The Eastern Mount Lofty Ranges Fish Inventory

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Aquasave

river murray catchment water management board

The Eastern Mount Lofty Ranges Fish Inventory

Distribution and conservation of freshwater fishes of tributaries to the Lower River Murray, South Australia

September 2004

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A joint program between **Native Fish Australia (SA)**, **Aquasave** and the **River Murray Catchment Water Management Board**.

This report may be cited as:

Hammer M (2004) The Eastern Mount Lofty Ranges Fish Inventory: Distribution and Conservation of Freshwater Fishes of Tributaries to the Lower River Murray, South Australia. Native Fish Australia (SA) Inc & River Murray Catchment Water Management Board.

ISBN 0-9581530-4-3

Front cover: from the top left; male and female southern pygmy perch, Finniss River stream habitat, flathead gudgeon and cut-out of mountain galaxias.

Acronyms commonly used in this document:

NFA(SA): Native Fish Australia (SA)
SAMA: South Australian Museum, Adelaide
RMCWMB: River Murray Catchment Water Management Board
EMLR: Eastern Mount Lofty Ranges
EPBC Act: *Environmental Protection and Biodiversity Conservation Act 1999* (Federal)
DWLBC: Department for Water Land and Biodiversity Conservation
TL: Total Length, **ds**: down stream, **us**: up stream

Acknowledgements

The extent and detail of this Inventory could not have been achieved without the involvement and expertise of many people, and the funding of the River Murray Catchment Water Management Board (RMCWMB).

Thanks in-particular to numerous members of Native Fish Australia (SA) for assistance in the field, Leanne Pillar for final proof reading, and to Kerri Muller and Mardi van der Wielen (RMCWMB) for supporting the project, spatial information layers and help in the field. Also, thanks to SARDI Aquatic Sciences (Inland Waters) for equipment hire and some field assistance, Ashwood Ceasar (DWLBC) for producing GIS maps that assisted with site selection/survey design, DWLBC for access to unpublished hydrological and aerial videography data and the South Australian Museum who provided important access to the historic fish collection.

The involvement and enthusiasm of the community was both encouraging and appreciated, with many landholders allowing access to locations on private property, participating in surveying and also sharing invaluable knowledge on the history and lie of the land. Members of Catchment and Landcare groups assisted with site access and sampling, which was greatly appreciated.

Foreword

Fishes are dependent on underwater environments for existence. Consequently species, particularly those restricted to dispersal within freshwater, cannot simply escape poor conditions by removing themselves from the water until favourable conditions return. Hence the diversity and abundance of fishes can tell us much about the natural history and health of aquatic habitats. The ecology and adaptations of such creatures to variable aquatic environments, particularly intermittent streams such as those in the Eastern Mount Lofty Ranges, is also fascinating.

At a time when water is in such heavy demand for irrigation supply and with ever increasing regional and rural development, it is timely to review the current status of fish in the region. This document sets the scene to begin to understand the characteristics and conservation requirements for a badly neglected faunal group, the freshwater fishes. It aims to ensure that fish and other underwater creatures are considered in regional planning and management by government and on the land, as fish have specific requirements linked within complex ecosystems.

The Eastern Mount Lofty Fish Inventory forms one in a series of similar surveys being conducted by Native Fish Australia (SA) as part of a determined effort to better document the distribution and conservation requirements of native fish in South Australia. Areas covered to date include the South East and Lower Lakes, with surveying on Kangaroo Island near completion and additional regions of the State being targets for future surveys.

An ideal introduction to local species and aquatic habitats as a context for this document is contained in the 'Data Sheet: Freshwater Fishes of Mount Lofty Ranges – Murray-Darling Basin in SA' (Hammer and Butler 2001).

This report details the distribution of threatened species as well as habitats on private property. While the benefits of having such information are invaluable in the long-term context of species conservation, consideration needs to be given to the sensible distribution and application of this information. The report has been prepared on the best information available at the time and no responsibility is taken for any errors or omissions.

About Native Fish Australia (SA)

Native Fish Australia (SA)'s activities and goals are directed towards the research and conservation of our native fish and aquatic environments. We recognise the need for the integration of ongoing research in our local area, the promotion of native fish, community involvement in research, and education aimed at the protection and enhancement of native fish into the future. This will involve the raising of issues important in ensuring these aims, such as the information featured in this Inventory. Get involved by contacting or becoming a member of NFA (SA). Membership forms and constitution are available from www.nativefishsa.asn.au

Executive summary

The Eastern Mount Lofty Fish Inventory is a cumulation of recent surveys and monitoring in a distinct section of the Murray-Darling Basin near Adelaide. It provides a comprehensive overview of the distribution of species in intermittent stream environments and terminal wetland areas for 16 catchments that drain toward the Lower River Murray or Lake Alexandrina. Data on fish species composition and abundance, water quality and habitat characteristics is presented for over 180 sites.

The Eastern Mount Lofty Ranges are an important refuge for aquatic biota at the local and Murray-Darling Basin level. Distinct patterns of species and habitat occurred within and between different catchments. In total sixteen native species were captured including one species of national conservation significance (Yarra pygmy perch), three endangered species 'protected' under state legislation (Yarra and southern pygmy perch, river blackfish) as well as six other species considered rare at the state level. In addition three hybrid forms of carp gudgeons were also collected. Museum specimens, literature and local reports indicate that another 11 native species were once present or might still occur in the study region. Seven introduced species were recorded.

The Inventory identified that the region has high natural values warranting protection and recognition within regional management such as distinctive habitat, threatened species and other taxa isolated in particular areas (and hence potentially genetically distinct). A summary of significant catchment features includes:

- **Currency Creek**: isolated populations of mountain galaxias and flathead gudgeon, diverse lowland fish community,
- **Tookayerta Creek**: unique spring fed and swamp habitat (local and national level significance), including patchy distributions of the threatened southern pygmy perch and river blackfish, also distinctive colour form of mountain galaxias,
- **Finniss River**: contrasting bedrock defined geomorphology with spring fed sections and some peat swamp, disjunct populations of threatened southern pygmy perch and good populations of mountain galaxias. Also diverse habitat structure and fish species richness in lowland areas including wetland habitat supporting Yarra pygmy perch,
- **Angas River**: spring fed upland and lowland pools, healthy population of river blackfish, severely restricted southern pygmy perch population and isolated dwarf flathead gudgeon and mountain galaxias populations,
- **Bremer River**: contrasting sub-catchments, large lowland pools, highly restricted habitat for river blackfish in Rodwell Creek,
- **Reedy Creek**: distinct geomorphology (waterfalls), few fish but including an isolated population of dwarf flathead gudgeon in distinctive habitat,
- **Salt Creek**: contrasting saline habitat, some large and isolated aquatic refuge pools,
- **Saunders Creek**: little water but important lowland spring-pools with Murray-Darling carp gudgeon,
- **Marne River**: rocky gorge with isolated mountain galaxias and unique spring fed section (large cool pools within Mallee surrounds) containing a restricted and ever contracting population of river blackfish as well as other small native fish.

Data indicates that water resource development has likely had, and will continue to have, a considerable effect on the health of fish populations in the region, especially during natural dry periods (accentuation or creation of no flow events, loss of base flow), reducing the presence and quality of permanent refuge pools. Specific cases of broad and localised habitat destruction also appear to have affected species distributions in the region and introduced predators were implicated in the restricted occurrence of small native fish. Under the premise that freshwater fish are ideal indicators of the health of our waterways, recommendations are made that identify areas for research and the future protection and enhancement of important aquatic habitat in the Eastern Mount Lofty Ranges.

Contents

1.0 Introduction

South Australia is largely devoid of stream habitat. Several lowland rivers sourced many hundreds of kilometres away flow through normally dry regions of the State (e.g. Cooper Creek, Diamantina and Murray rivers), while one naturally wetter region, the South East, mostly lacks natural drainage organisation and instead has aquatic habitats distributed as a mosaic of wetland features (at least under natural conditions).

The Mount Lofty Ranges, linking with the Flinders Ranges in the north and stretching in a southerly direction to the Fleurieu Peninsula, is one region where topography and rainfall do combine to provide stream habitats. Catchments in the region discharge into one of two major drainage divisions: (a) the South Australian Gulf Division - essentially those streams on the western slopes of the range that drain toward Gulf St Vincent and including a small section of the southern Fleurieu Peninsula that discharges directly into the Southern Ocean, and (b) the Murray-Darling Drainage Division or Murray-Darling Basin – streams in the Eastern Mount Lofty Ranges (EMLR) that drain towards either the Lower River Murray or Lake Alexandrina.

The current physical form of the Mount Lofty Ranges was evident by the early Tertiary period (~60-80 M years ago), shaped by significant earth movements along regional fault lines (Twidale 1976). The physical force of streams has since this formation, played an integral part in shaping the current landscape, and modern streams of the Mount Lofty Ranges retain a prominent role in the natural and cultural heritage of the region.

Being close to a large population base in Adelaide (over 1 million people) and linked to several major regional (Mt Barker, Strathalbyn, Murray Bridge) and rural centres, there is a large and continuing pressure on EMLR streams from intensive rural and urban development (e.g. extensive land clearance, considerable hydrological development - particularly in the last 15 years, stormwater, stock access, swamp drainage etc). As the ultimate point for runoff in catchments, the end result of harmful practices in surrounding landscapes can be felt in waterways (e.g. pollution, siltation, water abstraction in dams). It is thus important to have a level of knowledge of regional aquatic biodiversity and related environmental requirements to assist in the protection of remaining natural values and begin to restore ecosystems in the face of considerable anthropogenic change.

Freshwater fish should be viewed as important indicators of stream health due to their total reliance on aquatic (underwater) environments for all life history stages. For example certain native species require particular flow events for migration, access to habitat, and cues for ecological processes, while exotic species may thrive in altered conditions (e.g. Puckridge *et al.* 1998; Harris and Silveira 1999). As well, fish as higher order predators, can be affected (e.g. poor recruitment) by degradation of other ecosystem components and may have a role in ecosystem function (e.g. Flecker and Townsend 1994). These factors, combined with the familiarity and affection often shown toward fish by local communities, means that fish potentially serve as icons for the understanding and responsible stewardship of local waterways.

There are indications that the EMLR has a diverse and unique fish community. The list of freshwater fishes for the region is reasonably well-established, with the streams known to currently or historically support at least 26 native species. These fish range from tiny species such as carp gudgeons that reach just a few centimetres, to medium sized river blackfish and congolli (up to about 30cm), through to the mighty Murray cod, a species that can grow to well over a metre in length (Hammer and Butler 2001). Additional species are still being documented such as Yarra pygmy perch in 2001, and research into the population genetics of the southern pygmy perch has identified unique and divergent genetic sub-populations isolated in particular catchments (Hammer 2001, 2002b). Such patterns likely extend to other species restricted to dispersal in freshwater, and protecting genetic diversity is imperative as a base for biodiversity conservation within a regional and national context.

Beyond a general regional species list, there remain significant gaps in our understanding of the EMLR fish community such as: specific species distributions and environmental conditions at remaining habitat, the fauna present in specific regions or catchments, and how current communities compare to those before European settlement. Large sections of the EMLR have not been formally surveyed, with only patchy records (in time and space) lodged at the South Australian Museum, and a few published investigations of particular regions (e.g. Nettlebeck 1926; Hicks 1997; Sim *et al.* 2000; Hammer 2001, 2002a) or sites as part of broader surveys (e.g. Lloyd and Walker 1986; Bertozzi *et al.* 2000).

This report presents information aimed at filling knowledge gaps in our understanding of fishes in the Eastern Mount Lofty Ranges within the specific context of local conservation and management. A broad baseline survey of aquatic habitats in the region is combined with historic data and literature coverage to investigate patterns of species distribution, habitat and water requirements.

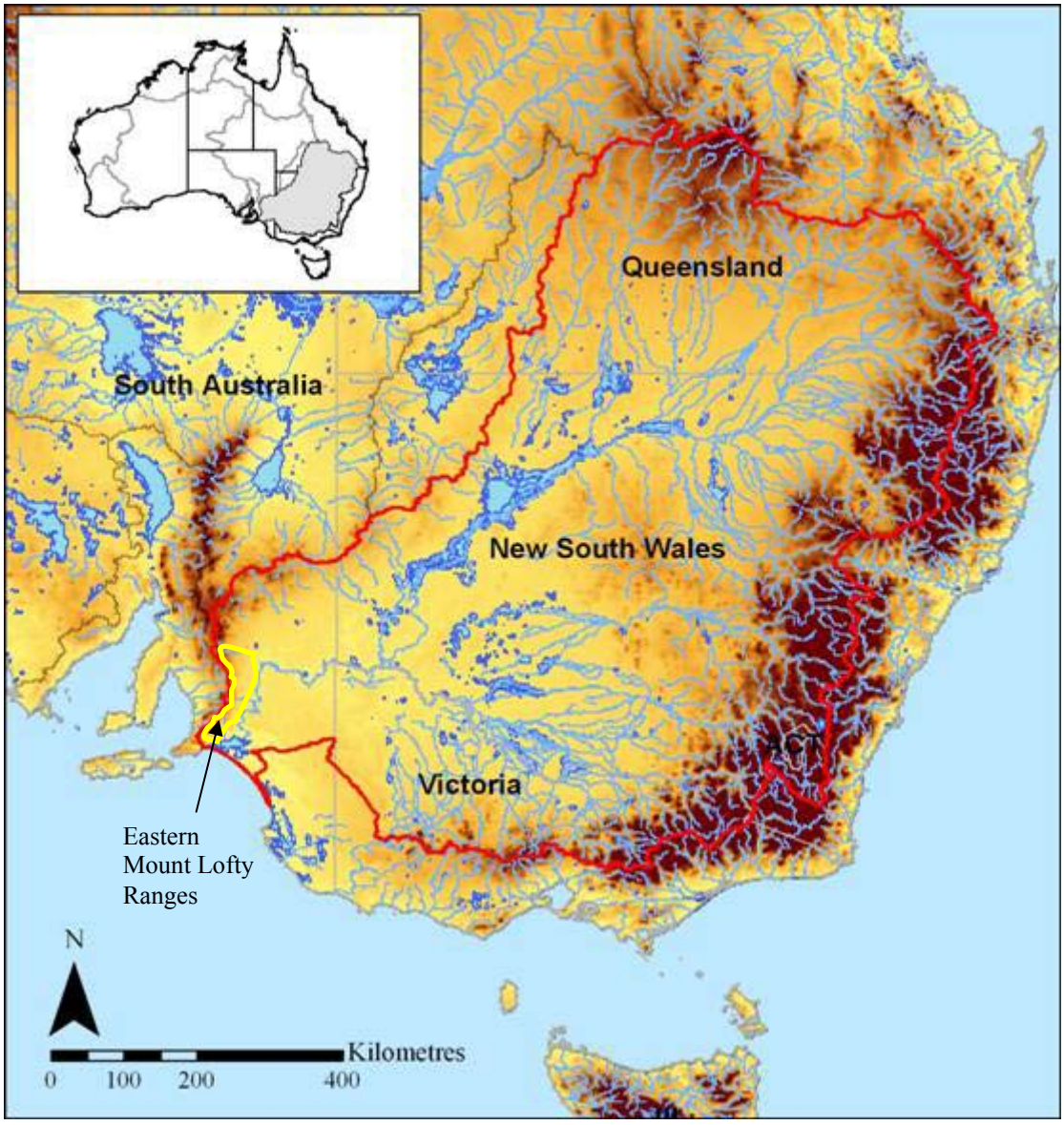


Figure 1. The geographical position of the Eastern Mount Lofty Ranges in south eastern Australia: situated at the terminus of the expansive Murray-Darling Drainage Division (Basin).

2.0 Methods

2.1 Collating historic records

A morphological examination of fish specimens housed at the South Australian Museum, Adelaide (SAMA) was conducted to obtain a verified catalogue of historic records for the EMLR. This was combined with a review of literature as an insight into species distributions, potential habitat and key survey locations. A dedicated effort was also made to document oral history regarding local knowledge of fish species in the region, past and present (see Appendix 3 for more detail).

2.2 Study area

The EMLR study region here includes whole stream catchments draining the south eastern flank of the Mount Lofty Ranges between Currency Creek in the South and the Marne River to the North and bounded by Lake Alexandrina and the River Murray (Figs 2 & 5), an area of some 4600km^2. The area includes 17 distinct catchments (Fig. 2), not all of which contain permanent surface water (e.g. no fish sampling sites could be located in the Bees Knees, Long Gully, Milendella Creek, Preamimma Creek, Rocky Gully and Sandergrove Plains catchments).

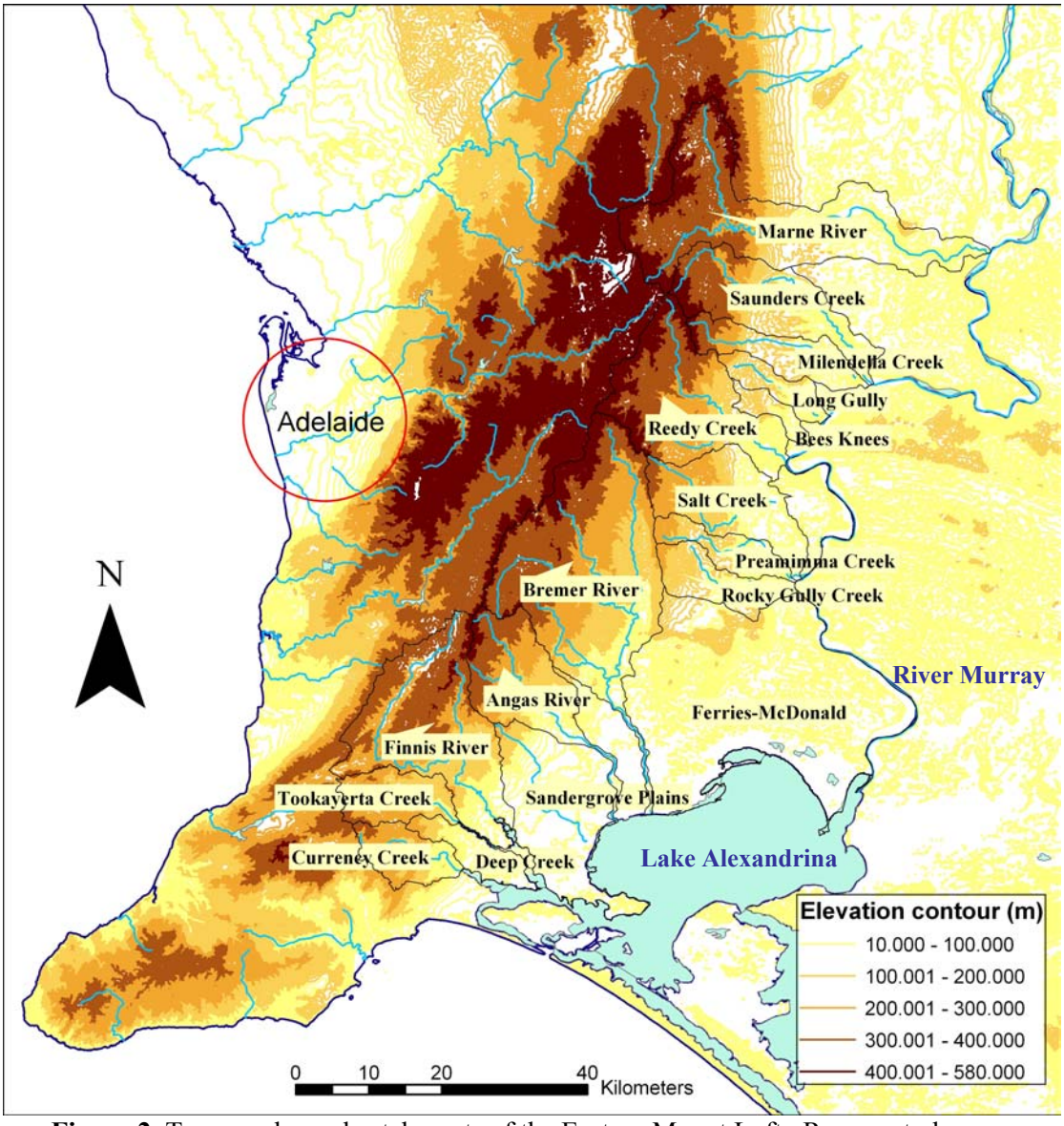


Figure 2. Topography and catchments of the Eastern Mount Lofty Ranges study area.

Elevation at the region of hydrological separation between the east and west Mount Lofty Ranges varies between 200-480m above sea level (Fig 2). The study area experiences a Mediterranean Type climate, with long hot summers and rainfall predominantly concentrated within winter and spring (prevailing low pressure systems from the south-west). Yearly average rainfall varies considerably from 800mm at higher elevations to a mere 300mm on flats at the base of the range (see Fig. 3).

The principal habitat type in the region is small streams (generally less than 20m wide), with some peat swamps, isolated spring pools and large lowland pools present, as well as larger river channel or wetland habitats at the junction of streams and the River Murray or Lake Alexandrina. There is considerable variation in the geomorphic and hydrological character of streams, further compounded by differing patterns and intensity of regional land use. In general, most catchments comprise a network of small tributaries originating from the moderate gradient 'slopes' of the Range that tend toward distinct habitat in a single lowland channel, usually via a steep gorge, and then meander across a lowland 'flat' before eventually reaching the Lower River Murray or Lake Alexandrina (actual stream discharge ranges from near permanent, seasonal and to highly erratic: see Section 4.0).

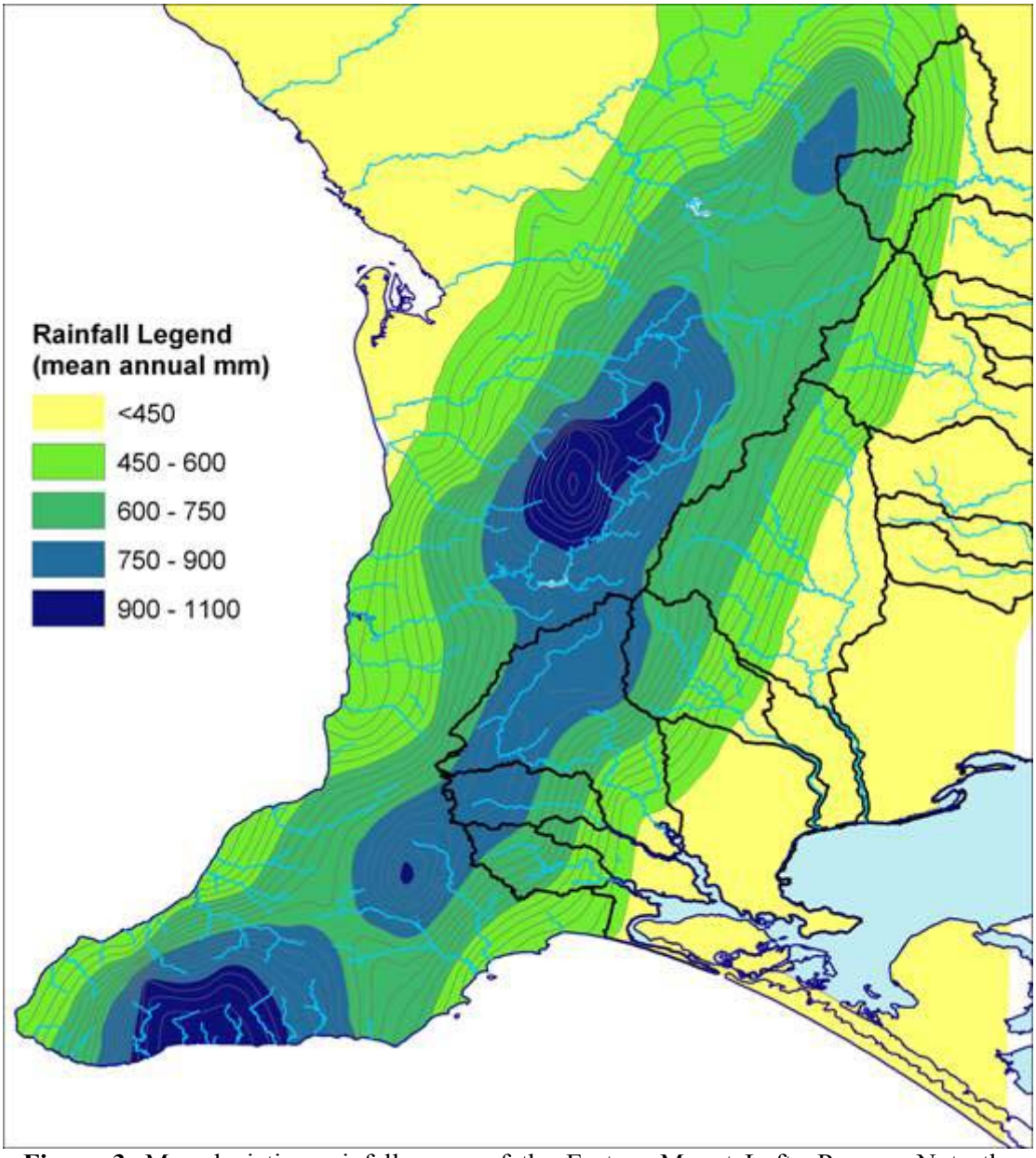


Figure 3. Map depicting rainfall zones of the Eastern Mount Lofty Ranges. Note the contrasting rainfall band areas for different catchments.

There is marked seasonal and longer temporal variation in stream flows, with the majority of streams experiencing episodic flow and at times large flood spates frequently occurring in winter and spring (see Fig. 4). During summer, most waterways contract to chains of interconnected or isolated pools. Some areas are fed by springs, however permanent base flow is rare. Nearly all waterways in the region flow through private land for most of their length, with only minor public access points (e.g. road crossings, towns, reserves).

