Natural Resources
SA Murray-Darling Basin

Frog Monitoring in the Coorong, Lower Lakes and Murray Mouth (CLLMM) Region

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Government of South Australia

Authors
This project was managed and implemented by Kate Mason and Melissa Tucker. This document was written by Kate Mason for the South Australian Murray-Darling Basin Natural Resources Management Board (SA MDB NRM Board).

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For more information
Natural Resources, SA Murray-Darling Basin
Department of Environment, Water and Natural Resources
PO Box 2343
MURRAY BRIDGE SA 5253
Phone: (08) 8532 9100
www.samdbnrm.sa.gov.au

Summary

Lake Alexandrina, Lake Albert and the Eastern Mount Lofty Ranges tributaries constitute a dynamic and subtly ever-changing landscape that supports diverse assemblages of aquatic biota. Over the past two years the region has experienced the first stages of recovery to a functioning freshwater and estuary system, following increased freshwater flows into the system. This period followed an extended period of reduced freshwater flows and over-allocation of water resources. Water-dependant species suffered marked declines in the region, with many species lost from former sites or retracting to remnant pools. With the continued return of water to fringing wetland habitats and waterways, the recovery of many once-common species, including the EPBC vulnerable-listed Southern Bell Frog (*Litoria raniformis*) has not been of the magnitude expected. The largest of the 12 frog species known in the Lower Murray, *L. raniformis* is responsive to flooding; readily occupying shallow, newly inundated vegetated areas to breed. Southern Bell Frog populations in the study region have declined, likely as a result of changes in natural water regimes, decline in availability of key habitat and increased surface water salinity.

Between September 2012 and January 2013, a monitoring project was undertaken to observe the biotic response of *L. raniformis* to changes in environmental conditions within Lake Alexandrina, Lake Albert and the mouths of the Eastern Mount Lofty Ranges tributaries. Identifying key extant populations, assessing habitat condition and detecting successful recruitment were the three main objectives of the project. Monitoring methods included a combination of call identification, active searching, and tadpole trapping (via fish surveys). With the combined help from volunteers, nocturnal surveys were undertaken at 76 locations across the region (37 project sites, 39 volunteer sites). A total of 227 survey events were completed. *L. raniformis* was detected at only two sites in the north and western areas of the study region at Pomanda Point (Nalpa Station) and near Clayton Bay Township. Overall detected abundance across the study region was low to extremely low.

Adult *L. raniformis* were observed calling within semi-open vegetated sheltered waterbodies comprising of inundated terrestrial, emergent and submerged vegetation. *L. raniformis* was not detected at sites which were dominated by the Common Reed (*Phragmites australis*) or Bulrush (*Typha domingensis*), a common feature of the region. Calling of male *L. raniformis* occurred during November and December and during periods when Lake levels were maintained above 0.8 mAHD. Successful recruitment of *L. raniformis* was not observed at either site occupied by calling male *L. raniformis*. The low abundance of calling male *L. raniformis* during nocturnal surveys suggests recruitment, if it occurred, may also have been low.

Results of this investigation show that there is a need to conserve and appropriately manage wetlands and vegetation communities associated with *L. raniformis* breeding habitat by building upon current land management practices and implementing a variable hydrological regime.

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Acronyms and abbreviations

AHD	Australian Height Datum
cm	centimeters
DEWNR	Department of Environment, Water and Natural Resources
DO	Dissolved Oxygen
EC	Electrical Conductivity
GWLMP	Goolwa Water Level Management Project
km	Kilometers
LAP	Local Action Planning Association
m	Meters
mg	milligrams
NR SAMDB	Natural Resources SA Murray Darling Basin
NRM	Natural Resources Management
NTU	Nephelometric Turbidity Units
pH	(p)otential of (H)ydrogen
ppm	parts per million
SA	South Australia
SA MDB NRM Board	South Australian Murray-Darling Basin Natural Resources Management Board
µS	Micro Siemens

1.0 Introduction

The Southern Bell Frog (*Litoria raniformis*) is a large ground-dwelling frog which was formerly common and widespread throughout much of south-eastern Australia and Tasmania. Over the past 20-25 years, the species has suffered noticeable declines in distribution and abundance and is now listed as nationally 'vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999*. At a State and Territory level the species is considered 'vulnerable' in South Australia and Tasmania and 'endangered' in Victoria, New South Wales and the Australian Capital Territory. This project addresses the need to monitor key populations around Lake Alexandrina, Lake Albert and the lower reaches of the tributaries: the Finniss River and Currency Creek, and the responses of the species to water level management below Lock 1.

1.1 Project objectives

This project is primarily being undertaken to determine the effects of changes in habitat features and the management of water levels through targeted surveys of frog (particularly *L. raniformis*) populations and habitat condition assessment within the Lower Lakes and Murray Mouth region. The results from monitoring conducted aims to address the key questions and test the hypothesis outlined in Table 1.

The broad services of the project are to:

- Conduct targeted broad-scale surveys for *L. raniformis* in habitat considered suitable for the species within the Lower Lakes and Tributaries
- Identify key extant *L. raniformis* populations
- Assess the habitat conditions at identified populations particularly in relation to water level and habitat structure with comparisons to past years where possible.

Table 1: Objectives, key questions and hypotheses for frog species monitoring in the Coorong, Lower Lakes and Murray Mouth.

Monitoring Objective	Key Questions	Hypotheses
To assess the response of: Frog Species to: A) the continued water availability following the recent drought (years), and; B) changes in habitat condition in comparison to drought conditions (comparison of past monitoring data)	1. What has been the response of frog species to continued water availability and re-inundation of suitable habitats? Has species distribution and abundance changed since re-inundation of these habitats? 2. Has there been any evidence of successful recruitment at three *L. raniformis* populations and how were these events likely influenced by water levels? 3. How have extended returned water levels influenced habitat structure and how has this influenced use by *L. raniformis*? 4. How does the data compare between the two methods of detecting frog populations (automatic sound recording vs. in-situ field monitoring).	1. Frog assemblages in the study area will have increased in abundance since re-inundation of wetland habitats. 2. Water levels above 0.8 m AHD will result in an increase in available habitat for *L. raniformis* and therefore an increase in the number of sites where *L. raniformis* is detected. 3. Successful *L. raniformis* recruitment will occur where preferred habitat is inundated for three or more months. 4. Automatic sound recording devices will detect greater species diversity than in-situ field monitoring.

1.2 The Coorong, Lower Lakes and Murray Mouth (CLLMM) region

The Coorong, Lakes Alexandrina and Albert and the Murray Mouth, together form the wetland and estuary system that is the terminus of the River Murray. The area was declared a Wetland of International Importance in 1985 under the Ramsar Convention as the Coorong and Lakes Alexandrina and Albert Wetlands (MDBC 2006). Terminating at the Southern Ocean in South Australia, the River Murray passes through the Lake Alexandrina, the Murray Estuary and, finally, the Murray Mouth. Together the Lakes cover approximately 648 square kilometres which makes them the largest freshwater body in South Australia (DEH 2000). The complex ecology of the area has been modified by a system of barrages which restrict connectivity between the Lower Lakes and the Murray Mouth and Coorong.

The Murray-Darling Basin experienced severe drought between 2001 and 2010 and as a result, the Lower Lakes which rely on flows from upstream, were directly affected by the quality and quantity of water reaching this area. Years of over-allocation, over-extraction and severe drought conditions lead to several significant impacts upon the Lower Lakes including unprecedented low lake levels, with Lake Alexandrina dropping 1 m below sea level in April 2009. With the absence of any freshwater flows through the barrages, water quality of the system declined significantly. As lake water levels receded, the lake beds and fringing wetlands dried out and extensive areas of aquatic and riparian habitat were lost. Previously submerged sulfidic soils became exposed, presenting the threat of acidification. These acid sulfate soils became a major issue in many wetlands around the lower lakes and tributaries (Currency Creek and the Finniss River) with affected wetlands and lake bed areas requiring aerial liming, seeding or major bioremediation works to treat the acidification. In an attempt to prevent major acidification in the tributaries, the Goolwa Water Level Management Project was established. A blocking bank between Clayton and Hindmarsh Island was constructed during 2009 across the Goolwa Channel, forming the 'Goolwa Water Level Management Area' (GWLMA). Water levels within the GWLMA were then maintained above the critical threshold for acidification by inflows from the Finniss and Currency Creeks and pumping from Lake Alexandrina.

During 2010, increased flow into the River Murray raised water levels in the Lakes and re-inundated fringing wetland habitats that had been dry for up to four years. The GWLMA blocking bank was partially removed in September 2010 reconnecting the Goolwa Channel to Lake Alexandrina. Since 2010, inflows into the Lakes have maintained water levels at relatively 'normal' levels and provided flows through the barrages and the Murray Mouth.

1.3 Species description

The Southern Bell Frog is also known as the Golden Bell Frog, Green and Golden Grass Frog, and the Growling Grass Frog due of their loud growling 'crawaark' calls (Stratman 2007). They are large compared to other frogs (up to 10 cm) and have warty green skin varying from dull olive-brown to bright emerald green, mottled with irregular brown to tan blotches depending on local conditions (Stratman 2007). These frogs reside in or near temporary ponds and wetlands, or near permanent water bodies along the River Murray (DEH 2006).

They are most active in spring and summer when they may be seen basking in the sun. In winter they can be found in groups beneath thick beds of reeds on the edges of wetlands. Feeding at night, *L. raniformis* eats small water bugs, beetles, termites and insect larvae. They can also be cannibalistic and eat other frogs. They are opportunistic predators, sitting and waiting to ambush whatever prey comes within reach (DEH 2006).

During spring and summer, the male *L. raniformis* calls with a repeated 'crawark crawaaark crok crok' to attract a mate, while floating in open water or under aquatic vegetation. Females lay jelly-like masses of eggs (up to 400) typically after a local rain or flooding (DEH 2006). Two days later, the tadpoles hatch, and hide in vegetation near

the water's edge where the water is shallower and warmer. The tadpoles metamorph into frogs in summer and autumn.

1.4 Threats

Decline of the species has been thought to be due to introduction of alien predatory fish; habitat loss, degradation and fragmentation; infection by Chytriodiomycosis disease; accumulation of chemicals in aquatic habitats; and possibly increased levels of ultra-violet-B (UV-B) radiation as a result of ozone depletion (Stratman 2007). Consequently, for the conservation of viable populations of *L. raniformis*, it is imperative that studies are carried out to clarify their distribution and abundance across its current known range.

1.5 Distribution within the Lower Lakes region

Knowledge of the distribution and abundance of *L. raniformis* in the Lower Lakes pre-2009 is limited. Historical records spanning more than 60 years were the basis for an inventory of the species conducted in 2009 (Mason 2010). Individuals were detected at a small number of sites in the Lower Lakes during this time, however, little was known of the species' status in the region prior to the drought and subsequent contraction of their habitats.

Based on records obtained from the Southern Bell Frog Inventory, Biological Survey Database, Frog Census, SA Museum, River Murray Baseline Database and ongoing monitoring, the species was known from a total of sixteen individual sites within the Lower Lakes District (Fig. 1). Some of these records pre-dated 1980, with *L. raniformis* recorded from three localities prior to 1976 from Narrung, Wellington and the Milang district (Figure 1). Voucher specimens were collected at each of these sites, all of which are currently held in the SA Museum. Frog census data collected in September 2000 also resulted in the identification of *L. raniformis* at the Wellington ferry and Langhorne Creek.

A number of frog surveys were carried out as part of the River Murray Baseline Survey during 2004 and 2005. *L. raniformis* was only recorded at two, out of 13, wetlands surveyed (Holt *et al.* 2004; Simpson *et al.* 2006). Several males were heard calling in March 2004 and November 2005 at Tolderol Game Reserve and Pelican Lagoon, respectively (Figure 1). The landholders of Mundoo Island, provided photographs of an adult *L. raniformis* collected on the Island in 2005.

L. raniformis was recorded at three locations during the 2009 inventory. The largest population (10-50 individuals) was recorded at Clayton Bay and smaller populations were detected in the Finniss River at 'Wally's Landing/Watchalunga' (2-9 individuals) and Mundoo Island (1 individual). Clayton Bay and Wally's Landing were located within inundated wetlands and shorelines following the implementation of the Goolwa Water Level Management Project (GWLMP).

Frog monitoring conducted in the region in 2010 detected *L. raniformis* at six locations in moderate to low abundances. Pelican Lagoon (Sites 1 & 2), Finniss 'Watchalunga/Wally's Landing', Finniss 'Sterling Downs', Clayton Bay 'Red Top Bay' and Mundoo Island. *L. raniformis* had been found at or near three of these sites in the past. A photograph of an adult discovered in a pump shed at Turvey's Drain was provided by landholders, north-east of Milang Township in 2010. No formal *L. raniformis* monitoring was conducted in 2011, however opportunistic survey events yielded moderate abundances at Nalpa Station 'Pomanda Point Causeway', approximately 4.5km south of Pelican Lagoon where they were recorded the previous year.

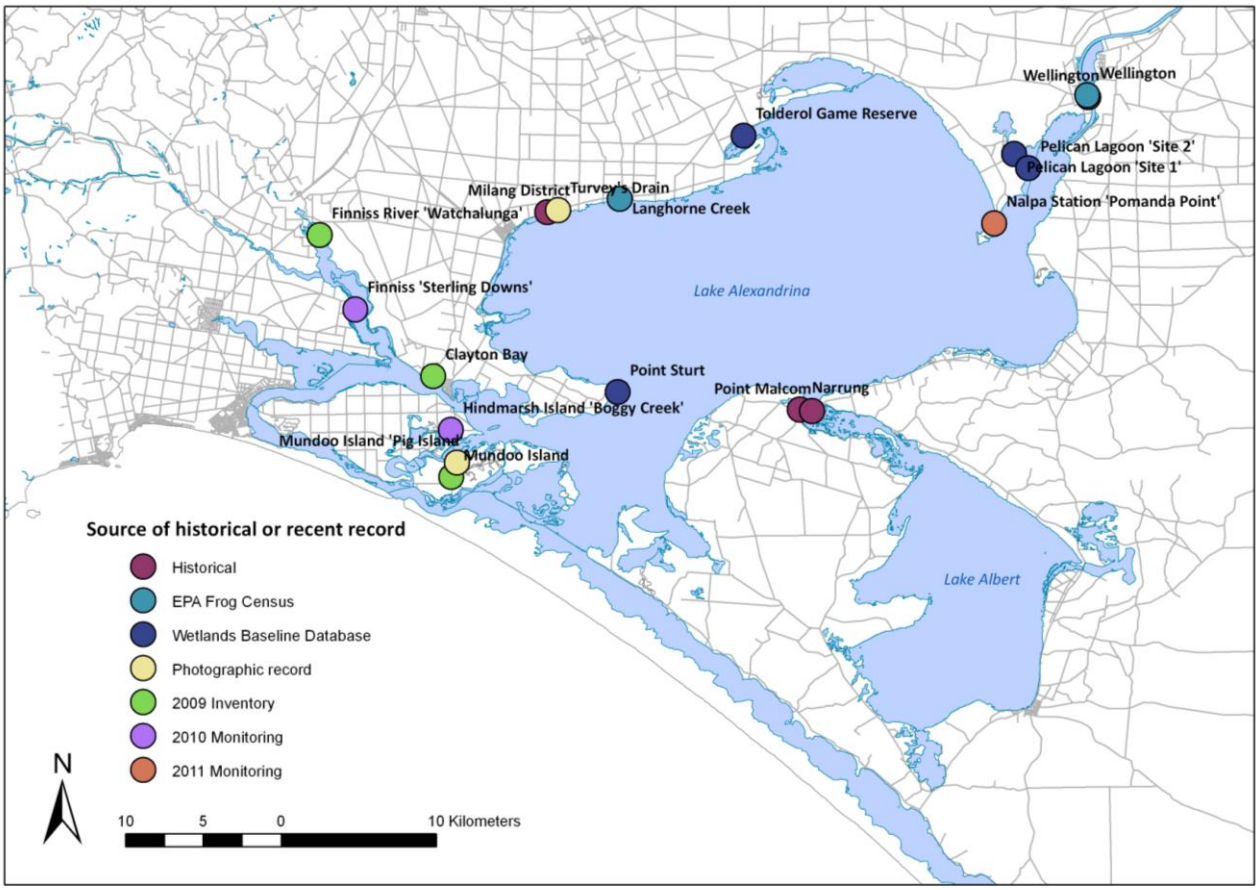


Figure 1: Known distribution of the Southern Bell Frog (*Litoria raniformis*) in the CLLMM region.

1.6 Habitat characteristics at historical sites

Litoria raniformis is known to occupy a range of natural and artificial habitat including permanent and ephemeral wetlands, streams, riverine floodplains, farm dams, flooded paddocks, marshes, garden ponds, quarries and irrigation channels (Stratman 2007). However, the habitat preference of *L. raniformis* in the Lake Alexandrina, Lake Albert and tributaries region has generally consisted of Lignum (*Muehlenbeckia florulenta*) shrublands, low sedgelands, inundated grasses, and dense floating aquatic plants such as filamentous algae.

