- Depth (maximum and sampling range)
- Substrate type (e.g. sand, gravel, mud).

Flow environment:

- A temporal measure of connectivity based on seasonal conditions and local landholder input (e.g. ephemeral, six months flow connection, or permanently connected), plus comments such as whether the area is spring fed.

Pool condition and flow:

- A measure of water level in comparison to the normal bank level of a pool (e.g. concentrated, bank level, in flood) and recording of flow ranked relative to magnitude:
- Flow category (low = <10 L/sec; medium 10-100 $Lsec^{-1}$; high 100-200 $Lsec^{-1}$; very high >200 $Lsec^{-1}$).

Contributions to cover (% of volume occupied and type):

- Submerged physical (e.g. snags, leaf litter, rock),
- Submerged biological (e.g. aquatic plants, *Chara*, other algae),
- Emergent (e.g. reeds, rushes and sedges, tea tree),
- Fringing vegetation within 2 metres of the waters' edge (particular note of small amphibious species on the bank such as *Crassula, Centella, Ranunculus*),
- Canopy – measure of overhanging vegetation (shade),
- General surrounding terrestrial vegetation cover.

Water quality:

- Recording, taken at 0.3m depth, of (a) temperature, (b) conductivity (k=10 probe, range 200-200,000µScm^{-1}), (c) pH, and (d) dissolved oxygen.
- Water transparency measured in situ against a white object with comments.

Appendix 2: Summary of sites targeted for dwarf galaxias over 2012, 2013 and 2014.

Date	Site Code	River System	Waterway	Location	Easting	Northing	3 m seine	Dip net	Dip tray	Large fyke	Small fyke	Double wing fyke	Bait traps
2-Oct-12	SE12-22	Lower Drain M	Sutherland Drain	Beachport-Penola Rd	415344	5854886	3	x	x				
2-Oct-12	SE12-25	Lower Drain M	Sutherland Drain	Burk Island Rd	417782	5854068				2	2	1	5
4-Oct-12	SE12-30	USE	Cortina Lakes	Log Crossing Bridge	402646	5986797	3	x	x				
8-Oct-12	SE12-34	Mosquito Creek	Drain M	ds Bool Lagoon outlet	468626	5888358		x	x				
10-Oct-12	SE12-42	USE	Katani Park	NW section of wetland	450861	5903607	3	x	x				
24-Sep-13	SE13-13	Dismal Swamp	Claypans	Southern edge	465565	5834223	3						
24-Sep-13	SE13-14	Dismal Swamp	Everglades	At fire track	466546	5833852	3						
24-Sep-13	SE13-15	Dismal Swamp	Everglades	West waterhole	466442	5833788	1	x					
24-Sep-13	SE13-16	Dismal Swamp	Perched Swamp	Mount McIntyre	457632	5841688	3	x					
24-Sep-13	SE13-17	Dismal Swamp	Blue Teatree Swamp	Mount Burr Rd	457459	5837242		x					
25-Sep-13	SE13-18	Dismal Swamp	Marshes	SW corner	459086	5835126	3	x					
25-Sep-13	SE13-19	Mosquito Creek	Deadmans swamp, southern end	at reserve	486500	5886743		x					
25-Sep-13	SE13-20	Mosquito Creek	Deadmans swamp	SE waterhole	487278	5887021		x					
25-Sep-13	SE13-21	Mosquito Creek	Mosquito creek	Forestry reserve	500701	5894081	3	x					
26-Sep-13	SE13-22	Lower South East	Piccaninnie Ponds	NE section	492273	5789438	3	x					
26-Sep-13	SE13-23	Lower South East	Eight Mile Creek	upstream Drain 5	482353	5789264	3	x					
14-Oct-13	SE13-24	Lower South East	Eight Mile Creek	edge of Conservation Park	482446	5790183	3	x					
14-Oct-13	SE13-25	Lower South East	Deep Creek Drain	Deep Creek drain channel	480675	5789341	3	x					
14-Oct-13	SE13-26	Lower South East	Deep creek spring pool	spring fed pool in paddock	479563	5789230							
15-Oct-13	SE13-27	Lakes Frome and Bonney	Drain 36	Alleyens Rd, junction 41	446648	5835071	3	x					
15-Oct-13	SE13-28	Lakes Frome and Bonney	Lake Bonney	At track on western end	439611	5829741	3	x					
15-Oct-13	SE13-29	Lower South East	Spring pond Cape Douglas	off Megaws Road	465677	5793162							
07-Nov-13	SE13-30	Lakes Frome and Bonney	Drain 31B	Sapiatzer Lane	443058	5846874	3						
07-Nov-13	SE13-31	Lower Drain M	Ephemeral drain - mid catchment	Road Bridge Reedy Ck Lane	454378	5850749	3	x					
07-Nov-13	SE13-32	Dismal Swamp	Isolated wetland 1	off Kangaroo Flat Road	468371	5826121	3	x					
07-Nov-13	SE13-33	Dismal Swamp	Isolated wetland 2	off Kangaroo Flat Road	467884	5826453		x					
08-Nov-13	SE13-34	Lakes Frome and Bonney	Snuggery drain	Top section	450994	5832307	3	x					
19-Nov-13	SE13-35	Dismal Swamp	Isolated wetland	Honans CR	468249	5822567	3						