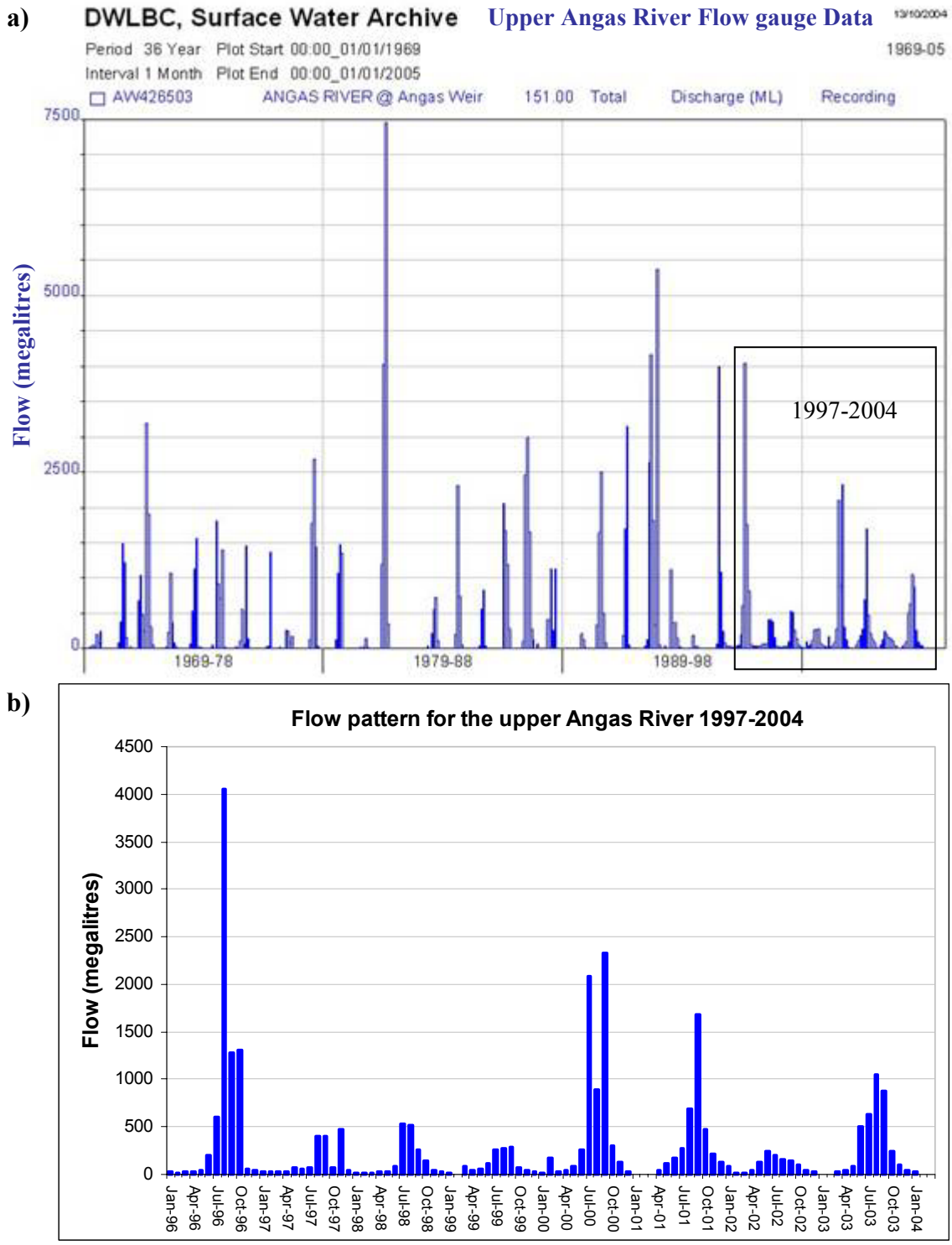


Figure 4. a) monthly flow gauge data for the upper Angas River above Strathalbyn between 1969 and March 2004 (DWLBC 2004). The hydrograph is representative of the strong seasonal and inter-annual variability of stream flow in the EMLR **(b)** a magnification of the recent hydrological history leading up to Inventory sampling indicating low flows in recent years, particularly 1997-2000 and 2002.

2.3 Sampling sites

Site selection was primarily designed to give an even spatial coverage of catchments and to include representation of distinct geomorphic zones within catchments (i.e. with the aid of GIS coverage and 1:50k topographic maps). The number of sites in a geomorphic zone was increased if there was considerable heterogeneity in habitat or hydrologic conditions. However, water availability and land access heavily dictated site location.

With the cooperation of land holders/managers and local Catchment and Landcare groups, many sites were deliberately located on private property to encourage community involvement, collect oral history and raise awareness of aquatic fauna (e.g. fish data sheet distribution).

Identification of permanent pools in 2004 sampling was aided with specialised GIS coverage of the survey region from aerial videography of catchments in autumn 2003 produced by the Department for Water Land and Biodiversity Conservation (DWLBC 2004). This data provided information on visible surface water from overhead helicopter surveys, and was a useful supplement to local knowledge, particularly in drier catchments (ground truthing was still required to increase the accuracy and reliability of these maps).

Inventory sites were grouped into the catchment areas listed in 2.2 to assist in the interpretation of results. Sites within catchments are arranged according to increasing distance from stream termini along the primary river, then in a similar manner for tributary streams progressing upstream in the catchment. Site number prefixes indicate year of sampling (e.g. ML04 = 2004). Site suffixes are used to indicate information on site sampling location or history:

- **A** – represents the same site sampled on a preceding occasion (temporal comparison),
- **M** – ongoing monitoring site for threatened fish species,
- **a** and **b** (small caps) – paired sites located in close proximity.

2.4 Climatic conditions during sampling

Sampling in 2004 followed a dry summer and virtually no rainfall occurred across the region during the March to June sampling period. The preceding 2003 winter did have reasonable rainfall and moderate flows in the more southern catchments, but 2002 was a low rainfall year. The longer term trend for the previous ten years was of below average rainfall and corresponding stream flow, especially during 1997-2000 (e.g. low stream flows in the Angas River: Fig. 4; see also Savadamuthu 2003).

2.5 Fish survey procedure

Thirty-eight field days/nights with a two or three person sampling team was used to collect 2004 Inventory data. This effort was supplemented by two other specific surveys in the Angas and Marne catchments, as well as opportunistic collections in various catchments occurring between autumn 1999 and autumn 2003. Data from a collaborative project involving the collection of mountain galaxias for future genetic studies (see Raadik 2001) was also included. Sampling was carried out under Section 59 permit exemptions under the *Fisheries Act 1982*.

A site generally consisted of a main pool or river channel location where sampling was concentrated and general site descriptors obtained (see section 2.7), with supplementary investigations employed within a 100m stretch of habitat. For consistency in method and interpretation of environmental parameters, all surveying was conducted by the author, with field assistants over the period including numerous Native Fish Australia (SA) members, representatives of community and government groups and landholders.

The sampling methodology was designed to assess fish species richness and relative abundance in high water conductivity pools with varying degrees of size, depth, habitat complexity and water clarity. It also aimed for minimum impact (e.g. low disturbance to sensitive habitats/concentrated pools, minimal handling, sub-sampling larger catches to be measured and avoiding hot weather). Timing was aligned to the autumn period when fish are easiest to sample owing to the concentrated nature of stream pools.

A range of gear types were used for field sampling, often applied in conjunction depending on habitat. Site specific details are maintained on a NFA(SA) data base for direct examination in future monitoring programs with a summary appearing in Appendix 2.

Standard sampling involved three ten-metre hauls of a seine net (7mx2m, 6mm mesh), with additional dip netting (square frame, 0.5m diameter, 4mm stretch mesh) of emergent or overhanging edge vegetation for 15-30 minutes. Some smaller pools required less hauls or could be sampled with dip nets. Sites with high structural integrity, difficult access or situated in sensitive areas (preventing seining) were sampled with bait traps (collapsible, 400x250x200mm, 3 & 6mm inlets; baited with dry cat food and set for 2 daylight hours) and other supplementary techniques. At larger deeper sites fyke nets (single 6m wing, 3 compartments and 5mm half mesh) were set and left overnight.

Supplementary techniques included underwater night observations (torch from bank or snorkelling) conducted for sites with high transparency. Angling was employed on a limited number of occasions for larger introduced species, with local reports providing valuable input on the presence of these species (the survey focus was on detecting remaining native fish populations and hence the gear used is most effective for medium and smaller species). Electrofishing was employed only at a handful of sites, as high water conductivities, low transparency, pool structure (e.g. narrow deep pools) and limited availability prevented wider use as a standard technique.

Due to taxonomic confusion the abundance of carp gudgeons *Hypseleotris* spp. was combined to produce a single figure. However, different forms at sites were recorded (*sensu* Bertozzi *et al.* 2000; Hammer and Butler 2001), with many identifications verified by genetic typing as part of ongoing studies being conducted at the Evolutionary Biology Unit of SA Museum (Hammer 2001; Adams and Hammer, unpublished data).

Notes were made on microhabitat where species were captured and any signs of reproductive condition and external disease or parasites were recorded. Total length (TL) was recorded for certain components of catches and to obtain general biological information (size range, snap shot of population structure) and specific ongoing monitoring data on threatened species and environmental flows.

Vouchers were taken, where specimens were abundant, and lodged with the SAMA as historical records and to verify identification. All introduced species were destroyed and the stomach content of introduced predatory species examined.

Inspecting catches from a seine net (*left*) and fyke net

2.6 Other fauna and flora

Records of opportunistic samples of turtles and larger macroinvertebrates such as yabbies and shrimps (*Macrobrachium* and *Paratya*) were made.

The survey design also encompassed specific cataloguing of 'aquatic plants' including submerged plants, charophytes (a particular group of algae) and small sensitive plants found near to the waters edge, with specimens collected and pressed, and lodged at the State Herbarium (a separate report has been prepared for aquatic plants).

2.7 Environmental descriptors

Location (description and GPS- WGS 84 datum), waterway, catchment, weather, land use, potential impacts and environmental characteristics were recorded for each sampling site to assist with the interpretation of results and future replication (monitoring). Environmental characteristics included details of aquatic and interlinked riparian condition as follows (see Hammer 2001 for specific details on category definitions):

- Habitat type (i.e. stream, spring pool, river channel, wetland, instream dam),
- Pool size (a reflection of surface area),
- Bank slope (e.g. steep, gradual incline),
- Depth (max and average),
- Substrate type (e.g. sand, gravel, mud).

Contributions to cover (% 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*) (**see images** on the right),
- Canopy – measure of over hanging vegetation (shade),
- Terrestrial vegetation cover.

Flow environment:

A temporal measure of connectivity based on seasonal conditions and local landholder input (e.g. ephemeral, annual connection or permanently connected).

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* at the time of sampling ranked relative to autumn conditions in local streams as either: seep, low, medium or high.

Water quality (TPS MC-81 meter):

- Temperature @ 0.3m,
- pH,
- Conductivity (range 10-25,000µS = μScm^{-1}), 1:2 dilutions were sometimes needed,
- Water transparency measured *in situ* against a white object with comments on contributions to low values such as natural tannin or algae.

A detailed database of environmental descriptors is also maintained by NFA(SA) and RMCWMB for more specific information and future comparison.

3.0 General Results

Some 146 sites were visited in autumn 2004. To complete regional coverage and also provide for a limited temporal comparison of fish captures, 49 sites visited between February 1999 and April 2003 are also included in subsequent analysis (a total of 180 different sites plus 15 temporal sampling events coinciding with 2004 sites). The supplementary data is sourced from:

- Specific surveys of the Angas River (Hammer 1999) and Marne River (Hammer 2002a),
- Collaborative research with T. Raadik (Arthur Rylah Institute, Melbourne) involving the collection of mountain galaxias for genetic research (six sites in the series: ML02-158 -172),
- Other opportunistic collections in the region by the author including threatened species monitoring.

Ten sites dry in 2004 were inspected and documented as important linkage to historic data (i.e. sites that previously did have water and fish) and/or as 'aquatic plant' sampling sites.

Fish were captured on a large number of sampling events (143 of 195 sites ~ 70%). In total over 31,000 fish were recorded (Table 3.0.1).

Sixteen native species were captured including one species of national conservation significance (Yarra pygmy perch), three endangered species 'protected' under state legislation (Yarra and southern pygmy perch, river blackfish) as well as six other species considered rare at the state level (see Table 3.0.1.). In addition three hybrid forms of carp gudgeons were also collected. Museum specimens, literature and local reports indicate that another 11 native species were once present or might still occur in the study region (these are discussed in Section 5).

Seven introduced species were recorded (Table 3.0.1). A single carp x goldfish hybrid was recorded from site ML02-06A in the Marne River.

3.1 Species richness

Native fish were captured at roughly two out of every three sites sampled (126 sites). Native species richness values were mostly low, with between one and four species for the majority of sites (Table 3.1.1). All sites with six or more native fish captured were located at the terminal end of streams with high connectivity to the River Murray or Lake Alexandrina. 'Reedlands' on the lower Finniss River (ML04-45) had a particularly high range of native species (n = 13). Only the occasional upstream site had high native richness (two had five native species: ML04-70 - Angas River, ML04-112 - Bremer River).

Table 3.1.1. Species richness.

Native Richness	# Sites
0	68
1	55
2	30
3	19
4	9
5	3
6	5
7	1
8	3
9	0
10	0
11	0
12	0
13	1
14	0

The most widespread native fish was the mountain galaxias (69 sites and 2729 individuals). Carp gudgeons were also widespread and numerically abundant (40 sites, 7340 captured), a similar trend for flathead gudgeon (36 sites, 1961 captured). Dwarf flathead gudgeon occurred at a reasonable number of sites but generally occurred in low relative abundance (26 sites, only 430 captured) and southern pygmy perch was patchily distributed and on occasion locally abundant (20 sites, 1404 captured). Rarer native species included river blackfish (12 sites), common galaxias (12 sites) and congolli (7 sites), while a range of species such as Yarra pygmy perch, smelt and Murray rainbowfish were only collected from a few wetland sites at stream termini.

Exotic fish were widely distributed throughout the EMLR occurring at 82 different sites, with up to a combination of four introduced species found at some sites. Gambusia was the most commonly encountered (16222 fish from 61 sites), followed by redfin (24 sites) and carp (23 sites). Tench were only recorded at three sites in the Angas River Catchment.

Table 3.0.1. Summary of freshwater fishes recorded in the Eastern Mount Lofty Ranges survey area (survey data and historic records) with national and state conservation status.

Common name	Scientific name	National	State	# sites	# caught
Pouched lamprey	*Geotria australis*		EN	0	0
Shortheaded lamprey	*Mordacia mordax*		EN	0	0
Shortfinned eel	*Anguilla australis*		R	0	0
Freshwater catfish	*Tandanus tandanus*		P, VU	0	0*
Bony herring	*Nematalosa erebi*			5	54
Australian smelt	*Retropinna semoni*			7	73
Climbing galaxias	*Galaxias brevipinnis*		VU	0	0
Common galaxias	*Galaxias maculatus*			12	201
Mountain galaxias	*Galaxias olidus*		R	69	2729
Murray rainbowfish	*Melanotaenia fluviatilis*		R	1	8
Smallmouthed hardyhead	*Atherinosoma microstoma*			3	29
Murray hardyhead	*Craterocephalus fluviatilis*	VU	EN	0	0*
Unspecked hardyhead	*Craterocephalus stercusmuscarum fulvus*		R	3	16
Chanda perch	*Ambassis agassizii*		P,CREN	0	0*
River blackfish	*Gadopsis marmoratus*		P, EN	12	176
Murray cod	*Maccullochella peelii peelii*	VU	R	0	0*
Murray-Darling golden perch	*Macquaria ambigua ambigua*			0	0
Southern pygmy perch	*Nannoperca australis*		P, EN	20	1404
Yarra pygmy perch	*Nannoperca obscura*	VU	P, EN	2	14
Silver perch	*Bidyanus bidyanus*		P, VU	0	0*
Congolli	*Pseudaphritis urvillii*		R	7	19
Carp gudgeons (total)	*Hypseleotris* spp.			40	7340
Midgley's carp gudgeon	*Hypseleotris* sp. 1			✓	
Murray-Darling carp gudgeon	*Hypseleotris* sp. 3		R	✓	
Hybrid forms	*Hypseleotris* spp.			✓	
Purple-spotted gudgeon	*Mogurnda adspersa*		P,CREN	0	0*
Flathead gudgeon	*Philypnodon grandiceps*			36	1961
Dwarf flathead gudgeon	*Philypnodon* sp.		R	26	430
Western bluespot goby	*Pseudogobius olorum*			4	9
Introduced species					
Goldfish	*Carassius auratus*			8	83
Carp	*Cyprinus carpio*			23	78
Tench	*Tinca tinca*			3	11
Rainbow trout	*Oncorhynchus mykiss*			3	14
Brown trout	*Salmo trutta*			9	95
Gambusia	*Gambusia holbrooki*			61	16222
Redfin	*Perca fluviatilis*			24	144

Conservation status: **National:** VU – vulnerable under the *EPBC Act 1999*. **State:** P – protected under the *Fisheries Act 1982*, CREN – Critically endangered, EN –Endangered, VU – vulnerable, R – Rare under the *draft Threatened Species Schedule NPWSA*.

* possible local extinctions. ✓ species/hybrid forms confirmed with genetic research (see text)

3.2 Historic data

This section provides a general background to and summary of sources of historic information. More in-depth findings (e.g. reference to individual SAMA specimens) are incorporated into regional and species summaries as a comparison to current Inventory data.

Pre 1930's: the South Australian Aquarium Society had a keen interest in the natural history of South Australian aquatic environments, particularly small native fishes. Formed in 1918, the group held regular field excursion to locations around Adelaide and occasionally more distant trips to Murray Bridge, Mannum and of particular interest here, the lower Finniss River region (Rutherford 1991). Nettlebeck (1926) and Hale (1928) provide specific accounts of fishes collected from the lower Finniss River on such trips, accounts offering intriguing insights into former species composition and habitats. Brief accounts are provided of other catchments such as Tookayerta Creek (Black Swamp) and Currency Creek (Hale 1928; Rutherford 1991). Aquarium society members also reported observation on native fish behaviour and breeding (e.g. purple-spotted gudgeon: Blewett 1929).

Only a few collections of fish from pre-1930 are represented in the current SAMA fish collection (Table 3.2.1), however most are notable as they represent species that are today threatened and for locations where they no longer occur. A few oral history accounts provided information on early fish captures passed on through generations, such as the presence of Murray cod in pools on the Bremer River near Langhorne Creek in the 1880's (Appendix 3).

Morrissy (1967) summarises available records of trout stocking prior to 1960 (sourced from the then Fisheries and Game Department, Adelaide and records of the SA Fly Fishers Association), as well as a general background to the history of trout in the state. Information presented suggests that brown and rainbow trout were stocked into several EMLR steams well prior to 1930, particularly the Finniss River Catchment, Angas River and Marne River.

Table 3.2.1. Early fish specimens from the Eastern Mount Lofty Ranges housed at the South Australian Museum, Adelaide (NB Scotts Creek is today known as Dawesley Creek).

F #	Date	Species	Catchment	Location	Collector
153	4/12/1914	Climbing galaxias	Angas	River Angas, Strathalbyn	Stirling Eric
1110	3/1887	Mountain galaxias	Bremer	Scotts Creek, Dawesley	Tate Prof. R.
1369	pre 1929	River blackfish	Bremer	Scotts Creek, Dawesley	Tate Prof. R.
1374	pre 1929	River blackfish	Bremer	Mount Barker Creek	Zietz A.
1200	1928	Yarra pygmy perch	Currency	Currency Creek	Zietz A.
1382	1929	Congolli	Currency	Currency Creek	Waite E.R.
1104	22/3/1886	Common galaxias	Finniss	Finniss River	Zietz A.
917	12/12/1924	River blackfish	Finniss	Meadows Creek	Morgan Dr. AM
906	23/3//1924	Southern pygmy perch	Finniss	Meadows Creek	Morgan Dr. AM
984	1927	Murray rainbowfish	Finniss	Finniss River	Cole Clive
1120	1928	Smelt	Finniss	Finniss River	Zietz A.
1372	pre 1929	River blackfish	Finniss	Finniss Creek	Waite E.R.
1764	2/12/1932	Rainbow trout	Finniss	Finniss River, nr Ashbourne	Pitt C.J.
1707	15/3/1924	River blackfish	Finniss/Tookayerta	Bull Creek & Mt.Compass	Waite E.R.
1371	pre 1929	River blackfish	Tookayerta	Mount Compass	N/A

1930 – 1960: only a single SAMA specimen of rainbow trout in 1932 (Table 3.2.1). Oral history provides the only real information for this period, and naturally most of recollections relate to larger edible fish such as river blackfish and Murray cod (Appendix 3). Most accounts cover the late 1940's and 1950's following the war years (WWII: 1939-1945). Soon after, accounts indicate significant declines in fish captures and a corresponding drop in interest in streams. Large numbers of trout were stocked during this period, mainly in the Angas, Bremer, Currency Marne and Finniss catchments (Morrissy 1967).

1960's and 70's: very little information was located for this period, with the exception of data for the lower Finniss River. Mr Mal Hogarth continued on the SA Aquarium Society tradition, with some notable records included in a series of specimens lodged at the SAMA (Table 3.2.2). Oral history provided a direct link to the fish community and environments of the time via John Endersby who grew up at 'Reedlands' on the lower Finniss, spending considerable time netting for small fish, an art he was taught by Mr. Hogarth (Appendix 3).

There are a few SAMA records for the 1970's including a pouched lamprey from the Bremer River. Some stream sites were surveyed by a joint Fisheries and SAMA team (stream survey program) (L. Grey, pers. comm.) - unfortunately data from this sampling was not published and specimens do not appear to have been lodged as documentation. Carp appeared in the district in the mid 1970's (Appendix 3) and Fulton (2004) summarises documented data on legal trout releases that have occurred in the region from 1979 onwards.

Table 3.2.2. SA Museum records for the lower Finniss River region in the 1960's.

F #	Species	Collection date		Location	Collector
7531	Goldfish	1 March	1961	Finniss River	Hogarth Mal
9037&35	Murray hardyhead	1 March & May	1961	Finniss River	Hogarth Mal.
7750	Gambusia	1 March	1961	Finniss River	Hogarth Mal.
7727	Carp gudgeon	1 March	1961	Finniss River	Hogarth Mal.
7666	Yarra pygmy perch	1 March	1961	Finniss River	Hogarth Mal.
5065	Dwarf flathead gudgeon	1 March	1961	Finniss River	Hogarth Mal.
7626	Freshwater catfish	1 March	1961	Finniss River	Hogarth Mal.
3087	Yarra pygmy perch	May	1962	Finniss River	Hogarth Mal.
7667	Chanda perch	April	1963	Finniss River	Hogarth Mal.
9034	Murray hardyhead	April	1963	Finniss River	Hogarth Mal.
10048	Un-specked hardyhead	April	1963	Finniss River	Hogarth Mal.
7633	Carp gudgeon	April	1963	Finniss River	Hogarth Mal.
7623	Purple-spotted gudgeon	April	1963	Finniss River	Endersby John
7443	Yarra pygmy perch	April	1963	Finniss River	Hogarth Mal
5722	Flathead gudgeon	April	1963	Finniss River	Hogarth Mal.
5064	Dwarf flathead gudgeon	1 March	1964	Finniss River	Hogarth Mal.

1980's: a period of renewed interest in the region mainly led by the studies of Lance Lloyd (University of Adelaide). He sampled select sites in a few catchments (Marne, Angas, lower Finniss and Tookayerta) as part of a broader investigation of the autoecology and conservation status of small fishes of the South Australian section of the Murray-Darling Basin (EMLR sites were revisited as part of the current survey). The official reference for this work is the peer reviewed paper by Lloyd and Walker (1986), however significant citation is also made to the raw data and additional detail of his masters thesis (Lloyd 1987). A range of specimens were left with SAMA verifying the data collected.

1990 onwards: studies on the *Hypseleotris* species complex identified hybrid forms in Dawson Creek and also recorded a juvenile blackfish on Dawson Creek (Bertozzi 1990; Bertozzi *et al.* 2000). Hicks (1997) investigated the affect of acid mine drainage on fish in Dawesley Creek which included comparison with sites in a number of EMLR southern catchments. There was a reasonable representation of specimens lodged at the SAMA, many deposited by the then Collection Manager of Ichthyology, Terry Sim (summarised in Sim *et al.* 2000). Bryan Pierce (formerly SARDI) did conduct research in the area (see Pierce 1997), however the nature and extent of this remains unclear due to a lack of publications to this date.

Most work just before or after 2000 is superseded or incorporated into this Inventory (e.g. Hammer 1999, 2002a). Wedderburn (2000) revisited some of Lloyd's sites and Hammer (2001) undertook a specific investigation of the range, habitat and genetics of southern pygmy perch in the EMLR as a foundation to recovery efforts (Hammer 2002b, 2004; Conallin and Hammer 2003). Lower stream sites are supplemented by recent work on the Lower Lakes (Wedderburn and Hammer 2003).

4.0 Regional summary

This section provides a summary of the characteristics, habitat types and condition for various catchments. Species patterns are discussed in relation to current and historic records as well as requirements for future monitoring and investigation. General catchment descriptors for the region are presented below, and then specific information is provided for ten main catchments where permanent pools were located during autumn 2004. Each summary includes mention of specific features such as rainfall and topography (see also 2.2), water conductivity (summarised visually in Fig. 5), natural barriers (summary Table 4.0.1) and the availability of long-term refuges. Sampling locations for southern catchments (draining towards Lake Alexandrina) and northern catchments (draining towards the lower River Murray) are displayed in Figures 6 and 8 respectively.

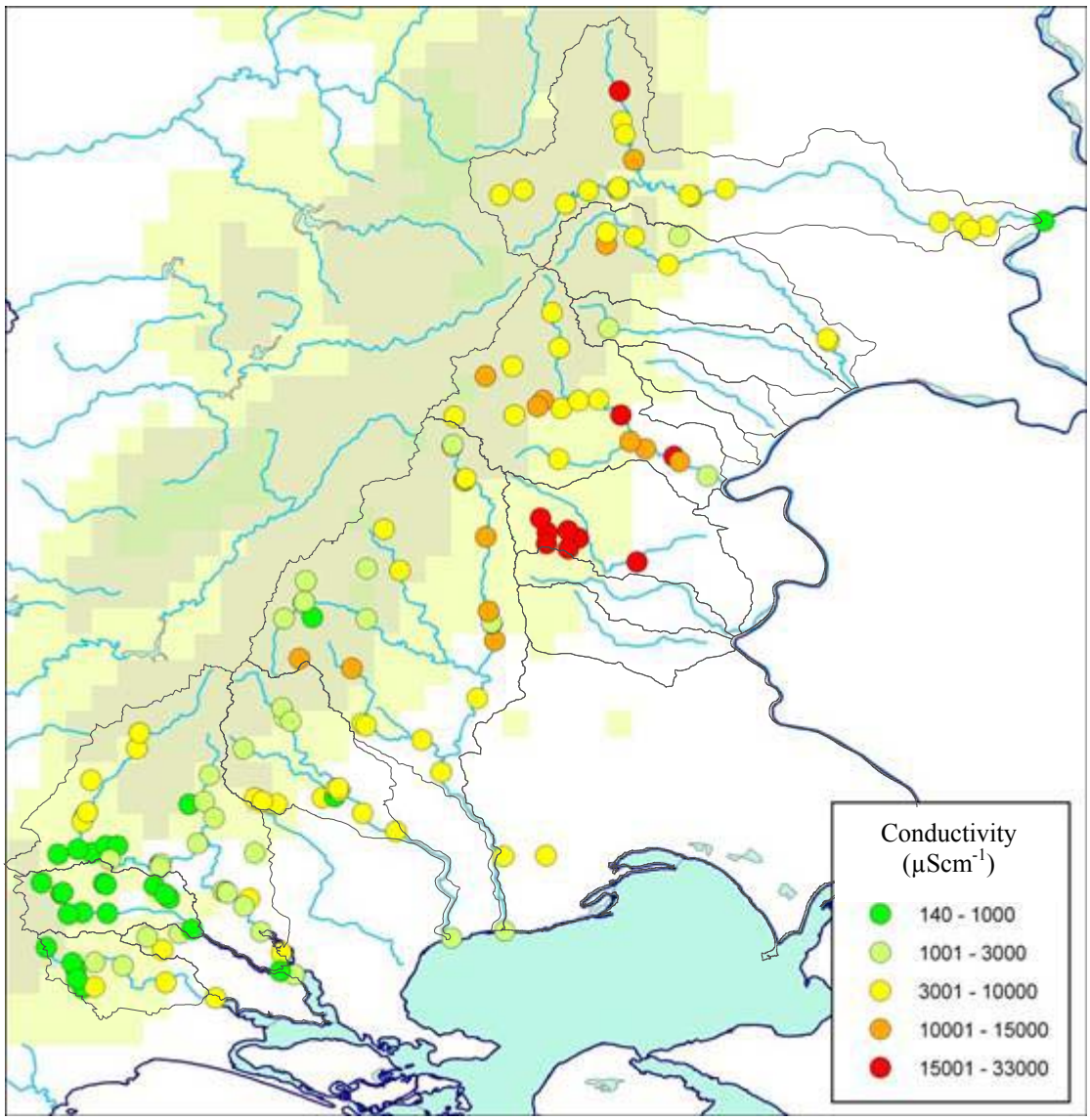


Figure 5. Visual representation of autumn water conductivity values at sampling sites (refer to Fig. 2 for catchment names).