Historical sites known to support extant populations are broadly characterised by permanently or temporarily inundated water bodies with emergent and submergent aquatic vegetation. Individuals detected within the Finniss River near Wally's Landing (Figure 1) in 2009 occupied an area dominated by Lignum shrublands with an understorey of Saltwater couch (*Paspalum vaginatum*), Sea Rush (*Juncus kraussii*) and scattered but not dense Common Reed (*Phragmites australis*) and Bulrush (*Typha domingensis*).

Clayton Bay contained extensive stands of emergent River Club-rush (*Schoenoplectus vallidus*) with large mats of filamentous algae caught between. These stands of *S. vallidus* and algae were recently inundated, standing in approximately 1.4m of water. The wetland fringes were dominated by *P. vaginatum*. Submerged aquatic plants such as Milfoil (*Myriophyllum sp.*), Widgeon Grass (*Ruppia sp.*) and Hornwort (*Ceratophyllulm demersum*) were also present in low to moderate abundance.

Individuals heard calling at Tolderol Game Reserve occupied Common spike-rush (*Eleocharis acuta*) dominated sedgelands comprising an understory of *P. vaginatum*, aquatic herbs and scattered clumps of Salt club-rush (*Bolboschoenus caldwellii*) (Holt *et al.* 2004). Tolderol Game Reserve fringes Lake Alexandrina and before the drought, consisted of a series of regulated artificial bays, which were temporarily inundated via a regulated pumping system. Dense, tall reed beds and water channels dominated by Bulrush. and Common Reed were also characteristic of the site (Holt *et al*. 2004).

Pelican Lagoon, a site known to support *L. raniformis* pre 2006, consists of three distinct permanent lagoons/billabongs connected by broad shallow channels. The site fringes the north-eastern shore of Lake Alexandrina and is characterised by a number of vegetation types. *L. raniformis* were heard calling within stands of Common Rush (*Juncus usitatus*) and Spiny flat-sedge (*Cyperus gymnocaulos*). The site also contains Lignum shrublands which are flooded intermittently.

In September 2000, between 10-50 male *L. raniformis* were heard calling in marshland and flooded paddocks near Langhorne Creek. Several males were also heard during the same month in riverine habitat at the Wellington ferry.

While habitat descriptions found to support *L. raniformis* were not recorded in the SA Museum database, most sites are characterised by permanent water and plentiful vegetative structure.

1.7 Impact of drought on *L. raniformis* populations

Following the decline in water levels in the River Murray reach below Lock 1 (at Blanchetown) during 2006/07, the fringing wetlands of Lake Alexandrina, Lake Albert, the lower Finniss River and Currency Creek and the Goolwa Channel dried. The exception to this was the provision of environmental water to three isolated wetlands or drains for the purpose of maintaining threatened fish populations or protecting viability of significant submerged aquatic plant seed-banks (K. Hillyard pers. comm.). Flooding and drying (or partial drying) is a recognised technique in wetland rehabilitation as it attempts to mimic pre-regulation water regimes (Tucker *et. al*. 2003). A number of the benefits that can be gained from fluctuating water regimes were observed during the 12 months following drying of fringing Lower Lakes wetlands such as the colonisation of terrestrial vegetation on exposed wetland and lakebed. However, prolonged drying of wetlands in the region occurred (up to four years) resulting in, but not limited to, loss of aquatic plant communities (from dry conditions and smothering from sand and sediment drift), increase in weed species, degradation of wetland sediments from wind and access by stock and exposure of sulfidic sediments.

As limited information on the abundance and distribution of *L. raniformis* in the region was available prior to the drying of their known habitats, it is difficult to accurately assess the impact drought and reduced freshwater flows had on populations in the study region. During 2009, inundation of wetlands and riparian zones within the GWLMA provoked a positive response in local frog communities, including *L. raniformis* (Mason 2010). However outside of this region, the majority of known *L. raniformis* locations remained dry. As *L. raniformis* is a species known to respond rapidly to increases in water levels, opportunities arose within the GWLMA for breeding events to occur providing water levels were maintained high enough to keep their preferred habitat inundated until metamorphosis of tadpoles could be completed.

2.0 Methodology

2.1 Site selection

Sites selected for inclusion in the 2010/2011 survey (Figure 2 and Table 2), fit one or more of the following criteria:

- were occupied by *L. raniformis* during the 2009/10 inventory and/or during monitoring in 2010/11;
- were the location of a historic record of the species and was inundated, and/or;
- contained similar attributes to sites that were occupied in 2009/10 or 2010/11 or suitable vegetation associations.

As part of this project, community groups/organisations, landholders and volunteers were encouraged to undertake frog monitoring at sites of their own choosing to enable greater spatial coverage of sites within the region. The locations of these sites surveyed as part of this project are included in Figure 2 and Table 3. A total of 39 sites were monitored by volunteers. In addition to the 28 sites formally selected, data from an additional nine sites were included in the results in-kind. Monitoring at these sites were undertaken as part of the SA MDBNRM Board's Aquatic Biodiversity Wetland Monitoring and Management Program.

Habitat assessments aided the final selection of sites and were undertaken at each location to describe and record current conditions. This assessment reviewed both physical and biological attributes of the site and was based upon the habitat assessment detailed by Native Fish Australia (Hammer 2005). Alterations were made to the recorded variables to reflect the wetland types that were being surveyed (Table 4). Table 5 shows cover abundance scores used to assess habitat features including submerged, floating, emergent, fringing and surrounding habitat.

Table 2: Location of NRM project survey sites (map datum GDA94)

#	SITE	EASTING	NORTHING	On or near location of historic or recent *L.raniformis* record
1	ANGUS MOUTH	318405	6081201	
2	BREMER MOUTH	323062	6082057	
3	FINNISS 'WALLY'S LANDING'	303099	6079610	*
4	FINNISS 'STERLING DOWNS'	306038	6074965	*
5	GOOLWA CHANNEL 'KNAPPSTEINS' 1	309991	6071160	
6	GOOLWA CHANNEL 'KNAPPSTEINS' 2	310220	6070872	
7	HINDMARSH ISLAND BOGGY CREEK	312194	6067197	*
8	HINDMARSH ISLAND 'BOGGY CREEK CULVERT'	311008	6065778	*
9	HINDMARSH ISLAND HUNTERS CREEK 'DENVER RD'	309173	6066386	
10	HINDMARSH ISLAND HUNTERS CREEK 'FISHWAY'	308282	6065505	
11	HINDMARSH ISLAND 'STEAMERS DRAIN'	310344	6066023	
12	HINDMARSH ISLAND 'WELLS/SHADOWS LAGOON'	311160	6067547	
13	JENNY'S LAGOON 1	328953	6058906	
14	JENNY'S LAGOON 2	329302	6058652	
15	LAKE ALBERT 'KENNEDY BAY'	343260	6044090	
16	LAKE ALBERT 'TOBIN LODGE'	340406	6061715	
17	LAKE ALBERT 'WALTOWA BAY'	352768	6058760	
18	LAKE ALBERT 'WALTOWA WETLAND STRUCTURE'	353209	6058224	
19	LOVEDAY BAY	326752	6061647	
20	LOW POINT	351405	6077178	
21	MILANG SHORES 'SNAKEY POINT'	315725	6079397	
22	MILANG SNIPE SANCTUARY	315969	6079535	
23	MUNDOO ISLAND 'PIG ISLAND'	312569	6065085	*
24	MUNDOO ISLAND 'STOCKYARD SWAMP'	312280	6064559	
25	NALPA STATION 'PELICAN LAGOON B'	348715	6084862	*
26	NALPA STATION 'PELICAN LAGOON C'	349370	6084099	*
27	NALPA STATION 'POMANDA POINT'	347197	6080490	*
28	NALPA STATION 'POMANDA POINT CAUSEWAY'	347134	6080440	*
29	NARRUNG 'NARFR01'	334692	6068522	
30	NARRUNG 'NARFR03'	334295	6069631	
31	NARRUNG NARROWS 'NURRA NURRA'	341958	6064014	
32	NARRUNG NARROWS 'THE LAKEHOUSE'	337928	6066842	
33	TOLFR01	331081	6084043	*
34	TOLFR02	331828	6083772	*
35	TOLFR03	332024	6084482	*
36	TOLFR43	330854	6084234	*
37	TURVEYS DRAIN	319095	6081360	*

Table 3: Location of community monitored survey sites (map datum GDA94)

#	SITE	EASTING	NORTHING	On or near location of historic or recent *L.raniformis* record
38	3113 Strathalbyn rd Dam	301960	6109865	
39	Alison Avenue SW Goolwa	301877	6070094	
40	Currency Creek 'Ballast Stone'	298289	6073926	
41	Bird Viewing Hut Goolwa	299358	6066990	
42	Boggy Lake	335446	6090936	
43	Currency Creek Rd	301093	6071621	
44	Dam at Finniss	300795	6098161	
45	Dunn'a Lagoon 'Ducks Hospital'	312161	6070048	
46	Gilbert Currency Creek	302961	6072240	
47	Gollans Waterhole	326579	6090238	
48	Hayter Finniss	306883	6075491	
49	Heinicke Reserve Goolwa	298176	6068311	
50	Hindmarsh Island 'Goolwa Channel Drive'	307200	6064321	
51	Hindmarsh Island Marina	300546	60678781	
52	Huczko Wetland	322809	6069768	*
53	Kessell Rd Stormwater ponds Goolwa	297676	6069711	
54	McKinlay Currency Creek	300296	6072217	
55	Meningie Foreshore	349527	6049467	
56	Milang Bay	316639	6080378	
57	Milang N.E. Wetland	316318	6080069	
58	Milang S.W. Wetland ALE010	315995	6079513	
59	Mosquito Creek 'Gollan's Waterhole'	326579	6090238	*
60	Murray Mouth Rd HI	307396	6065514	
61	Murray Smith Park Goolwa	298746	6068962	
62	Narrung Wetland 'NARWQ01'	334103	6068709	
63	Nurra Nurra	341706	6063639	
64	Old Bull Creek Rd	300795	6098161	
65	Pobbybonk	315731	6079375	
66	Poldollie Bay, Rumply Point	338563	6056001	
67	Snug Cove Jetty	312396	6069224	
68	Swamp 333, Meningie	350043	6049829	
69	Swamp on Barnhill Rd Finniss	302823	6081311	
70	Teringie Wetland Site 1	328783	6068008	
71	Teringie Wetland Site 2	327971	6067163	
72	Tookayerta	300460	6078668	
73	Wally's Landing	303099	6079610	*
74	Wetland near CC regulator	302302	6072338	
75	Wetland near Gollans Waterhole	326598	6090374	
76	Wetlands Beach Clayton Bay	311420	6073708	*

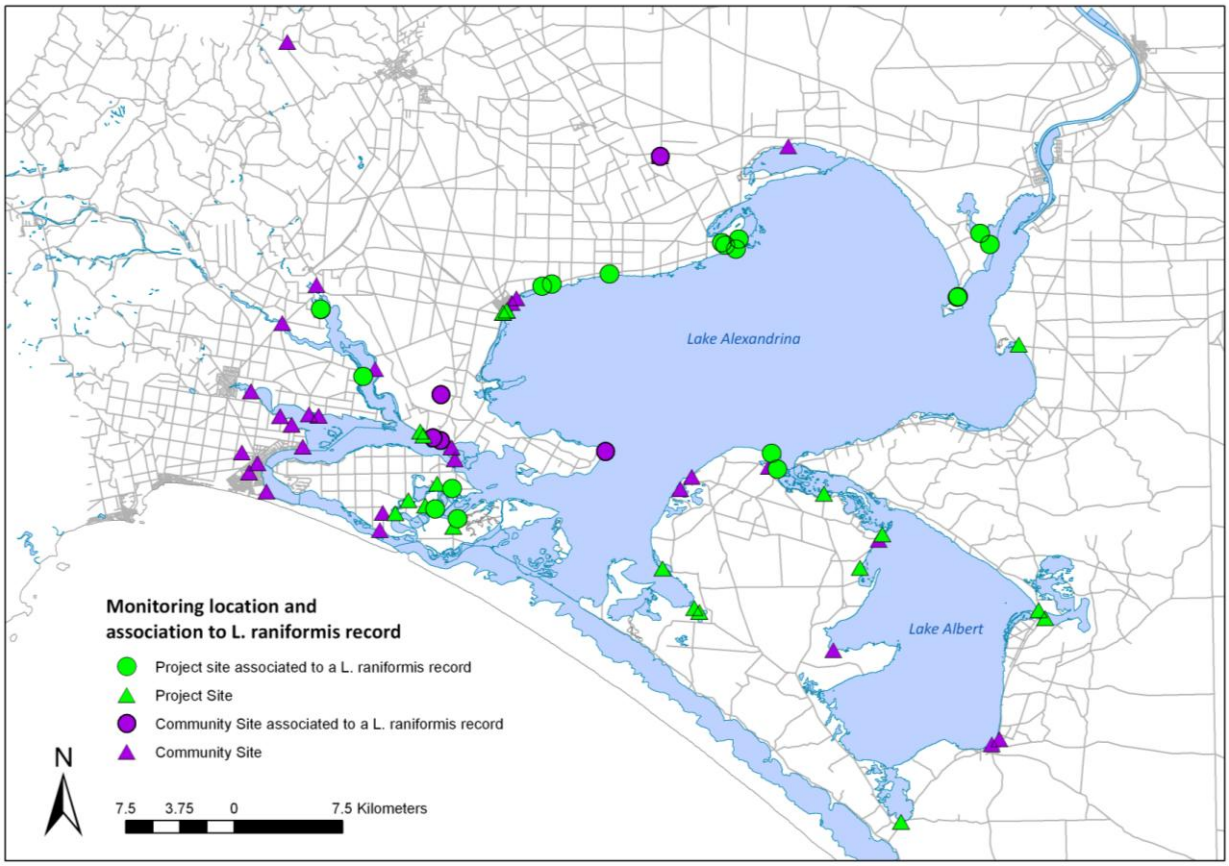


Figure 2: Map location of monitoring sites including community monitored sites and those associated to a recent or historical *L. raniformis* location.

Table 4: Habitat variables recorded at each frog survey site.

Habitat Variables	
Wetland type (e.g. lake edge, marsh/swamp)	Submerged biological and physical cover (%)
Pool Condition (e.g. dry, concentrated)	Floating vegetative cover (%)
Flow Environment (e.g. ephemeral)	Emergent vegetative cover (%)
Flow	Fringing vegetative cover (%)
Land use	Surrounding vegetation cover (%)
Bank Slope	Canopy cover (%)
Water quality (salinity, temperature, pH and turbidity)	

Table 5: Cover abundance scoring used within habitat assessments.

Score	**Cover Abundance (%)**
0	0
1	<5
2	5-25
3	25-50
4	50-75
5	>75

2.2 Nocturnal surveys

It has been observed that the male *L. raniformis* can be variable in its calling behaviour and that more than one method to detect *L. raniformis,* on repeated occasions, is recommended (Heard *et al*. 2006). Following these recommendations, the following efforts were undertaken to increase chance of detection:

- Call recording and recognition: methodology outlined by Tucker (2004) and adjusted with increased recording time from three minutes to five minutes (start and finish times were recorded). Humidity and air temperature were recorded and scores were given to amount of moon, wind, rain and cloud present at the time of each survey (Table 6).
- Active searching: scanning fringes of water body with small spotlight over a standard area.
- Multiple survey events: four survey rounds, one in September, October, November and December.

An abundance score was given to all species recorded at each site (Table 7). As frogs become difficult to count in higher abundances, scoring is an effective way to estimate numbers.

Equipment used included a Sony digital voice recorder (Model ICD-P620), Yoga shotgun uni-directional microphone (Model EM-2700), combination hygrometer and thermometer (Model LM-81HT) and a spotlight head-torch.

Automated call recording units were deployed at six locations for one week periods in December and January 2012. The units were programmed to record frogs on an hourly basis for half-hour periods commencing at 8pm, 9pm, 10pm and 11pm. The units were constructed by SoundID Professional and fitted with SonyLS-10 digital recorders and dual microphones and secured in cage traps close to the ground.

2.2 Nocturnal surveys - community collected data

In addition to targeted surveys, frog monitoring loan kits were available for landholders, volunteers and groups/organisations. The same methodology and equipment types as the targeted surveys were used but with a narrowed focus on the five-minute recording and descriptive atmospheric and habitat conditions. Identification of frog species from sound files was undertaken by project staff. The loan kit field datasheet (Appendix 1) was adapted from the Zoos SA Frog Atlas (formally the EPA Frog Census) datasheet.

Over 35 volunteers contributed approximately 110 hours to the project.

Table 6: Atmospheric variables observed and recorded at each location and at each recording.

Variable	Measure
Air temperature	Degrees Celsius
Humidity	% relative humidity
Moon	0-4 scale
Wind	0-4 scale
Rain	0-4 scale
Cloud	0-5 scale

3.0

Table 7: Abundance scores for nocturnal frog surveys.

