Regional status update of the dwarf galaxias (*Galaxiella pusilla*) in the South East of South Australia – Spring 2012-13

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Aquasave – Nature Glenelg Trust (2014)

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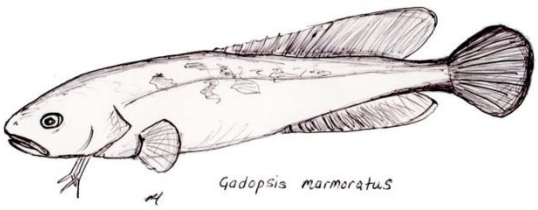

Ecology, Monitoring, Conservation

Figure 1 – A male (top) and female (bottom) dwarf galaxias (Photo: Michael Hammer)

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). The species is endemic to south-eastern Australia, where it occurs in Tasmania, South Australia and Victoria (see Figure 2). The Dwarf Galaxias is listed as nationally Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*. As indicated in Figure 2, 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.

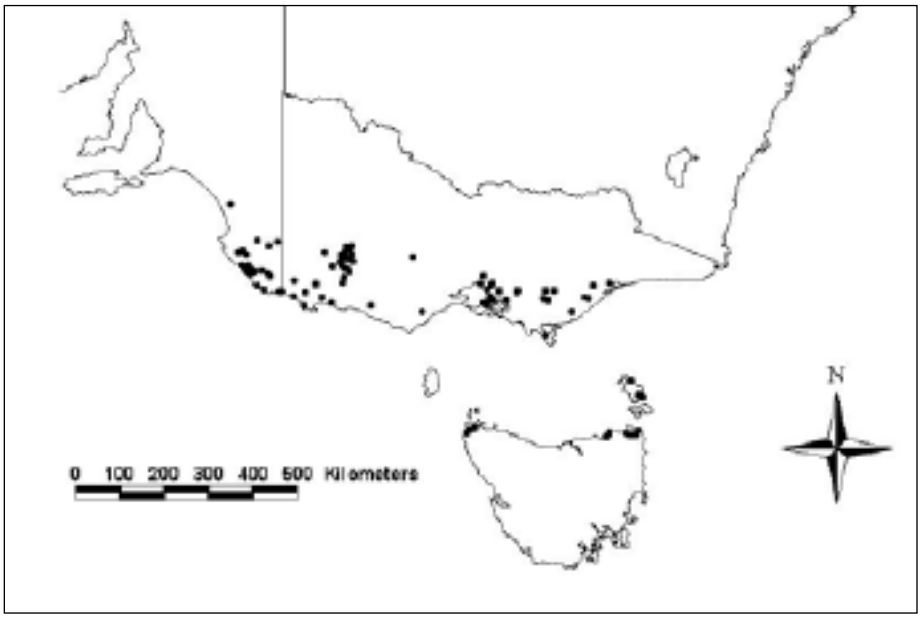

Figure 2 – the national distribution of the Dwarf Galaxias (from Saddlier *et al* 2010)

2. Biology, Threats and Background to the 2013 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) potentially 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; namely, 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 survey 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 re-detect the species from 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 be 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 2012-13 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 November 2013, 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 and 9902631) 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 3mm 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 (30cm 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).

All sampled fish were identified to species, 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 destroyed 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).