Appendix 2 Continued…

Date	Site Code	River System	Waterway	Location	Easting	Northing	3 m seine	Dip net	Dip tray	Large fyke	Small fyke	Double wing fyke	Bait traps
19-Nov-13	SE13-36	Dismal Swamp	Isolated wetland	Honans CR	467259	5823310	2						
14-Oct-13	SE13-38	Lower South East	Pick Swamp	Pick fishway, western end	494598	5788415				1	3	1	
14-Oct-13	SE13-39	Lower South East	Pick Swamp	Top centre levee	494694	5788532				1	3		
14-Oct-13	SE13-40	Lower South East	Pick Swamp	Below shed, eastern end	494764	5788671		x	x	2	1		
16-Oct-13	SE13-45	Lower South East	Hammerhead Pond	Hammerhead Pond	492208	5789548							10
16-Oct-13	SE13-46	Lower South East	Main Ponds wetland	West of Pick Road	495900	5788500				1	3		
16-Oct-13	SE13-47	Lower South East	Eastern wetland	East of Pick Road	495298	5788700						1	
17-Oct-13	SE13-48	Lower South East	Eastern wetland	Limestone Pool	495582	5788629							5
17-Oct-13	SE13-49	Lower South East	Eastern wetland	Northeast transect	496410	5788391							5
17-Oct-13	SE13-50	Lower South East	Eastern wetland	Southeast dune	496357	5788126							5
17-Oct-13	SE13-51	Lower South East	Eastern wetland	Boundary dune	496583	5788129							5
18-Oct-13	SE13-52	Lower South East	Main Ponds wetland	Ponds Road	495188	5788892							5
17-Dec-13	SE13-56	Lower South East	Eight Mile Creek	Interconnecting Channel B	481766	5791061							10
04-Sep-13	SE13-65	Drain L	Bray Drain	Robe Rd	418754	5876970	3	x	x				
04-Sep-13	SE13-66	Drain L	Reedy Creek - Willmott Drain	Naracoorte Rd	426531	5882549	3	x	x				
04-Sep-13	SE13-67	Drain L	Drain L	Princess Hwy	418596	5895585	3	x	x				
04-Sep-13	SE13-68	Drain L	Drain BR45	Princess Hwy	421249	5879940	3	x	x				
05-Sep-13	SE13-69	Lakes Frome and Bonney	Bevilaqua Drain	Ford at Canunda CP	431128	5840386	3	x	x				
05-Sep-13	SE13-70	Lakes Frome and Bonney	Narrow Neck Drain	Rendelsham	429113	5843663	3	x	x				
05-Sep-13	SE13-71	Lakes Frome and Bonney	Hartherleigh Drain 20B	Princess Hwy	435909	5850507	3	x	x				
17-Nov-14	SE14-31	Lakes Frome and Bonney	Coastal wetland	Spring-fed freshwater pool	446647	5808748		x					
17-Nov-14	SE14-32	Lower South East	Bucks Lake Game Reserve	Downstream of drain	447132	5804625	3	x					
18-Nov-14	SE14-33	Lake Hawdon	Lake Hawdon South	Connector Drain, DS bridge	405560	5884873	3	x					
18-Nov-14	SE14-34	Lake Hawdon	Lake Hawdon South	Bradys Drain	408619	5879439	3	x					
17-Nov-14	SE14-35	Lakes Frome and Bonney	Lake Bonney	Near spring-fed pool	446859	5808958	2	x					
19-Nov-14	SE14-36	Lower South East	Middle Point Swamp	Outlet Drain	467883	5790356	2	x					
05-Dec-14	SE14-37	Mosquito Creek	Mosquito Creek	Badmans Pool	491627	5899523	2	x					
05-Dec-14	SE14-38	Mosquito Creek	Mosquito Creek	Elderslie 2	502726	5893980		x					
05-Dec-14	SE14-39	Mosquito Creek	Mosquito Creek	Hateleys Pool	506864	5889467	2	x					