Score	Abundance
0	0
1	1
2	2-9
3	10-50
4	>50

2.3 Tadpole surveys

Tadpole surveys were conducted in January 2013 at sites representing a 1-2 month interval from the peak calling recording during nocturnal surveys, during which time tadpoles would have grown to an easily identifiable size. Tadpole surveys were conducted at 2 sites (Figure 3), selected due to the presence of calling males during the nocturnal surveys.

Fyke nets were used to capture tadpoles and were set in or around fringing and emergent vegetation at each site. Two single-winged fyke nets were set at each survey location spread across a distance of approximately 50 metres of wetland fringe (depending on habitat type and water depth).

The traps were set pre-dusk and were left overnight for an average of 15 hours. All species caught, including frogs, fish and crustaceans, were identified and abundances were recorded. To avoid potentially transferring pathogens between sites, traps were cleaned in a diluted bleach solution before re-use.

In 2009, bait traps were used in preference to fyke nets to standardize methods with interstate projects for comparable data. Bait traps also allowed more sites to be included in the project within a short timeframe. However, fyke nets (fitted with 50mm plastic mesh in the trap mouth to exclude large fish) have the ability to catch greater numbers of tadpoles and were included in this project. All *L. raniformis* tadpoles caught during surveys were measured to the nearest millimetre (mouth to tail tip).

Water quality parameters monitored at each location during the tadpole surveys included electrical conductivity (a proxy for salinity) (µS/cm), pH, turbidity (Nephelometric Turbidity Units: NTU) and temperature (degrees Celsius) using a TPS multi-parameter meter (model 90-FLT Field Lab Analyser).

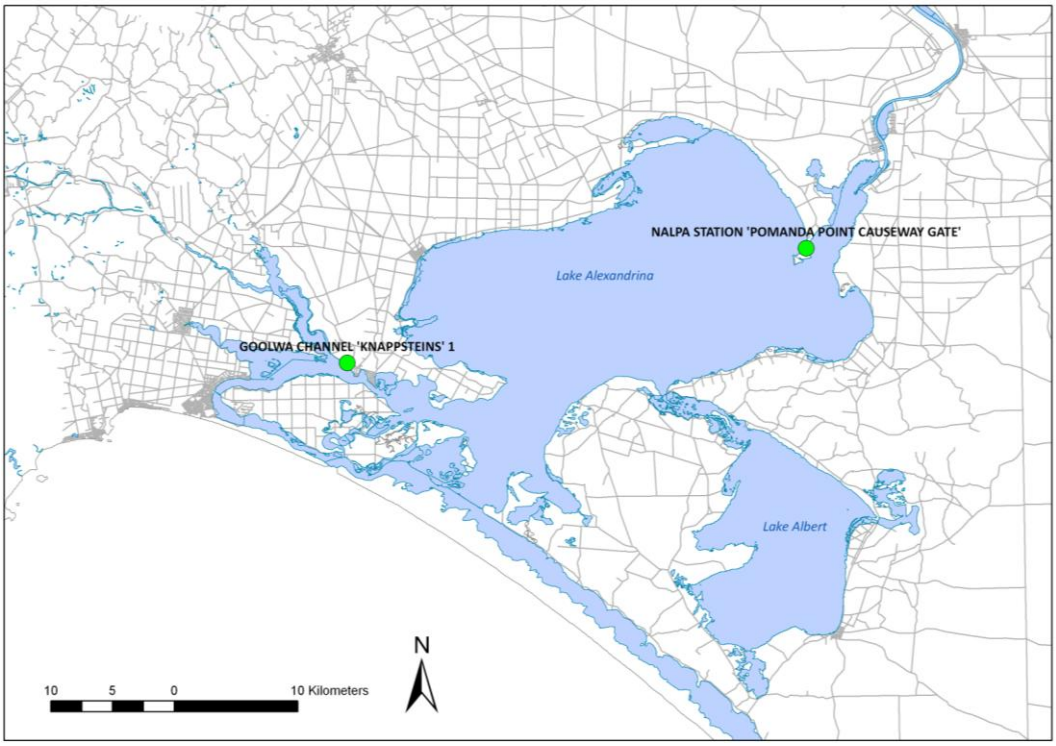


Figure 3: Site locations of tadpole surveys.

3.0 Results

3.1 *L. raniformis* results

3.1.1 Nocturnal survey results

Nocturnal surveys were conducted at 37 sites (148 survey events) on four occasions between September and December 2012. Surveys were undertaken during early nightfall (between 8pm and 1am). An additional 39 sites were surveyed by community volunteers on one to three occasions between September and December 2012 (77 survey events). Opportunistic surveys were conducted at two sites in January 2013. A total of 227 survey events were undertaken between project staff and volunteers.

L. raniformis was detected at only two of the 76 locations surveyed, Nalpa Station 'Pomanda Point Causeway' and Goolwa Channel 'Knappsteins 1' (Table 8, Figure 4). Both of these sites are known, or near areas known, to be inhabited by the species from recent records (Holt et. al 2004, Mason 2010, Mason & Hillyard 2011). Detection was more successful by call recognition with few individuals at Nalpa Station visually identified by active searching (spotlighting) however, the few that were spotlighted did not increase the overall abundance score for that survey event. Spotlighting was not undertaken at sites dominated by dense stands of Common Reed.

Abundance of *L. raniformis* was considered to be low with a maximum of 10-50 individual males calling at Nalpa Station 'Pomanda Point Causeway' (in November and December 2012) and only one individual calling on one occasion (December 2012) at Goolwa Channel 'Knappsteins 1'. No *L. raniformis* were observed calling during the first two survey rounds in September and October.

At Nalpa Station, male *L. raniformis* were observed rafting amongst floating and emergent plants and organic debris amongst scattered emergent Common Reed. Rafting material included damaged/crushed Common Reed stems (the result of Swamp Hen activity), filamentous algae, Hornwort (*Ceratophyllum demersum*), Water Milfoil and Azolla (*Azolla* sp.). The single male observed at Goolwa Channel 'Knappsteins 1' in December 2012 was utilising open shallow habitat with scattered emergent low reeds (predominantly *Juncus* species) and dead terrestrial plants and submerged and floating aquatic plants and algae.

L. raniformis were observed calling between 8pm and 10pm, and nocturnal surveys were generally undertaken inside this period at the two occupied sites. *L. raniformis* calls were captured by the automated call recording units in December 2012 at 8pm, 9pm and 10pm intervals but not at 11pm intervals or morning intervals. Other frog species were observed calling within all recording intervals.

Weather and atmospheric conditions recorded at each survey event, presented in Table 8, show little trend in detection rates in relation to moon phase, rain presence, wind speed, cloud cover, temperature and relative humidity. Only a small percentage of survey events detected *L. raniformis* (1.3 percent (%) of all survey events) limiting analysis of trends in weather and atmospheric conditions.

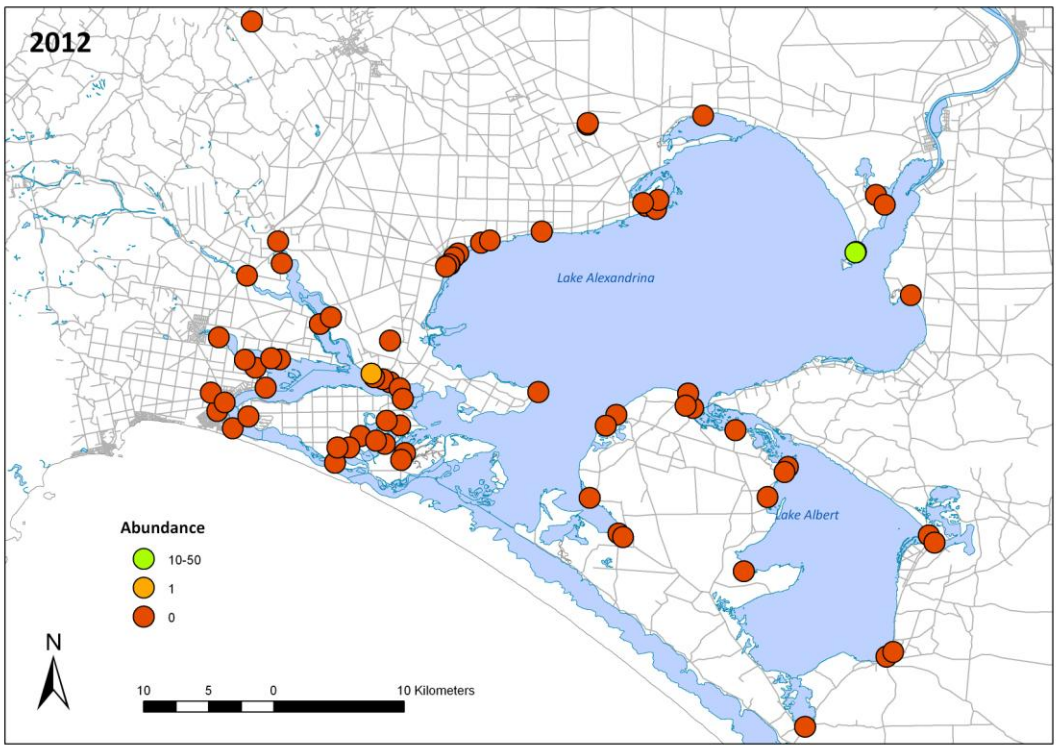
Table 8: Abundance of *L. raniformis* according per method and weather and atmospheric scores and results per survey event where *L. raniformis* were detected.

Site and Date	*L. raniformis* abundance		Weather Observation Scores				Atmospheric Conditions	
	Call Recognition	Active Searching	Moon (0-4)	Rain (0-4)	Wind (0-4)	Cloud (0-5)	Temperature (°C)	Relative Humidity (%)
GOOLWA CHANNEL 'KNAPPSTEINS' 1								
25/09/2012	0	0	3	0	0	0	12.1	86
24/10/2012	0	0	0	0	2	2	NR	NR
21/11/2012	0	0	2	0	2	1	14.8	65.5
12/12/2012	**1**	0	0	0	0	0	24.9	57.3
***NALPA STATION 'POMANDA POINT'**								
10/09/2012	0	0	0	0	0	0	10	97.9
31/10/2012	0	0	0	1	3	5	18.6	75.6
22/11/2012	0	0	2	0	2	1	16	73.6
11/12/2012	0	0	0	0	2	1	19.8	71.4
24/01/2013	0	0	0	0	1	4	26.1	57.4
NALPA STATION 'POMANDA POINT CAUSEWAY GATE'								
22/11/2012	**10-50**	**2-9**	2	0	2	1	16.7	73.1
11/12/2012	**2-9**	**1**	0	0	3	4	20.6	71.5
24/01/2013	0	0	0	0	1	4	26.2	56.4

*Original site located 80m south of 'Pomanda Point Causeway'

NR No Record

a)



b)

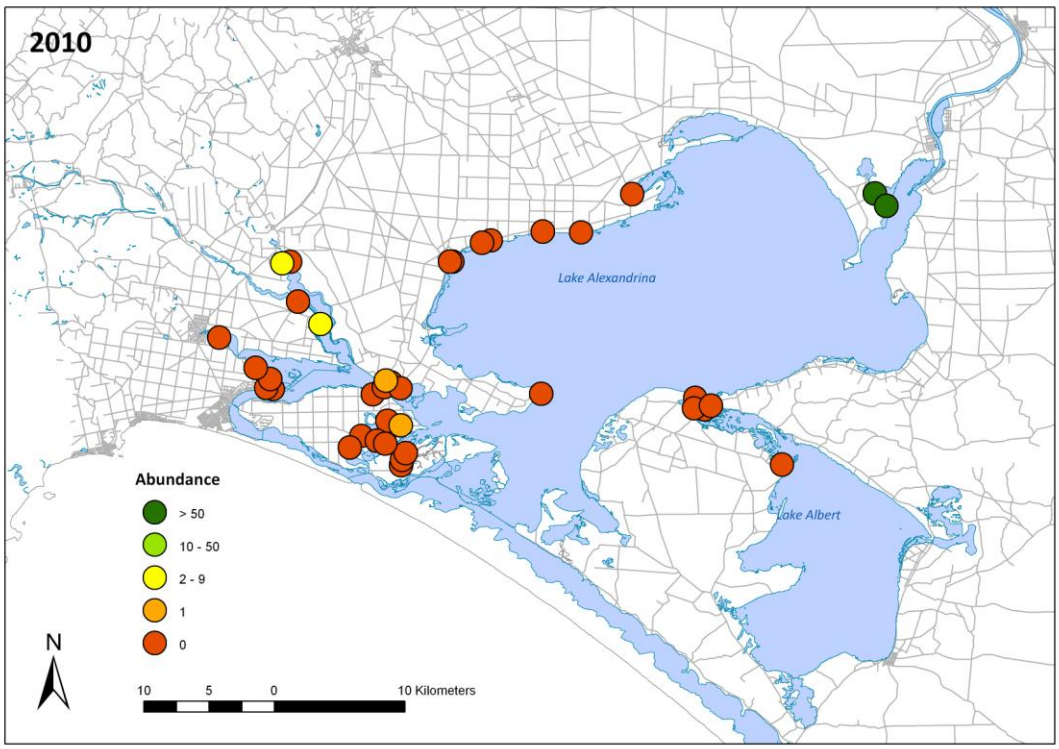


Figure 4: a) Maximum *L. raniformis* abundance recorded across 76 sites between September and December 2012 b) Maximum *L. raniformis* abundance recorded across 36 sites between October and December 2010.

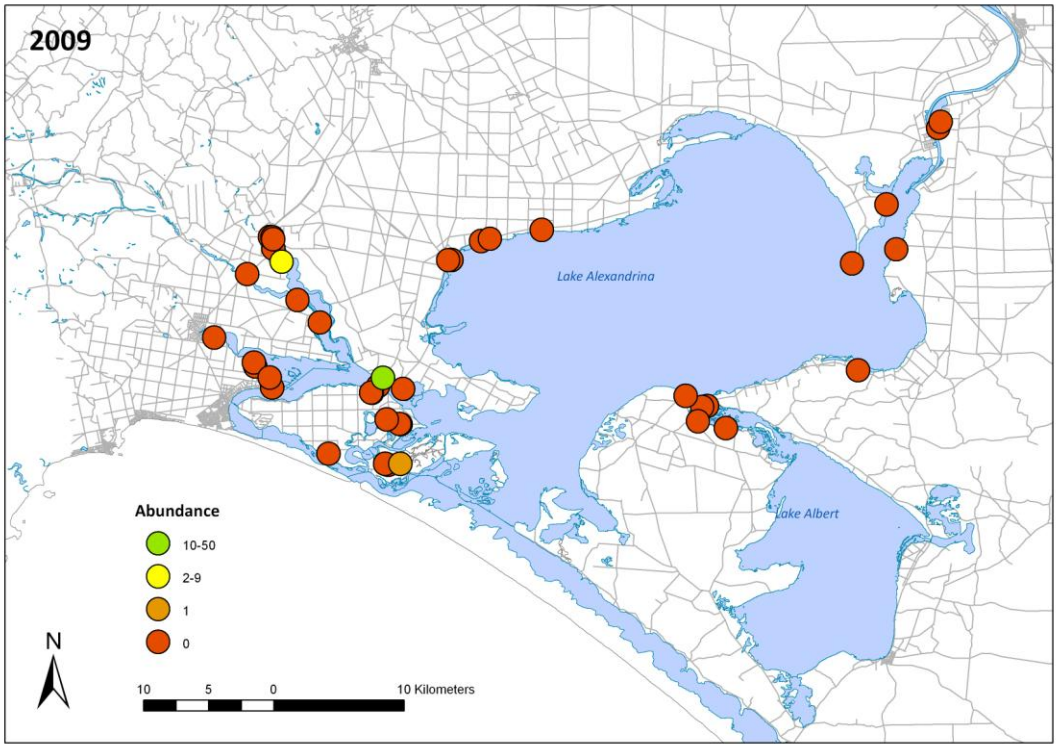


Figure 5: Maximum *L. raniformis* abundance recorded across 37 sites between October and December 2009.

3.1.2 Description of sites occupied by *L. raniformis*

Sites occupied by *L. raniformis* in 2012 were characterised by permanent or connected water-bodies (at time of assessment) of either lake edge and wetland environments and with little to no flow (Table 9

Table 9). Although all sites are considered wetland environments, in this assessment the term wetland was used to describe well-defined lagoons/water bodies in comparison to sites that directly fringe a lake or river/creek which can be less easily defined. Wind seiching (wind tides) is a significant feature of the River Murray reach below Lock 1. The movement of water by wind can be significant, raising or lowering water levels on a regular basis by ±10-60 cm, occasionally more. In this assessment, wind seiching was not incorporated into the definition of flow, but it is important to note that it was present at all sites connected to Lake Alexandrina and Lake Albert.