Table 4.0.1. Examples of *natural barriers* on streams of the Eastern Mount Lofty Ranges. Such barriers might act as natural filters or barriers to species dispersal, potentially affecting short and long term processes (e.g. colonisation by diadromous species, genetic isolation).

Catchment	Barrier type	Description
Currency Creek	Waterfall	5m rock face, upstream of Lions Park
Deep Creek	Intermittent stream reach	>10km stretch of ephemeral channel (plus significant instream dam barriers).
Tookayerta Creek	Dense swamp	Stretching from Black Swamp upstream ~5km. Even more pronounced historically prior to swamp drainage/channel formation (**C**)
Finniss River	Waterfall	10m rock face upstream of Goolwa-Strathalbyn Road
Angas River	Intermittent stream reach	~11km stretch of naturally ephemeral channel, annual connectivity with Lake Alexandrina
Bremer River	Intermittent stream stretch	Small sections of intermittent channel in lowland reaches. Recently extended with loss of permanent pools near Langhorne Creek (**B**)
Salt Creek	Intermittent stream reach	>20km of poorly defined, intermittent channel (retains modern connection to Murray?)
Reedy Creek	Several waterfalls	Significant steep rocky reaches in lower section, plus other major features on tributaries (**A**)
Saunders Creek	Intermittent stream reach	~25km intermittent lowland channel, only occasional connectivity with Murray
Marne River	Intermittent stream stretch	~10km of channel from above Black Hill to below Gorge - decreasing frequency of connection

Examples of natural barriers in the Eastern Mount Lofty Ranges: waterfall (*left*), dry stream reach (*top right*) and dense swamp (see Table 4.0.1 for descriptions).

Table 4.0.2. Summary of species composition for the major catchments of the Eastern Mount Lofty Ranges (X – captured in Inventory sampling, P –reported as present/sampled recently, * recorded historically, ? – possibly occurred based on suitable current or historic habitat).

Common name	Currency Creek	Deep Creek	Tookayerta Creek	Finniss River`	Angas River	Bremer River	Salt Creek	Reedy Creek	Saunders Creek	Marne River
Pouched lamprey	?		?	P	*	*				?
Shortheaded lamprey	?		?	?	?	?				?
Shortfinned eel				?		*				
Freshwater catfish				*						
Bony herring	X			X	X	X				X
Australian smelt	X			X	X	X		X		X
Climbing galaxias	?			?	*					
Common galaxias	X		X	X	X	X		X		*
Mountain galaxias	X	?	X	X	X	X		?	?	X
Murray rainbowfish				*						X
Small-mouthed hardyhead	X			X	X	X				
Murray hardyhead	?			*	*			?		*
Unspecked hardyhead	X			X		P				X
Chanda perch				*						*
River blackfish	?		X	*	X	X				X
Murray cod				*		*				
Murray-Darling golden perch				P		P				*
Southern pygmy perch	?		X	X	X	?				?
Yarra pygmy perch	*		X	X						
Silver perch				*		*				*
Congolli	X		P	X	X	X		?		*
Carp gudgeons	?		X	X	X	X		X	X	X
Purple-spotted gudgeon				*		?		?		?
Flathead gudgeon	X		X	X	X	X		X		X
Dwarf flathead gudgeon	X		X	X	X	X		X		X
Western bluespot goby	P		X	X	X	X				
Introduced species										
Goldfish				X	X	X		X		X
Carp	X			X	X	X		X		X
Tench				*	X	*				*
Rainbow trout	P		X	X	X	X				*
Brown trout	P		X	X		*		*		*
Gambusia	X	X	X	X	X	X	X	X	X	X
Redfin	X		X	X	X	X		X		P
Total species known per catchment	15	1	14	30	21	24	1	10	2	22
Number native	11	0	10	23	15	17	0	5	1	15

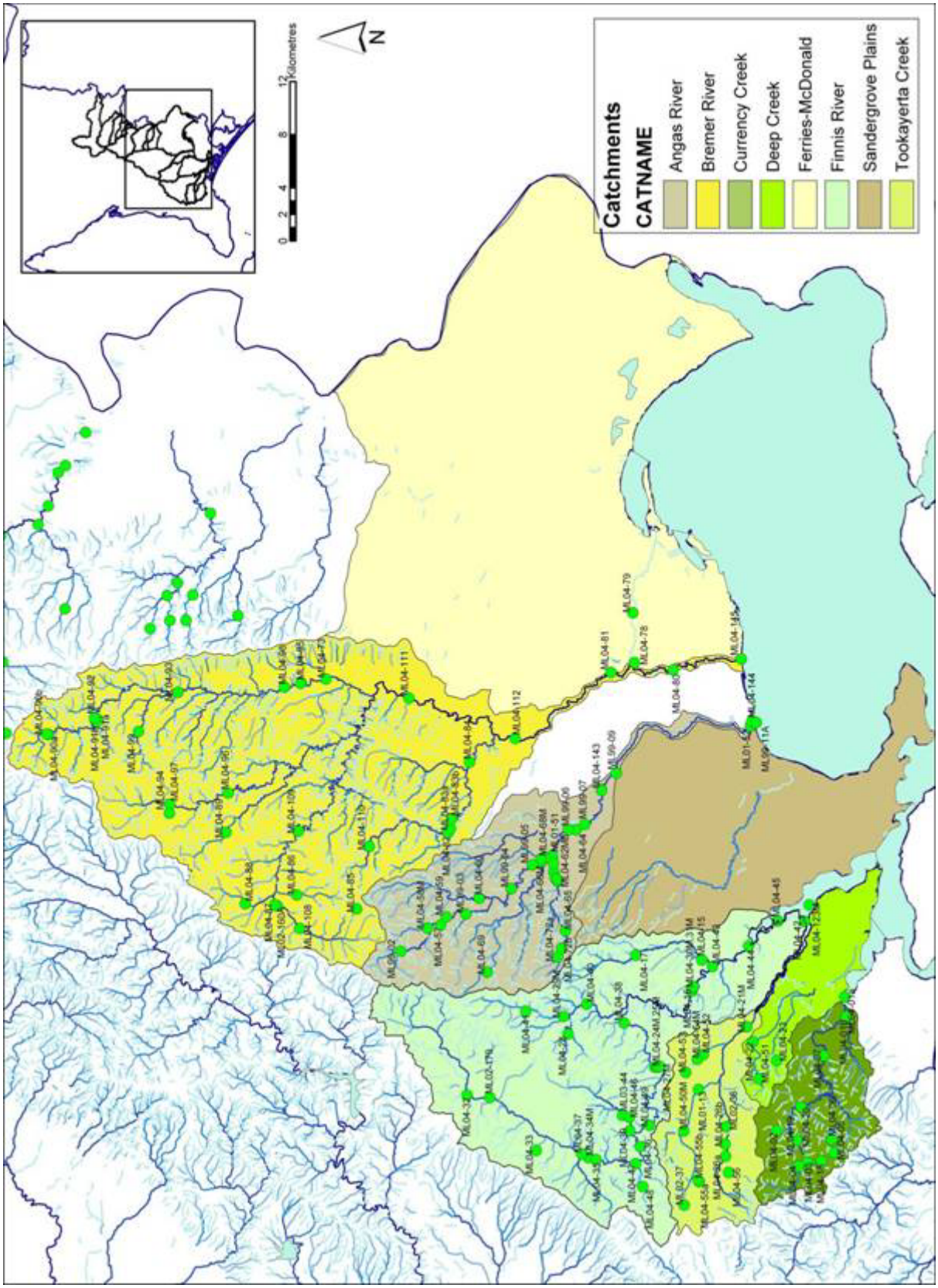


Figure 6. Location of sampling sites in the Eastern Mount Lofty Ranges for southern catchments that drain toward Lake Alexandrina.

4.1 Currency Creek

The most southerly of the EMLR catchments, Currency Creek is a small (88km^2) and heavily branched system, experiencing moderate rainfall. It drains swampy upland areas through relatively steep alluvial and rocky creeks in an easterly direction. The main stream network comprises a north and south branch that join just before a steep gorge and then flows on a gradual slope past Stuart's Bridge (Mt Compass to Goolwa Road). There is a small waterfall just above the railway bridge near the Currency Creek Township and from here Currency Creek meanders toward an extend arm of Lake Alexandrina via a river channel. Remnant vegetation in the catchment is sparse, with often only a thin riparian strip of gums was present.

Flow is largely intermittent in most of the catchment (today) but localised springs were detected at several sites. Pools are generally small and shallow, with heavy erosion and siltation obvious in the mid catchment. Larger and deeper pools do occur in the lower section of the catchment above and below the waterfall. Cover values were generally low comprising snags and some emergent vegetation (submerged aquatic plants were rare). Some sampling sites were in fenced sections, however much of the catchment has unrestricted stock access. Water quality was reasonable at sampling sites, with generally low autumn conductivity values, increasing to greater than 5000µS at Stuart's Bridge and at Goolwa Road.

Nine native and three exotic species were captured, most of these in the section below the waterfall (Table 4.1.2). Schools of common galaxiids were observed below the waterfall (upstream of site ML04-01a), however they appeared unable to negotiate this barrier. Above the waterfall, mountain galaxias were wide spread (six out of nine sites) and locally abundant at site ML04-07 including many large adults (up to 125mm TL). They were absent from suitable habitat at ML04-20. Flathead gudgeon were restricted to lowland pools below the gorge and were also abundant at site ML04-07. Populations in the upper catchment were restricted to strings of isolated pools, while lower down, habitats were more continuous.

Introduced fish were not widely recorded, and were generally in low numbers with the exception of Gambusia in shallow pools at site ML04-19 and instream dams at ML04-18 (Table 4.1.2). Brown and rainbow trout are reported to be stocked in the gorge stream section between sites ML04-20 and ML04-07, with 4000-12,000 fingerlings released per year in the years 1979-2002 (Fulton 2004). An early record of trout release in the catchment is also noted by Morrissy (1967) - 200 brown trout in 1938. Large rainbow trout have been previously observed by landholders at site ML04-20.

There is an historic record of Yarra pygmy perch from the lower section of the catchment (Table 3.2.1) and common galaxias, congolli and yellow eye mullet (estuarine species) downstream from near the Goolwa Road Bridge in 1929 (Hale 1929, cited in Rutherford 1991). Virtually no historic data exists on native fish upstream of the waterfall. An additional section of the catchment, Crayfish Creek (southern branch) was inspected in 2001 (Hammer 2001). No fish were detected, however, restoration works were improving the condition of the stream. The section of deeper, red gum lined pools below Stuart's Bridge appeared suitable river blackfish habitat, while swampy sections in the upper catchment are similar to southern pygmy perch habitat in Tookayerta Creek that prior to extensive dam construction and swamp clearance might have supported a pocket of the species. Similarly, an extensive flat in the mid-section of the catchment at site ML04-20 was historically thought to be a large swampy area (Appendix 3) and may have supported southern pygmy perch, prior to drainage and incision of a stream channel leading to the loss of swamp habitat.

Future sampling could target the potential river blackfish habitat in the lower catchment and involve more intensive range mapping to determine the security of mountain galaxias populations (potentially genetically distinct), especially with respect to the potential impact of decreasing flows and trout.

Table 4.1.1. Sampling locations in the Currency Creek Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-01a	24/02/2004	Currency Creek	Lions Park, Goolwa Road	Stream
ML04-01b*	01/03/2004	Currency Creek Trib.	Peel Road	Stream
ML04-07	01/03/2004	Currency Creek	Stuart's Bridge	Stream
ML04-20	11/03/2004	Currency Creek	'Arundell'	Stream
ML04-03	24/02/2004	Currency Creek (Nth branch)	Mt Compass to Victor Road	Stream
ML04-19	11/03/2004	Currency Creek (Sth branch)	'Kilchoan'	Stream
ML04-06	01/03/2004	Currency Creek (Sth branch)	Off Mosquito Hill Road	Stream
ML04-02	24/02/2004	Currency Creek Trib.	Below Kidman Road	Stream
ML04-04	01/03/2004	Currency Creek Trib.	Leane Road	Stream
ML04-05	01/03/2004	Currency Creek Trib.	Mt Compass to Victor Road	Stream
ML04-18	01/03/2004	Currency Creek Trib.	'Berrima' -series of dams	Instream

* Dry upon inspection in autumn 2004

a and **b** (small caps) – paired sites located in close proximity.

Table 4.1.2. Fish species and relative abundance recoded for the Currency Creek Catchment.

Site Code	Bony herring	Australian smelt	Common galaxias	Mountain galaxias	Smallmouthed hardyhead	Unspecked hardyhead	Southern pygmy perch	Yarra pygmy perch	River blackfish	Congolli	Western bluespot goby	Carp gudgeon spp.	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-01a	30	5	65		25	4		X[F]		1			150	6				1		25	6	11	3
ML04-01b																						0	0
ML04-07				75									216									2	0
ML04-20													3		X[B]					50		2	1
ML04-03				37																		1	0
ML04-19				25																200		2	1
ML04-06				6																		1	0
ML04-02				6																		1	0
ML04-04				12																		1	0
ML04-05																						0	0
ML04-18																				500		1	1

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).

Upland and lowland habitat in the Currency Creek Catchment: (*above*) a large pool below the old Goolwa Road bridge (ML04-01a) and (*right*) a stream pool (ML04-02)

4.2 Deep Creek

A small catchment (68km^2) nested between the Currency Creek and Tookayerta Creek catchments. Two small tributaries extend from a steep hillside (small elevated section of the catchment with medium rainfall) and transcend into a highly incised lowland channel. Aquatic habitat consisted mainly of instream dams, and water was relatively fresh where present with spring fed sections in the upper reaches. A long dry stretch across the plain forms a considerable natural barrier.

Only the introduced Gambusia was located (Table 4.2.2) and it appears to be widespread in relation to limited surface waters (e.g. the species was observed during casual inspection of several other instream dams). There were reports of rainbow trout being stocked into an instream dam at ML04-51, and no other fish were recalled by locals interviewed. Numerous small emergent plants and tea tree were located near some springs. No shrimp were recorded.

Future sampling could target the spring fed sections in remnant vegetation at the top of the main two tributaries (e.g. potential mountain galaxias habitat) as these could not be accessed during the survey.

Spring fed habitat on a small tributary of the Deep Creek Catchment (ML04-51) (*left*) and heavily eroded ephemeral channel lower in the catchment.

Table 4.2.1. Sampling locations in the Deep Creek Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-22	11/03/2004	Deep Creek (North branch)	Deep Creek Road	Instream dam
ML04-51	27/03/2004	Deep Creek (North branch)	'Kunmunya' -above and below dam	Stream
ML04-23	11/03/2004	Deep Creek (South branch)	Kokoda Rd	Stream

Table 4.2.2. Fish species and relative abundance recorded for the Deep Creek Catchment.

Site Code	Climbing galaxias	Common galaxias	Mountain galaxias	Smallmouthed hardyhead	Southern pygmy perch	Yarra pygmy perch	River blackfish	Carp gudgeon spp.	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-22																1000		1	1
ML04-51											X^{B}					300		1	1
ML04-23																		0	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence. Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).

4.3 Tookayerta Creek

Characterised by glacial sands, peat, swamp heath vegetation and high rainfall, the Tookayerta Creek Catchment is highly contrasting to other catchments in the region and indeed elsewhere in the state and Murray-Darling Basin. It is a small catchment (100km^2) perched in a low gradient basin with headwaters originating on either side of the Mount Compass Township. However, these are not headwaters in the traditional sense, rather a series of interconnected swamps (under natural conditions) along shallow depressions. The catchment is Y shaped and basically has three main arms: the Nangkita Creek and upper Tookayerta Creek (forming the branches of the Y) and a smaller tributary, Swampy Creek. These unite to form a continuous lower Tookayerta Creek section eventually connecting with the Finniss River arm of Lake Alexandrina.

Stream habitats are generally heavily associated with swampy littoral areas or disappear into swamp vegetation (e.g. tea tree) or large beds of *Phragmites* along stream sections. The Swampy Creek area (and indeed much of the catchment) would have once been a continuous swamp, however, clearance (physical and by stock), excavation and drainage now means that fragments of swamps are interconnected by channels or dams. Creek lines are modified or artificial in many areas but there are still true lotic habitats, particularly in upper Tookayerta Creek. There is stock access in places of the catchment, but considerable areas, including most sites sampled, are fenced or have alternate land use.

Habitat values recorded were generally high. Instream cover values were generally low (e.g. few snags or rocks, occasional site with beds of *Potamogeton ochreatus*) but most sites had a very high percentage cover of emergent vegetation. This likely reflects the strong lateral connectivity of permanent flow or spring feeding detected at the majority of sites, and the swampy nature of the catchment (substrate was generally silt or peat, with occasional sections of sand). The catchment is renowned for outstanding water quality (e.g. low autumn water conductivity values recorded: <500µS for most of the catchment) and is one of very few catchments in the state with year round stream flow (although a small section of Nangkita Creek at site ML01-13 stopped flowing in summer 2003; suspected to be due to pumping upstream).

A total of ten native and four introduced species were recorded in the catchment including southern and Yarra pygmy perch and river blackfish (Table 4.3.2). These included three species sampled recently (i.e. marked as present) at the mouth of Tookayerta Creek (Wedderburn and Hammer 2003) and redfin at ML04-26ba (local report). Hybrid carp gudgeon (MD x Sp. X) were recorded at site ML04-42M. Species richness was highest at the terminus of the catchment with most exposure to Lake Alexandrina, and ranged between one and three native species for upstream sites. Mountain galaxias and southern pygmy perch were well spread in the catchment (ten and seven sites respectively). There is a clear separation in the native fish fauna from the lowest sites (ML04-42M, 123M) and elsewhere in the catchment, and for the only species overlapping these zones, the southern pygmy perch, there are two genetically distinct populations represented (lower catchment fish are part of a Lake Alex sub-population; Hammer 2001). Native fish abundance was reasonable, with southern pygmy perch and mountain galaxias locally common but patchily distributed. River blackfish numbers were low probably owing to the generally small size of available habitat. Sampling sites were located in contiguous sections or large areas (e.g. swamps) as opposed to highly restricted and fragmented pools observed in other catchments.

Exotic species seem well established in the Tookayerta Catchment (recorded at seven sites: Table 4.3.2), particularly Gambusia which occupied sites that had low flow during autumn. Gambusia have additionally been recorded at site ML02-172 (a monitoring site) in the past when the area experienced low summer flows and pool contraction in summer 2000/01 (Hammer unpublished data). Brown trout were common in flowing sections of upper Tookatyerta Creek and the general presence and distribution of large predatory species (redfin and trout spp.) is probably higher as indicated by previous sampling which targeted these species.

Redfin have been captured at ML04-21M and just below this site at Goolwa Road, an instream dam at Winery Road (above site ML04-24M), and are also present in the upper Tookayerta Creek (Hammer pers. obs; Hicks unpublished data; landholder reports). Rainbow trout have been recorded at Goolwa Road in 1998 (Hicks unpublished data).

The Tookayerta Creek Catchment does not appear to have been stocked as heavily with trout as surrounding EMLR catchments, with documented stockings under permit limited to an introduction of 500 brown trout into Nangkita Creek in 1986 (Fulton 2004). Current distribution suggests there have been other illegal releases or trout farm escapees.

There are few historic fish records for the catchment, not surprising given the inaccessible nature of swamps (the dominant historic habitat). River blackfish were recorded from the vicinity of Mt Compass before the 1930's (Table 3.2.1). Four additional species, single specimens of Murray rainbowfish and Murray hardyhead as well as flyspecked hardyhead and carp gudgeon, were previously recorded in the general vicinity of site ML04-123M at the mouth of the Tookayerta Creek/Lake Alexandrina (Lloyd 1987). Lloyd held warranted fears for the future of southern pygmy perch in the upstream catchment as he witnessed the invasion of Gambusia to the system after 1984 (Lloyd 1991). Sampling of southern pygmy perch numbers before and after Gambusia invasion (1982-84 vs 1987-88) revealed alarming decreases in pygmy perch abundance and possible declines in recruitment (Lloyd 1991). Fortunately, southern pygmy perch appears to have remained stable in this catchment, although it has apparently disappeared from the Mt Compass Boardwalk Swamp (ML04-55a) where it was recorded in 1996 (SAMA F8076).

Future research should continue to map the range of threatened species and monitor the population dynamics of known populations with respect to variation in environmental conditions. Such work could link with considerable restoration efforts underway in the catchment.

Unique spring fed swamp habitats in the Tookayerta Creek Catchment: Swamp Creek (*top left*), a larger pool on Tookayerta Creek (ML04-21M) (*bottom left*) and a close up of peat swamp, habitat of southern pygmy perch and mountain galaxias (*right*)

Table 4.3.1. Sampling locations in the Tookayerta Creek Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-123M	30/04/2004	Tookayerta Creek	Mouth Tookayerta Creek/Lake Alexandrina	Wetland
ML04-42M	24/03/2004	Tookayerta Creek	Protea farm, Black Swamp	Instream dam
ML04-21M	11/03/2004	Tookayerta Creek	'Sleepy Hollow,' Deep Creek Road	Stream
ML02-36	30/05/2002	Tookayerta Creek	ds Ice Factory	Stream
ML04-26b	17/03/2004	Tookayerta Creek	Cleland Gully Road	Stream
ML04-26a	17/03/2004	Tookayerta Creek	Country Cabins	Stream
ML04-56	30/03/2004	Tookayerta Creek Trib.	'Square Waterhole'	Swamp
ML04-52	30/03/2004	Swampy Creek	Scott property @ causway	Drain
ML04-54M	30/03/2004	Swampy Creek	Brawleys Swamp	Swamp
ML04-53	30/03/2004	Swampy Creek	SA Forest dam	Instream dam
ML01-13	26/10/2001	Nangkita Creek	off Waterfall Drive	Stream
ML02-172A	17/05/2002	Nangkita Creek	us Willowburn Road	Stream
ML04-50M	27/03/2004	Nangkita Creek	us Willowburn Road	Stream
ML02-37	30/05/2002	Nangkita Creek	Gauging station us Adelaide-Victor Road	Stream
ML04-55b	30/03/2004	Nangkita Creek Trib.	Mt Compass-Victor Road	Stream
ML04-55a	30/03/2004	Nangkita Creek Trib.	Mt Compass Boardwalk Swamp	Swamp

A – represents the same site sampled on a preceding occasion (temporal comparison),
M – ongoing monitoring sites for threatened fish species.
a and **b** (small caps) – paired sites located in close proximity.

Table 4.3.2. Fish species and relative abundance for the Tookayerta Creek Catchment.

Site Code	Common galaxias	Mountain galaxias	Smallmouthed hardyhead	Murray hardyhead	Unspecked hardyhead	Murray rainbowfish	Southern pygmy perch	Yarra pygmy perch	River blackfish	Congolli	Western bluespot goby	Carp gudgeon spp.*	Purple-spotted-gudgeon	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-123M	P			X^C	X^C	X^C	P	12		P	1	X^C		14	1			P			6		9	2
ML04-42M	4						37			P		$300^{1,4}$		2	4						50		7	1
ML04-21M							80		1							X^B					30	X^B	3	1
ML02-36		1															5						2	1
ML04-26b																	4						1	1
ML04-26a		P							5								P					P	2	2
ML04-56		20					40																2	0
ML04-52		12					94		1														3	0
ML04-54M		P					4		P														3	0
ML04-53																							0	0
ML01-13		10																			20		2	1
ML02-172A		30					35		20								X^B				X^A		3	0
ML04-50M		17					16		P								X^B				X^A		3	0
ML02-37		1																					1	0
ML04-55b		50																					1	0
ML04-55a		10					X^B																1	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).
*Carp gudgeon species and hybrid forms detected:
[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X

4.4 Finniss River

In contrast to other EMLR catchments the Finniss is relatively well vegetated, with significant patches of remnant vegetation in the mid section of the catchment. Nevertheless, agricultural pursuits are a common land use, with ever-increasing horticulture in lower sections. Much of this large catchment (372km^2) experiences medium to high rainfall and has steep topography through its middle section. The upper Finniss Catchment is a complex blend of tributaries, with the main arm an extension of the alluvial Meadows Creek originating near Meadows and then flowing in a south westerly direction through Kuitpo to Yundi. Near Yundi, Meadows Creek is subsumed by the Finniss River and takes a sharp turn to the east through a constrained bedrock defined or loose rock dominated watercourse. A small swamp section originating from near Mt Compass (know today as Finniss Creek) also joins near Yundi. Major tributaries Bull Creek and Blackfellows Creek all join the main stem before Ashbourne. Downstream of Ashbourne is generally an intermittent reach through summer, except where a small region of base flow occurs just before a substantial waterfall. Below the waterfall, the stream is a lowland meander through to braided channel and into an extensive area of wetland that forms the upper section of an extended arm of Lake Alexandrina.

Rock barrier (waterfall) on the Finniss River

Stream habitat in the Finniss Catchment is highly variable, with considerable heterogeneity at broad (i.e. geomorphic zones) and local scales with sites in close proximity often having contrasting habitat and hydrology and corresponding fish captures. Small to medium intermittent stream pools were the predominant habitat, with areas of peat swamp (e.g. Finniss Creek), rocky riffles (e.g. Finniss River above the waterfall) and long lowland pools and river channel (below the waterfall) also occurring. Occasional large and deep pools were located on the main stem of the Finniss River (e.g. ML04-27M, ML04-36). A significant instream dam was observed in the mid Finniss (newly constructed) which altered local habitat significantly (see Conallin and Hammer 2003; Hammer 2004).