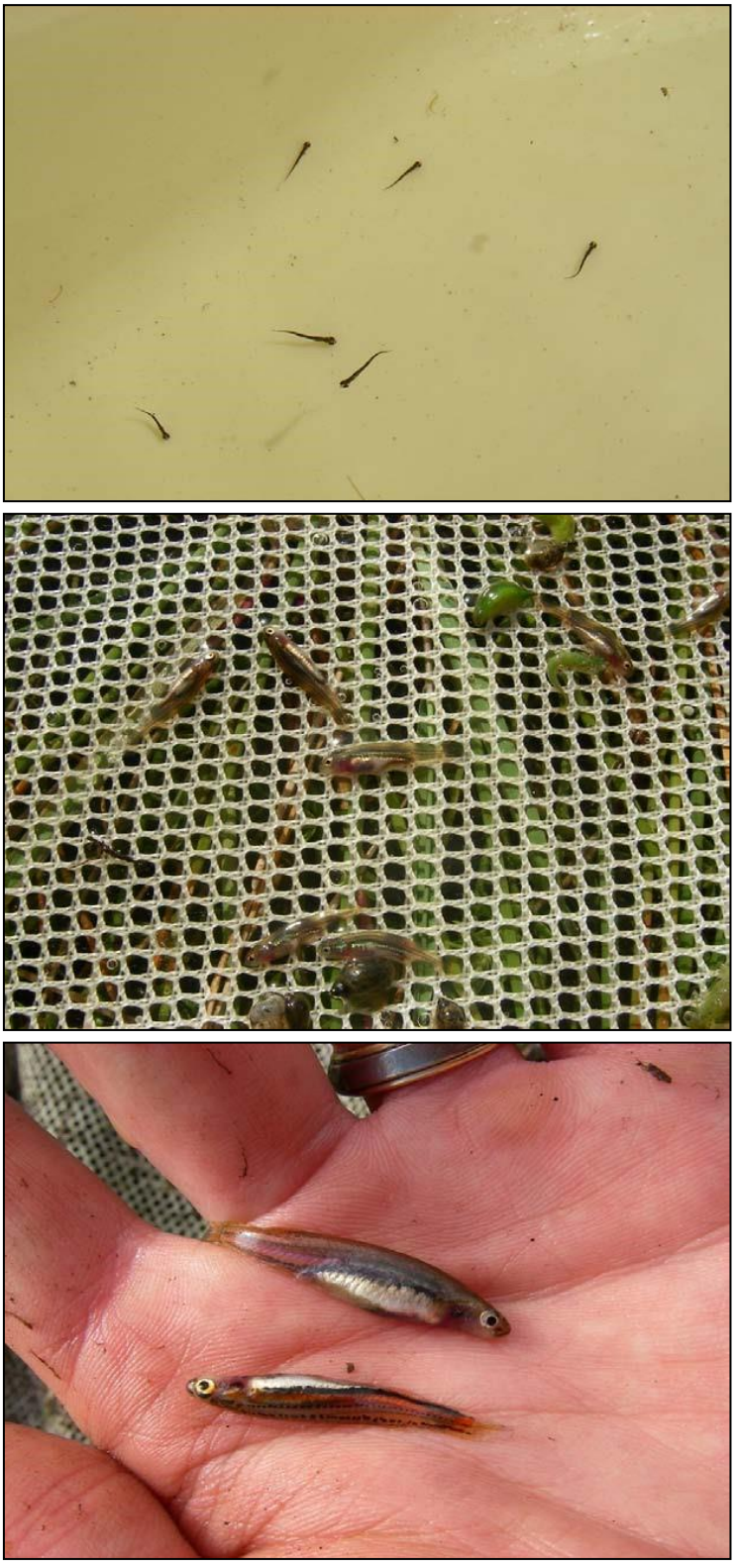

Figure 3 – Different life stages of Dwarf Galaxias (top – larvae; middle – juveniles; bottom – adults)

4. Results

In total, 8628 fish were recorded across 15 fish species from 48 sites sampled in 2012-13 (Table 1). Site conditions are recorded in Table 2.

Table 1 – Summary of catch data at sites targeted for Dwarf Galaxias. Life stage: A = Adult, J = Juvenile, L = Larvae.

Site Code	Region	Dwarf Galaxias		Australian 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															
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	
SE12-22	Lower Drain M	10	2A, 8J					4			3			1				1
SE13-23	LSE					8					29	7			12			
SE13-24	LSE					6						8	7					
SE13-25	LSE					11	2					4			2			
SE12-25	Lower Drain M	3	3A	4	4	11		49			4	309		8		4		3
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
SE12-30	USE										500							
SE13-31	Lower Drain M											1						
SE13-32	Dismal Swamp																x	
SE13-33	Dismal Swamp																x	
SE13-34	Bonney/Frome											21						
SE12-34	Mosquito Creek																	4
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						
SE12-42	USE				30							2						
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															