The highest abundance of *L. raniformis* was observed at Nalpa Station 'Pomanda Point Causeway'. The survey site lies along the eastern side of the manmade isthmus connecting Nalpa Station highland to a small island of higher land that protrudes into Lake Alexandrina (Figure 3). Prior to the construction of the access road, this island would have been intermittently isolated with high water levels. The western side of the isthmus is more exposed to prevailing winds and wave action and contains only sparse vegetative cover. The eastern side at the survey side was generally more sheltered and contained predominantly Common Reed and Narrow-leaf Bulrush (*Typha domingensis*) reed beds with some sedge, grass, herb and shrublands. The area is grazed by cattle and sheep, however the extent of grazing was not captured within the habitat assessment. It was observed that grazing pressures were frequent, but not constant. The depth of the water where *L. raniformis* were observed rafting, which was approximately 0.6-1 m during survey events, generally limited grazing to some extent. Crushing and trampling of Common Reed at the site was most likely the result of Purple Swamphen (*Porphyrio porphyrio*) activity which was observed during field surveys. The depth of water combined with waterbird activity may have been inhibiting the growth of Common Reed. Lignum shrublands and dense monocultures of Narrow-leaf Bulrush and Common Reed were observed in the vicinity.

Goolwa Channel 'Knappstein's 1' is a modified fringing wetland on the north side of the Goolwa Channel, west of Clayton Bay Township. The survey site lies within the sheltered, semi-open highland side of the wetland which contains remnant features from the period when the area was reclaimed for irrigated Lucerne (pers. comm. C. Knappstein). The wetland is generally shallow (<0.5 m) and contains low emergent sedge lands and dead standing terrestrial plants that had colonised the wetland bed when it was dry between 2007 and 2009. Dense monocultures of Bulrush and Common Reed separate the wetland from the Goolwa Channel.

Both sites contain generally steep sloping edges (Table 9) which were, in both cases, man-made banks for access purposes. *L. raniformis* were not observed calling from these edges but from the open/semi-open water habitats. The two sites were predominantly surrounded by grassland vegetation communities which were often pastures.

Table 9: Observational site description and attributes of each site occupied by *L. raniformis* from results of habitat assessment.

Occupied Site	Habitat Type	Site Modification	Flow Environment	Flow	Bank Slope	Landuse	Substrate
GOOLWA CHANNEL 'KNAPPSTEINS' 1	Wetland	Modified	Permanent	None	Steep	Recreation, Restoration	Mud, sand
NALPA STATION 'POMANDA POINT CAUSEWAY'	Lake Edge/Wetland	Modified	Permanent	None	Steep/Gradual Incline	Grazing	Mud, gravel, organic/fine

3.1.3 Assessment of habitat values of sites occupied by L. raniformis

Description of the of vegetation communities at each site was divided into submerged, floating, emergent, and fringing vegetation, and an estimation of cover abundance (%) was given to each of these categories.

Both sites occupied by *L. raniformis* contained submerged aquatic vegetation of between 1-5 percent (%) cover (Table 10). Nalpa Station 'Pomanda Point Causeway' contained scattered filamentous algae, Hornwort and Milfoil. Goolwa Channel 'Knappstein's 1' contained filamentous algae, Sago Pondweed (*Potamogeton pectinatus*), Widegon Grass/Water Tassel (*Ruppia sp.*) and Milfoil.

Scores assigned to floating vegetation included non-living organic debris which constituted the majority of floating cover abundance at Nalpa Station 'Pomanda Point' with some Ferny Azolla but less than 5% of combined vegetative cover. No floating vegetation was observed at Goolwa Channel 'Knappstein's 1'. In 2009, floating vegetation was incorporated within the emergent vegetation score which needs to be taken into consideration when comparing 2010 and 2012 results with that of 2009. In 2010 floating vegetation was separated out into a separate category following the analysis of 2009 data and field observations of how *L. raniformis* were utilising floating plants and debris for rafting.

L. raniformis were observed calling within areas of 5-50% cover of emergent vegetation (Table 10). At Nalpa Station 'Pomanda Point' emergent vegetation was dominated by sparse Common Reed with scattered Water Ribbons (*Triglochin procerum*) and Water Couch (*Paspalum* sp.), Common Spike-rush (*Eleocharis acuta*) and Water Buttons (*Cotula coronopifolia*) on the bank edge. At Goolwa Channel 'Knappsteins 1' Sea Rush (*Juncus kraussii*) and dead Austral Seablite (*Suaeda australis*) were the dominant emergent vegetation with patchy Water Couch and Blown Grass (*Agrostis avenacea*).

The results showed little trend in the abundance of *L. raniformis* in relation to cover abundance of each vegetation type due to the low number of sites in which they were found. However, calling males were observed to be utilising similar habitats with similar vegetation scores in 2009 and 2010. In all years, the highest abundance of calling males was found amongst semi-open emergent vegetation of 5-50% cover and 1-25% cover of submerged or floating vegetation/debris (Table 11 & Table 12).

Table 10: Assessment of vegetative cover at sites occupied by *L. raniformis* in 2012 (0=0% cover, 1=<5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=>75%) displayed as averages taken across three assessments.

Occupied Site	Submerged (0-5)	Floating (0-5)	Emergent (0-5)	Fringing (0-5)	Maximum *L. raniformis* abundance recorded
GOOLWA CHANNEL 'KNAPPSTEINS 1'	1	0	2	4	1
NALPA STATION 'POMANDA POINT CAUSEWAY'	1	1	3	2	10-50

Table 11: Assessment of vegetative cover at sites occupied by *L. raniformis* in 2010 (0=0% cover, 1=<5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=>75%) displayed as averages taken across three assessments.

Occupied Site	Submerged (0-5)	Floating Aquatic (0-5)	Emergent (0-5)	Fringing (0-5)	Maximum *L. raniformis* abundance recorded
Clayton Bay 'Community Boardwalk	3	1	4	5	1
Hindmarsh Island 'Boggy Creek'	1	1	3	5	1
Hunters Creek 'Wyndgate Crossing'	1	1	3	5	1
Finniss 'Sterling Downs'	2	0	3	5	2-9
Finniss 'Wally's Landing'	2	1	2	5	2-9
Pelican Lagoon 'Site 1'	1	1	2	4	>50
Pelican Lagoon 'Site 2'	1	0	2	5	>50

Table 12: Assessment of vegetative cover at sites occupied by *L. raniformis* in 2009 (0=0% cover, 1=<5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=>75%) displayed as averages taken across three assessments.

Occupied Site	Submerged (0-5)	*Emergent (0-5)	Fringing (0-5)	Maximum *L. raniformis* abundance recorded
Clayton Bay 'Red-top Bay'	2	5 (3 – emergent, 2 – floating)	5	10-50
Finniss 'Wally's Landing'	2	4	3	2-9
Mundoo Island	5	2	3	1**

*this score incorporated floating vegetation (predominantly green filamentous algae)

**One individual spotlighted, no frogs calling

a)

b)

Figure 6: a) Nalpa Station ‘Pomanda Point Causeway’ and b) Goolwa Channel ‘Knappsteins 1’

3.1.4 Water quality and water levels

The increase in water levels in the River Murray and Lake Alexandrina during 2010 resulted in the reinundation of the CLLMM regions' fringing wetlands. All but three survey locations in 2012 had been continuously inundated for over 24 months at the time the first nocturnal round commenced in September 2012 (Figure 7). Milang Snipe Sanctuary is an ephemeral stormwater wetland and was dry for two of the four nocturnal survey rounds. Table 13 presents water quality results from sites occupied by *L. raniformis*. The data for Nalpa Station 'Pomanda Point' has been included in Table 13 as this was the original site selected for inclusion in the project and lies approximately 80m south of the occupied site 'Pomanda Point Causeway' which was not sampled in the September and October nocturnal survey round. See Appendix 2 for water quality results at all sites.

Surface water salinities (measured as electrical conductivity) ranged between 461 and 2750 µs/cm at survey locations occupied by *L. raniformis* (Table 13). Salinities ranged between 461 and 915 µs/cm at occupied sites during survey events where *L. raniformis* were detected. Salinity levels were generally lower at Nalpa Station 'Pomanda Point Causeway' (461-530 µs/cm) which receives incoming freshwater flows from upstream as it lies within the area where the River Murray enters Lake Alexandrina. Salinities at Goolwa Channel 'Knappsteins 1' ranged between 915-2750 µs/cm. The highest salinity result of 2750 µs/cm was recorded during the first nocturnal round at Goolwa Channel 'Knappsteins 1' when water levels were marginally lower than 'normal' pool level (Figure 7) and the movement of water to the site would have been restricted due to reed beds and old banks.

No trend was observed between pH or turbidity of surface water and abundance of *L. raniformis.* Surface water was predominantly alkaline ranging between 7.41 and 8.36 at sites occupied by *L. raniformis* and turbidity ranged between 36.5 and 71.3 NTU.

Dissolved oxygen (DO) levels ranged between 5.12 and 10.1 ppm at occupied sites. DO shows a diurnal cycle where lowest DO is generally recorded in the early morning and increases during the day as a result of the photosynthetic activities of aquatic plants and algae (Tucker, 2003). With this in mind, it is important to note that water quality monitoring was predominantly undertaken during evening and night hours when DO would generally be decreasing. DO was variable across unoccupied sites ranging between 0.73 and 17.48 ppm (Appendix 2). DO fluctuated greatly at some sites, indicating a high level of primary production (photosynthesis during daylight, respiration at night). This was more commonly observed at saline or semi-isolated/sheltered areas (such as Tolderol, Narrung Wetland, Jenny's Lagoon and areas of Hindmarsh Island).

Throughout the duration of the survey period between September 2012 and January 2013, variations in water level had an influence on the availability of habitat for adult *L. raniformis*. Water levels exceeded 0.8 mAHD at the time of the three survey where *L. raniformis* were recorded in November and December 2012 (Figure 8). Water levels exceeded 0.8 mAHD during survey periods in September 2012, although fluctuated greatly.

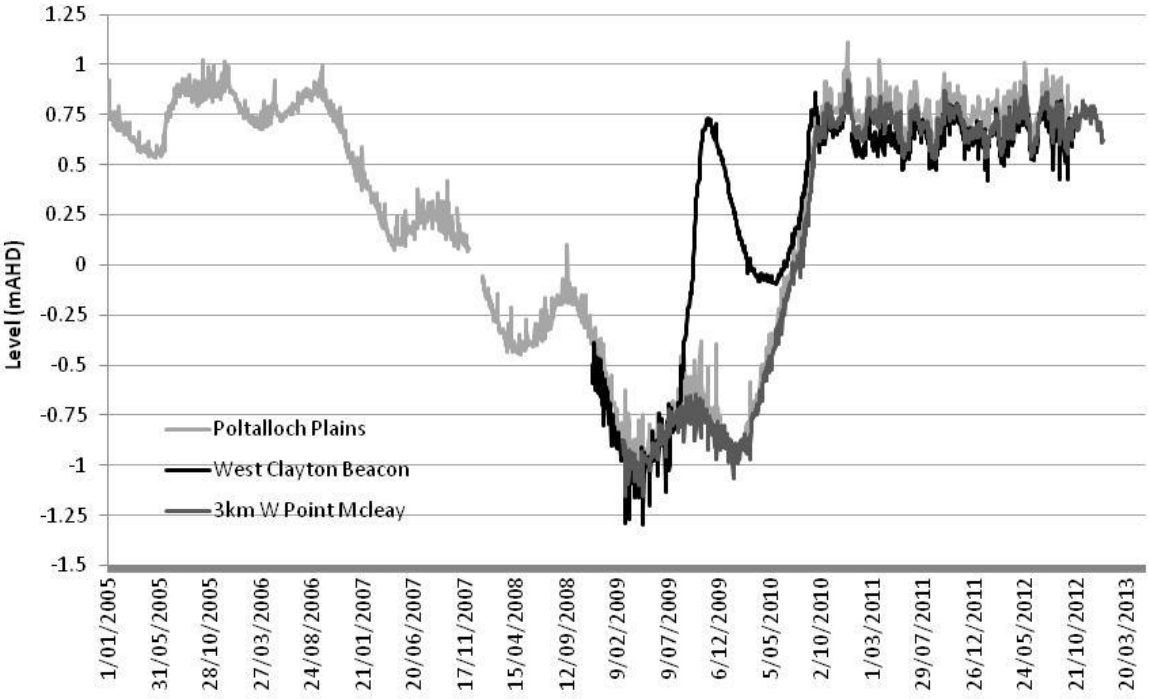


Figure 7: Water level readings from telemetry stations Poltalloch Plains, West Clayton Beacon and 3km W Point Mcleay between 2005 and 2013.

Table 13: Water quality results at sites occupied by *L. raniformis* using handheld instruments

Site/Date	Time	Temperature (°C)	Electrical Conductivity (µs/cm)	pH	Dissolved Oxygen (ppm)	Turbidity (NTU)	*L. raniformis* abundance recorded
GOOLWA CHANNEL 'KNAPPSTEINS' 1							
25/09/2012	8:44:00 PM	11.8	2750	8.05	9.64	74.3	0
24/10/2012	8:15:00 PM	19.7	1194	7.53	6.83	239.2	0
21/11/2012	8:25:00 PM	19.9	986	8.36	10.1	54.1	0
12/12/2012	9:51:00 PM	28.8	915	7.98	7.56	47.8	1
NALPA STATION 'POMANDA POINT CAUSEWAY'							
22/11/2012	8:51:00 PM	17.7	530	7.69	6.77	50.2	10-50
11/12/2012	8:36:00 PM	23.2	466	8.35	5.87	56.4	2-9
24/01/2013	8:35:00 PM	23.2	461	7.41	6.68	36.5	0
***NALPA STATION 'POMANDA POINT'**							
10/09/2012	10:12:00 PM	15.9	641	7.98	8.04	38.2	0
31/10/2012	9:35:00 PM	19	504	7.06	5.12	38.7	0
22/11/2012	8:36:00 PM	18.4	1059	6.8	6.37	2.8	0
11/12/2012	9:12:00 PM	22.9	494	7.75	8.28	55.6	0
24/01/2013	8:50:00 PM	24.3	501	7.66	5.46	64.2	0

*Original site located 80m south of 'Pomanda Point Causeway'

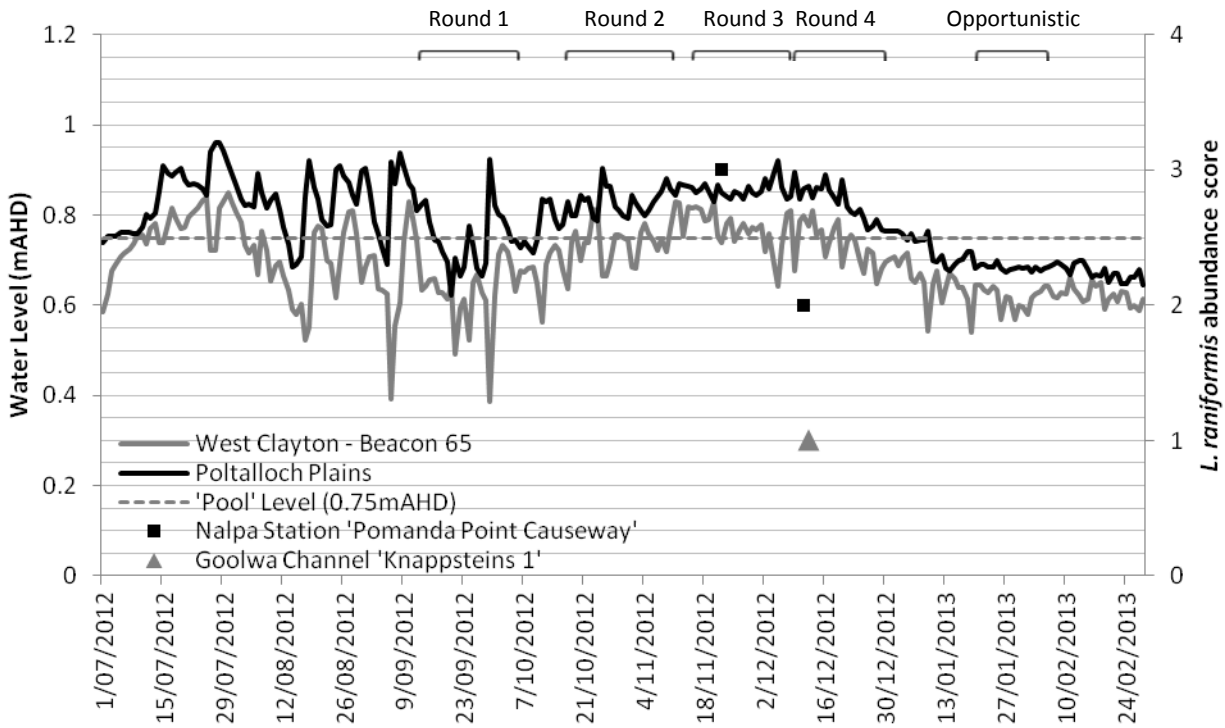


Figure 8: Timing and abundance of *L. raniformis* per monitoring round against water levels (in metres Australian Height Datum) measured at telemetry stations closest to sites occupied by *L. raniformis* between July 2012 and February 2013 (water level data source www.waterconnect.sa.gov.au) (1 = 1; 2 = 2-9; 3 = 10-50 and 4 = >50 individuals)

3.2 Detection of *L. raniformis* recruitment

3.2.1 Tadpoles

Fish surveys were undertaken at sites occupied by calling male *L. raniformis* at Goolwa Channel 'Knappsteins 1' and Nalpa Station 'Pomanda Point Causeway' in January 2013. Nets were set inside the perimeter in which *L. raniformis* were calling. Some species, including *L. raniformis,* are able to be identified by staff to species level at the tadpole stage. Remaining species were identified to genus level.