Habitat values recorded were reasonable. Rock, snags and leaf litter were the dominant cover type with patchy sections of submerged aquatic plants or filamentous algae in stream sections (the lowest two sites in the catchment, ML04-44 & 45, had sections of *Vallisneria* and *Ceratophyllum* respectively). Cover provided by emergent vegetation was generally low (<20%), a reflection of the rocky nature of stream banks or stock grazing in more alluvial sections (e.g. Bull Creek, unfenced sections of Meadows Creek). As with physical habitat, hydrology at sites was variable and unpredictable, with areas of localised spring feeding and base flow distributed throughout the catchment and in close proximity to intermittent areas experience large fluctuations in water levels over summer (e.g. sites ML04-35 & 37 on Meadows Creek, ML04-30M & ML04-16 on Finniss River). Water quality data collected was again variable, with low autumn conductivity readings (<1000µS) recorded in the Yundi area (Finniss River and Finniss Creek) and also Blackfellows Creek. Other readings ranged from 1000-5000µS with an outlier of 9020µS at lower Giles Creek (ML04-15). Transparency values were generally low (<0.6m due to tannin or turbidity), expect for exceptionally clear waters at two sites on upper Bull Creek.

A total of 15 native and six introduced fish species were recorded in the catchment including southern and Yarra pygmy perch (Table 4.4.2). Hybrid carp gudgeon (MD x Midg) were also recorded in Bull Creek (ML04-40).

Recorded presence for some species (i.e. marked as present) included recent captures of a pouched lamprey and a rainbow trout from below the waterfall (just upstream from site ML04-43: Hammer 2001), three smaller native species (smallmouthed hardyhead, western bluespot goby and bony herring) from the vicinity of ML04-45 at 'Reedlands' (Hammer 2001) and Murray-Darling golden perch in the vicinity of ML04-44 & 45 (recent angler reports and a SAMA specimen).

Species richness was highest below the waterfall (11-17 species), with six native species recorded above the waterfall. Mountain galaxias was wide-spread in the catchment and represented at a large number of sites (21 of 29). Flathead gudgeon and southern pygmy perch were wide spread along the main stem of the catchment from Meadows Creek through to 'Reedlands', however the latter only occurred in isolated sites or groups of sites. There is some overlap in the fish fauna above and below the waterfall, including low numbers of common galaxias that must negotiate this barrier (recorded at site ML03-53A) and mountain galaxias recorded in riffle sections between larger pools at sites ML04-43 & 44 in the lowland section. Southern pygmy perch above the waterfall are a distinct genetic sub-population of the species (Hammer 2001). Native fish abundance was variable with some species locally common (e.g. mountain galaxias in tributaries, southern pygmy perch in select pools). Sampling locations were generally located in patchy strings of waterholes or continuous stream sections.

Exotic species are well represented in the catchment (Table 4.4.2). Gambusia (14 sites) were common in Meadows Creek, mid Finniss River and at 'Reedlands', redfin (9 sites) were found along the main stem of the catchment and brown trout (9 sites) in the mid section of the catchment (lower Meadows Creek, mid Finniss River, Bull Creek, Blackfellows Creek). The occasional rainbow trout is recorded near Yundi (Appendix 3) while brown trout were reported as present at several additional sites by anglers (e.g. ML04-27M & 49). Large numbers of brown trout (in excess of 20,000) have been stocked into the catchment in recent years (mid Finniss, Meadows Creek and Bull Creek); a process which has occurred for some time (Fulton 2004). Trout (assumedly brown trout as these were stocked in the catchment at the time: Morrissy 1967) were known in the vicinity of ML04-45 (lowland channel) in the 1920's (Hale 1928) as were tench in the 1960's (near site ML04-45: Appendix 3).

Several larger native species have been known to occur in the region below the waterfall through to Lake Alexandrina historically: a large Murray cod was caught slightly upstream from site ML04-44 in about 1940 (Appendix 3) and there are rumours of more recent captures downstream below the Winery Road ford culvert; silver perch (known locally as bream) were angled from near the Strathalbyn to Goolwa Road Bridge (between sites ML04-43 & 44) in the 1950's (Appendix 3); freshwater catfish were recorded in the 1920's (e.g. Nettlebeck 1928), with a more recent capture of a juvenile near site ML04-45 in 1984 by Lance Lloyd (SAMA F10098); and river blackfish from near ML04-44 (Hale 1928). A range of small native species have also previously been recorded including Murray rainbowfish in the 1920's (Nettlebeck 1926), southern purple-spotted gudgeon (records for near site ML04-44 in the 1920's and at site ML04-45 in the early 1960's: Nettlebeck 1926, Hale 1928; Table 3.2.2), chanda perch in the 1960's (vicinity of ML04-45: SAMA F7667) and Murray hardyhead near site ML04-45 in the 1980's (common at the time: Lloyd 1987).

Upstream from the waterfall, river blackfish appear to have been wide spread before the 1950's with records from the mid catchment (near Coles Crossing and Yundi) through to Meadows Creek and also Bull Creek (Table 3.2.1; Appendix 3). Southern pygmy perch were dip netted from Brayside Ford (ML04-16) in winter 2003 but were not located in subsequent autumn 2004 sampling (perhaps a temporary record washed downstream from a nearby population).

Ideally the spatial resolution of sampling in this catchment needs to be increased for a more detailed understanding of species distributions in relation to habitat and the threat posed by specific processes such as water abstraction and trout stocking. The amount of habitat offered and the recorded historic presence of river blackfish suggests this species may still remain in isolated pockets, and dedicated field work to locate the species may be worthwhile.

Table 4.4.1. Finniss River Catchment sampling locations.

Site Code	Date	Waterway	Location	Habitat type
ML04-45	25/03/2004	Finniss River	'Reedlands'	River Channel
ML04-44	24/03/2004	Finniss River	Railway Bridge	Stream
ML04-43	24/03/2004	Finniss River	'Wirra Wirra' (Junction Giles Ck)	Stream
ML04-31M	19/03/2004	Finniss River	us waterfall in flowing section	Stream
ML03-53A	07/04/2003	Finniss River	Top of springs above waterfall	Stream
ML04-30M	19/03/2004	Finniss River	Top of springs above waterfall	Stream
ML02-11A	02/03/2002	Finniss River	Brayside Road Ford	Stream
ML04-16	09/03/2004	Finniss River	Brayside Road Ford	Stream
ML04-38	22/03/2004	Finniss River	Finniss Bridge	Stream
ML04-25M	17/03/2004	Finniss River	ds Coles Crossing (us causeway)	Swamp/instream dam
ML03-51A	07/04/2003	Finniss River	ds Cole's Crossing (clay cliff pool)	Stream
ML04-24M	17/05/2004	Finniss River	ds Cole's Crossing (clay cliff pool)	Stream
ML04-27M	17/03/2004	Finniss River	ds Coles Crossing (large pools)	Stream
ML04-49	27/03/2004	Finniss River	Enterprise Road	Stream
ML04-36	21/03/2004	Finniss River	East of Yundi (Chaplin prop.)	Stream
ML04-15	09/03/2004	Giles Creek	Below Signal Flat Road	Stream
ML04-17	10/03/2004	Giles Creek	Haines Road	Stream
ML04-29M	18/03/2004	Bull Creek	Mcharg Creek Road Bridge	Stream
ML04-40	22/03/2004	Bull Creek	North of Ashbourne @ creek junction	Stream
ML04-41	22/03/2004	Bull Creek	us Bald Hills Road	Stream
ML04-28	18/03/2004	Mcharg Creek	Opposite Ti Tree Road	Stream
ML04-39	30/03/2004	Blackfekllows Creek	'Riverside'	Stream
ML03-44	19/01/2003	Blackfellows Creek	Heritage Scrub	Stream
ML04-46	25/03/2004	Blackfellows Creek	Heritage Scrub, opp. Mt Magnificent CP	Stream
ML04-47	27/03/2004	Finniss Creek	Burma Road	Stream
ML04-48	27/03/2004	Finniss Creek	'Shoshanna'	Instream dam
ML04-34M	21/03/2004	Meadows Creek	Thorn Dairy (1st Causway)	Stream
ML04-35	21/03/2004	Meadows Creek	Thorn Dairy (2nd Causway)	Stream
ML04-37	21/03/2004	Meadows Creek	Water Reserve	Stream
ML02-170	17/05/2002	Meadows Creek	Wickhams Hill Road	Stream
ML04-32	21/03/2004	Meadows Creek	Heyson Trail Crossing	Stream
ML04-33	21/03/2004	Meadows Creek Trib.	Badgers Road	Stream

A – represents the same site sampled on a preceding occasion (temporal comparison),
M –monitoring sites for threatened fish,
a and **b** (small caps) – paired sites located in close proximity.

Habitat at sites in the Finniss Catchment was highly variable: a lowland *Vallisneria* filled pool (ML04-44) (*above*); rocky pool mid-Finniss River (ML04-24M) (*top right*) and an alluvial pools on Meadows Creek (*top right*). See also bedrock based, spring fed pool in Section 7.3

Table 4.4.2. Fish species and relative abundance recoded for the Finniss River Catchment.

Site Code	Pouched lamprey	Freshwater catfish	Australian smelt	Common galaxias	Mountain galaxias	Murray hardyhead	Unspecked hardyhead	Murray rainbowfish	Chanda perch	Murray cod	Murray-Darling golden perch	Southern pygmy perch	Yarra pygmy perch	River blackfish	Silver perch	Congolli	Carp gudgeon spp.*	Purple-spotted-gudgeon	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-45		X[C]	P	P		X[C]	10	X[F]	X[D]		P	3	2			P	40[1]	X[D]	100	50			30	2	X[D]	200	P	17	4
ML04-44			20	40	5					X[E]	P			X[F]		2		X[F]	10	70		X[B]	5	4		20	1	11	4
ML04-43	P			25	5										X[E]	8				10	P			4			3	8	3
ML04-31M					5							150																2	0
ML03-53A				4	26							101							5									4	0
ML04-30M				P	10							94							P									4	0
ML02-11A					40												1[1]		40	5								4	0
ML04-16												P							3	1						10	13	5	2
ML04-38																	1[1]		38								27	3	1
ML04-25M					X[A]							X[A]							13							50		2	1
ML03-51A					20							117							15			1						4	1
ML04-24M					3							113							P									3	0
ML04-27M					1							3		X[E]					22			P					2	5	2
ML04-49																			3			P				100	2	4	3
ML04-36					6									X[E]					7		P	2				50	7	6	4
ML04-15				4	2																					80		3	1
ML04-17																												0	0
ML04-29M					216																							1	0
ML04-40					244												116[1,3]					2						3	1
ML04-41					300									X[F]								15						2	1
ML04-28					150																							1	0
ML04-39					15																							1	0
ML03-44					4																	60						2	1
ML04-46																												0	0
ML04-47					13														2			3				60		4	2
ML04-48					410							380														1000		3	1
ML04-34M					10							111							5							40		4	1
ML04-35												4							5			3				100	6	5	3
ML04-37					1									X[F]					2							10		3	1
ML02-170					60														60							15		3	1
ML04-32					150														40							500		3	1
ML04-33																												0	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).
*Carp gudgeon species and hybrid forms detected:
[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X

Note: the following species were also recorded as present (P) at site ML04-45: bony herring, smallmouthed hardyhead and western bluespot goby

4.5 Angas River

The Angas River Catchment is moderate in size (199km^2) and has reasonable rainfall for most of its area. Much of the land has been cleared and dedicated to stock grazing, dairy or viticulture. It has a semi-circular arc of elevated land draining toward a main drainage channel, the Angas River, which extends from headwaters near Flaxley, through Strathalbyn, and to its confluence with Lake Alexandrina near Milang. A fan of tributaries including Middle/Paris, Dawson, Doctors and Burnside creeks join in or near Strathalbyn. Under current conditions, the later two creeks are ephemeral (no permanent pools located), and the upper Angas River and Dawson and Middle creeks are episodic stream systems.

There is a large degree of geomorphic variation within the catchment and considerable hydrological variability between stream sections. Much of the catchment consists of alluvial red gum (*Eucalytus camaldulenis*) lined tributaries, with spring fed upper reaches near Macclesfield. Below Strathalbyn, the character of the Angas differs considerably consisting of bedrock based, larger pools fringed with *Phragmites* and *Typha*. The stream gains permanent flow through much of this approximately 5km section via groundwater base flows. Further downstream, the stream becomes an ephemeral channel (significant natural barrier), meandering 13km across a lowland flat before reaching its terminus with Lake Alexandrina via a small section of river channel. Pools are generally smaller in upland areas, with a long series of deeper pools in the mid section of the catchment

Large pool in the section of the Angas below Strathalbyn (ML04–64)

Habitat values recorded were generally low to moderate, with contributions to instream cover mostly from physical components such as snags and rock (generally <30%) and emergent vegetation such as *Typha* and *Phragmites* (generally 10-30%). Few sites had significant amounts of submerged aquatic vegetation, with the exception of Angas River-Middle Creek junction (ML04-68M: thick bed of *Potamogeton tricarinatus*) and Bagley Bridge (ML04-144: river channel thick with *Ceratophyllum*). Some sections of the catchment have been fenced or do not have stock access, with a visible demonstration of the benefits of fencing toward the density of riparian vegetation and general stream condition observable at a pair of fenced and unfenced sites on upper Dawson Creek (ML04-72a,b). Autumn salinities were generally high, increasing along a stream gradient from the upper Angas at 1800µS to between 6000-7000µS for most sites in the mid catchment, and approaching 10,000µS in lower Dawson Creek (with an outlier ML04 at 430µS probably recently filled from road runoff).

A total of 12 native and six introduced species were recorded including southern pygmy perch and river blackfish (Table 4.5.2). Hybrid carp gudgeon (MD x Midg) were also recorded at numerous sites. A single southern pygmy perch was recorded recently (i.e. marked as present) at Bagley Bridge in 2003 (Conallin and Hammer 2003) along with mountain galaxias at ML99-03 (P. Kerby, Waterwatch pers. comm: Appendix 3). Species richness was highest at the small section of river channel at the terminus of Lake Alexandrina (ten native species), with species occurring in this section having only minor overlap with six species from upstream sites: dwarf flathead gudgeon (both regions), only two carp gudgeons down stream (at ML99-10A), flathead gudgeon (2 only upstream at ML04-70) and the single pygmy perch at Bagley Bridge (likely to belong to a Lake Alexandrina genetic sub-population rather than the highly genetically distinct Angas River sub-population: see Hammer 2001).

Mountain galaxias and carp gudgeons were wide spread (18 and 15 of 32 sites respectively), carp gudgeons in particular were abundant at many localities. Dwarf flathead gudgeon were patchily distributed (eight sites) and southern pygmy perch and river blackfish restricted to a few sites in small areas (Table 4.5.2), with the former species in particularly low abundance. Some sampling sites were located in continuous stream sections (e.g. below Strathalbyn, near Macclesfield) however, most sites represented isolated pools and in areas like Middle Creek, the only water in a stream stretch.

Introduced species were not common in the Angas Catchment (except for the river channel habitat at the River mouth) but occurred widely (15 sites) and with six different species represented (Table 4.5.2). Gambusia was only noted at the River Channel habitat and three sites in the mid-catchment. Redfin occurred slightly more widely including lower Middle Creek (six sites). Tench were collected at three sites in the Mid Angas and in Dawson Creek. Rainbow trout were located upstream and downstream of an instream dam on the Angas River in Macclesfield (stocked there four years ago: Appendix 3) as well as a small pool in the Dawson Creek (ML99-01A). At the latter site removal of this predator corresponded to increasing richness and abundance of native fish over time (see ML00-02A & ML04-62Mb). Rainbow and brown trout were stocked in the Angas River in the early 1900's around Strathalbyn (Morrissy 1967) with other stockings of rainbow trout under permit reported in 1984/85 (Fulton 2004) or illegally into instream dams (e.g. ML00-01: Hicks 1997). Carp have been recorded in Middle Creek pools in 2001 (Hammer 2001), they have dried seasonally since and similarly tench have been recorded at additional sites in Dawson Creek (Hicks 1997; Hammer 2001).

Historic records indicate that several native species were once more widespread in the catchment. River blackfish were until the 1950's quite common in the Angas River from Strathalbyn through to downstream of 'Riverview' (Sim *et al.* 2000; Appendix 3). The species experienced considerable decline in the ensuing years and today has a contracted upstream and downstream range in comparison to former records (see Table 4.5.2). River blackfish also now appeared to have been extirpated from Dawson Creek where they were common at ML00-01 in the 1980s (Lloyd 1987) and persisted to at least 1990 (a single juvenile specimen: Bertozzi 1990).

Southern pygmy perch have also declined in Dawson Creek with major pool drying witnessed in the last five years. This species and mountain galaxias were previously recorded from:

- Border pool (ML04-62Ma) prior to 2003 when it dried (a single fish was located in 2004),
- Friesian Drive (ML04-61) in 1983 (Lloyd 1987; dry for at least six months in 2004),
- Ashbourne Road (ML04-63) in 1997 (Hicks 1997; pool had dried in 2004).

Pools in Middle Creek (ML04-66M) that were dry in 2004 (likely as the combined result of earthworks to realign the creek in the mid 1980's, upstream water abstraction and a dry climatic period) have previously contained southern pygmy perch as well as mountain galaxias and dwarf flathead gudgeon (Sim *et al.* 2000; Hammer 2001). It also appears that congolli have been able to migrate up the ephemeral lowland channel in times of flow (e.g. records at Belvidere in the 1950's: Appendix 3) and another diadromous species, the climbing galaxias was recorded at Strathalbyn in 1914 (Table 3.2.1). A single Murray hardyhead was recorded from the Angas River Mouth in 1983 (Lloyd 1987).

The spatial coverage of this catchment is more detailed than for other catchments, specifically in the mid section due to efforts to monitor and map the range of declining threatened native fish. Future research should continue regular monitoring and could further map the range, abundance and habitat of river blackfish. The carp gudgeons of the catchment have been of considerable interest in taxonomic research (Bertozzi *et al*. 2000) and populations look to play an important future part in understanding the species complex and in the study of unisexual vertebrates through research at the SA Museum (M. Adams pers. comm.). Understanding why introduced fish are less prevalent in sections of the Angas than in other catchments would also be of potential use in the broader control of these species.

Table 4.5.1. Sampling locations in the Angas River Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML99-11	25/03/1999	Angas River	Angas River Mouth	River Channel
ML99-10A	25/03/1999	Angas River	Bagley Bridge	River Channel
ML04-144	06/06/2004	Angas River	Bagley Bridge	River Channel
ML01-52	11/03/2001	Angas River	500m us Bagley Bridge	River Channel
ML99-09	17/05/1999	Angas River	'Riverview'	Stream
ML99-08A	17/05/1999	Angas River	Belvidere	Stream
ML04-143	06/06/2004	Angas River	Belvidere	Stream
ML99-07	21/04/1999	Angas River	Gurney property	Stream
ML04-64	31/03/2004	Angas River	ds Willyaroo bridge	Stream
ML99-06	21/02/1999	Angas River	us Humberg Road Ford	Stream
ML01-51	11/02/2001	Angas River	Strathalbyn	Stream
ML01-12	25/10/2001	Angas River	Strathalbyn footbridge	Stream
ML04-70	05/04/2004	Angas River	North Parade	Stream
ML04-68M	01/04/2004	Angas River	Middle Creek/Angas R junction	Stream
ML04-71	06/04/2004	Angas River	'The Lodge'	Stream
ML99-05	07/05/1999	Angas River	Rankine property	Stream
ML99-04	17/05/1999	Angas River	'Martindale', bend in River	Stream
ML99-03	17/03/1999	Angas River	'The Downs'	Stream
ML04-59	31/03/2004	Angas River	'Willowdene'	Stream
ML04-57	31/03/2004	Angas River	Crystal Lake, below dam	Stream
ML04-58M	31/03/2004	Angas River	Searle Rd	Stream
ML99-02	10/03/1999	Angas River	Quarry Rd -Flaxley Rd Junction	Stream
ML04-63	31/03/2004	Dawson Creek	Ashbourne Road	Stream
ML04-61*	31/03/2004	Dawson Creek	Reserve -Friesian Drive	Stream
ML04-62Ma	31/03/2004	Dawson Creek	Border pool	Stream
ML99-01A	03/04/1999	Dawson Creek	Pool below dam spillway	Stream
ML00-02A	13/02/2000	Dawson Creek	Pool below dam spillway	Stream
ML04-62Mb	31/03/2004	Dawson Creek	Pool below dam spillway	Stream
ML00-01	13/02/2000	Dawson Creek	Large instream dam	Instream dam
ML04-65	31/03/2004	Dawson Creek	Dog Trap Road	Stream
ML04-72b	06/04/2004	Dawson Creek	'Dorset Park' (fenced section)	Stream
ML04-72a	06/04/2004	Dawson Creek	'Dorset Park'	Stream
ML04-60*	31/03/2004	Doctors Creek	Macclesfield Road	Stream
ML04-66M*	01/04/2004	Middle Creek	Earthworks area	Stream
ML04-67	01/04/2004	Middle Creek	Whittwers property	Stream
ML04-69	01/04/2004	Paris Creek	Old Mine off Paris Creek Rd	Stream

* Dry in autumn 2004; **A** –the same site sampled on a preceding occasion (temporal comparison);
M – monitoring site for threatened fish species; **a** and **b** (small caps) – paired sites located in close proximity.

Stream pools on the Angas River above Strathalbyn and (*right*) Paris Creek (ML04-69)

Table 4.5.2. Fish species and relative abundance recorded for the Angas River Catchment.

Site Code	Bony herring	Australian smelt	Climbing galaxias	Common galaxias	Mountain galaxias	Smallmouthed hardyhead	Murray hardyhead	Southern pygmy perch	Yarra pygmy perch	River blackfish	Congolli	Western bluespot goby	Carp gudgeon spp.*	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML99-11	16	31		7		3					5			3					5			1	8	2
ML99-10A	5	5		14			X[C]						2[3]	4	1				4		28	3	9	3
ML04-144				19			X[C]	P			1	2		17	23			7	4		30	1	10	4
ML01-52				10								5		10					15		50		5	2
ML99-09					X[E]					X[E]	X[E]		1[1]								1		2	1
ML99-08A										X[E]	X[E]		2[1,3]		1							8	3	1
ML04-143					18					X[E]	X[E]		163[1,3]		3				2			3	5	2
ML99-07					8					17			400[1,3]		5			1			20		6	2
ML04-64					4					62			600[1,3]		5			2		5	30		7	3
ML99-06										3			50[1,3]								25	3	4	2
ML01-51					7					4			14[1,3]						2			4	5	2
ML01-12			X[F]							X[E]			800[1,3]		3	X[E]			2	1			4	2
ML04-70					2			1		X[E]			800[1,3]	2	1								5	0
ML04-68M								8					33[1,3]										2	0
ML04-71					2			7					176[1,3]									2	4	1
ML99-05													89[1,3]		17								2	0
ML99-04																							0	0
ML99-03					P																		1	0
ML04-59					60																		1	0
ML04-57					30											12							2	1
ML04-58M					40																		1	0
ML99-02					15																		1	0
ML04-63					X[B]			X[B]					X[A]							X[B]			0	0
ML04-61					X[C]			X[C]					X[C]										0	0
ML04-62Ma					22			1					X[A]							X[A]			2	0
ML99-01A													6[1,3]			1							2	1
ML00-02A													250[1,3]										1	0
ML04-62Mb					13			1					19[1,3]										3	0
ML00-01					2					X[B]			500[1,3]			X[C]				5			3	1
ML04-65					5																		1	0
ML04-72b					100																		1	0
ML04-72a					30																		1	0
ML04-60																							0	0
ML04-66M					X[A]			X[A]					X[A]		X[C]				X[A]				0	0
ML04-67								4					800[1,3]										2	0
ML04-69					80																		1	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).
*Carp gudgeon species and hybrid forms detected:
[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X

4.6 Bremer River

The Bremer is a large catchment (589km^2; second only in size to the mostly dry Ferriss-McDonald Catchment to which the Bremer River contributes flow intermittently via a lowland channel, Mosquito Creek, that branches off near Langhorne Creek). The Bremer River runs roughly north to south parallel with the base of the Range extending from small headwaters above Harrogate, through Callington then along a lowland plain via Langhorne Creek to its junction with Lake Alexandrina. The latter sections of the River from above Langhorne Creek are today ephemeral, with a small section of permanent river channel at the junction of the Lake. Two major tributaries drain from the flank of the range east toward the Bremer River: the Mt Barker Creek sub catchment that includes Western Flat, Nairne and Dawesley creeks, and Rodwell Creek, joining the Bremer just below Woodchester. Hence sections of the catchment are contrasting in topography, geology, rainfall and vegetation, particularly between the Mt Barker Creek sub-catchment (high rainfall, elevation and gradient, considerable urban areas) and elsewhere (more agricultural, low rainfall and topography).

Stream habitats vary in the two distinct regions of the catchment, with shallower creeks in headwater areas compared to a series of deep irregular pools along the Bremer main channel. Significant pollution has occurred as a result of mining activities along side Dawesley Creek at Brukunga (Hicks 1997) and stock access is commonplace in areas that are not urbanised. Specific cases of habitat alteration with council works were observed at Mt Barker (infilling of stream at ML04-87) and at the Harrogate Bridge (infilling and disruption of stream pools).

Habitat values were generally moderate, with instream cover often provided by rock and snags (generally 10-30%) and at patchy sites there was significant amounts (>20%) of submerged aquatic vegetation such as *Potamogeton* spp. and *Chara* (e.g. sites ML04-82, 98 &108). Values for submerged cover provided by emergent vegetation were low (<20%) perhaps due to large seasonal variations in pool level (i.e. riparian plants stranded above the waterline) and the small relative edge ratio of large pools that might be fringed by species such as *Typha* and *Phragmites* (i.e. low overall percentage of the pool occupied, but still could be important cover). Autumn water conductivity values were high along the Bremer River, particularly from Harrogate through to Callington (range: 9990-12,810µS) and slightly fresher downstream (e.g. 4190µS at ML04-111). Conductivities were also high along Rodwell Creek (4300-11,620µS) but slightly fresher in the Mt Barker Creek sub-catchment (generally <3000µS for stream environments). Water transparency values were mostly low (<0.8m).

A total of eleven native and five introduced species were recorded including the first record of river blackfish from the catchment for 50 years (see Fig. 7). Hybrid carp gudgeon (MD x Midg) were recorded at eight sites (Table 4.6.2). One species, the Murray-Darling golden perch, was included (i.e. marked as present) based on recent reports by anglers at ML04-145 & 112. As with several preceding catchments, species richness was high at the terminus of the catchment (ML04-145: eight native species) with three species only recorded from this small region. However, upstream and downstream species composition was not as contrasting as observed in catchments like the Tookayerta or Angas with distributions for flathead gudgeon, and common galaxias, congolli and Murray-Darling golden perch recorded both up and downstream of the ephemeral lowland channel. Flathead gudgeon and carp gudgeon were wide spread (11 and ten sites respectively) and often locally abundant (Table 4.6.2). Mountain galaxias were rare (7 of 32 sites) as was dwarf flathead gudgeon, recorded only at three sites. River blackfish were only located at two proximate sites in Rodwell Creek (ML04-82 & 83a). Sampling sites were often isolated stream pools, with the exception of sites on Mt Barker Creek and a long series of lowland pools below Callington (ML04-111).

Translocated carp gudgeon and freshwater catfish were captured in one small instream dam off Dawesley Creek (ML04-94).