Table 2 – Summary of environmental descriptors

Site Code	Region	pH	Conductivity (uS/cm)	Temperature (oC)	Dissolved oxygen (ppm)	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	5.20	0.1
SE13-13	Dismal Swamp	7.5	445	17	5.50	0.3
SE13-14	Dismal Swamp	7.2	269	14.5	0.45	0.2
SE13-15	Dismal Swamp	7.2	638	13.8	0.69	0.3
SE13-16	Dismal Swamp	7.5	263	14.9	0.51	>0.3
SE13-17	Dismal Swamp	7.3	267	15.7	0.45	0.3
SE13-18	Dismal Swamp	6.4	321	13.9	52.00	>0.2
SE13-19	Mosquito Creek	8.2	412	19	16.94	>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	1495	15.9	18.75	>0.1
SE13-24	LSE	6.2	1888	16.5	18.00	10
SE13-25	LSE	6.2	2217	17.4	22.00	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	16.95	-
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	12.35	0.3
SE13-32	Dismal Swamp	5.8	149	16	2.46	0.1
SE13-33	Dismal Swamp	6.3	430	17	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	4.34	1
SE13-45	LSE	7.6	1076	12.1	3.56	2
SE13-46	LSE	7.6	2700	13.7	3.28	3
SE13-47	LSE	7.9	2730	12.8	3.45	1.1
SE13-48	LSE	7.4	2400	14	2.76	1
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	0.75
SE13-56	LSE	7.1	758	17.0	8.90	>1.9
SE13-65	Drain L	7.9	1571	13.9	8.92	>0.43
SE13-66	Drain L	8.2	1185	16.5	9.96	0.15
SE13-67	Drain L	8.6	2372	16.3	4.36	0.75
SE13-68	Drain L	7.6	2020	16.7	4.21	0.05
SE13-69	Bonney/Frome	8	1653	14.2	3.66	>1.2
SE13-70	Bonney/Frome	8	1734	13.4	4.15	>0.83
SE13-71	Bonney/Frome	8.3	1330	14.8	3.05	>0.9

Of the total number of sites visited, 262 Dwarf Galaxias were captured from 23 of the sampled sites (48% of sites). Total numbers of fish recorded were down from 1286 fish, from 19 sites, in 2008. For a summary comparing the relative fish survey results from 2008 to 2012-13, please refer to Tables 3 and 4.

Table 3 – Dwarf Galaxias capture results in 2008 and 2012-13 (sites grouped according to capture region)

Waterway	Location	Region	Dwarf Galaxias	
			2008	2013
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
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
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	
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	Mosquito Creek	Mosquito Creek	7	
Mosquito Creek	Mosquito Creek	Mosquito Creek	26	
Mosquito Creek	Mosquito Creek	Mosquito Creek	318	
		TOTAL fish	**1286**	**262**
		# detection sites	19	23

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 2012-13; 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.

Table 4 – Comparing Dwarf Galaxias capture sites visited in both 2008 and 2012-13

Waterway	Location	Region	Dwarf Galaxias	
			2008	2013
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
Bray Drain	Robe Rd	Drain L	21	1
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
		TOTAL fish	**935**	**67**
		Relative Abundance Ratio	14	1

Note: boxes shaded are for grouped sites (highlighted in Table 3) that are within the same general area and are being treated as representative of a single site for comparative purposes

Some key summary statistics that can be gleaned from the data in Tables 1-4 include:

- Twenty-eight sites were visited in 2008, with captures recorded from 19 sites.
- Forty-seven sites were visited in 2012-13, with captures recorded from 23 sites.
- Including the grouped sites in Tables 3 and 4, 24 of the 28 sites surveyed in 2008 were revisited, with 16 of those sites resulting in Dwarf Galaxias captures in either survey (15 in 2008, and 13 in 2012/13).
- Of the sites that were revisited:
    - Twelve sites resulted in Dwarf Galaxias captures in both 2008 and 2013 (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
- A minor gap in survey coverage occurred in Mosquito Creek (3 sites) between the two survey periods, with 2 additional sites able to be confirmed as sustaining populations on the basis of nearby records at new sites in 2013.
- The abundance of Dwarf Galaxias at sites where the species was detected in either survey was significantly higher in 2008 than equivalent sites in 2013; resulting in an abundance ratio of 14 fish captured in 2008 for every 1 fish captured in 2012-13.

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.

The result of this blended approach was that a handful of previous capture sites (those that were targeted for other species in 2008 but also resulted in Dwarf Galaxias captures) were not able to be accommodated within the time allocated to the 2012-13 survey. Although the grant funds have been exhausted on the work undertaken so far, Nature Glenelg Trust is voluntarily committing to continue to visit a handful of additional sites in the Mosquito Creek catchment (3 sites) in spring 2014 to complete the evaluation. This interim report will also be updated to accommodate the additional data.

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 4).