No *L. raniformis* tadpoles were captured however a total of six tadpoles of the *Limnodynastes* genus were caught. Three frog species of the *Limnodynastes* genus were observed calling during nocturnal surveys; Long-thumbed/Barking Marsh Frog (*Limnodynastes fletcheri*), Eastern Banjo Frog (*Limnodynastes dumerilii*) and Spotted Grass Frog (*Limnodynastes tasmaniensis*). Abundances of tadpoles captured of species other than *L. raniformis* were expected as the timing of peak calling of these species occurred earlier and metamorphosis was likely to have been completed.

3.2.2 Fish abundance and diversity

A total of 825 fish from 10 species (seven native, three alien) were captured across the two sites sampled (Table 14). Fish abundance was higher at Nalpa Station 'Pomanda Point Causeway' where 583 individuals were captured. The most dominant species at both sites was the introduced Eastern Gambusia (*Gambusia holbrookii*) which constituted 34% of the catch at Nalpa Station and 72% of the catch at Goolwa Channel. Flat-headed Gudgeons (*Philypnodon grandiceps*) and Carp Gudgeons (*Hypseleotris sp.*) were also caught in higher numbers at Nalpa Station (141 and 135 individuals respectively).

No species of conservation significance were observed.

Table 14: Results of fish surveys, including abundances, conducted in January 2013.

COMMON NAME	SPECIES NAME	GOOLWA CHANNEL 'KNAPPSTEINS' 2	NALPA STATION 'POMANDA POINT CAUSEWAY'
Frogs			
Tadpole	*Limnodynastes sp.*	1	5
Native Fish Species			
Bony Herring	*Nematalosa erebi*		21
Carp Gudgeon complex	*Hypseleotris spp.*	1	135
Common Galaxias	*Galaxias maculatus*	3	3
Congolli	*Pseudaphritis urvillii*		25
Flat-headed Gudgeon	*Philypnodon grandiceps*	4	141
Un-specked Hardyhead	*Craterocephalus stercusmuscarum fulvus*	38	
Western Blue-spot Goby	*Pseudogobius olorum*	23	
Alien Fish Species			
Common Carp	*Cyprinus carpio*	4	37
Eastern Gambusia	*Gambusia holbrooki*	189	199
Redfin Perch	*Perca fluviatilis*		2
Other			
Yabby	*Cherax destructor*	7	2

3.3 Other frog species results

A total of seven frog species (including *L. raniformis*) were recorded in the study region in 2012. The most widespread and abundant species was the Common Froglet (*Crinia signifera*) which was detected at 95% of sites and in abundances of greater than 50 individuals at 60% of sites (Figure 9). The Spotted Grass Frog Eastern Banjo Frog was also abundant, detected at 92% and 88% of sites respectively.

A greater abundance of Long-thumbed/Barking Marsh Frogs was observed in 2012, detected at 35.5% of sites compared to 27% in 2010 and 17.5% in 2009. Abundance of Long-thumbed Frogs per site was greater within the Narrung Narrows and the north-eastern side of Lake Alexandrina where it was detected in abundances of greater than 50 (score of 4) at six locations. It was observed to be favouring more complex habitat with multiple vegetation associations within relatively small areas. This species was more commonly observed calling in low abundances of 2-9 (score of 2).

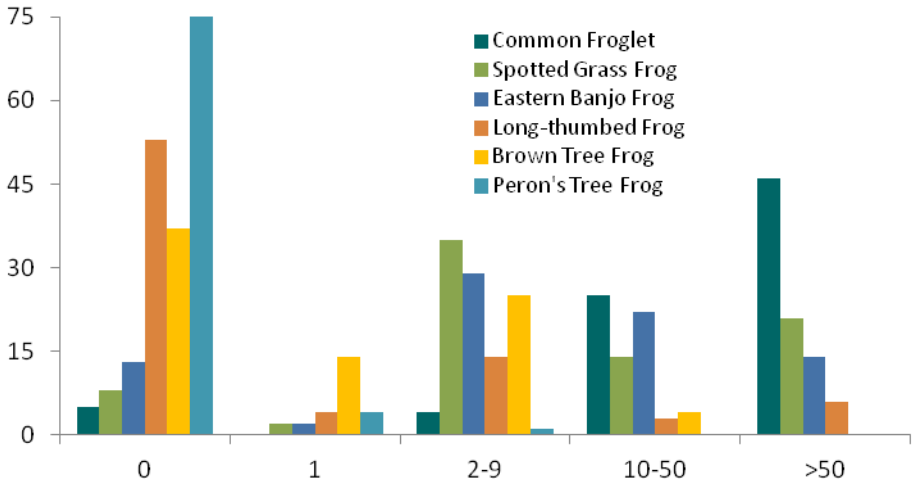
The Brown Tree Frog (*Litoria ewingi*) was relatively well distributed within the region, however generally in low abundances per site. It was detected at 57% of sites in 2012 compared to 46% in 2010 and 17.5% in 2009. This species would likely have been detected in higher abundances earlier in the year than the first nocturnal survey that occurred in September.

The Peron's Tree Frog (*Litoria peroni*) was observed at fewer sites and in lower abundances in 2012 than in 2010 or 2009. The species was detected at 7% of sites in 2012 in low abundances compared to 46% in 2010 and 17.5% in 2009. A table of the full results for each species per monitoring site can be found in Appendix 3. Individual species abundance maps are presented in Appendix 4.

Species known to occur in the CLLMM region but not detected in 2012 include Bibron's Toadlet (*Pseudophryne bibroni*), the Painted Frog (*Nebatrachus pictus*) and Sudell's Frog (*Neobatrachus sudelli*) all of which generally breed following heavy rainfall or outside of the target survey period as part of this project (Tyler and Walker 2011). These species are also not commonly known to favour fringing wetlands in the CLLMM region.

The highest diversity of species observed at a single site was six species (Figure 10) recorded at two sites; Goolwa Channel 'Knappsteins 1' and 'Wetlands Beach - Clayton Bay'. Average species diversity per site has been higher in 2012 than in 2010 or 2009 (Figure 10 and Figure 11) when comparing those sites that have been replicated in those three years. In 2009 low diversity and abundance of frogs was the result of the lack of wetland habitats due to low water levels. The blocking and artificial filling of the Goolwa Water Level Management Area (GWLMA) was the primary available habitat for frogs in 2009, including *L. raniformis*. Small-scale emergency environmental watering projects undertaken in the region to protect threatened fish species also provided localised frog habitat in 2009. Following widespread reinundation of fringing wetlands on the return of lake levels in 2010, species diversity was generally dominated by the Common Froglet, Spotted Grass Frog and Eastern Banjo Frog. These were generally as widespread in 2012; however, more species were detected in higher abundances.

a)



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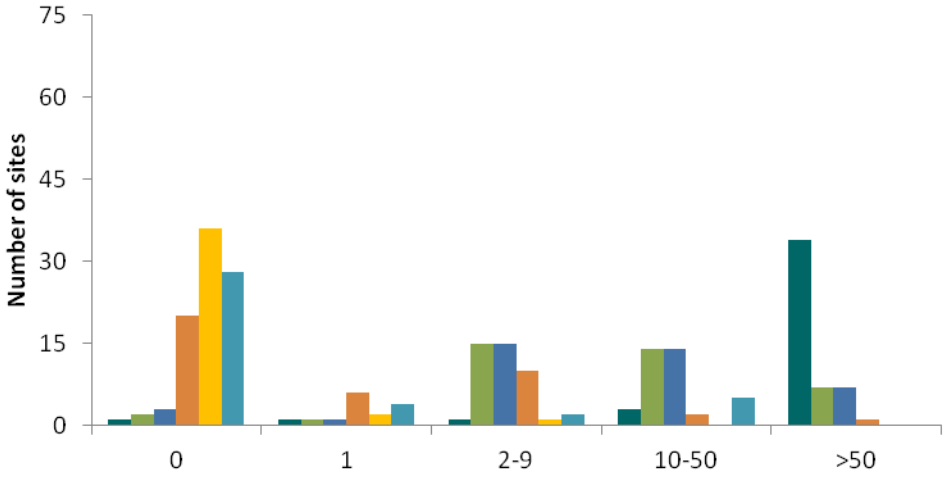

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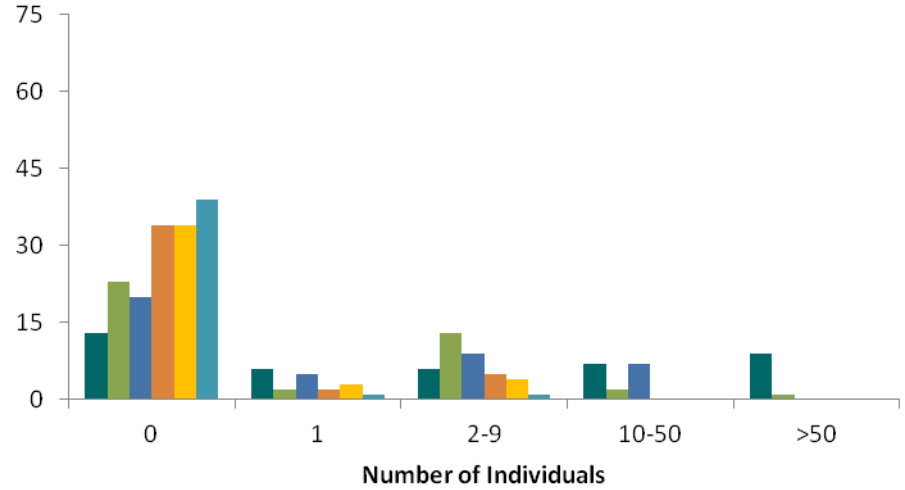
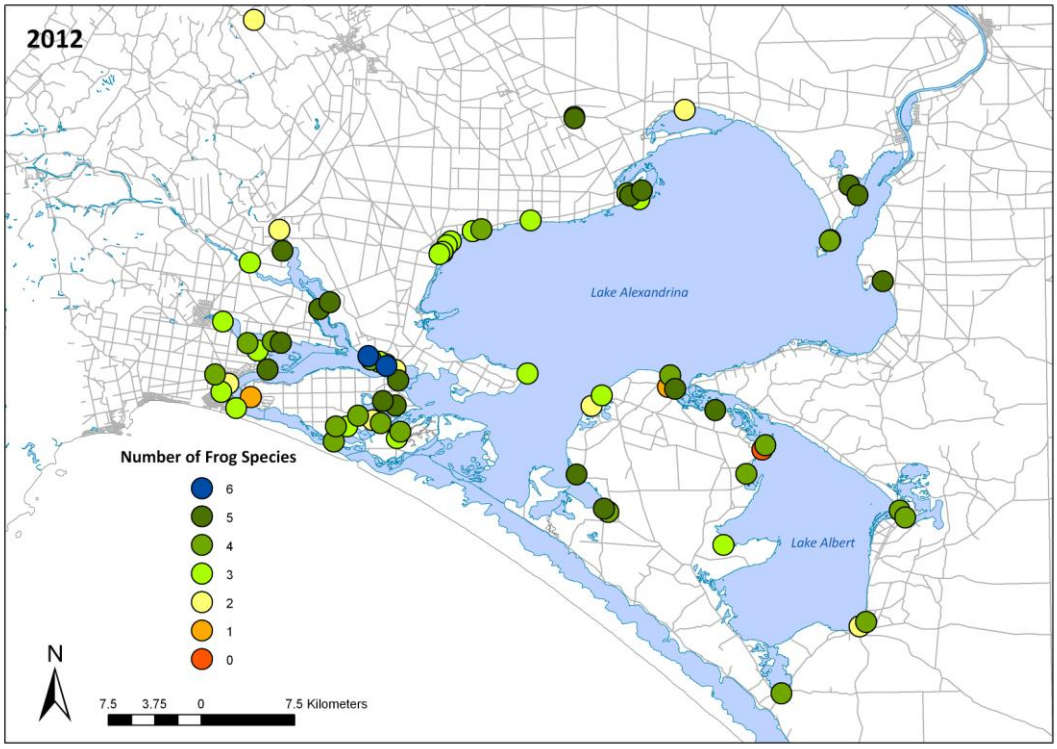


Figure 9: Distribution of abundance scores per species in a) 2012 across 76 sites; b) 2010 across 41 sites and c) 2009 across 41 sites.



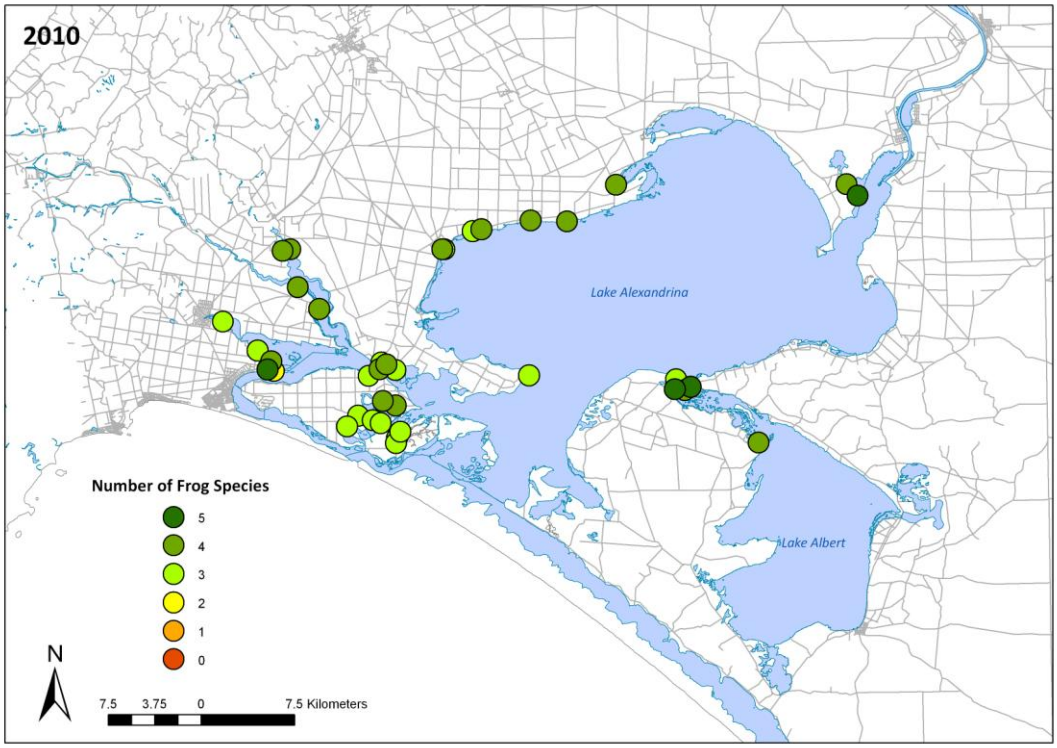


Figure 10: Species diversity including *L. raniformis* observed across all monitored locations in a) 2012 and b) 2010

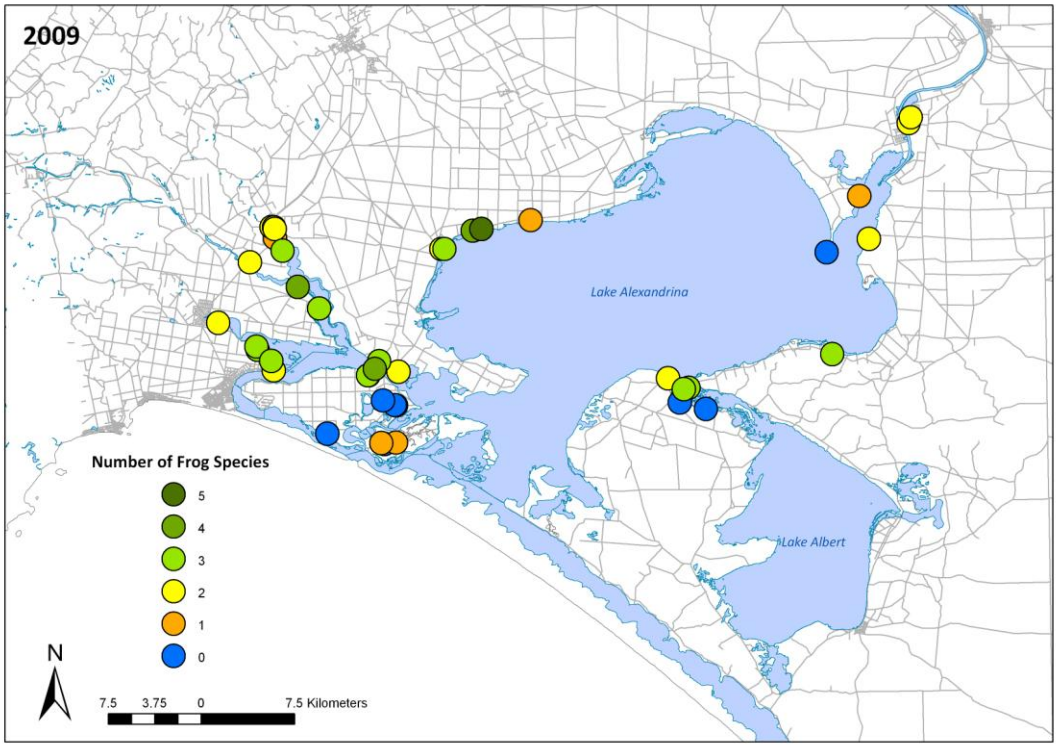


Figure 11: Species diversity observed across all monitored locations in 2009

4.0 Discussion

4.0 Abundance and Distribution

Together with data provided by volunteers, this project has provided good spatial coverage of *L. raniformis* monitoring sites in the Lake Alexandrina, Lake Albert and Murray Mouth region. Lake Alexandrina and Lake Albert has experienced relatively stable water levels (within the band of 0.4-1.0m AHD) since the return of flows to the region in 2010 and the 150 or more fringing wetland water bodies have remained inundated (with the exception of some ephemeral sites) and continued in the trajectory of recovery . The response by *L. raniformis* to water level management since reinundation has been assessed over four consecutive surveys incorporating historic locations, recent observations and suitable *L. raniformis* habitat.