Exotic species were overall widespread in different sections of the Catchment but with the exception of Gambusia were not commonly captured (Table 4.6.2). Recent reports by anglers indicated that carp and redfin do occur at additional sites (marked as present) and such larger bodied species were probably under sampled in the large and deep pools of the lower Bremer due to the difficulty in sampling this habitat. A single rainbow trout was captured (ML04-111). Historically there is documentation of brown trout having been stocked into the Bremer River and Mt Barker, Nairne and Bryce creeks (Morrissy 1967).

Historic records indicate that several native species were once more widespread in the catchment. The iconic Murray cod occurred in the lower Bremer River downstream of Hartley through to Langhorne Creek until about 1942 (Sim *et al*. 2000; Appendix 3). River blackfish were recorded in Mt Barker Creek and Dawesely Creek (pre 1929: Table 3.2.1; Appendix 3), the upper Bremer at Harrogate (Appendix 3), the mid Bremer River (e.g. at Callington) and additional locations on Rodwell Creek including: a large pool at Woodchester (ML04-84) where the species was caught until the 1950's (Sim *et al*. 2000) and other pools near ML04-83b where they were collected in the early 1900's (the exact pools where fish were caught historically dried this summer for the first time in living memory: Appendix 3). Congolli were also recorded in Rodwell Creek (ML04-83b: Appendix 3). Mountain galaxias were previously known from Dawesley Creek (Table 3.2.1) and at sites in Harrogate prior to extensive pool drying in the last two years (Table 4.6.2). There is a speculative report that a southern purple-spotted gudgeon was caught near Callington (ML04-73) in the 1970's (Appendix 3).

Future research should focus on finding if additional pools of river blackfish occur in Rodwell Creek (although initial on ground inspection and aerial videography data suggest that only a few other pools are present in the area) and sample more intensively the large pools on the lower Bremer (ideally with bigger nets).

Contrasting sections (sub-catchments) of the Bremer Catchment: *top left* – Mt Barker Creek; *above* –upstream of Callington (ML04-95); *top right* - Rodwell Creek blackfish habitat (ML04-83a) and large lowland pool (ML04-111)

Table 4.6.1. Sampling locations in the Bremer River Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-79	09/04/2004	Mosquito Creek	Gollan's Waterhole	Waterhole
ML04-145	06/06/2004	Bremer River	Bremer River Mouth	River Channel
ML04-80*	09/04/2004	Bremer River floodplain	'Metella'	Wetland
ML04-78	09/04/2004	Bremer River floodplain	Hill Swamp	Swamp
ML04-81*	07/06/2004	Bremer River	Frank Potts Reserve, Langhorne Creek	Stream
ML04-112	28/04/2004	Bremer River	Wandstead Road	Stream
ML04-111	27/04/2004	Bremer River	us Jeanch Rd	Stream
ML04-73	18/04/2004	Bremer River	'Collray' (old Princess Hwy xing)	Stream
ML04-95	18/04/2004	Bremer River	'Collray'	Stream
ML04-98	19/04/2004	Bremer River	ds Crofton Park	Stream
ML04-93	15/04/2004	Bremer River	Military Road	Stream
ML04-92	15/04/2004	Bremer River	Appleton Cottage	Stream
ML01-10A	20/10/2001	Bremer River	Harrogate main bridge	Stream
ML02-159A	16/05/2002	Bremer River	Harrogate main bridge	Stream
ML04-91a	15/04/2004	Bremer River	Harrogate main bridge	Stream
ML01-11A	20/10/2001	Bremer River	Harrogate, behind Tennis Courts	Stream
ML04-91b*	15/04/2004	Bremer River	Harrogate, behind Tennis Courts	Stream
ML04-90a	15/04/2004	Bremer River	The Swimming Hole 'Taworri'	Stream
ML04-90b	15/04/2004	Bremer River	Instream dam, 'Taworri'	Instream dam
ML04-99	19/04/2004	Bryce Creek	us Harrogate Road	Stream
ML04-96	18/04/2004	Dawesley Creek	Princess Hwy	Stream
ML04-97	18/04/2004	Dawesley Creek	us Peggy Buxton Road	Stream
ML04-94	18/04/2004	Dawesley Creek Trib.	'Kiah Nangara'	Instream dam
ML04-109	27/04/2004	Mt Barker Creek	Mt Barker Springs Gauging Station	Stream
ML02-160A	16/05/2002	Mt Barker Creek	ds Adelaide Road	Stream
ML04-87	14/04/2004	Mt Barker Creek	ds Adelaide Road	Stream
ML04-86	14/04/2004	Mt Barker Creek Trib.	Hurling Drive	Stream
ML04-88	14/04/2004	Mt Barker Creek Trib.	Clegget Road	Stream
ML04-108	27/04/2004	Western Flat Creek	'Newenham', us bridge	Stream
ML04-85	14/04/2004	Western Flat Creek	'Madabareenah'	Instream dam
ML04-89	14/04/2004	Nairne Creek	Sydney Road	Stream
ML04-84	09/04/2004	Rodwell Creek	The Lagoon, Woodchester	Stream
ML01-50A	04/01/2001	Rodwell Creek	'Highland Valley' (b) corner pool	Stream
ML04-83b*	09/04/2004	Rodwell Creek	'Highland Valley' (b) corner pool	Stream
ML04-83a	09/04/2004	Rodwell Creek	'Highland Valley' (b) cliff pool	Stream
ML04-82	09/04/2004	Rodwell Creek	'Highland Valley' (a)	Stream
ML04-110	27/04/2004	Rodwell Creek	off Bunnetts Road	Stream

* Dry upon inspection in autumn 2004

A – represents the same site sampled on a preceding occasion (temporal comparison),

M – ongoing monitoring sites for threatened fish species.

a and **b** (small caps) – paired sites located in close proximity.

Large flathead gudgeon captured near Callington on the Bremer River - 107mm total length

Table 4.6.2. Fish species and relative abundance recorded for Bremer River Catchment.

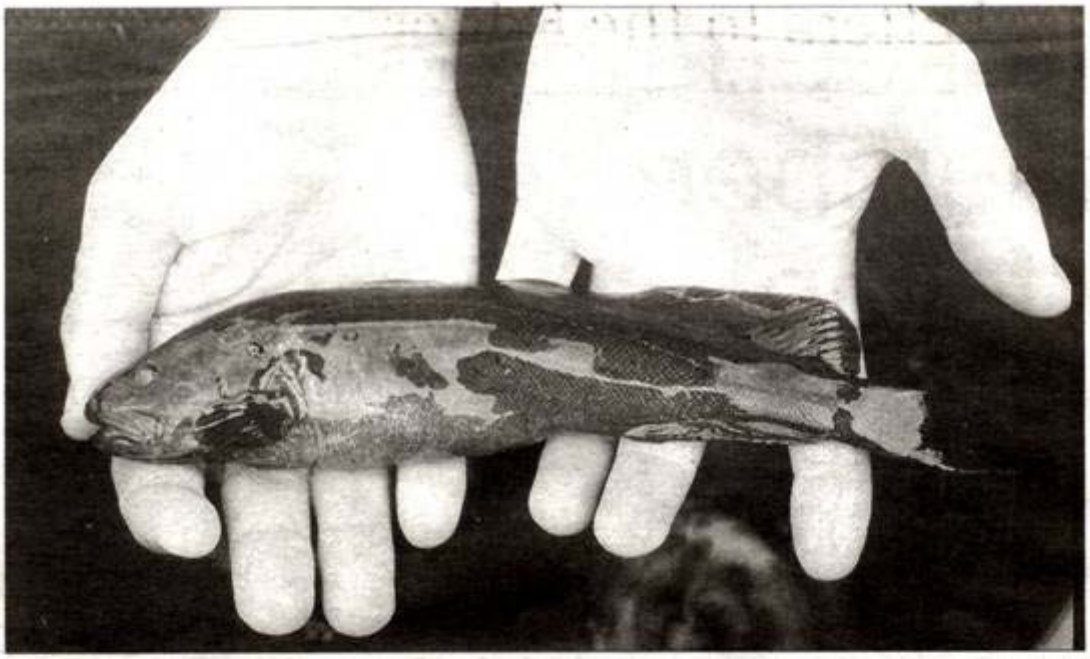
Site Code	Pouched lamprey	Shortfinned eel	Bony herring	Freshwater catfish	Common galaxias	Mountain galaxias	Smallmouthed hardyhead	Murray cod	Murray-Darling golden perch	Southern pygmy perch	River blackfish	Silver perch	Congolli	Western bluespot goby	Carp gudgeon spp.*	Purple-spotted-gudgeon	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-79																								5000		1	1
ML04-145			1		3		1		P			X^{E}	1	1			20	1				P		10	P	10	3
ML04-80																										0	0
ML04-78									X^{A}								X^{A}				10	1			6	3	3
ML04-81		X^{C}			X^{C}			X^{F}	X^{A}		X^{F}										X^{C}	X^{A}		X^{C}	X^{C}	0	0
ML04-112	X				5			X^{E}	P				1				30	7				1		200	2	8	3
ML04-111								X^{E}			X^{E}				1^{1}		32	4	1			1				5	2
ML04-73											X^{E}				2^{3}	X?	363	X^{C}						1104		3	1
ML04-95															1^{3}		210					4		100		4	2
ML04-98																	20									1	0
ML04-93															$539^{1,3}$											1	0
ML04-92																	25									1	0
ML01-10A						23									1^{3}		2					1			2	5	2
ML02-159A						23									$30^{1,3}$		50					1			1	5	2
ML04-91a						X^{A}									1^{1}		9					X^{A}			X^{A}	2	0
ML01-11A						6					X^{D}				$13^{1,3}$							6			1	4	2
ML04-91b						X^{A}					X^{D}				X^{A}							X^{A}			X^{A}	0	0
ML04-90a																	5									1	0
ML04-90b																	2					2			31	3	2
ML04-99																										0	0
ML04-96						X^{F}					X^{F}															0	0
ML04-97																										0	0
ML04-94				T											$T^{1,3}$											0	0
ML04-109											X^{F}													50		1	1
ML02-160A						40					X^{F}														7	2	1
ML04-87						P					X^{F}													30	P	3	2
ML04-86																										0	0
ML04-88						1																				1	0
ML04-108																								50		1	1
ML04-85																										0	0
ML04-89						8																				1	0
ML04-84											X^{E}				$63^{1,3}$		94						X^{E}	30		3	1
ML01-50A						4					X^{F}		X^{F}		$500^{1,3}$									50		3	1
ML04-83b											X^{F}		X^{F}													0	0
ML04-83a						1					7				$110^{1,3}$									30		4	1
ML04-82											17				35^{1}									15		3	1
ML04-110																								20		1	1

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence, **T**: translocated species.

Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).

*Carp gudgeon species and hybrid forms detected:

[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X



This endangered River Blackfish was found in Rodwell Creek near Woodchester by native fish experts.

Rare fish find good news for Hills farm practices

By **COREY NORRIS**

The recent discovery of rare native fish in a creek near Woodchester was an encouraging sign that farmers were managing their waterways better, a fish expert said this week.

However, Native Fish Australia (SA) scientific officer Michael Hammer warned that more needed to be done to protect fish species native to the Hills.

His comments follow a recent find of River Blackfish – a species that hasn't been seen in most Hills waterways for nearly 100 years – in a creek near Woodchester.

Mr Hammer discovered the endangered fish in Rodwell Creek, a tributary stream of the Bremer River, on April 10.

Once a target for river fisherman, the native River Blackfish, also known as 'muddies' or 'slipperies', were once widespread in streams and even the River Murray, but is now severely restricted and considered endangered.

Mr Hammer said the find was an encouraging sign of good farming methods.

"The River Blackfish is a very sensitive species and is usually associated with areas of higher water quality and abundant cover such as boulders, snags and reeds," he said.

"It shows the section of creek is of a good water quality and hasn't been over-stocked with introduced fishes.

"It's also a great example of responsible landholders using appropriate farming practises."

Mr Hammer said sedimentation could effect the lifecycle stages of the River Blackfish while habitat removal and modification, chemicals and flow alterations and stocking of introduced species were threats to all native fish.

He said while the discovery was exciting, the River Blackfish and many other native fish species faced an uncertain future.

"Local efforts to restore the catchment through the Rodwell Creek Catchment Group are making excellent progress in terms of re-establishing native vegetation and fencing creek lines, but many once-permanent pools are drying up due to the amount of surface water captured and groundwater pumping," he said.

"I urge landholders and managers in the Mt Lofty Ranges to consider measures to return flows to rivers in the knowledge that the water is badly needed by native animals and plants in local aquatic ecosystems.

"Simple actions such as installing low flow bypasses on dams or taking unused dams off-line are a good start."

Mr Hammer is keen for anyone who has sighted the River Blackfish recently or in the past to contact the Mt Lofty Ranges Catchment Centre.

The River Blackfish

- They are a long-lived, nocturnal fish that eat small fish, baby yabbies, shrimps and waterbugs.
- They prefer deep pools that are often spring-fed and lined with bullrushes and redgums.
- They lay their eggs in hollow logs or undercut banks where the male stands guard.
- They have unique pelvic fins that are branched like fingers and they use this to probe the bottom of pools in search of prey.
- They grow to about 30cm in length.

Figure 7. Article appearing in "The Mount Barker Courier" (April 21st 2004, pg. 7) following the rediscovery of river blackfish in Rodwell Creek during Inventory sampling.

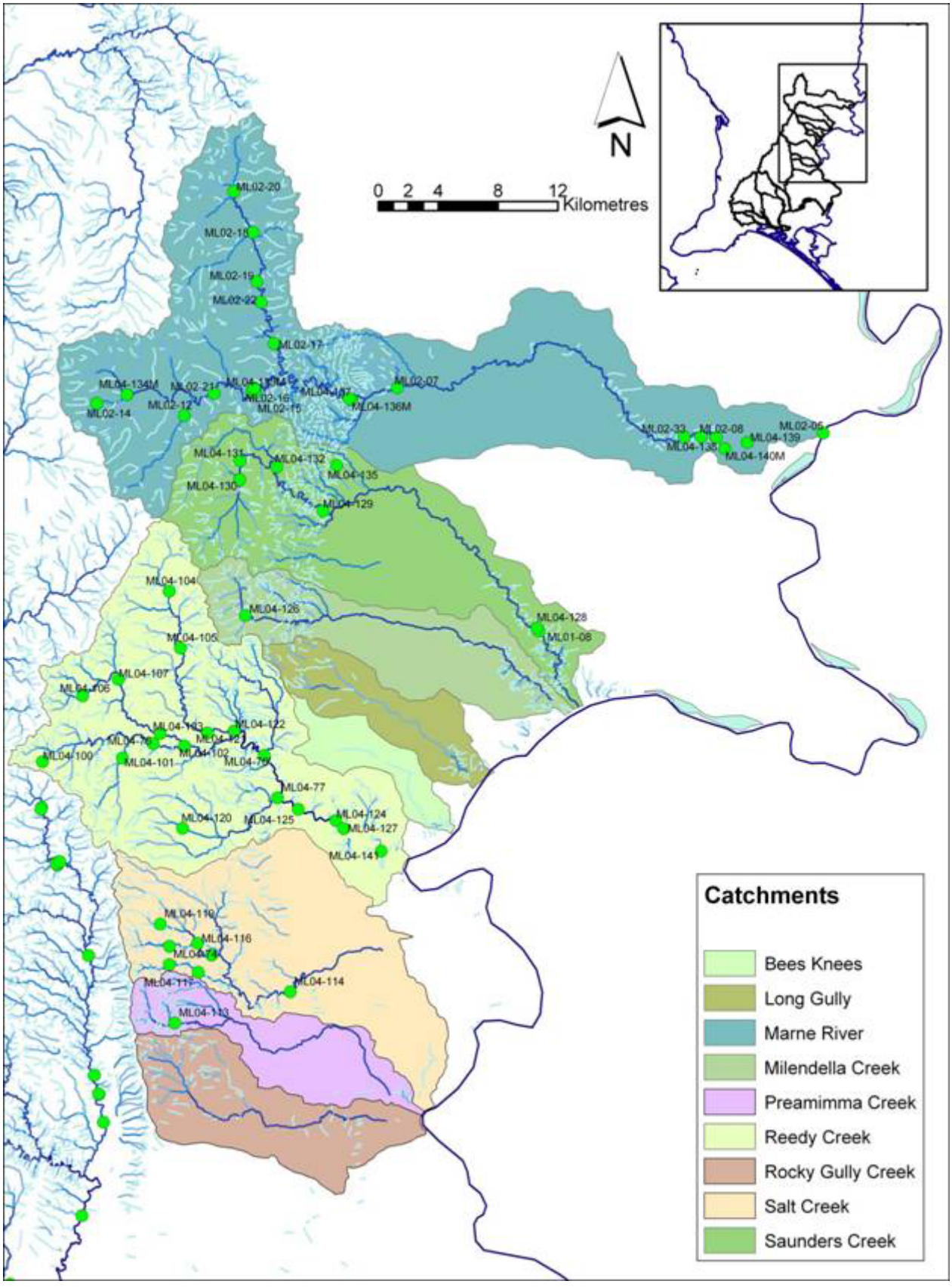


Figure 8. Location of sampling sites in the Eastern Mount Lofty Ranges for northern catchments that drain toward the lower River Murray.

4.7 Salt Creek

The Salt Creek Catchment is a medium size catchment (199km^2) at the extremities of the Mount Lofty Ranges (small spit of the Range on the eastern edge of the Bremer Valley). As a consequence it has low topography and low, highly variable rainfall. Much of the catchment comprises plains, with only a small defined section of elevation and hydrological organisation in the upper sections stretching from near Bondleigh to Tepko (i.e. Salt Creek and Long, Mitchell, Gum and Flag gullies). From below the Murray Bridge to Wellington Road the main ephemeral channel is shallow and poorly defined.

Stream habitat was restricted to irregular pools along defined channels and given the dry, warm landscape, permanent pools were clearly maintained by vertical connectivity to groundwater sources. While there were not a great number of permanent pools located, it was surprising to note some were quite large and up to 1.5m deep (e.g. Round Waterhole – ML04-116; ML04-117 on Long Gully Creek), serving as drought refuges. Usually sampling sites represented the only water for considerable distances and several of these refuges were fenced. Otherwise stock access is common along watercourses in the catchment.

Habitat values were generally low, with a little instream cover such as rock (<20%), however some sites had dense beds of filamentous algae and/or *Chara* (ML04-114, 117), with this cover present at most sites (between 5-60%). Emergent vegetation was virtually absent, with minor instream cover at some sites provided by *Juncus*. Autumn water levels were often below a line of fringing sedges, and most pools were exposed with little shade. Salt Creek lived up to its name, with autumn conductivity readings in the catchment ranging from 17,530-30,000µS. Water transparency values were often high (~0.8m).

A single (introduced) species was captured in the catchment, Gambusia (3 of 7 sites: Table 4.7.2). They occurred at sites on the main branch of Salt Creek from 'Pine Villa' (ML04-114) upstream to Round Waterhole (ML04-116) and were common when present. There was no indication that any other native or exotic fish have been recorded previously in the catchment.

The presence of freshwater shrimp (*Paratya*) at Round Waterhole was of interest and the location also had numerous longneck turtles present. Survey coverage was reasonable. Aerial videography proved a good representation of actual surface water, and there are there do not appear to be many other pools within the broader coverage that could be investigated.

Round water hole – one of a handful of permanent refuges in the Salt Creek Catchment

Table 4.7.1. Sampling locations in the Salt Creek Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-114	28/04/2004	Salt Creek	'Pine Villa'	Stream
ML04-115	28/04/2004	Salt Creek	us Rockleigh Rd xing	Stream
ML04-116	28/04/2004	Salt Creek	Round Waterhole	Stream
ML04-119	29/04/2004	Salt Creek Trib.	Gum Gully, Federation Trail xing	Stream
ML04-118	29/04/2004	Mitchell Gully Creek	Mitchell Gully Ruins	Stream
ML04-117	29/04/2004	Long Gully Creek	off Annie Lane	Stream
ML04-74	08/04/2004	Long Gully Creek	Critchley Road	Stream

Table 4.7.2. Fish species and relative abundance recorded for the Salt Creek Catchment.

Site Code	Common galaxias	Mountain galaxias	Smallmouthed hardyhead	Murray hardyhead	Western bluespot goby	Carp gudgeon spp.	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-114														200		1	1
ML04-115														250		1	1
ML04-116														50		1	1
ML04-119																0	0
ML04-118																0	0
ML04-117																0	0
ML04-74																0	0

Reedy Creek Catchment: *left* – Mannum waterfalls section transcending from the 'slopes' onto the lower Murray plain; *bottom left* – fenced habitat on Bryce Creek (ML04-107) with dense and diverse riparian vegetation and *lower* – highly saline pool on mid-Reedy Creek (ML04-76), habitat of dwarf flathead gudgeon and Gambusia

4.8 Reedy Creek

The Reedy Creek catchment is a large catchment (314km^2), reasonably elevated in its upper half which experiences moderate rainfall. Two main sub-catchments drain this upper section: Dairy/Baker Creek and Harrison Creek with an area stretching between Mount Torrens, Tungkillo and the Mt Pleasant-Sedan Road. These drainage networks transcend through very steep rocky sections (numerous natural rock barriers and waterfalls) as they converge towards a point above the Palmer to Mannum Road. Below the junction Reedy Creek is a lowland stream containing interspersed pools (the small Loxton/Gorge Creek sub catchment joins the main channel in this section), before reaching the Mannum waterfalls. Below the Murray Bridge to Mannum Road crossing, the channel enters an extensive shallow wetland with an opening to the River Murray near Caloote.

Stream habitats are highly variable based on the distinct catchment sections. The section above Palmer has a general lack of large and deep permanent pools (long term refuges). There were some springs, but most pools also had highly variable water levels, with significant contraction over summer. Spring feeding was apparent in a small section below Palmer (ML04-125). Stock access to watercourses is common in the catchment, with fenced areas highly contrasting to elsewhere (e.g. thick and diverse riparian vegetation at ML04-107 on Bryce Creek).

Habitat values were generally low mostly comprising physical contributions to instream cover (~20-40%: rock with some snags). Only a few sites had biological contributions to cover with dense beds of *Chara* at ML04-77 & 125, and most had low amounts (<20%) of instream emergent vegetation (small patches of *Typha* and *Schoenoplectus pungens*, and fringing *Juncus*) probably owing to the often gravel or rocky stream edges and variation in water levels. Autumn water conductivity values were high, mostly ranging between 6000-12,500µS across the catchment, with lower values at a section of Bryce Creek (ML04-107; 3660µS) and upper Harrison Creek (ML04-104; 3870µS). An extremely high conductivity value was recorded for a concentrated pool in the section below Palmer (ML04-76; 33,000µS). Transparency values were low (mostly < 0.5m) and a few sites had clearer water (e.g. ML04-107 & 125).

A total of five native and four exotic species were recorded in the catchment (Table 4.8.2). Hybrid carp gudgeon (Midg x species X) were also recorded at ML04-127. Species richness was highest in the lower catchment, with all but one native species, the dwarf flathead gudgeon, restricted in range to below the Mannum waterfalls. An interesting isolated (and potentially genetically distinct) population of dwarf flathead gudgeon was recorded in the section between the Mannum waterfalls and steep gorges near Palmer (i.e. ML04-76 & 125). The abundance of gudgeon at these sites was reasonable to high (Table 4.8.2). Permanent pools in the reach are patchy being mostly isolated with a small spring fed section at and below ML04-125 (mid catchment). No native fish, and few fish in general, were located upstream of the Palmer to Mannum Road.

Introduced fish were restricted to either below the Palmer Road or to the upper section within a single tributary, Bryce Creek (Table 4.8.2). Gambusia occurred in three distinct regions, below and above the Mannum waterfalls and then at site ML04-106 on Bryce Creek, and were common or abundant when present. Redfin were only recorded in low numbers at site ML04-107 (Bryce Creek), and carp and goldfish were restricted to sites below the Mannum waterfalls. There is a report that 500 brown trout were stocked in an unspecified section of the catchment in 1989 (Fulton 2004). There are no records of additional native species having been known from the Catchment. Smelt and common galaxias were previously present at ML04-127 below the Mannum Waterfalls in 2001 (Hammer 2001).

Further field investigations could monitor and map the range of the isolated dwarf flathead gudgeon population and possibly further examine permanent pools in Bryce Creek as the most likely area where native species might be located in the upstream catchment.

Table 4.8.1. Sampling locations in the Reedy Creek Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-141	22/05/2004	Reedy Creek	Reedy Creek Wetland	Wetland
ML04-127	03/05/2004	Reedy Creek	Waterfalls Reserve	Stream
ML04-124	02/05/2004	Reedy Creek	Waterfalls	Stream
ML04-125	02/05/2004	Reedy Creek	'Abrahams'	Stream
ML04-76	29/04/2004	Reedy Creek	Palmer to Mannum Road	Stream
ML04-77	08/04/2004	Gorge Creek	Spring off Peachs Rd	Spring pool
ML04-120	29/04/2004	Loxton Creek	ds Kubens Rd	Stream
ML04-122	29/04/2004	Harrison Creek	ds Gorge	Stream
ML04-121	29/04/2004	Harrison Creek	Waterfall	Stream
ML04-105	22/04/2004	Harrison Creek	Tungkillo - Palmer Rd	Stream
ML04-104	22/04/2004	Harrison Creek	Rosebank @ Ck Junction	Stream
ML04-103	21/04/2004	Baker Creek	ds Henschke Road	Stream
ML04-107	22/04/2004	Bryce Creek	us Hoads Woolshed Road	Stream
ML04-106	22/04/2004	Bryce Creek	East of large power lines	Stream
ML04-102	21/04/2004	Dairy Creek	Junction of Dairy and Baker Ck	Stream
ML04-75	08/04/2004	Dairy Creek	'Thorlindah' (ds Henschke Rd)	Stream
ML04-100	19/04/2004	Dairy Creek	'Dairy Springs'	Stream
ML04-101	21/04/2004	Dairy Creek tributary	Tea Tree Spring	Stream

Table 4.8.2. Fish species and relative abundance recorded for the Reedy Creek Catchment.

Site Code	Australian smelt	Common galaxias	Mountain galaxias	Murray hardyhead	Unspecked hardyhead	Murray rainbowfish	Southern pygmy perch	River blackfish	Congolli	Western bluespot goby	Carp gudgeon spp.*	Purple-spotted-gudgeon	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML04-141	1	1									1[1]			1				P		50		6	2
ML04-127	X[A]	X[A]									17[1,5]		304	5			19	6		50		6	3
ML04-124														2						100		2	1
ML04-125														143						200		2	1
ML04-76														31						200		2	1
ML04-77																				500		1	1
ML04-120																						0	0
ML04-122																						0	0
ML04-121																						0	0
ML04-105																						0	0
ML04-104																						0	0
ML04-103																						0	0
ML04-107																					2	1	1
ML04-106																				400		1	1
ML04-102																						0	0
ML04-75																						0	0
ML04-100																						0	0
ML04-101																						0	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).