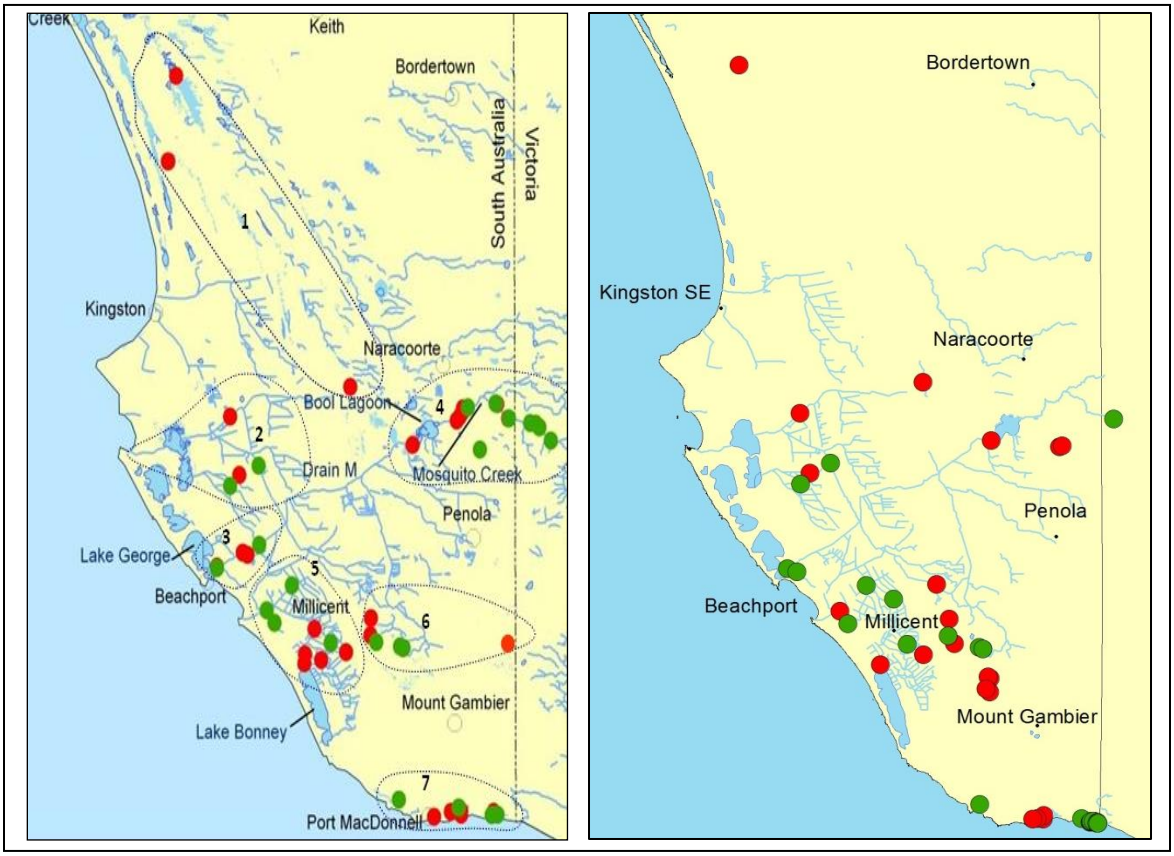

Figure 4: Dwarf Galaxias 2008 survey results (which included sites targeted for other species and groupings according to sub-region, from Hammer 2009) – LEFT; and, 2012/13 survey results – RIGHT. **Green** indicates presence, **red** indicates absence.

[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, while some minor gaps in coverage still exist (as explained in Section 5.1), 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 a single fish to 329 fish detected) 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 do voluntarily in 2014, in conjunction with filling in the other minor gaps in survey coverage (as previously described), including re-evaluation of priority pools in the Mosquito Creek catchment. 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.

Although the species still occurs at a number of sites, across a range of land systems in the South East, widespread available wetland habitat (like that it can be inferred 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 3 and 4) also indicated 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 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 more widespread and populations are 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. 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. Hence, further sampling is required to confirm the status of populations at these locations.

With this in mind, it may be necessary for the methodology in future to compensate for this reduced probability of detection during wetter climatic phases, by either waiting until later in the season when aquatic habitat has become more restricted or concentrated (bearing in mind that this will restrict the collection of spring recruitment related data), or to spend additional effort sampling, linking survey effort to habitat area to compensate, if surveying during peak winter/spring conditions. This will reduce some of the otherwise unavoidable sampling effort bias in the methodology, and make the survey data more reliable for comparison after repeat visits to the same site.

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.

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).

Figure 5: 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 Piccaninnie Ponds Conservation Park (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.