The two sites found to be occupied by *L. raniformis* in 2012 were located at opposite sides of the study area; Nalpa Station 'Pomanda Point Causeway' in the north-east of Lake Alexandrina and Goolwa Channel 'Knappsteins 1' near the township of Clayton Bay in the south-west of the region. Results from nocturnal surveys show that the abundance of *L. raniformis* in the CLLMM region was notably low. Only one individual was detected calling at 'Knappsteins 1'. This site is, however, located within one kilometer of what was an occupied site in 2009 at Clayton Bay following the artificial blocking and inundation of the Goolwa Water Level Management Area. The *L. raniformis* observed at Nalpa Station were also within a relatively short distance of a previously occupied site, Pelican Lagoon, 4.5 km upstream. Pelican Lagoon has been considered the 'stronghold' population of the CLLMM region, having been occupied in moderate to high abundances by *L. raniformis* in 2005 (Simpson et. al. 2006) and 2010 (Mason & Hillyard 2011) (no surveys were conducted in between these periods). As wetland habitats continue to recover post-drought and vegetation species assemblages are changing, it is realistic that *L. raniformis* distribution will also change. These changes in habitat structure and preferences are discussed in the following section. The changes observed in the distribution of *L. raniformis* in 2012 in comparison to past years demonstrate their responsiveness to changes in habitat as a result of water level and land management.

Although the results showed little trend in the abundance of *L. raniformis* in relation to atmospheric conditions due to the small number of sites in which they were detected, the highest abundance observed in *L. raniformis* coincided with a period when water levels were maintained at relatively high levels (>0.75 mAHD). The response from *L. raniformis* to higher water levels was a notable trend during monitoring in 2009 and 2010 but unlike these previous years, in 2012 occupied sites remain inundated when levels are at pool and below (until approximately 0.2-0.4 mAHD). *L. raniformis* were not detected at occupied sites when water levels were below 0.8 mAHD.

The key changes observed in the distribution and abundance of remaining frog species was the increase in Long-thumbed Frog abundance and the increase in average species diversity across sites.

The trial use of automated call recording units was partially successful in that recordings complemented field observations of *L. raniformis* occupation and abundance. However, constraints regarding unit construction, prevailing weather conditions which affect sound quality (e.g. wind, particularly when combined with the presence of reedbeds) and software manoeuvrability resulted in the trial being amended as a testing phase for the benefit of automated call recording in spring 2013. It was clear from the testing conducted that there are a number of constraints currently facing this system of complementary monitoring in the CLLMM region but as the system develops more fine-scale information to assist with water level and habitat management will be able to be collected.

4.1 Breeding Success and recruitment

The results provide no evidence to support successful breeding events in the CLLMM region in 2012 at sites occupied by *L. raniformis*. No *L. raniformis* tadpoles were captured during fish monitoring which was conducted at a time consistent with the presence of tadpoles of an identifiable size based on the timing of peak calling activity in November/December. The low abundance of calling males detected at one of the occupied sites in the Goolwa Channel and the absence of tadpoles suggests that spawning may not have occurred. Moderate to low abundance of *L. raniformis* at the second site implies spawning may still have occurred but remained undetected.

4.2 Habitat Requirements and Management

The structural composition of habitat utilised by *L. raniformis* in 2012 followed similar trends to that of occupied sites in past years. Where *L. raniformis* were detected, adult males were typically recorded calling from within semi-open water bodies with vegetative structure in the form of emergent reeds and rushes, floating debris and some submerged aquatic plants.

In 2009 and 2010 it was observed that sites entirely dominated by dense reedbeds of Common Reed did not yield successful detection of *L. raniformis* (Mason 2010, Mason & Hillyard 2011). Although the species was identified at only two locations in 2012, both of these sites contained dense reed monocultures within the close vicinity of the site, however were not utilised by calling males. The maintenance of more complex habitats in the region is considered to be an important element in promoting successful breeding events. *L. raniformis* is a species highly responsive to flooding, and inundation of suitable breeding habitat is one of the known cues for calling (Schultz 2007). Seasonal fluctuations in water level may allow plant communities to diversify which can then be utilised by *L. raniformis* once re-inundated. Dense reedbeds may however provide habitat for the species outside the peak breeding period when frogs disperse from the breeding area.

The sites found to be occupied by *L. raniformis* in 2012 remain inundated if water levels are below pool level (until approximately 0.4mAHD). However, calling of male *L. raniformis* was only detected when water levels exceeded 0.8 mAHD, despite inundated reeds and sedges available. This partially supports hypothesis 2 in section 1.1 which states increased water levels will increase the number of sites in which *L. raniformis* are detected. In 2010 the inundation of previously exposed ground was considered to increase the area of availability of suitable *L. raniformis* habitat (Mason & Hillyard 2011). However, as increased water levels did not increase area of inundation at the two occupied sites due to steep bank slopes, further assessment of the importance of water depth on breeding populations needs to be undertaken.

It is not clear why Pelican Lagoon, which was the most abundantly occupied site by *L. raniformis* during monitoring conducted in 2005 and 2010, was not utilised by the species in 2012. Grazing regimes in this area have not altered (J. Withers pers. comm.) and water levels were suitably high enough in October and November to inundate the semi-open Lignum shrublands that were considered to be an important characteristic of the site in 2010 (Mason & Hillyard 2011). One influencing factor may be the increase in coverage and density of vegetation at the site (including Common Reed). The flow path that feeds Pelican Lagoon proper has also become obstructed due to an increase in coverage and density of Common Reed and Bulrush which may also be contributing to the decline of the sites suitability as *L. raniformis* habitat. In 2013 intervention to reinstate the flow path for the purpose of irrigation infrastructure maintenance was undertaken which has increased the connectivity of the lagoon to the River Murray. Monitoring in spring 2013 will determine any influence this may have on the quality of *L. raniformis* habitat within Pelican Lagoon.

References

Baldwin, D. S., Nielsen, D. L., Bower, P. M. & Williams, J., 2005. *Recommended Methods for Monitoring Floodplains and Wetlands.* Canberra: Murray-Darling Basin Commission and the Murray-Darling Freshwater Research Centre.

Christy, M.T. and Dickman, C.R. 2002. *Effects of salinity on tadpoles of the green and golden bell frog* (*Litoria aurea*). Amphibia-Reptilia 23: 1–11.

DEH, 2006. *Threatened species of the South Australian Murray-Darling Basin: Golden Bell Frog* Litoria raniformis*, Vulnerable*. Department for Environment and Heritage Murraylands Region, Fact Sheet 2542.06/Golden Bell Frog 7/06.

DfW 2010a. *River Murray Flow Update – 3rd December 2010*. www.waterforgood.sa.gov.au/news-info/publications/river-murray-flow-advice, Department for Water, Adelaide

Hammer, M. 2005. *Fish Survey Manual*. Draft. Native Fish Australia, South Australian Branch, Adelaide SA

Heard, G.W. Robertson, P. Scroggiec, P. 2006. *Assessing detection probabilities for the endangered growling grass frog (*Litoria raniformis*) in southern Victoria*. Wildlife Research 33(7) 557–564

Holt, M., Swingler, K., O'Donnell, E., Shriley, M., Malke, M., Conallin, A., Meredith, S., Ho, S., Prider, J., Poulson, D., Richardson, S., and Cooling, M. 2004. *River Murray Wetlands Baseline Survey: Volume 1 Data Report 2, 2004*. Sinclair Knight Merz, Melbourne, for the SA Murray Darling Basin Natural Resources Management Board, Adelaide

Mason, K. 2010. *Southern Bell Frog (*Litoria raniformis*) Inventory of Lake Alexandrina, Lake Albert and Tributaries*. SA Murray Darling Basin Natural Resources Management Board, Murray Bridge, South Australia.

Mason, K., Hillyard, K. 2011. *Southern Bell Frog (*L. raniformis*) monitoring in the Lower Lakes. Goolwa River Murray Channel, tributaries of Currency Creek and Finniss River and Lakes Alexandrina and Albert*. Report to Department for Environment and Natural Resources. The South Australian Murray Darling Basin Natural Resources Management Board, Murray Bridge. South Australia.

Simpson, D., Holt, M., Champion, T., Horan, A and Shirley, M. (Eds.). 2006. *River Murray Wetlands Baseline Survey-2005*. Sinclair Knight Merz, Melbourne, for the SA Murray Darling Basin Natural Resources Management Board, Adelaide

Paton, D and Bailey, C. 2010. *Responses of aquatic vegetation to environmental watering of the Narrung wetland 2009-10*. Draft report. School of Earth and Environmental Sciences University of Adelaide, SA.

Schultz, M. 2007. *Distribution and detectability of the Southern Bell Frog Litoria raniformis in the South Australian River Murray Floodplain*. SA Murray Darling Basin Natural Resources Management Board, Berri.

Seaman, R. L. 2003. *Coorong and Lower Lakes habitat-mapping program.* Conservation Programs, Department for Environment and Heritage, South Australia.

Smith M.J, Schreiber S.G, Scroggie M.P, Kohout M, Ough K, Potts J, Lennie R, Turnbill D, Jin C & Clancy T. 2006. *Associations between anuran tadpoles and salinity in a landscape mosaic of wetlands impacted by secondary salinisation*. Arthur Rylah Institute, Heidelberg, Victoria, Department of Sustainability and Environment, Environmental Water Reserve and River Health Division, East Melbourne, Victoria, Department of Agriculture, Fisheries and Forestry Bureau of Rural Sciences, Canberra, Australia

Stratman, B. 2007. *A survey for the Southern Bell Frog (*Litoria raniformis*) in the Mosquito Creek Catchment, south-eastern Australia.* Department for Environment and Heritage.

Tucker, P. et al., 2003. *Your Wetland; Supporting Information*. Renmark: Australian Landscape Trust.

Tucker, P. 2004. *Your Wetland: Monitoring Manual – Data Collection*. River Murray Catchment Water Management Board, Berri and Australian Landscape Trust, Renmark

Tyler, M. J. & Walker, S. J. 2011. *Frogs of South Australia.* Third Edition. Belair SA

Walker, S. Frog Census 2002: *Community monitoring of water quality and habitat condition in South Australia using frogs as indicators*. Environmental Protection Agency, Adelaide.

Wassens, S., Arnaiz, O., Healy, S., Watts, R. and Maguire, J. 2008 *Hydrological and habitat requirements to maintain viable Southern Bell Frog (*Litoria raniformis*) populations on the Lowbidgee floodplain- Phase 1*. Final Report DECC. Queanbeyan

Wassens S. 2005. *The use of space by the endangered Southern Bell Frog (*Litoria raniformis*) in the semi-arid region of New South Wales*, Australia. PhD Thesis Charles Sturt University

Wedderburn, S. and Hillyard, K. 2010. *Condition Monitoring of Threatened Fish Species at Lake Alexandrina and Lake Albert (2009-2010)*. Page 42. The University of Adelaide, Adelaide.

Appendices

Appendix 1: Field data sheet for community frog monitoring loan kits

Field Datasheet

Date of Recording *(eg 23/09/2007)*	**Starting Time** *(eg 21:30)*
Your name:	**Frog Kit Number:**
Your contact number:	**Recording Number:**

Site Name

Details of New Site – *Collect at location data at site with GPS or Map references or ask one of the staff to find the location data for you*

Map / GPS Reference Northing (7 digits) or Latitude:	Easting (6 digits) or Longitude:
Map Zone (52,53 or 54):	
Site description:	

WEATHER *(please circle)*

Rain: No Rain / Drizzle / Showers / Moderate Rain / Heavy Rain

Moon-phase: No Moon / Quarter Moon / Half Moon / Three-quarter Moon / Full Moon / Hidden

Wind Speed: No Wind / Slight Breeze / Strong Breeze / Moderate Wind / Strong Wind

Cloud cover: 0% / <5% / 5-25% / 25-50% / 50-75% / >75%

Temperature:

Cold / cool / mild / warm / hot

HABITAT *Please select **one** habitat type that best reflects the major habitat at the site.*

☐ Dam ☐ Pond ☐ Wetland ☐ Swamp or Flooded Paddock or Marshland

☐ Drain/Channel ☐ River or Floodplain ☐ Stream/Creek ☐ Garden (eg Fernery or Grassy Area)

☐ Lakeshore ☐ Reservoir or Lake ☐ Other_____

WATER QUALITY *If you can see the water, please indicate the condition of the site. Please select all categories that apply.*

Water Appearance: ☐ Clear ☐ Polluted ☐ Foamy ☐ Oily ☐ Stained ☐ Muddy ☐ Other

Describe water appearance:

Could you hear frogs calling? *(please circle)* **Yes** **No**

COMMENTS or OBSERVATIONS *(such as; site is grazed by stock, water is flowing, water has pungent smell etc.)*

Thank you for being involved; we hope you had fun.