*Carp gudgeon species and hybrid forms detected:

[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X

4.9 Saunders Creek

The Saunders Creek Catchment is of moderate size (222km^2), being a narrow, long area stretching from near Springton through to the River Murray north east of Mannum. Only a small section of the catchment extends into higher elevations and hence rainfall is low and irregular across most of the catchment (and even here there appears to be a significant rain shadow effect). Its headwaters comprise two small tributary streams that flow in a northerly direction, before both turn to the east. They join just before a steep rocky gorge. From below the gorge, the Saunders Creek is an ephemeral channel that meanders in a roughly south easterly direction until reaching a small section of spring fed, permanent pools lined with red gum and *Phragmites* in the region of Lenger Reserve (~5km upstream from the River Murray). Below here, the channel is once again ephemeral and shallow, with no real wetland area where the Creek joins the Murray.

There is little permanent stream habitat in the catchment today, with only a few pools upstream of and in the Saunders Gorge, and the small string of pools near Lenger Reserve. Hence sampling sites represented most of the permanent water in the Catchment and pools were generally isolated. Stock access is common, however, significant sections of the Catchment where water occurs have been fenced or have no stock (e.g. Saunders Gorge Sanctuary and some areas upstream from here; Lenger Reserve and upstream pools). Instream habitat values were low, with generally ~20-30% submerged physical cover (rock, snags), no submerged aquatic vegetation (with the exception of *Chara* recorded from a small spring on Kinappa Creek, a small gully near Saunders Gorge) and only small amounts of submerged *Typha* or *Phragmites* at a few sites. Autumn water conductivity values were moderate to high ranging from 5780-10,030µS but were lower (2920µS) at Kinappa Creek.

Only a single native fish, carp gudgeon, was recorded in the catchment, restricted to the small section of permanent pools at or above Lenger Reserve (ML04-128, ML01-08; Table 4.9.2). Hybrid carp gudgeon (MD x species X) were also recorded at these two sites. The abundances of carp gudgeons at ML04-128 was very high and less at ML01-08 (habitats there were deeper and snag filled and hence harder to sample). No records of any other native fish being recorded in the catchment were located.

One exotic fish, Gambusia, was common at three sites – Lenger Reserve area and also at ML04-131 on upper Saunders Creek (Table 4.9.2). There is anecdotal evidence that carp are occasionally sighted at Lenger Reserve and at Saunders Gorge (Carlsa Carter, National Trust, pers. comm.; Appendix 3). Sample coverage was reasonably comprehensive, and future sampling should monitor the small population of native carp gudgeon in the catchment and investigate any reports of permanent pools not sampled or sightings of small fish.

Very little permanent water was located in the Saunders Catchment, most pools were small and isolated – *left* ML04-131 and *right* – rocky pool in the Saunders George.

Table 4.9.1. Sampling locations in the Saunders Creek Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML04-135	05/05/2004	Kinappa Creek	Weir on spring	Spring pool
ML01-08	03/12/2001	Saunders Creek	Lenger Reserve	Stream
ML04-128	03/05/2004	Saunders Creek	us Springs Road Junction	Stream
ML04-129	03/05/2004	Saunders Creek	Saunders Gorge Sanctuary	Stream
ML04-130	03/05/2004	Saunders Creek	ds Strachans Road	Stream
ML04-131	04/05/2004	Saunders Creek	'Myrtle Grove'	Stream
ML04-132	04/05/2004	Saunders Creek	ds Jutland Road	Stream

Table 4.9.2. Fish species and relative abundance recorded for the Saunders Creek Catchment.

Site Code	Climbing galaxias	Common galaxias	Mountain galaxias	River blackfish	Congolli	Western bluespot goby	Carp gudgeon spp.	Purple-spotted-gudgeon	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML01-08							15[1, 4]							X[B]		40		2	1
ML04-128							500[1,4]									600		2	1
ML04-129														X[B]				0	0
ML04-132																		0	0
ML04-131																200		1	1
ML04-130																		0	0
ML04-135																		0	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).
*Carp gudgeon species and hybrid forms detected:
[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X

Large pool on lower Saunders Creek – one in a series within an isolated spring fed section of the Catchment and an interesting ecological scenario with red gum and reed-lined pools situated within harsh Mallee country. *Top* – a female Murray-Darling carp gudgeon from the stream section.

4.10 Marne River

The Marne River Catchment is large catchment (476km^2) with surface flows supported mostly by rainfall in its upper sections at higher elevations spreading between Springton, Eden Valley and Keyneton. The upland catchment area comprising two separate sub-catchments (upper Marne and North Rhine Rivers) spills through a confined gorge before becoming an ephemeral red gum lined channel through much drier lowland areas until it reaches the township of Black Hill. The stretch following forms a unique ecological scenario, with harsh Mallee terrain sliced by a lush valley supported by a spring fed stream. Historically this stream stretch was continuous through to a deep clear wetland at the Marne Mouth near Wongulla (around 20km upstream of Mannum) before flowing into the River Murray. Surface water connection between the upper and lower sections is only facilitated by flows and flood spates of sufficient magnitude to traverse the ephemeral channel (e.g. a flow event in winter 2004 was continuous from the Gorge to the Marne Mouth for a few days in August).

There was broad variation in the nature of pools in different regions of the catchment. Generally small shallow, highly contracted and isolated pools were located in the North Rhine River. Similar but more permanent pools were present in the upper Marne and Marne Gorge, with a notable longer stretch of pools at the top of the Marne Gorge. The Black Hill Springs section has an ever contracting section of continuous deep pools. Much of the catchment has unrestricted stock access, with several fenced sites contrasting in the amount and diversity of riparian plant species (e.g. ML02-16, ML04-138 & 140M).

Stream habitats values were variable, especially the amount of submerged physical cover (5-50% of snags or rock) and the submerged area of emergent plants (5-60%: *Typha* provided cover where waters were more permanent e.g. ML04-140M at Black Hill Springs; sites above the Marne Gorge such as ML02-16 & 158A). Very few sites had significant amounts of submerged aquatic vegetation with the exception of *Vallisneria* at the Marne Mouth (ML02-05). There was permanent flow at some sites at Black Hill Springs and at the gauging station in the Marne Gorge (ML04-137) otherwise flow was largely intermittent with pools contracting over summer.

A total of nine native and three introduced species were recorded including river blackfish (Table 4.10.2). Hybrid carp gudgeon (MD x Midg, Midg x X) and a carp x goldfish hybrid were also recorded at sites ML02-05 and ML02-06A respectively. Species richness declined upstream from the Marne Mouth (ML02-05; eight native species). Four native species were recorded in the Black Hill Springs stream section, and a single species, the mountain galaxias, at select sites upstream of there (no fish were found in the North Rhine River). The overall abundances and extent of populations in the Marne River were generally poor. Mountain galaxias were common in a few pools (ML04-133M & 134), however, these sites represented the only water for considerable distances and only ML04-133M (with ML02-15, 16 & 158A) had a series of pools containing mountain galaxias. The Black Hill Springs section, while once extensive, is now effectively reduced to a series of pools between ML04-138 & 139 and a pool of stagnant water at ML02-33. Reasonable numbers of fish do occur with remaining water (i.e. river blackfish, mountain galaxias, carp gudgeon and dwarf flathead gudgeon).

Exotic fish had a restricted distribution in the catchment only being recorded in the Black Hill Springs section and the Marne Mouth. Redfin were previously known from the Black Hill Springs section (ML02-07) and the pools at the top of the Marne Gorge (Appendix 3; Wedderburn 2000). Rainbow trout have previously been record in the Black Hill Springs section and at pools at the top of the Marne Gorge (Appendix 3) with documented trout stocking records for the Marne including 500 brown trout in 1915, 5000 rainbow trout between 1951-1960 and yearly or biannual stockings of 500-2000 rainbow trout between 1979-1988 (Morrissy 1967; Fulton 2004). Tench were recorded from the Marne Mouth in the 1950's (Appendix 3).

Several additional native species and extended ranges for currently represented species are known from historic records. Single specimens of chanda perch, Murray hardyhead and congolli were collected from the Marne Mouth in 1983 (Lloyd 1987) and common galaxias from small pools just upstream (now dry) in the 1980's (Appendix 3). A range of larger native fish species were present in a deep lagoon about 500m upstream of the Marne Mouth in the 1950's (now also dry): Murray-Darling golden perch, silver perch and congolli (Appendix 3). Congolli were also known to migrate into the Black Hill Springs section, where river blackfish, Murray-Darling golden perch and mountain galaxias were more widespread and occurred at several locations (see Table 4.10.2) that are now dry or nearly so (Appendix 3).

Future surveying in this catchment should concentrate on further documenting the range and monitoring the abundance of river blackfish. Increased investigation in upper catchment sites may also be useful to better assess the range of mountain galaxias and to determine if the broader pattern of no fish in the North Rhine River is true at smaller scales (although aerial vidoegraphy only indicated a few additional unsurveyed pools).

Upland stream habitat (ML04-134M) with good instream cover on the Marne River (*top*) with large mountain galaxias (126mm) and *lower* – Black Hill Springs pool with underwater photo of a river blackfish (ML02-06A)

Table 4.10.1. Sampling locations in the Marne River Catchment.

Site Code	Date	Waterway	Location	Habitat type
ML02-05	25/02/2002	Marne River/River Murray	Marne Mouth & wetland	Wetland
ML04-139	05/05/2004	Marne River	Black Hill Springs (c)	Swamp
ML02-06A	25/02/2002	Marne River	Black Hill Springs (b)	Stream
ML04-140M	05/05/2004	Marne River	Black Hill Springs (b)	Stream
ML04-138	05/05/2004	Marne River	Black Hill Springs (a)	Spring pool
ML02-33	16/03/2002	Marne River	Spring tributary to main channel	Spring pool
ML02-08*	25/02/2002	Marne River	Christian Reserve	Stream
ML02-07	26/02/2002	Marne River	Behind turf farm	Stream
ML02-28A	26/02/2002	Marne River	Marne Gorge ds Gauging Station	Stream
ML04-136M	05/05/2004	Marne River	Marne Gorge, ds Gauging station	Stream
ML04-137	05/05/2004	Marne River	Gauging Station, Marne Gorge	Stream
ML02-158A	16/05/2002	Marne River	off Jutland Road	Stream
ML04-133M	04/05/2004	Marne River	ds Jutland Road	Stream
ML02-15	07/03/2002	Marne River	above and below Jutland Road ford	Stream
ML02-16	08/03/2002	Marne River	Rhine Water Reserve	Stream
ML02-13A	07/03/2002	Marne River	off Vigars Road, ds creek junction	Stream
ML04-134M	04/05/2004	Marne River	Creek Junction, off Vigars Road	Stream
ML02-21	10/03/2002	Marne River	Moss Smith Road	Stream
ML02-12	07/03/2002	Marne River Trib.	Shearers Road	Stream
ML02-14	07/03/2002	Marne River Trib.	Boehm Springs Road	Stream
ML02-17	08/03/2002	North Rhine River	M. Wrights Road	Stream
ML02-18	08/03/2002	North Rhine River	Sedan Road	Stream
ML02-19	08/03/2002	North Rhine River	Water Reserve 'Netherford'	Stream
ML02-20	10/03/2002	North Rhine River	Ford north of Keyneton	Stream
ML02-22	08/03/2002	North Rhine River	us Pine Hut Road	Stream

* Dry upon inspection in autumn 2004

A – represents the same site sampled on a preceding occasion (temporal comparison),

M – ongoing monitoring sites for threatened fish species.

a and **b** (small caps) – paired sites located in close proximity.

Black Hill Springs pool in flood during August 2004 - receiving a short burst of low conductivity water

Table 4.10.2. Fish species and relative abundance recorded for the Marne River Catchment.

Site Code	Pouched lamprey	Bony herring	Australian smelt	Common galaxias	Mountain galaxias	Murray hardyhead	Unspecked hardyhead	Murray rainbowfish	Chanda perch	Murray-Darling golden perch	River blackfish	Silver perch	Congolli	Carp gudgeon spp.*	Purple-spotted-gudgeon	Flathead gudgeon	Dwarf flathead gudgeon	Rainbow trout	Brown trout	Goldfish	Carp	Tench	Gambusia	Redfin	Species richness	Number exotic
ML02-05		2	1	X^{C}		X^{C}	2	8	X^{C}	X^{E}		X^{E}	X^{C}	112[1,2,3,5]		4	3			9	2	X^{E}	56		10	3
ML04-139			X^{C}		X^{B}						X^{C}		X^{C}	X^{B}			6			X^{C}	5		50		3	2
ML02-06A					9						21			6[1]			10				3		2		6	2
ML04-140M					P						10			P			P				P		5		6	2
ML04-138					3						8			20[1]			11				P		10		6	2
ML02-33					X^{B}						X^{B}			210[1]							X^{A}		1970	X^{B}	2	1
ML02-08					X^{C}						X^{C}			X^{C}			X^{C}	X^{C}					X^{C}		0	0
ML02-07					X^{B}																X^{B}				0	0
ML02-28A					25																				1	0
ML04-136M					X^{A}																				0	0
ML04-137					3																				1	0
ML02-158A					26																				1	0
ML04-133M					53																				1	0
ML02-15					2													X^{B}						X^{A}	1	0
ML02-16					15																				1	0
ML02-13A					20																				1	0
ML02-21					2																				1	0
ML04-134M					19																				1	0
ML02-12																									0	0
ML02-14																									0	0
ML02-17																									0	0
ML02-18																									0	0
ML02-19																									0	0
ML02-20																									0	0
ML02-22																									0	0

X: recoded historically but not sampled in the current survey, **P**: recently sampled/report of presence.
Historical records: **A** (2000-2002), **B** (1990-1999), **C** (1980-1989), **D** (1960-1979), **E** (1930-1959), **F** (<1930).
***Carp gudgeon species and hybrid forms detected:**
[1] Murray-Darling (MD), [2] Midgely's (Midg), [3] MD x Midg, [4] MD x species X, [5] Midg x species X

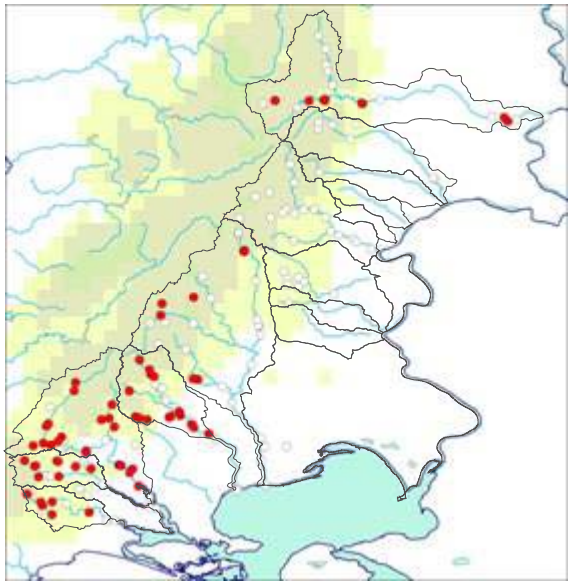
5.0 Species summary

This section provides an overall summary of the range, distribution and remaining habitats occupied by species, perceived environmental requirements, ecological notes, and details of species decline. Some of these aspects have been addressed in the regional summary, particularly regarding current and historic distribution. Future analysis of spatial data (species composition and environmental descriptors) should ideally involve detection of patterns using statistical methods such as ordination to support the general observations made below (e.g. Hammer 2001).

For the purpose of further discussion, species are grouped based on occupancy of specific EMLR broad habitat types and summation of their life history mode. Streams, as the core habitat type under investigation, are the foundation of two categories: fish that complete their lifecycle in stream environments (i.e. stream species – wholly freshwater) and another group that migrate into EMLR streams (i.e. stream species – diadromous). Some larger, wholly freshwater native species overlap between EMLR stream habitat and river or open water habitat of the lower Murray Region (i.e. larger river species) and a group of smaller native taxa were recorded in interconnected wetlands at the terminus of EMLR stream habitat (i.e. wetland species). There is naturally some overlap in these categories. Patterns for sites with *no fish, translocated native species* and *exotic fish* are also discussed. Small distribution maps are provided for selected species (see Figure 2 for catchment details) and red dots in distribution maps represent positive sites unless noted otherwise.

5.1 Stream species (wholly freshwater)

Mountain galaxias: have a wide range but a disjunct distribution including the five catchments draining into Lake Alexandrina plus the Marne River Catchment. Within this distribution the species was commonly recorded (69 sites) and occurred above natural barriers in mid catchment and headwater areas, with only small populations detected in lowland areas in the lower Finniss and Marne Rivers. Specific habitat types included intermittent stream pools, spring fed sections (larger pools and riffles), swamps and the occasional instream dam. The species was often recorded in moderate to high abundance where present, but showed variation even at proximate sites.



Small to medium stream pools in series, with near year-round flow and at higher elevations (wetter areas) was suitable mountain galaxias habitat. However, habitat conditions at recorded sites were overall highly variable, ranging from tiny streams (e.g. Mcharg Creek: ML04-28) to large, deep lowland pools (e.g. Black Hill Springs & lower Angas River). About half the sites where the species occurred experienced some sort of vertical connectivity to groundwater sources (i.e. flow or pools maintained by groundwater) and nearly all locations where the species was common or abundant (abundance >20) had flow prior to the onset of seasonal rains (i.e. spring fed pool or local base flow). Most sites were also well shaded (>30% canopy) and both flow and shade are likely to be important components in maintaining cool required habitat over summer. Positive sites usually had reasonable instream physical cover contributions, but seldom was there submerged aquatic vegetation at sites nor did emergent vegetation contribute significant amounts of instream cover (e.g. Table 5.1.1). Collection sites had autumn water conductivities ranging from 140-9660µS.

Autumn length measurements were collected for a total of 408 mountain galaxias with fish ranging between 36 and 126mm TL (equal largest individuals were located at sites ML04-07 on Currency Creek and ML02-13A on the Marne River). The species appears to spawn in winter or early spring based on opportunistic observations of breeding condition: ripe male and female fish were detected on 6/6/04 from the lower Angas River (ML04-143), running ripe male fish (4/5/04) from the upper Marne (ML04-134M) and running ripe male and female fish (16/5/02) from the mid Marne (ML02-158A).

Supplementary winter 2004 observations of the Finniss River in flood (at ML04-16) identified that mountain galaxias are active (or are moved) during flooding as they were located in freshly flooded habitat (on a road!). A local report at the same site also indicated that fish matching the description of mountain galaxias migrated over the culvert when a small flow of water was trickling over the ford in early winter 2003. A migratory nature, or local mobility, is consistent with the species being able to occupy variable stream environments (e.g. recolonisation).

Mountain galaxias were often the only species sampled at a stream site (29 of the 69 sites where the species was sampled). Otherwise they commonly occurred with southern pygmy perch, carp gudgeon and river blackfish but had an anti-distribution with respect to introduced predators. At stream sites where introduced predators (rainbow and brown trout, redfin: see 5.7) were captured or known to occur, mountain galaxias were either absent from otherwise suitable habitat or occurred in pools free from introduced predators (see Table 5.7.2). At micro-habitat scales mountain galaxias often occurred in tiny sub-sets of habitat such as:

- a small pool in a riffle section between larger deeper pools occupied by brown trout and redfin (ML04-36 - Finniss River);
- in a shallow sub-section of a pool, with a brown trout in the deeper more permanent section (ML03-51A - mid-Finniss River);
- above a barrier (road culvert) with brown trout below (ML04-47 - Finniss Creek);
- a tiny rock pool with four mountain galaxias within a series of large pools occupied by brown trout (ML03-44 - Blackfellows Creek);
- small shallow pools otherwise unsuitable for adult trout or redfin (e.g. ML04-40 on Bull Creek, ML04-35 on Meadows Creek).

There was a clear displacement of mountain galaxias by trout at microhabitat scales, however, in two instances they co-existed in reasonable numbers at the broader site. Mountain galaxias showed resistance to the effects of trout at sites with permanent flow (i.e. availability of quality shallow habitats), combined with low trout numbers, on the upper Angas River (ML04-57) and a site on Bull Creek (ML04-41). Mountain galaxias were found to recolonise a small pool on Dawson Creek (ML99-01A) following the removal of a rainbow trout (see temporal site data in Table 4.5.1).

The overall distribution and abundance of mountain galaxias has likely been reduced considerably from historic levels given changes to the flow regimes (i.e. heavy abstraction and reduced pool availability) and the introduction of large predatory species. There is evidence for recent declines where pools have dried in the Angas, Bremer and Marne catchments and broader loss of habitat with the pollution of Dawesley Creek (historic record for prior to the 1930's: Table 3.2.1).

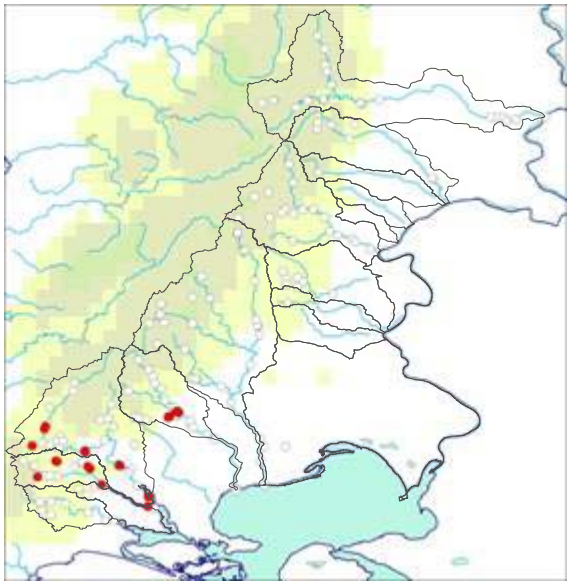
There is currently confusion surrounding the taxonomy of mountain galaxias (Raadik 2001). Locally, the species displays visible variation in colour pattern between different catchments which provides an indication of potentially genetically distinct populations (e.g. as shown for southern pygmy perch: Hammer 2001) or even different species. Tookayerta Creek mountain galaxias are particularly distinct as a yellow spotted form contrasting to variable greyer forms elsewhere (see pictures pg. 49). This important aspect of local biodiversity will be investigated in the near future as part of molecular genetic investigations into the mountain galaxias species complex as a collaborative project lead by T. Raadik (Arthur Rylah Institute, Melbourne) and involving the South Australian Museum.

Table 5.1.1. Environmental conditions at mountain galaxias sites (abundance >20). * spring fed

Site Code	Abundance	River System	Habitat	Depth max (m)	Connectivity	Flow	Subsurface physical %	Subsurface biological %	Emergent %	Shade %	Conductivity (µS)
ML04-62Ma	22	Angas River	Stream	0.5	Annual connection	None	30	2	20	60	3050
ML01-10A	23	Bremer River	Stream	1.5	Medium connection (6mo)	Low	30	0	10	80	-
ML02-159A	23	Bremer River	Stream	0.6	Medium connection (6mo)	None	30	0	20	50	6880
ML04-19	25	Currency Creek	Stream	0.8	Medium connection (6mo)*	Low	20	0	10	20	1040
ML02-28A	25	Marne River	Stream	1.5	Annual connection	None	20	10	0	40	4600
ML03-53A	26	Finniss River	Stream	1.5	Medium connection (6mo)*	Low	30	10	20	60	2000
ML02-158A	26	Marne River	Stream	1.0	Medium connection (6mo)	None	20	0	30	10	3470
ML04-57	30	Angas River	Stream	1.0	Permanent connection*	Medium	30	10	20	40	1700
ML04-72a	30	Angas River	Stream	1.0	High Connection (9 mo)*	Low	30	5	2	10	9660
ML02-172	30	Tookayerta Creek	Stream	1.2	Permanent connection*	Medium	30	10	30	80	270
ML04-03	37	Currency Creek	Stream	1.6	Medium connection (6mo)	None	20	0	30	60	690
ML04-58M	40	Angas River	Stream	1.6	High Connection (9 mo)	Low	10	2	50	60	1800
ML02-160A	40	Bremer River	Stream	1.2	High Connection (9 mo)	Medium	20	10	30	20	1370
ML02-11A	40	Finniss River	Stream	1.0+	Medium connection (6mo)	Low	40	0	0	60	2600
ML04-55b	50	Tookayerta Creek	Stream	0.6	Permanent connection*	Low	30	0	10	80	300
ML04-133M	53	Marne River	Stream	1.0	Medium connection (6mo)	None	30	0	20	60	4970
ML04-59	60	Angas River	Stream	1.5	Permanent connection	Medium	20	10	30	50	1890
ML02-170	60	Finniss River	Stream	0.5	Medium connection (6mo)	None	20	0	10	30	4110
ML04-07	75	Currency Creek	Stream	2.0	High Connection (9 mo)	Low	40	10	5	60	5080
ML04-69	80	Angas River	Stream	2.0	High Connection (9 mo)*	Low	30	10	30	70	1740
ML04-72b	100	Angas River	Stream	0.6	High Connection (9 mo)*	Low	30	20	10	60	8430
ML04-28	150	Finniss River	Stream	1.5	High Connection (9 mo)*	Seep	10	10	30	80	1000
ML04-32	150	Finniss River	Stream	1.2	High Connection (9 mo)*	Seep	5	50	15	30	4860
ML04-29M	216	Finniss River	Stream	2.0+	Permanent connection*	Low	20	10	20	80	1680
ML04-40	244	Finniss River	Stream	1.0	High Connection (9 mo)*	Low	40	10	20	80	1990
ML04-41	300	Finniss River	Stream	2.0	Permanent connection*	Low	15	5	10	80	1160
ML04-48	410	Finniss River	Instream dam	1.5	Permanent connection*	Low	2	0	5	5	850

The two main **forms of mountain galaxias** in the Eastern Mount Lofty Ranges – *left* a speckled (often yellow) form inhabiting the Tookayerta Catchment (also a similar grey speckled form in the Finniss) and a variable marbled form that occurs in the Currency, Angas, Bremer and Marne (*shown below*) catchments.

Southern pygmy perch: the current Inventory confirms the restricted range and distribution of this species in the EMLR: patchy areas of three southern catchments, Tookayerta Creek Finniss River and Angas River, as well as fringes of Lake Alexandrina, that represent the spatial boundaries of four distinct genetic sub-populations (Hammer 2001). Most positive locations were monitoring sites from previously identified pygmy perch habitat, however broader sampling located the species from a new section of the Finniss River catchment in the swampy Finniss Creek (ML04-48) and also upper Tookayerta Creek (ML04-56). Specific habitat types included intermittent stream pools, spring fed pools, swamps and one instream dam. Was found to be locally abundant at some sites.



The distribution of southern pygmy perch in some of the catchments is highly restricted especially in the Angas. The number of sites identified (20) is an over reflection of their distribution as many of these were in close proximity (e.g. ML04-67, 68M &71; ML04-62Ma & 62Mb; ML04-30M & 31M; ML04-24M & 27M). Close sites were located in areas with diversity in local habitat and hydrology indicating some variation in remaining habitat which shows distinct characteristics in different catchments (Hammer 2001).