Several of the new detection sites in 2013 were from wetlands either created or enhanced by the recent restoration works, and where Dwarf Galaxias have colonised extremely effectively. For an example of this newly created/restored habitat, see Figure 6.

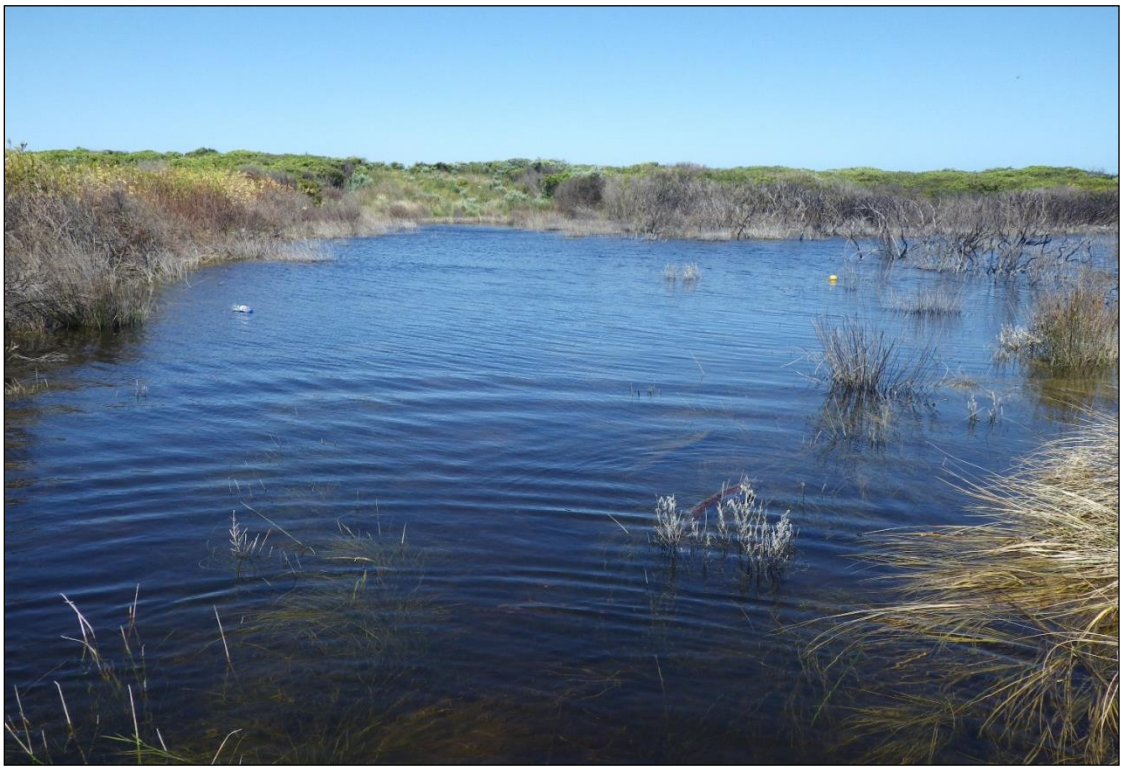

Figure 6: Newly inundated habitat within the Piccaninnie Ponds system (SITE: Southeast dune – Eastern Wetland, SE13-50)

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

6. Conclusion

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 2012-13, 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,
- would significantly benefit from additional wetland restoration works at strategic location in the South East region in the future; 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

Beck, R. G. (1985). Field observations upon the dwarf galaxiid *Galaxiella pusilla* (Mack)(Pisces: Galaxiidae) in the south-east of South Australia, Australia. South Australian Naturalist 60, 12-22.

Saddlier, S., Jackson, J. and Hammer, M. (2010). National Recovery Plan for the Dwarf Galaxias *Galaxiella pusilla*. Department of Sustainability and Environment, Melbourne.

Hammer, M. (2002). The South East fish inventory: distribution and conservation of freshwater fishes of south east South Australia. Native Fish Australia (SA) Inc., Adelaide. p. 53.

Hammer, M. (2009). Status assessment for nationally listed freshwater fishes of south east South Australia during extreme drought, spring 2008. Report to Department for Environment and Heritage, South Australian Government. Aquasave Consultants, Adelaide. 39 p.

Slater, S. and Hammer, M. (2009). Drought Response Plan for Nationally Listed Fishes of South East South Australia: Regional Action, Contingency and Long Term Recovery. Department for Environment and Heritage, South East region.

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 L/sec; high 100-200 L/sec; very high >200L/sec).

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.