Appendix 2: minimum and maximum water quality results from all project sites

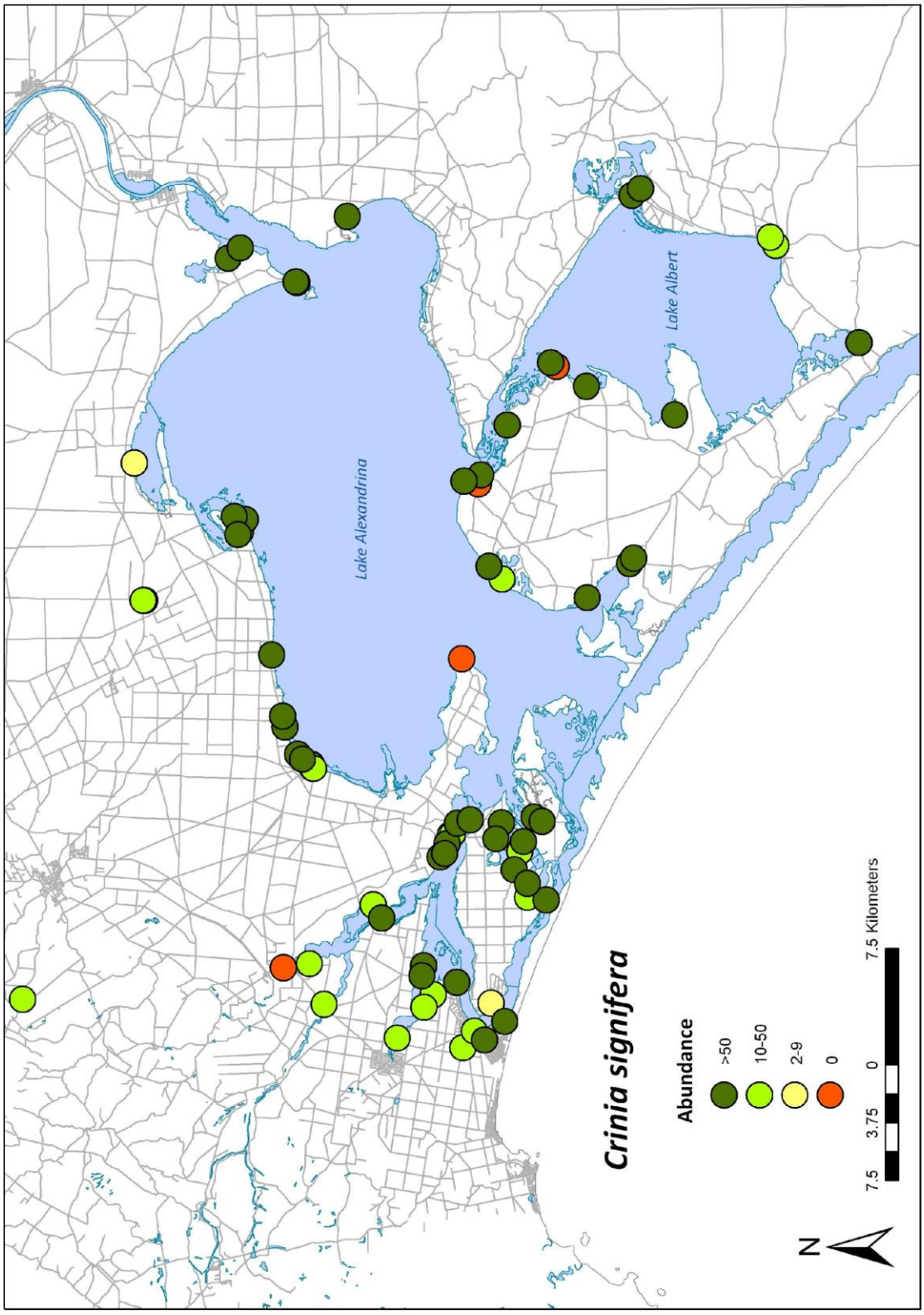
Site	Minimum Temperature (°C)	Maximum Temperature (°C)	Miniumum Electrical Conductivity (µs/cm)	Maximum Electrical Conductivity (µs/cm)	Minimum pH	Maximum pH	Minimum Dissolved Oxygen (ppm)	Maximum Dissolved Oxygen (ppm)	Minimum Turbidity (NTU)	Maximum Turbidity (NTU)
ANGUS MOUTH	14.8	25.5	1188	2241	7.59	7.92	2.15	13.32	2.3	10.2
BREMER MOUTH	13.8	28.2	370	6690	7.66	8.09	2.42	8.27	24.2	78.2
FINNISS 'WALLY'S LANDING'	10.2	29.1	1762	17700	7.31	7.59	5.07	8.39	15.2	52.1
FINNISS 'STERLING DOWNS'	10.8	28.4	1340	1607	7.6	7.77	6.79	9.12	26.1	76
GOOLWA CHANNEL 'KNAPPSTEINS' 1	11.8	28.8	915	2750	7.53	8.36	6.83	10.1	47.8	239.2
GOOLWA CHANNEL 'KNAPPSTEINS' 2	14.7	27.8	823	1265	7.4	8.09	4.8	643	48.2	170.8
HINDMARSH ISLAND BOGGY CREEK	13.4	22.4	649	4230	7.39	8.31	2.09	6.9	16.1	26.1
HINDMARSH ISLAND 'BOGGY CREEK CULVERT'	12.7	20.5	386	2420	7.19	8.04	5.25	7.98	31.1	62
HINDMARSH ISLAND HUNTERS CREEK 'DENVER RD'	13.7	19.2	585	2690	7.47	9.14	2.89	5.22	15.1	25.2
HINDMARSH ISLAND HUNTERS CREEK 'FISHWAY'	13.4	21.7	651	2880	7.67	8.37	6.14	8.99	32.2	59.2
HINDMARSH ISLAND 'STEAMERS DRAIN'	11.7	21.8	317	1886	7.09	7.83	4.56	6.6	43.4	74.8
HINDMARSH ISLAND 'WELLS/SHADOWS LAGOON'	12.1	22.1	698	2360	7.71	8.44	2.27	9.65	22.5	55.5
JENNY'S LAGOON 1	15.2	23.3	951	5790	7.13	8.12	0.73	10.75	7.8	41.3
JENNY'S LAGOON 2	13.4	25.3	1027	4500	7.19	8.3	1.53	7.22	2.7	7.4
LAKE ALBERT 'TOBIN LODGE'	9.5	22.3	1987	4150	7.39	8.17	2.79	9.04	7.6	25.5
LAKE ALBERT 'WALTOWA BAY'	11.2	13	3720	3960	7.24	8.08	4.19	6.15	18.4	36
LAKE ALBERT 'WALTOWA WETLAND STRUCTURE'	13.7	23.1	4.43	4550	7.53	8.33	3.1	8.74	33.6	85.3
LOVEDAY BAY	9.9	17.8	733	4080	6.95	7.81	1.51	4.2	2.4	30.2
LOW POINT	12	23.2	308	434	7.84	8.33	3.04	7.59	17.2	134.1
MILANG SHORES 'SNAKEY POINT'	17.3	17.3	7510	7510	7.58	7.58	4.72	4.72	10	10
MILANG SNIPE SANCTUARY	15.9	15.9	5140	5140	7.84	7.84	6.98	6.98	1	1
MUNDOO ISLAND 'PIG ISLAND'	12.9	20.5	338	1047	7.25	8.12	3.88	7.98	16.3	102.8
MUNDOO ISLAND 'STOCKYARD SWAMP'	11.9	23.1	451	1558	7.29	7.92	2.79	7.8	29.5	68.9
NALPA STATION 'PELICAN LAGOON B'	9.7	22.4	363	1532	7.16	8.05	4.72	7.54	86.4	338
NALPA STATION 'PELICAN LAGOON C'	10.5	24.7	220	442	6.73	8.12	6.5	12.12	57	106.1
NALPA STATION 'POMANDA POINT'	15.9	24.3	494	1059	6.8	7.98	5.12	8.28	2.8	64.2
NALPA STATION 'POMANDA POINT CAUSEWAY GATE'	17.7	23.2	461	530	7.41	8.35	5.87	6.77	36.5	56.4
NARRUNG 'NARFR01'	9.6	26.7	2580	6030	7.75	8.31	5.9	15.19	35.5	64.2
NARRUNG 'NARFR03'	16.3	19.1	1920	4920	7.64	8.09	1.04	10.62	28.5	204
NARRUNG NARROWS 'NURRA NURRA'	9.2	25.9	3.49	2447	7.52	7.81	1.76	7.39	14	42
NARRUNG NARROWS 'THE LAKEHOUSE'	9.5	26.1	615	3240	7.52	8.11	3.08	8.46	25.8	108.9
TOLFR01	11.2	24.7	361	3190	6.67	8.31	2.89	10.33	1.6	77.7
TOLFR02	11.6	23.1	354	497	7.51	8.31	8.14	9.13	70.4	131.2
TOLFR03	7.6	19.2	383	608	6.95	8.2	1.16	8.63	15.4	45.1
TOLFR43	10.1	21.1	1095	8680	6.74	8.56	3.35	17.48	0.2	5.5
TURVEYS DRAIN	14	14	1332	1332	7.46	7.46	3.8	3.8	21.2	21.2

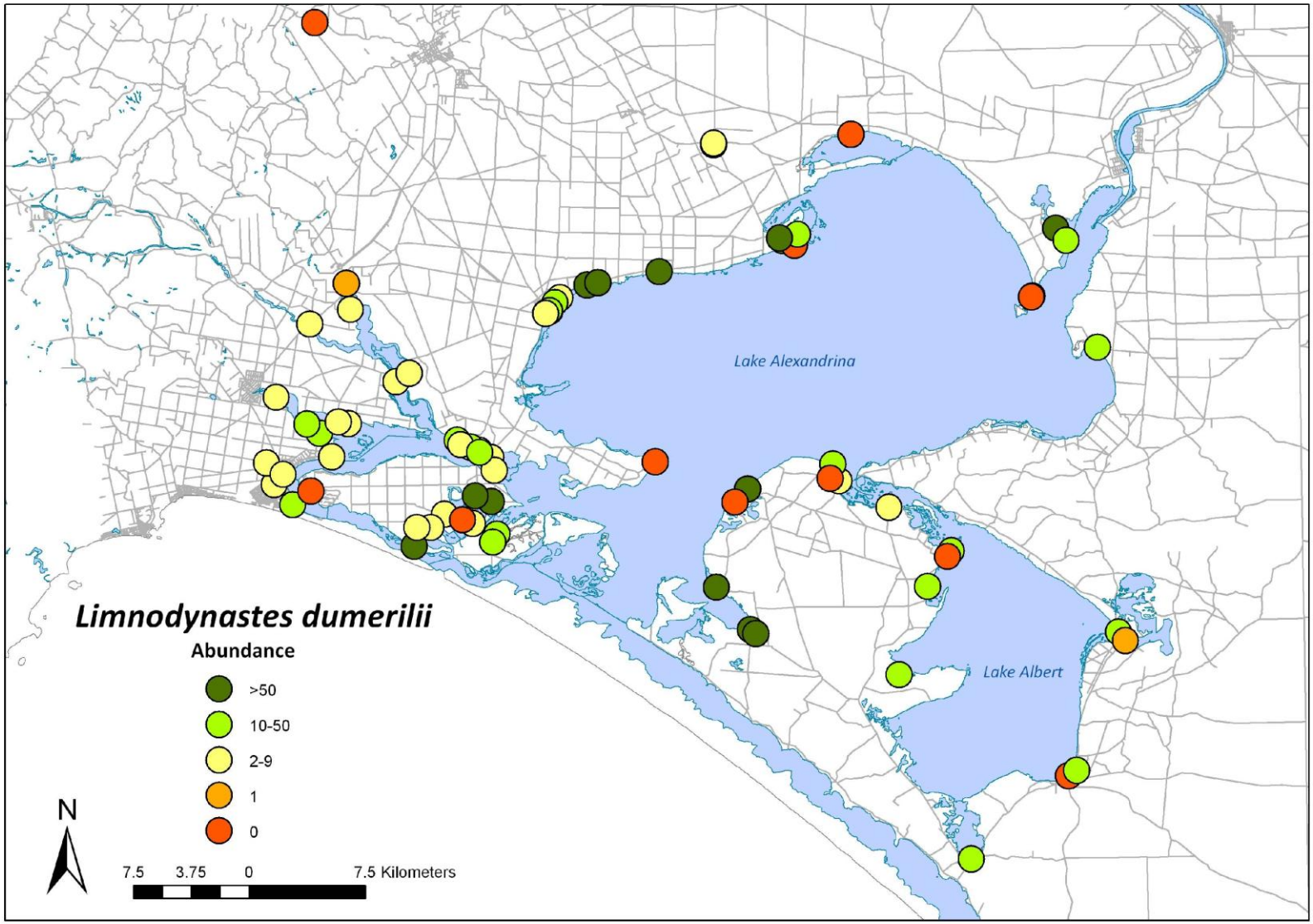
Appendix 3: Results of nocturnal surveys at all sites including abundance scores assigned to each species (1 = 1; 2 = 2-9; 3 = 10-50; 4 = >50)

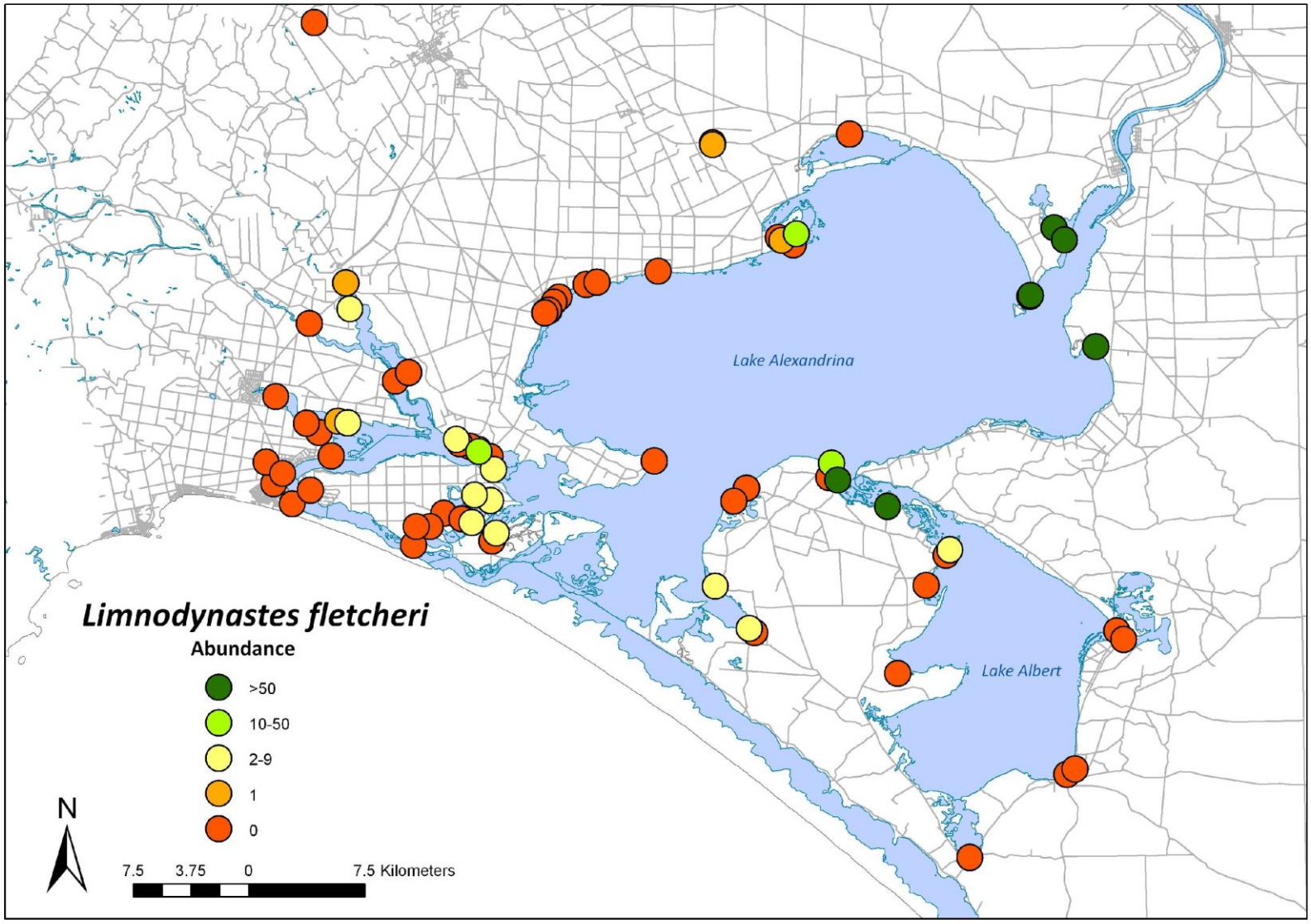
Site	Southern Bell Frog	Eastern Banjo Frog	Common Froglet	Spotted Grass Frog	Brown Tree Frog	Peron's Tree Frog	Long-thumbed Frog	Total Species Recorded
GOOLWA CHANNEL 'KNAPPSTEINS' 1	1	3	4	4	1	0	2	**6**
Wetlands Beach Clayton Bay	0	3	3	2	2	1	3	**6**
Alison Avenue SW Goolwa	0	2	4	3	2	1	0	**5**
FINNISS 'WALLY'S LANDING'	0	2	3	2	2	0	2	**5**
FINNISS 'STERLING DOWNS'	0	2	4	2	2	1	0	**5**
Gilbert Currency Creek	0	2	4	3	1	0	2	**5**
Gollans Waterhole	0	2	3	2	1	0	1	**5**
Hayter Finniss	0	2	3	2	1	2	0	**5**
HINDMARSH ISLAND BOGGY CREEK	0	4	4	4	2	0	2	**5**
HINDMARSH ISLAND 'WELLS/SHADOWS LAGOON'	0	4	4	4	2	0	2	**5**
JENNY'S LAGOON 1	0	4	4	4	2	0	2	**5**
LOVEDAY BAY	0	4	4	4	2	0	2	**5**
LOW POINT	0	3	4	3	2	0	4	**5**
NALPA STATION 'PELICAN LAGOON B'	0	4	4	4	1	0	4	**5**
NALPA STATION 'PELICAN LAGOON C'	0	3	4	3	2	0	4	**5**
NARRUNG 'NARFR01'	0	2	4	4	3	0	4	**5**
NARRUNG NARROWS 'THE LAKEHOUSE'	0	2	4	3	3	0	4	**5**
Snug Cove Jetty	0	2	2	2	1	0	2	**5**
TOLFR01	0	4	4	4	2	0	1	**5**
TOLFR03	0	3	4	4	3	0	3	**5**
3113 Strathalbyn rd - dams	0	3	4	3	2	0	0	**4**
GOOLWA CHANNEL 'KNAPPSTEINS' 2	0	2	4	3	1	0	0	**4**
HINDMARSH ISLAND 'BOGGY CREEK CULVERT'	0	2	4	3	0	0	2	**4**
HINDMARSH ISLAND 'GOOLWA CHANNEL DRIVE'	0	4	4	2	2	0	0	**4**
HINDMARSH ISLAND HUNTERS CREEK 'DENVER RD'	0	2	4	3	2	0	0	**4**
JENNY'S LAGOON 2	0	4	4	4	2	0	0	**4**
Kessell Rd Stormwater ponds Goolwa	0	2	3	2	1	0	0	**4**
LAKE ALBERT 'KENNEDY BAY'	0	3	4	4	2	0	0	**4**
LAKE ALBERT 'TOBIN LODGE'	0	3	4	3	2	0	0	**4**
LAKE ALBERT 'WALTOWA BAY'	0	3	4	4	2	0	0	**4**
LAKE ALBERT 'WALTOWA WETLAND STRUCTURE'	0	1	4	4	1	0	0	**4**
McKinlay Currency Creek	0	3	3	2	1	0	0	**4**
MOSQUITO CREEK 'GOLLAN'S WATERHOLE'	0	2	3	2	2	0	0	**4**
MUNDOO ISLAND 'PIG ISLAND'	0	3	4	4	0	0	2	**4**
Murray Mouth Rd HI	0	2	3	2	1	0	0	**4**
NALPA STATION 'POMANDA POINT'	0	0	4	3	2	0	4	**4**
NALPA STATION 'POMANDA POINT CAUSEWAY'	3	0	0	2	2	0	2	**4**
NARRUNG 'NARFR03'	0	3	4	4	0	0	3	**4**
NARRUNG NARROWS 'NURRA NURRA'	0	3	4	4	0	0	2	**4**