Remaining stream habitat generally consisted of small, shallower and often well-shaded pools, commonly with spring feeding and usually high levels of submerged cover (algae, rocks, snags, emergent vegetation and occasionally submerged aquatic plants), however, they were also found in some larger pools that lacked introduced predators (e.g. ML04-42M & 56) (Table 5.1.2). The species appears to make use of emergent vegetation (especially overhanging grasses), with juveniles commonly found here. Edge vegetation also appears to be important during high flows as the species has been noted to move out of flow and shelter in this cover (Hammer 2001). Hence stream side riparian buffers can be important, and perhaps not co-incidentally most sites where southern pygmy perch were caught had high levels of edge vegetation (often fenced) that would be immersed in winter.

Over 650 southern pygmy perch were measured in autumn 2004. The largest individual was 68mm TL from Tookayerta Creek (fish over 70mm are rare in EMLR streams) and 90% of fish were between 20-50mm TL. There appeared to be flexibility in spawning season under different environmental conditions, with small juveniles (15-20mm) collected in March from Tookayerta Creek (ML04-21M) – at most other locations juvenile fish were much larger by this stage (30-40mm TL).

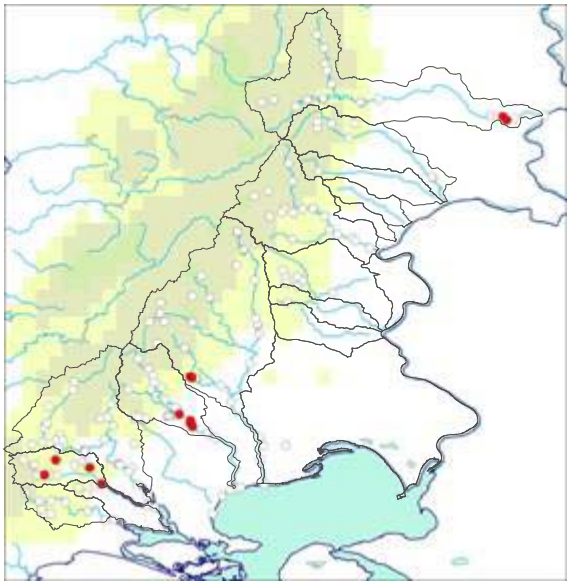
At stream sites southern pygmy perch was often recorded with mountain galaxias and occasionally with carp gudgeons, river blackfish and Gambusia (occurred with a range of species in wetland habitats). The species had a mostly complementary distribution with respect to large introduced predators (see 5.2) and there was evidence that southern pygmy perch were forced to more marginal habitats of smaller and shallower pools (more likely to dry) when larger pools (longer-term refuges) were occupied by such species (e.g. Dawson Creek, ML99-01A; Meadows Creek, ML04-35; mid Finniss River, ML03-51A & ML04-27M).

Decline has been most noticeable in the Angas River Catchment in Dawson Creek (see 4.5), and historically the species was almost certainly located in other intervening habitat occurring between or near currently isolated population fragments (e.g. more extensive populations in Meadows Creek, Finniss River, Angas River, Middle Creek).

Table 5.1.2. Environmental conditions at southern pygmy perch sites. * spring fed

Site Code	Date	Abundance	River System	Habitat type	Depth max (m)	Connectivity	Subsurface physical %	Subsurface biological %	Emergent %	Edge vegetation %	Shade %	Conductivity
ML04-62Ma	31/03/2004	1	Angas River	Stream	0.5	Annual connection	30	2	20	60	60	3050
ML04-62Mb	31/03/2004	1	Angas River	Stream	1.2	Annual connection	5	0	30	30	40	-
ML04-67	01/04/2004	4	Angas River	Stream	1.1	Medium connection (6mo)	20	0	0	10	30	3750
ML04-68M	01/04/2004	8	Angas River	Stream	1.5	Medium connection (6mo)*	5	70	15	80	10	6810
ML04-70	05/04/2004	1	Angas River	Stream	2.0	Medium connection (6mo)	30	2	30	80	10	3660
ML04-71	06/04/2004	7	Angas River	Stream	2.0	Medium connection (6mo)	30	5	20	20	40	4120
ML03-51A	07/04/2003	117	Finniss River	Stream	0.5	Medium connection (6mo)	30	10	0	30	40	2330
ML03-53A	07/04/2003	101	Finniss River	Stream	1.5	Medium connection (6mo)*	30	10	20	40	60	2000
ML04-24M	17/05/2004	113	Finniss River	Stream	0.8	Medium connection (6mo)	15	15	0	60	60	1820
ML04-27M	17/03/2004	3	Finniss River	Stream	2.0+	Medium connection (6mo)	30	10	10	60	50	1650
ML04-30M	19/03/2004	94	Finniss River	Stream	1.2	Medium connection (6mo)*	30	20	10	60	80	1870
ML04-31M	19/03/2004	150	Finniss River	Stream	0.6	Permanent connection*	30	40	10	80	60	1860
ML04-34M	21/03/2004	111	Finniss River	Stream	0.8	High Connection (9 mo)*	40	30	10	80	80	2690
ML04-35	21/03/2004	4	Finniss River	Stream	1.2	High Connection (9 mo)	20	20	15	80	80	4050
ML04-45	25/03/2004	3	Finniss River	R.Channel	2.0+	Permanent connection	2	60	20	20	0	3010
ML04-48	27/03/2004	380	Finniss River	Instream dam	1.5	Permanent connection*	2	0	5	10	5	850
ML02-172	17/05/2002	35	Tookayerta Creek	Stream	1.2	Permanent connection*	30	10	30	10	80	270
ML04-21M	11/03/2004	80	Tookayerta Creek	Stream	2.0	Permanent connection*	5	5	30	90	10	590
ML04-42M	24/03/2004	37	Tookayerta Creek	Instream dam	2.0	Medium connection (6mo)	2	0	5	75	10	900
ML04-50M	27/03/2004	16	Tookayerta Creek	Stream	1.2	Permanent connection*	10	10	20	10	80	350
ML04-52	30/03/2004	94	Tookayerta Creek	Drain	1.2	Permanent connection*	10	10	30	80	10	580
ML04-54M	30/03/2004	4	Tookayerta Creek	Swamp	0.2	Permanent connection*	5	0	90	100	50	590
ML04-56	30/03/2004	40	Tookayerta Creek	Swamp	2.0	Permanent connection*	10	5	30	60	0	320

Distinct genetic sub-populations of southern pygmy perch (*inset*) occur in the EMLR in contrasting habitat in three different catchments: *left* - rocky habitat in the Finniss, *centre* – Tookayerta swamp habitat and *right* – pool habitat on the mid-Angas River



River blackfish: current range includes a thin band encompassing lowland habitats in three southern tributaries (Tookayerta, Angas, Bremer) plus the Marne River, however, distribution is highly restricted to small pockets of habitat. The populations in the Marne and Bremer River catchments in-particular are small and isolated. In the Marne River, available spring fed pools are now limited to an approximate 1.5km of stream, and aerial videography and on ground investigation indicates that there are no pools upstream and only a few possible pools downstream of the Rodwell Creek population that might be suitable (currently known from 2 pools <0.5km of stream). Even the other two catchments do not offer huge areas; the section of the Angas River offering deep permanent pools stretches for about 5km downstream of Strathalbyn and the Tookayerta Creek Catchment is overall quite small, where river blackfish distribution is likely patchily distributed along ~20km of stream/swamp. Abundances at sites were generally moderate to low, with the exception of ML04-64 on the Angas River.

Remaining habitat recorded for the species was quite distinct, constituting medium to large pools that were deep (>1.0m), that often had good instream cover and always well developed emergent structure (usually large sections of *Typha* on vertical or undercut banks). The unique environmental conditions of the Tookayerta Creek offered a slightly different subset of habitat parameters that included permanent flowing swamp sections.

River blackfish habitat nearly always experienced spring feeding that maintained cool (< 20ºC), deep pools over summer. Many had permanent flow as a result of springs and these seemed to be the main factor in maintaining suitable habitat, especially in warm areas with unreliable stream flow (increasingly so in the Marne River and Rodwell Creek). Autumn salinity levels at blackfish sites ranged from fresh in the Tookayerta Catchment (270-590µS) to reasonably saline elsewhere (4300-8890µS). They were recorded at a range of pH values (6.27-8.96).

Table 5.1.3. Environmental conditions at river blackfish sites. * Spring fed

Site Code	Date	Abundance	River System	Habitat	Depth max (m)	Connectivity	Subsurface physical %	Subsurface biological %	Emergent %	Transparency (m)	Conductivity (µS)
ML01-51	11/02/01	4	Angas River	Stream	1.5	High Connection (9 mo)	30	0	30	0.4	-
ML99-06	21/02/99	3	Angas River	Stream	4.0	High Connection (9 mo)*	30	2	20	1.2	-
ML04-64	31/03/04	62	Angas River	Stream	1.5	High Connection (9 mo)*	20	20	30	0.4	6600
ML99-07	21/04/99	17	Angas River	Stream	3.0	Permanent connection*	20	20	20	1.5	-
ML04-83a	09/04/04	7	Bremer River	Stream	2.0	Medium connection (6mo)*	20	0	30	0.5	6820
ML04-82	09/04/04	17	Bremer River	Stream	1.5	Medium connection (6mo)*	20	30	20	0.3	4300
ML04-140M	05/05/04	10	Marne River	Stream	1.2	Permanent connection*	5	5	30	1	5150
ML04-138	05/05/04	8	Marne River	Spring pool	3.0+	Irregular connection*	20	0	10	1	8890
ML04-21M	11/03/04	1	Tookayerta Creek	Stream	2.0	Permanent connection*	5	5	30	0.5	590
ML04-26a	17/03/04	5	Tookayerta Creek	Stream	2.0	Permanent connection*	10	50	20	0.8	330
ML04-52	30/03/04	1	Tookayerta Creek	Drain	1.2	Permanent connection*	10	10	30	0.8	580
ML02-172	17/05/02	20	Tookayerta Creek	Stream	1.2	Permanent connection*	30	10	30	0.5	270

Autumn length data was collected for 104 river blackfish, with fish ranging from a 46mm TL juvenile (Tookayerta Creek) to a 323mm TL large adult from the Marne River. Lloyd (1987) studied a population on Dawesley Creek and found that spawning occurred during November and that their diet included aquatic insects, macrocrustaceans (e.g. shrimp, yabbies) and small fish.

Water transparency at river blackfish sites was often high allowing opportunistic observations of their behaviour (at night by torch from the bank or while snorkelling). For example at site ML04-50M on Nangkita Creek, juvenile fish (40-60mm) were observed foraging in shallows just before dusk, but were not seen later in the night when larger adult fish were foraging. On the Angas River (ML99-07) snorkelling provided insight into habitat use where fish were evenly spaced on a silt bank below emergent *Typha.* Similarly, at a small clear pool on the Marne (ML02-06A) fish were observed to shelter in undercut banks within *Typha* stems and roots and emerge to forage mostly on the substrate, but throughout the water column at times to chase and prey on mobile invertebrates such as *Micronecta.*

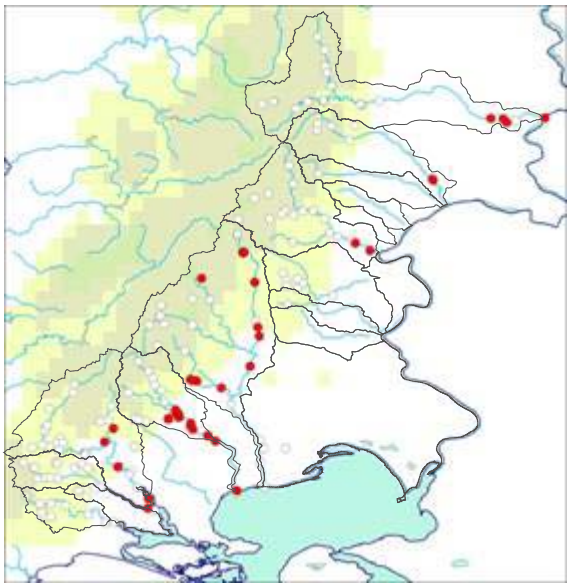
River blackfish often occurred with carp gudgeons and mountain galaxias, occasionally with dwarf flathead gudgeon and southern pygmy perch (no other native species) and was rarely with introduced species, although Gambusia was recorded at several blackfish sites.

There is sufficient information to show a significant documented decline for river blackfish in the EMLR at varying scales from a broad reduction in historic range to more recent continuing contraction. River blackfish could not be located in the Finniss River Catchment, where it was wide spread historically (e.g. Meadows and Bull Creeks, mid Finniss and lowland pools: see section 4.4; Appendix 3). The species also now appears to be absent from significant portions of the Bremer River Catchment such as Mt Barker Creek, Dawesley Creek, the Upper and Mid Bremer and historically large permanent pools near Langhorne Creek (Table 3.2.1; Appendix 3). Anecdotal evidence suggests a broad decline in range and abundance during the 1950's, when it appears to have disappeared from many of the localities previously known. It is notable that this decline coincided with the common and wide spread use of DDT on pastures in agricultural districts (Appendix 3), but undoubtedly other significant habitat changes were occurring as a result of landuse (clearing and stock) and water pumping.

More recently declines have been noted in several areas. In the early 1980's Lance Lloyd conducted a specific study of a healthy population in a section of Dawson Creek in the Angas River Catchment, estimating the population to contain around 220 fish of varying sizes (Lloyd 1987). This population had disappeared by the late 1990's (Hicks 1997; site ML00-01) as springs in the creek dried up (tench also became established). Similarly, in the Black Hill Springs section of the Marne River, permanent pool contraction and the concomitant loss of river blackfish habitat has progressed steadily upstream and downstream of the remaining pools since 1997 as spring feeding declines (Section 4.10). Habitat loss has almost certainly occurred in the last two years in Rodwell Creek as previously deep pools in close proximity to those where blackfish were recorded in 2004 have dried for the first time in living memory.

River blackfish – large adult (295mm) from the Black Hill Springs on the Marne and juvenile (65mm) from the Tookayerta Creek Catchment

Carp gudgeons: the carp gudgeon species complex (Bertozzi *et al.* 2000; Hammer and Butler 2001) has historically caused considerable confusion for species lists of the region. The current Inventory benefited from identification experience as part of the SA Museum's genetic studies into the group. Two species were positively identified: the Murray-Darling carp gudgeon and Midgley's carp gudgeon, as well as a variety of F1 hybrid forms. The western carp gudgeon was not found in the region. The hybrid forms often occurred in the absence of one of the parental species, and hence it is suspected that there are unisexual forms occurring (i.e. clonal populations). Accordingly the EMLR appears to have local, national and international significance for the study of unisexual vertebrates.



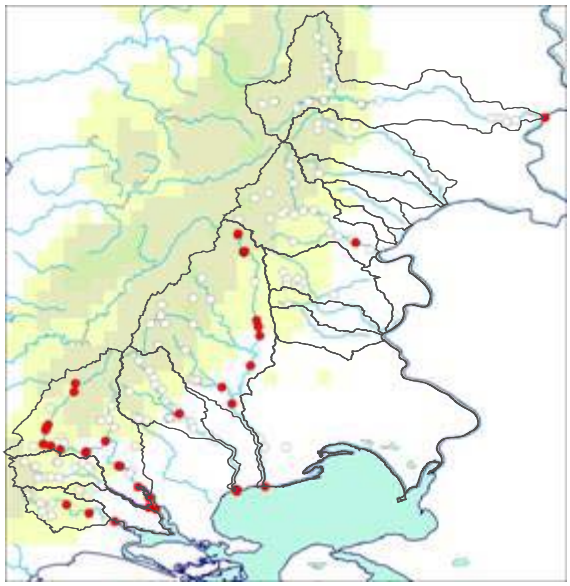
Distinct patterns of species and hybrid forms were recorded in different catchments and habitat types (see Section 4). Midgely's carp gudgeon (and the Midg x sp X form) was restricted to wetland habitat at the junction of the Marne and Murray rivers and lower Reedy Creek. The Murray-Darling carp gudgeon and its hybrid forms (MD x Midg, MD x sp. X) (referred to as Murray-Darling type carp gudgeon hereafter) were found in a range of stream and wetland habitats in the lower to middle reaches of streams, including isolated pockets in spring pools (e.g. Marne River & Saunders Creek), small tributaries (e.g. Bull Creek, Finniss Catchment), an instream dam (Dawson Creek), stable lowland pools (e.g. Angas River & Bremer River) and small pools with highly fluctuating conditions (e.g. Middle Creek, Angas Catchment). Habitat and water quality was subsequently highly varied (e.g. 900 to over 10,000µS) but interestingly often constituted only low to medium levels of submerged and emergent cover (i.e. 20-30%). Underwater observations in the Angas River indicated that at night they were distributed throughout the water column. Murray-Darling type carp gudgeon were found concentrated below a small cement ford on the Bremer River above Harrogate during winter flows (ML01-11A) suggesting they might be migratory at least at local scales.

Murray-Darling type carp gudgeon were often in high abundance with a range of other species, though seldom were they in high abundance at the same sites that large introduced predators or Gambusia occurred. The largest individuals were located at site ML04-128: two 68mm TL males and a 69mm TL female fish (general size range was 20-50mm TL).

Given the taxonomic confusion, little is known of the historic distribution of different species and hybrid forms, with a more in-depth morphological revision of museum specimens required, although there are only a few specimens. Lloyd and Walker (1986) listed the western carp gudgeon for several sites, however it is likely the same species from the current survey were detected and not the true western carp gudgeon *Hypseleotris klunzingeri* s.s. There are indications of some localised declines for 'carp gudgeons' in the Bremer and Angas catchments due to recent pool drying over summer.

Carp gudgeons - male hybrid (MD x Midg) (*top*) and female (MD) from the Angas River

Flathead gudgeon: occupied a wide range across the survey area in a band along the terminal end of major catchments and occurring considerable distances upstream in the Finniss, Currency and Bremer catchments and to a lesser degree (only two individuals captured upstream) in the Angas River. Was often recorded in high abundance and preferred pool and wetland areas that offered a base of physical instream structure (~20-30% rock and snags) or significant vertical structure from undercut banks. This microhabitat type encompassed a range of pool conditions (stable, flowing and highly fluctuating areas), pool size and water quality (e.g. 300->12,000µS, cool waters of the Finniss to warmer habitat of the Bremer).

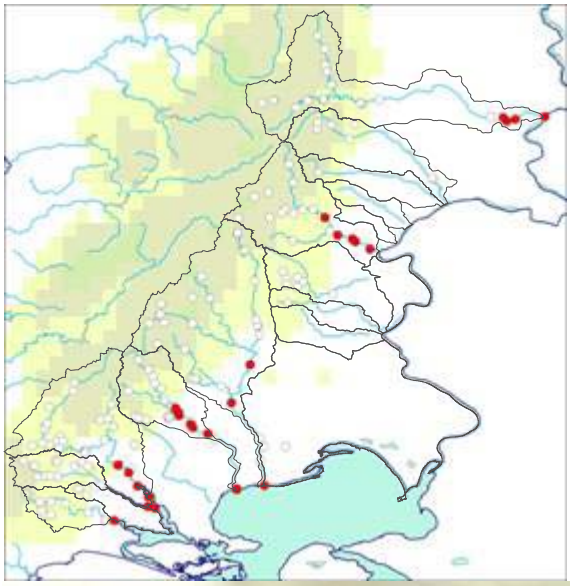


The largest size record was 111mm TL from the Bremer and Currency Creek Catchments. The species occurred with a range of other species, but interestingly never in the same habitat as river blackfish (i.e. cool spring fed areas). Flathead gudgeon were present and on occasions common at sites with introduced predators, perhaps due to thier benthic nature (they did still appear in the stomach content of introduced predators however: Table 5.7.3).

Historic distribution likely remains similar, and given broad environmental tolerance (e.g. salinity) may have actually increased its distribution in some areas following environmental degradation (e.g. upper Bremer River).

Dwarf flathead gudgeon: has a wide range in the region, however distribution is patchy (25 sites). The species was normally in low abundance but was occasionally locally common (Table 5.1.4). It was present in most terminal wetland areas and upstream along main river stems including above some natural barriers on the Finniss, Angas, Bremer, Reedy and Marne. The population in Reedy Creek in-particular is isolated above a series of significant waterfalls.

Occurred in areas with larger more permanent pools, and these usually showed minimal summer concentration (i.e. stable water level) – river channel/wetland habitats as well as spring pools and larger mainstream pools. Habitat had high submerged cover (usually >30%) and the species was often netted from within thick vegetation (wetland areas) or from within structure such as rocks, snags or under bark (streams). The species was found across a very wide range of autumn water conductivities from 900µS up to extremely high levels in Reedy Creek (33,000µS at the main survey pool of ML04-76, other small individuals were found in a nearby pool with a reading of 42,000µS: ~80% of seawater!).



Male dwarf flathead gudgeon from mid-Reedy Creek (ML04-125)

The largest fish measured in sampling was 58mm TL (a ripe female from the Marne River springs) and large individuals (>50mm) were common at ML04-125 on Reedy Creek and other sites on the lower reaches of streams. A 65mm TL adult male was collected close to ML04-45 on the lower Finniss River in supplementary sampling (lodged at SAMA).

Dwarf flathead gudgeon co-occurred with most other species, and were commonly recorded with dwarf flathead gudgeon included carp gudgeons, flathead gudgeon, carp and Gambusia (16-19 matching sites). A presence at one site was confirmed via stomach content analysis of redfin (ML99-08A). The isolation of some populations combined with varied and unusual habitat (e.g. saline pools on Reedy Creek) provides a good incentive for future genetic research to define variation between different local and national populations.

Table 5.1.4. Environmental conditions at dwarf flathead gudgeon sites. * Spring fed

Site Code	Date	Abundance	River System	Habitat type	Depth max (m)	Connectivity	Subsurface physical %	Subsurface biological %	Emergent %	Conductivity (µS)
ML04-144	06/06/04	23	Angas River	River Channel	1.5	Irregular connection	2	80	10	2370
ML04-143	06/06/04	3	Angas River	Stream	2.0	High Connection (9 mo)	20	0	30	6210
ML04-111	27/04/04	4	Bremer River	Stream	3.0	Medium connection (6mo)	20	0	10	4190
ML04-112	28/04/04	7	Bremer River	Stream	1.0	Medium connection (6mo)	30	2	10	8030
ML04-138	05/05/04	11	Marne River	Spring pool	3.0+	Irregular connection*	20	0	10	8890
ML04-139	05/05/04	6	Marne River	Stream	1.0	Irregular connection*	10	0	20	5740
ML04-141	22/05/04	1	Reedy Creek	Wetland	0.8	Permanent connection	5	0	20	1140
ML04-125	02/05/04	143	Reedy Creek	Stream	1.5	Annual connection*	10	50	5	14080
ML04-124	02/05/04	2	Reedy Creek	Stream	1.0	Annual connection	30	10	0	18270
ML04-127	03/05/04	5	Reedy Creek	Stream	0.6	Annual connection	30	0	0	12300
ML04-123M	30/04/04	1	Tookayerta Creek	Wetland	1.5	Permanent connection	10	70	10	2540
ML04-42M	24/03/04	4	Tookayerta Creek	Instream dam	2.0	Medium connection (6mo)	2	0	5	900
ML04-43	24/03/04	10	Finniss River	Stream	1.5	High Connection (9 mo)*	30	2	10	1840
ML04-44	24/03/04	70	Finniss River	Stream	1.5	High Connection (9 mo)*	20	10	20	3000
ML04-45	25/03/04	50	Finniss River	River Channel	2.0+	Permanent connection	2	60	20	3010
ML04-64	31/03/04	5	Angas River	Stream	1.5	High Connection (9 mo)*	20	20	30	6600
ML04-70	05/04/04	1	Angas River	Stream	2.0	Medium connection (6mo)	30	2	30	3660
ML04-76	29/04/04	31	Reedy Creek	Stream	0.6	Annual connection	30	10	20	33000
ML99-05	07/05/99	17	Angas River	Stream	2.0	Medium connection (6mo)	30	0	10	-
ML99-07	21/04/99	5	Angas River	Stream	3.0	Permanent connection*	20	20	20	-
ML99-08A	17/05/99	1	Angas River	Stream	2.0	High Connection (9 mo)	20	0	30	-
ML99-10A	25/03/99	1	Angas River	River Channel	1.5	Irregular connection	5	65	15	-
ML04-01a	24/02/04	6	Currency Creek	Stream	2.0	High Connection (9 mo)	40	5	5	5210
ML04-16	09/03/04	1	Finniss River	Stream	2.0	Medium connection (6mo)	40	0	2	2730
ML02-05	25/02/02	3	Marne River	Wetland	1.0	Permanent connection	10	50	5	780
ML02-06A	25/02/02	10	Marne River	Stream	1.3	Permanent connection*	10	2	60	5000
ML02-11A	02/03/02	5	Finniss River	Stream	1.0+	Medium connection (6mo)	40	0	0	2600
ML01-12	25/10/01	3	Angas River	Stream	1.5	High Connection (9 mo)	10	0	30	-

5.2 Stream species (diadromous)

Congolli: limited to a few terminal wetlands and lowland stream sites in the Finniss and Bremer rivers (seven sites). A generally rare catch and only recorded in higher numbers (n = 8) at site ML04-43 on the lower Finniss.

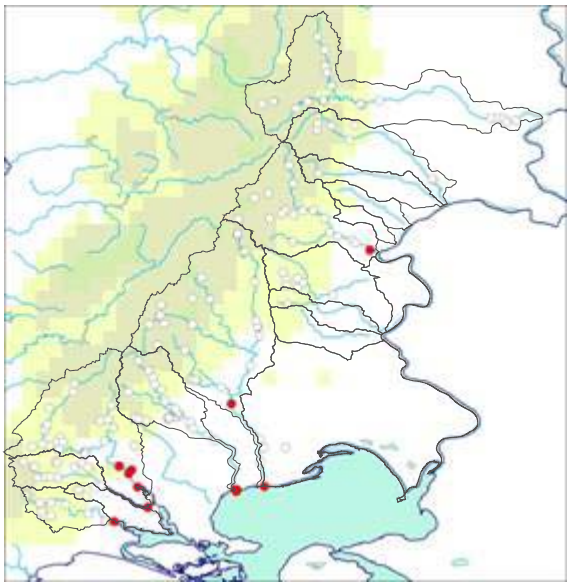
The few fish captured in streams were all larger individuals (182-261mm TL). In the Bremer River large congolli are reported as 'riding at the front of the wave' of the first waters that flow downstream in the lowland channel toward Lake Alexandrina near the township of Langhorne Creek (Appendix 3).

Previously recorded from the Marne Mouth wetland and up into the Black Hill Springs (Appendix 3). A few individuals also apparently negotiated the intermittent lowland channel of the Angas River historically, being caught as far up as Strathalbyn (Appendix 3), and they occurred further up the Bremer River (e.g. site ML04-83b on Rodwell Creek).

Little is known about the lifecycle of this species or the importance of stream habitat in the region for recruitment.

Congolli from the lower Finniss River being measured

Common galaxias: a common species in the Lower Lakes and to a lesser degree the lower section of the River Murray. This species occurs at stream termini and penetrates small distances upstream in well connected systems (e.g. Finniss River, Bremer River, Reedy Creek). Its upstream distribution was often marked by barriers such as waterfalls on the Finniss River and Currency Creek. In lowland stream habitat it occupied larger pools with reasonable cover (30-40%) and could often be observed in small schools feeding from the surface (e.g. Currency Creek Lions Park and upstream to the waterfall).