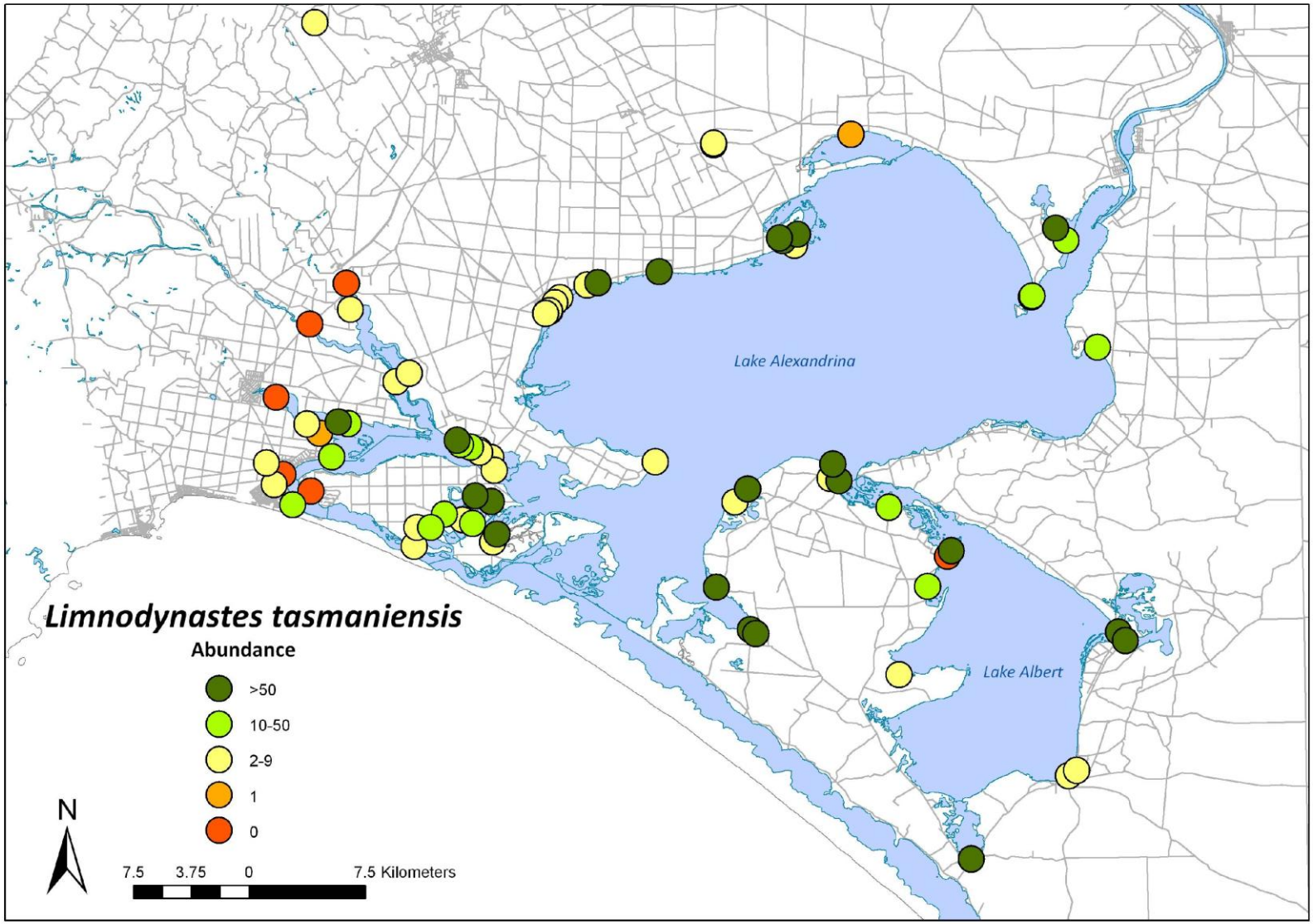
Site	Southern Bell Frog	Eastern Banjo Frog	Common Froglet	Spotted Grass Frog	Brown Tree Frog	Peron's Tree Frog	Long-thumbed Frog	Total Species Recorded
Swamp 333, Meningie	0	3	3	2	2	0	0	**4**
TOLFR43	0	4	4	4	1	0	0	**4**
TURVEYS DRAIN	0	4	4	4	2	0	0	**4**
Wally's Landing	0	2	3	2	0	0	2	**4**
Wetland near CC regulator	0	2	4	4	0	0	1	**4**
Wetlands Beach Clayton Bay	0	2	3	0	1	0	2	**4**
ANGUS MOUTH	0	4	4	2	0	0	0	**3**
Ballast Stone	0	2	3	0	1	0	0	**3**
Bird Viewing Hut Goolwa	0	3	4	3	0	0	0	**3**
BREMER MOUTH	0	4	4	4	0	0	0	**3**
CLAYTON BAY 'COMMUNITY BOARDWALK'	0	2	3	2	0	0	0	**3**
CLAYTON BAY 'RED TOP BAY'	0	3	4	3	0	0	0	**3**
Currency Creek Rd	0	3	3	1	0	0	0	**3**
DUNNS LAGOON 'JETTY'	0	4	4	2	0	0	0	**3**
Heinicke Reserve Goolwa	0	2	4	2	0	0	0	**3**
HINDMARSH ISLAND HUNTERS CREEK 'FISHWAY'	0	2	4	3	0	0	0	**3**
Huczko Wetland	0	0	0	2	2	1	0	**3**
Milang Bay	0	2	4	2	0	0	0	**3**
Milang N.E. Wetland	0	3	4	2	0	0	0	**3**
Milang S.W. Wetland ALE010	0	3	3	2	0	0	0	**3**
MILANG SNIPE SANCTUARY	0	3	3	2	0	0	0	**3**
MUNDOO ISLAND 'STOCKYARD SWAMP'	0	3	4	2	0	0	0	**3**
Pobbybonk	0	2	3	2	0	0	0	**3**
Poldollie Bay, Rumply Point	0	3	4	2	0	0	0	**3**
TERINGIE WETLAND 1	0	4	4	4	0	0	0	**3**
TOLFR02	0	0	4	2	3	0	0	**3**
Tookayerta	0	2	3	0	2	0	0	**3**
wetland near Gollans	0	2	3	2	0	0	0	**3**
Boggy Lake	0	0	2	1	0	0	0	**2**
Ducks Hospital	0	0	3	2	0	0	0	**2**
DUNNS LAGOON 'DUCK'S HOSPITAL'	0	2	4	0	0	0	0	**2**
HINDMARSH ISLAND 'STEAMERS DRAIN'	0	0	3	2	0	0	0	**2**
Meningie Foreshore	0	0	3	2	0	0	0	**2**
MILANG SHORES 'SNAKEY POINT'	0	2	0	2	0	0	0	**2**
Murray Smith Park Goolwa	0	2	3	0	0	0	0	**2**
Old Bull Creek Rd	0	0	3	2	0	0	0	**2**
Swamp on Barnhill Rd Finniss	0	1	0	0	0	0	1	**2**
TERINGIE WETLAND 2	0	0	3	2	0	0	0	**2**
Dam at Finniss	0	0	2	0	0	0	0	**1**
Hindmarsh Island Marina	0	0	2	0	0	0	0	**1**
NARRUNG WETLAND 'NARWQ01'	0	0	0	2	0	0	0	**1**

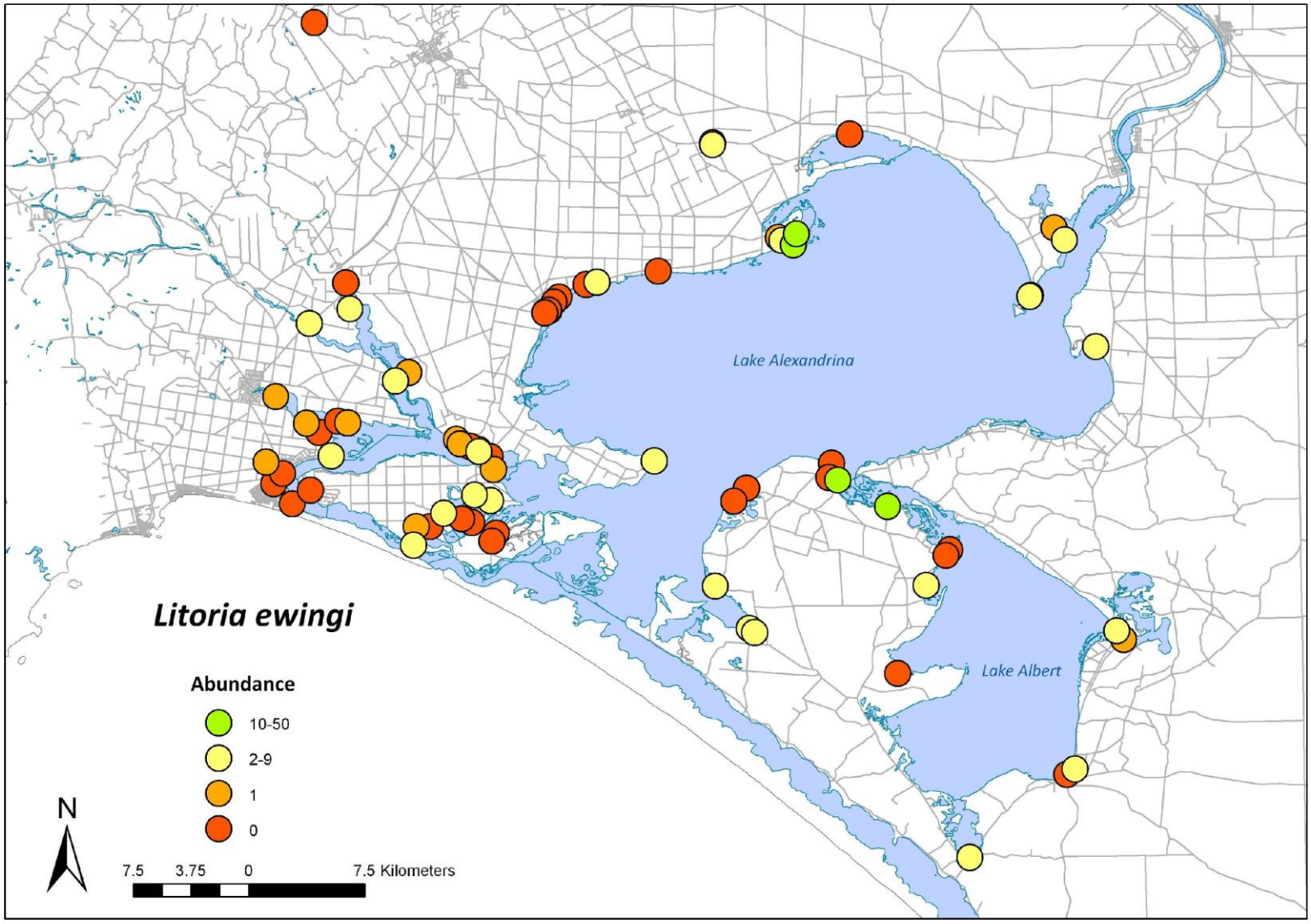
Appendix 4: Abundance of each frog species per monitoring site 2012

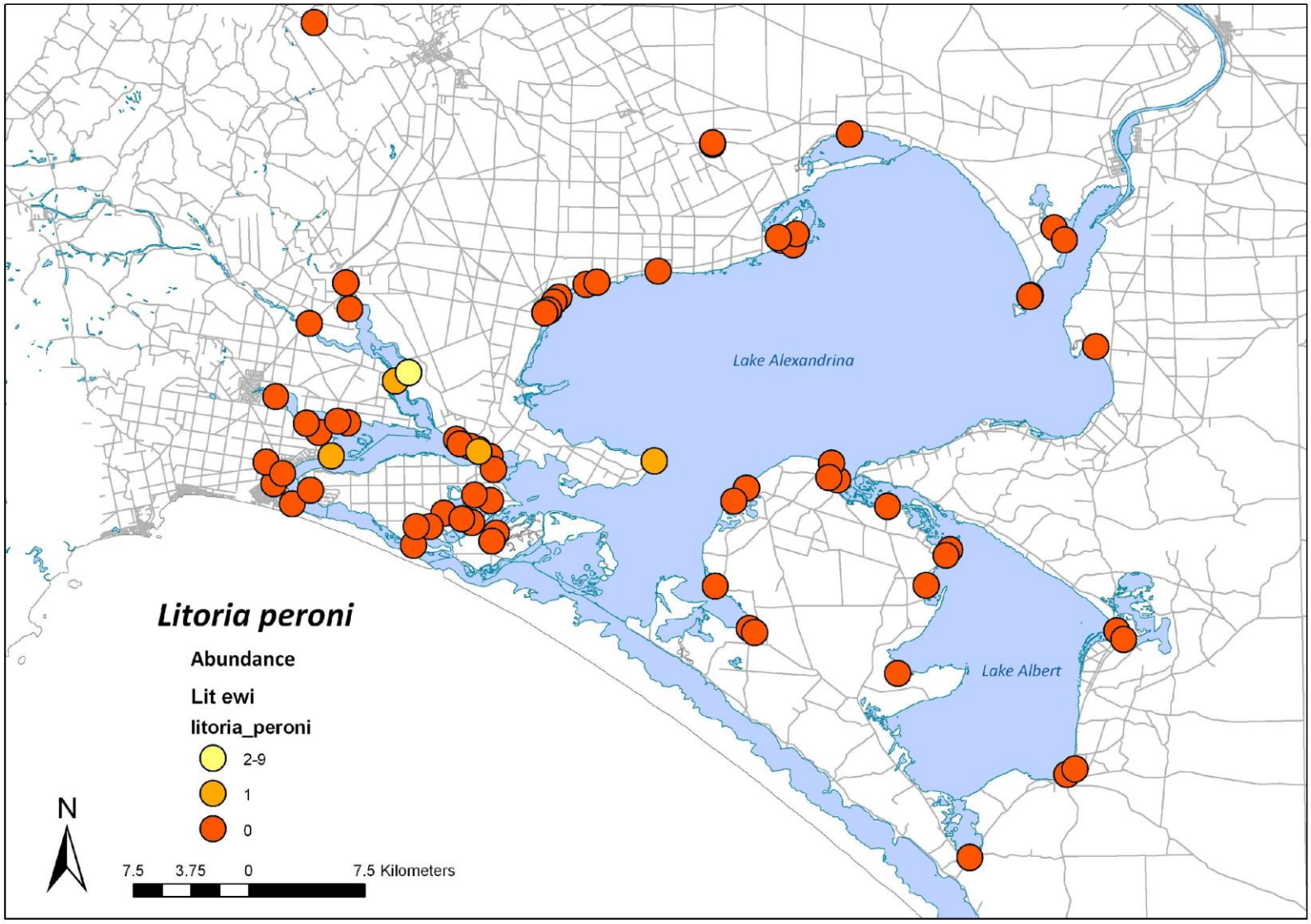



Lake Alexandrina
Lake Albert
Limnodynastes dumerilii
Abundance
>50
10-50
2-9
1
0
N
7.5 3.75 0 7.5 Kilometers


Lake Alexandrina
Lake Albert
Limnodynastes fletcheri
Abundance
>50
10-50
2-9
1
0
N
7.5 3.75 0 7.5 Kilometers


Lake Alexandrina
Lake Albert
Limnodynastes tasmaniensis
Abundance
>50
10-50
2-9
1
0
N
7.5 3.75 0 7.5 Kilometers


Lake Alexandrina
Lake Albert
Litoria ewingi
Abundance
10-50
2-9
1
0
N
7.5 3.75 0 7.5 Kilometers


Lake Alexandrina
Lake Albert
Litoria peroni
Abundance
Lit ewi
litoria_peroni
2-9
1
0
N
7.5 3.75 0 7.5 Kilometers