The largest individual captured measured 148mm TL (Finniss River). Formerly reported to occur in a reed-lined pool at the Marne Mouth wetland prior to it going dry (Appendix 3).

Climbing galaxias: this species is known only from a single specimen in the region, a large adult collected from Strathalbyn in 1914. There is very little suitable habitat for the species accessible in the EMLR due to natural migration barriers, however it probably occurred more commonly before construction of the Barrages and abstraction in stream catchments that would serve to reduce connectivity to lowland streams and hence larval migration upstream.

The historic record confirms a natural presence in the Murray-Darling Basin as fish in upstream areas of the Murray are believed to have been translocated via the Snowy River Hydroelectric Scheme (Waters *et al.* 2002). Climbing galaxias still remain on southern Fleurieu streams and migratory larvae might potentially find their way to the Murray Mouth and on to local streams.

Lampreys: the status of pouched and shorthead lamprey in the area remains little known as they are hard to detect owing to cryptic larval behaviour and short periods of movement. There are indications that they were once more common in the River Murray, detected at barriers (locks and weirs) during inland migrations (Scott *et al.* 1974), and presumedly this would translate to patterns of occurrence in the EMLR also (i.e. upstream migration of adults returning from the sea). A dead adult pouched lamprey (possibly post spawning) was captured from below the Finniss River waterfall in 2001 (SAMA F10095) and another individual of the same species from the lower Bremer River in 1978 (SAMA F4384). There is an historic record of a large (~70cm) lamprey taken from the Angas River at Strathalbyn in 1898 (Sim *et al*. 2000; Appendix 3) and the size is consistent with it also being a pouched lamprey (Potter 1996 refers to the size of adult shorthead lamprey returning to freshwater as 300-440mm and pouched as 500-700mm).

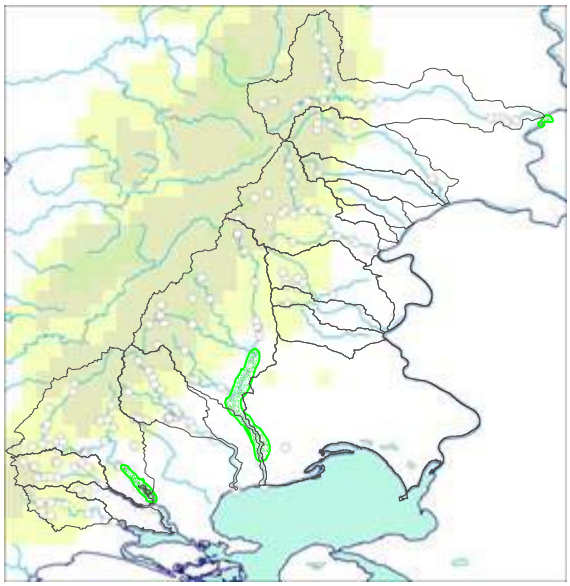
A targeted survey may reveal some information about the suitability of lower streams as habitat for ammocetes (larval lampreys that live in sediment) and hence whether EMLR streams are important for the conservation of these unique species (e.g. the flowing Black Hill Springs section of the Marne and Lower Finniss would appear ideal habitat for ammocetes).

Main: **Shorthead lamprey** captured from Hindmarsh Island, *insets* oral discs of shorthead lamprey (*left*) and pouched lamprey (*right*)

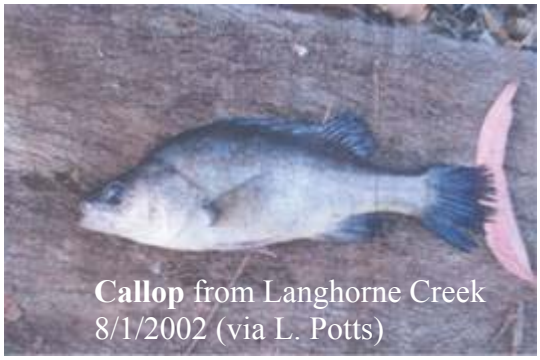
Shortfinned eel: a record from the Bremer River above Langhorne Creek (SAMA F6357, September 1988), with the occasional adult located in the lower Murray region. Its presence is probably a natural part of the species distribution as the westernmost area for occasional larval migration.

5.3 Larger river species

Murray cod: occurred within the Bremer River catchment historically in lowland habitat of large snag filled (red gum) pools within and upstream of the Langhorne Creek township (Sim *et al*. 2000; Appendix 3). Given the long time period of reports (1800's through to 1940's) and a reasonable area of available habitat, this population was possibly self-sustaining, however only larger fish (>5lbs) were recalled (i.e. memorable catches). Additional historic records from the Lower Finniss River (where it may still occur –see Section 4.4) likely formed part of a broader Murray population that may have benefited locally from stream habitat or flows. Similarly a healthy population was previously known just outside the mouth of the Marne Wetland: Appendix 3. Detailed surveys of historic habitat with larger gear types may detect any remnant fish.



Green shading = historic stream records



Callop from Langhorne Creek 8/1/2002 (via L. Potts)

Murray-Darling golden perch (callop): whilst the species was not collected a current and/or historic presence was confirmed by local reports and SAMA specimens from the lower Bremer, Finniss and Marne rivers (see Section 4; Appendix 3). Habitat extending upstream into streams currently includes larger snag filled pools on the Bremer and prior to significant loss of flows from the Black Hill Springs included pools near Christian Reserve (Appendix 3). The species is known to be highly migratory (Reynolds 1983), and probably occurs in streams as immigrants from the Murray. However it is possible that the species spawns locally in response to stream discharge (especially on the Finniss). It would be interesting to investigate the source of fish (i.e. local stream, the Lower Lakes or further upstream on the Murray) and identify the types and duration of flows required for successful migration (colonisation) of streams and/or local recruitment (e.g. through otolith microchemistry linked to environmental data).

Silver perch: known from the Marne Mouth wetland, channel at the Bremer River Mouth and the lower Finniss River historically, this species has undergone large declines in the South Australian section of the River Murray since the 1970's. It may have formed a local population in the Finniss or spawned in association with stream discharge, however the small stream population likely were sourced from the Murray and relied on the health of this broader population for persistence. Hence silver perch may re-establish at former habitats with a resurgence of numbers in the River Murray and Lower Lakes.

Catfish: the broader Murray range of this species appeared to just overlap in the region historically, known from the lower Finniss channel and wetland area as well just at the edge of the Marne Mouth historically (see Section 4). As with silver perch this species has undergone broader declines in the Murray since the 1970's. The last record for the Finniss River was in 1984 (SAMA F10098), suggesting that suitable habitat and environmental conditions occurred relatively recently and that the species may still survive in the extensive area of wetland on the Finniss.

5.4 Wetland species

Yarra pygmy perch: one of the most restricted wholly freshwater species in the Murray-Darling Basin, occurring today in only two distinct areas of Lake Alexandrina – the upper Finniss/Tookayerta arm of Lake Alexandrina and Hindmarsh Island (Wedderburn and Hammer 2003). Was recorded at two sites in the current Inventory at heavily vegetated sites (submerged cover) at the terminus of the Finniss River and Tookayerta Creek. These areas receive strong seasonal discharge of tannin stream water that appears to provide flow (e.g. habitat maintenance) and water of adequate quality to support suitable habitat for the species. Yarra pygmy perch appeared to have recruited well at site ML04-123M in 2003/04, where juveniles (~40mm) were common within thick *Myriophyllum*.

The species was confused with the southern pygmy perch in the region for some time (first reported in 2001, actual records date back to the early 1900's) and the upper Finniss/Tookayerta arm of Lake Alexandrina was likely to be a long-term freshwater refuge for the species prior to river regulation. Previously recorded from lower Currency Creek in 1928 (SAMA F1200).

Extensive wetlands at the terminus of the Finniss River into Lake Alexandrina ('Reedlands')

Chanda perch: little is known of this species in the South Australian section of the Murray, and the few data indicate that it occurred in wetland habitat and possibly with clearer water. The last record in the state was from the Marne Mouth wetland in 1983 (a single fish: Lloyd 1987). It has also been recorded in the Reedlands wetland area of the Finniss River in the 1960's (Table 3.2.2). Observations on populations in the Queensland section of the MDB indicate a preference for areas with dense submerged and emergent cover (Moffat and Voller 2002).

Purple-spotted gudgeon: previously known from wetland and lowland stream habitat on the lower Finniss River (at sites ML04-44 & 45) amongst aquatic vegetation (*Vallisneria* and *Cerataphylum*) (Nettlebeck 1926; Hale 1928; Appendix 3). Also likely to have occurred in the Marne Mouth wetland (SAMA records for nearby wetlands). The last EMLR record was in the 1960's from the Finniss (Table 3.2.2) and they are now considered extinct in the Lower Murray (last official record from a Murray wetland in 1973 – SAMA F3727).

Southern puplespotted gudgeon from the lower Finniss River collected in 1963 *(courtesy of the South Australian Museum)*

Hardyheads: flyspecked and smallmouthed hardyhead were captured in wetland habitat at the lower end of streams, part of a broader distribution in the Lower Lakes (see Wedderburn and Hammer 2003). The Murray hardyhead has previously been recorded at Reedlands on the lower Finniss, the Mouth of the Tookayerta, Angas River Mouth and Marne River Mouth in the 1980's (Lloyd 1987). The reason for this temporal variation is uncertain (possibly reduced stream discharge at wetland sites), especially the apparent absence from former (and still seemingly suitable) habitat in the Finniss River arm of Lake Alexandrina.

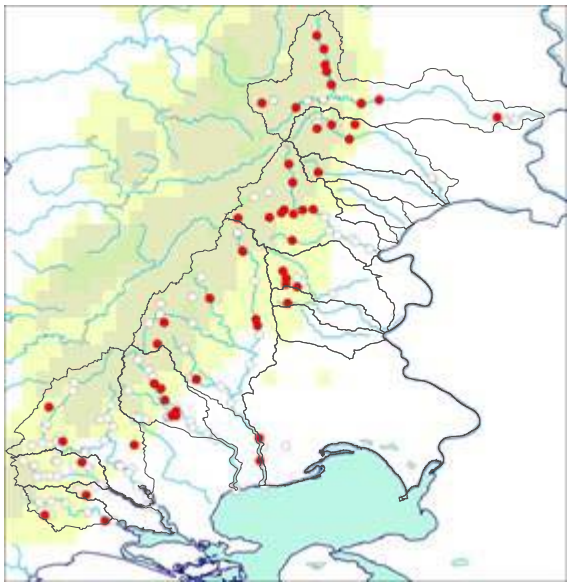
Murray rainbowfish: recorded at the Marne Mouth wetland and common in Murray wetlands through to Wellington. Historic records indicate the species occurred in a small pocket of the lower lakes in the Reedlands/lower Finniss River region through to the 1980's (see 3.2 and 4.4).

Smelt: recorded in open areas of wetlands at stream termini and also appears to venture small distances up some streams at times, probably following flows (e.g. resident in lower Finniss River - ML04-44) and records in stream habitat of the Marne River at ML04-139 in 1983 (Lloyd 1987) and Reedy Creek in 2001 (ML04-127; Hammer 2001). Flood observations during August 2004 from the Winery Road causeway on the Finniss River (between sites ML04-44 & 45) identified that smelt are active during periods of high flow as they were recorded in still water flooded out onto the roadway.

Bony herring: recorded in a few wetland sites, strictly an open water species of the Lakes and Lower Murray. Similarly, the **western bluespot goby** was restricted to stream termini wetlands connected with Lake Alexandrina.

5.5 No fish…

There were particular patterns to sites with no fish recorded. Nine sites in the southern and Marne catchments were dry at the time of sampling with most of these having permanent water and fish in the past - an indication of recent trends in the decline of local ecosystems (e.g. Christian Reserve, Marne River; sites on Dawson Creek - Angas Catchment; upper Bremer River at Harrogate; pools on Rodwell Creek; Langhorne Creek, lower Bremer River).



There were point source problems at other sites such as on Dawesley Creek that is currently too polluted from mine tailings (low pH, high metal concentrations) to support fish (Hicks 1997) (although improvements are being made). Other 'no fish sites' occurred in areas such as the North Rhine River (probably too salty and/or ephemeral today to support native fish) or otherwise small tributaries that might be ephemeral or marginal habitat.

Drier northern catchments (Salt, Reedy and upper Saunders creeks) are significantly isolated from sources of native fish by natural barriers (modern and historic influence), have relatively low rainfall and highly variable aquatic environments, and today have few large permanent refuges, strong seasonal pool contraction and generally high conductivity. A lack of historic records makes it difficult to assess whether native fish occupied these areas prior to European settlement.

An almost dry pool on Rodwell Creek (ML04-83b) –this pool was a deep (~2m) permanent pool prior to the summer of 2004

Table 5.5.1. Environmental conditions at sites where fish were not recorded. NB Most sites in naturally isolated sections of Reedy, Salt and Saunders creeks are not shown. * Dry.

Site Code	Waterway	Location	Comment
ML99-04	Angas River	'Martindale', bend in River	Freshly risen pools
ML04-66M*	Middle Creek	Earthworks area	Formerly pygmy perch, mountain galaxias, carp gudgeon
ML04-61*	Dawson Creek	Reserve -Fresian Drive	Formerly pygmy perch, mountain galaxias
ML04-60*	Doctors Creek	Macclesfield Road	Ephemeral creek
ML04-63	Dawson Creek	Ashbourne Road	Freshly filled: formerly pygmy perch, mountain galaxias, carp gudgeon
ML04-91b*	Bremer River	Harrogate, behind Tennis Courts	Dried 03 & 04. Formerly blackfish, galaxias, carp gudgeon (**A**)
ML04-96	Dawesley Creek	Princess Hwy	Polluted (mining): formerly mountain galaxias, blackfish
ML04-97	Dawesley Creek	us Peggy Buxton Road	Polluted (sewage): formerly mountain galaxias, blackfish
ML04-99	Bryce Creek	us Harrogate Road	High conductivity
ML04-83b*	Rodwell Creek	'Highland Valley' (b) corner pool	Dried first time 04: formerly galaxias, carp gudgeon and blackfish
ML04-81*	Bremer River	Frank Potts Reserve, Langhorne Creek	Historically permanent: formerly cod, blackfish, callop
ML04-80*	Bremer River	'Metella' -floodplain	Aquatic plant site
ML04-86	Mt Barker Creek Trib.	Hurling Drive	Ephemeral trib.
ML04-01b*	Currency Creek Trib.	Peel Road	Ephemeral trib. (formerly perm. pools)
ML04-05	Currency Creek Trib.	Mt Compass to Victor Road	Small trib.
ML04-23	Deep Creek	Kokoda Rd	Isolated catchment
ML04-46	Blackfellows Creek	Heritage Scrub, opp. Mt Magnificent Conservation Park	Probably has brown trout (common just upstream) excluding galaxiids
ML04-17	Giles Creek	Haines Road	Upper tributary
ML04-33	Meadows Creek Trib.	Badgers Road	Ephemeral trib.
ML02-18	North Rhine River	Sedan Road	High conductivity
ML02-20	North Rhine River	Ford north of Keyneton	High conductivity
ML02-22	North Rhine River	us Pine Hut Road	Nice pools - heavy seasonal contraction
ML02-19	North Rhine River	Water Reserve 'Netherford'	Nice pools and spring
ML02-17	North Rhine River	M. Wrights Road	Eutrophic, saline
ML02-12	Marne River Trib.	Shearers Road	Upper tributary
ML02-08*	Marne River	Christian Reserve	Formerly spring fed: blackfish, mountain galaxias, gudgeons
ML02-07	Marne River	Behind turf farm	Suitable pool; formerly mountain galaxias
ML02-14	Marne River Trib.	Boehm Springs Road	Upper tributary
ML04-136M	Marne River	Marne Gorge, ds Gauging station	Fish present two years ago: high conductivity, eutrophication, pumping
ML04-126*	Milendella Creek	us Creek Jn., off The Gap Road	Isolated catchment, no perm. water
ML04-113*	Preamimma Creek	Off Preamimma Rd	Isolated catchment, no perm. water
ML04-129	Saunders Creek	Saunders Gorge Sanctuary	Springs have stopped flowing, pools drying up and concentrated

5.6 Translocated native species

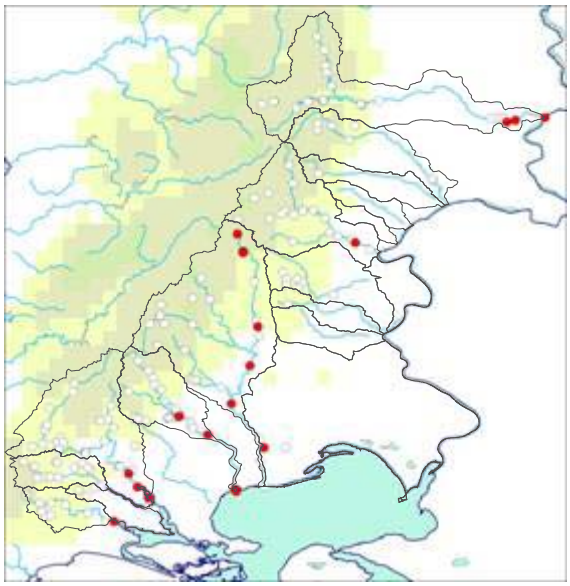
Self-sustaining populations (recruits detected) of locally sourced catfish (lower Murray) and carp gudgeon (same catchment) were collected from one small dam off Dawesley Creek (ML04-94). There were reports of Murray-Darling golden perch and fly-specked hardyhead being stocked into an instream dam on Doctors Creek (a tributary to the Angas River), and on-ground communication with landholders indicates that larger native species such as Murray cod and golden perch are commonly stocked into farm dams in the Eastern Mount Lofty Ranges, often without the required permit from PIRSA (generally due to a lack of awareness).

5.7 Exotic species

Most exotic species only occupied less variable, warmer or degraded habitats often associated with the lower end of catchments or terminal wetlands. However, Gambusia and three introduced predators (redfin, brown and rainbow trout) warrant special attention as they had wide ranges including stream habitat.

Goldfish: has had a long term presence in the region (known as golden carp) and remains widespread across lowland habitats, generally in association with wetland areas. Its distribution and abundance in stream habitats appears limited as it was only detected at a few stream pool sites below Strathalbyn on the Angas River and the lower Bremer River.

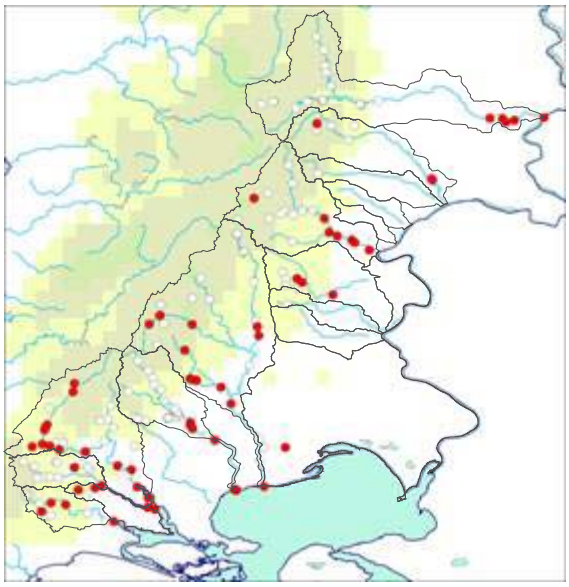
Carp: arrived in the region in the mid 1970's and rapidly became abundant (Sim *et al.* 2000; Appendix 3). Survey data indicates they are widespread in the lower areas of catchments (24 sites) but they were not present in large numbers. Most individuals captured in stream habitat were large adults (>400mm TL) with the limited number of juvenile fish a potential indicator that many carp are sourced from the River Murray/Lake Alexandrina or farm dams (e.g. ML04-90b above Harrogate, other reports in the Angas River Catchment) rather than local instream recruitment. The species occurred in larger stream pools or river channel habitats with a range of species, most often with the three gudgeon species and Gambusia.



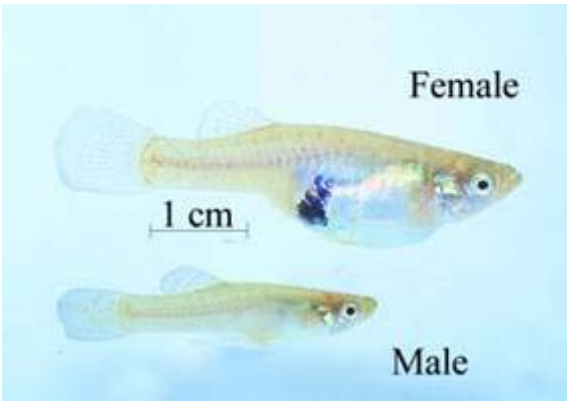
Tench: reported to have been common historically, declining soon after carp appeared in the region (Sim *et al*. 2000; Appendix 3). Was detected in low abundance within a restricted range in the mid Angas River Catchment (in and below Strathalbyn and Dawson Creek). Large adults and juveniles were both represented, but occupied a limited range encompassed large deep pools where carp gudgeon were abundant.

A large tench captured on Dawson Creek, a tributary to the Angas River

Gambusia: ranged throughout the region and was recorded in all catchments that had surface water. Its distribution was somewhat patchy, with the species locally abundant at certain sites (>100 recorded at 20 of 61 sites) therefore providing a significant contribution to its status as the most abundant species captured. Occurred across a broad range of habitat types in shallow pools or sections of larger pools, particularly in stagnant (no flow) situations (Table 5.7.1), and across a wide range of water quality (e.g. still abundant at water conductivities ranging up to 33,000µS).



Perhaps of most interest is areas of Gambusia absence or low abundance, which covered distinct sections of catchments that experienced either high seasonal variation (e.g. upper stream sections of the Marne and Bremer rivers, and most of upper Reedy Creek) or areas that had base flow and spring feeding and hence cool areas with some water velocity (e.g. Black Hill Springs, Bull Creek, upper Tookayerta Creek). The species does not appear to respond well to flow related disturbance in general, with abundance often reduced noticeably after flow events or over cooler winter months in southern catchments. An explanation may be two fold – they lack an innate response to dislodgment during flows (e.g. an overseas study by Matthews and Styron 1981) and cooler temperatures are not optimal for growth and reproduction (compared to warm shallow habitat where they can breed in profusion).



Where Gambusia was recorded in high abundance, other small native species were generally absent or in low numbers. This is possibly due to local environmental conditions and/or potential negative interaction with Gambusia. The availability of habitat structure seems important to allow native fish some chance to co-exist (outside area with flow and high variability) as gudgeons and southern pygmy perch were occasionally in reasonable numbers with Gambusia at pools or microhabitat with high instream or emergent cover and beyond shallow depths (i.e. > 0.5m).

Seine net haul of Gambusia (~5000) caught from Gollans Waterhole on Mosquito Creek (ML04-79): a warm, shallow and still (no flow) environment favourable to the species

Table 5.7.1. Environmental conditions at Gambusia sites (abundance >100). * Spring fed

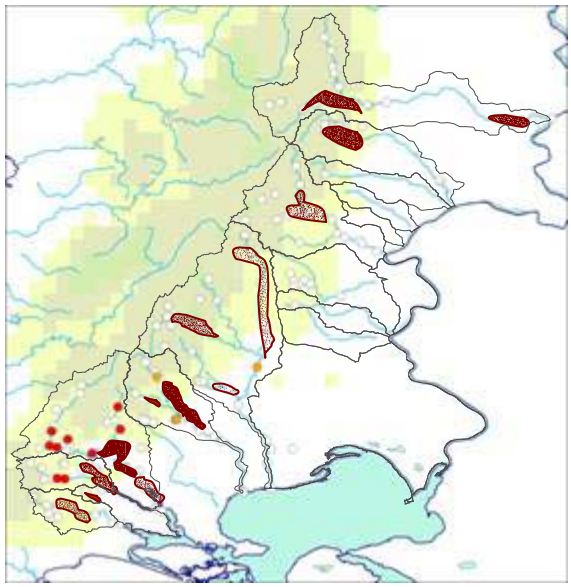
Site Code	Abundance	River System	Habitat type	Depth max (m)	Connectivity	Flow	Subsurface physical %	Subsurface biological %	Emergent %	Shade %	Conductivity (µS)
ML04-112	200	Bremer River	Stream	1.0	Medium connection (6mo)	None	30	2	10	30	8030
ML04-73	1104	Bremer River	Stream	2.0	Medium connection (6mo)	None	30	5	20	10	12270
ML04-79	5000	Bremer River	Waterhole	0.5	Irregular connection	None	20	0	0	0	5050
ML04-95	100	Bremer River	Stream	1.2	Medium connection (6mo)	None	20	30	10	0	10380
ML04-18	500	Currency Creek	Stream	1.0	High Connection (9 mo)*	None	10	0	40	0	510
ML04-19	200	Currency Creek	Stream	0.8	Medium connection (6mo)*	Low	20	0	10	20	1040
ML04-22	1000	Deep Creek	Instream dam	2.0+	Medium connection (6mo)	None	20	0	0	0	1360
ML04-51	300	Deep Creek	Stream	1.5	Permanent connection*	Low	10	0	20	20	1190
ML04-32	500	Finniss River	Stream	1.2	High Connection (9 mo)	Seep	5	50	15	30	4860
ML04-35	100	Finniss River	Stream	1.2	High Connection (9 mo)	None	20	20	15	80	4050
ML04-45	200	Finniss River	River Channel	2.0+	Permanent connection	None	2	60	20	0	3010
ML04-48	1000	Finniss River	Instream dam	1.5	Permanent connection*	Low	2	0	5	5	850
ML04-49	100	Finniss River	Stream	2.0	High Connection (9 mo)	Low	30	0	20	30	1270
ML02-33	1970	Marne River	Spring pool	1.0	Irregular connection	None	10	2	20	30	3660
ML04-106	400	Reedy Creek	Stream	1.2	Annual connection	None	40	0	20	40	10620
ML04-124	100	Reedy Creek	Stream	1.0	Annual connection	None	30	10	0	20	18270
ML04-125	200	Reedy Creek	Stream	1.5	Annual connection*	Low	10	50	5	10	14080
ML04-76	200	Reedy Creek	Stream	0.6	Annual connection	None	30	10	20	20	33000
ML04-77	500	Reedy Creek	Spring pool	1.0	Annual connection*	None	0	70	10	0	10530
ML04-114	200	Salt Creek	Stream	0.6	Annual connection*	None	10	60	2	0	23970
ML04-115	250	Salt Creek	Stream	1.0	Annual connection*	Low	10	30	10	0	30000
ML04-128	600	Saunders Creek	Stream	1.1	Irregular connection*	None	30	0	5	50	8660
ML04-131	200	Saunders Creek	Stream	1.5	Annual connection*	Low	30	0	10	10	8860

Cool, flowing habitat on Tookayerta Creek (ML04-26a) *left* and *above* - warm shallow habitat (irregular flow connection) at Gollans Waterhole, Mosquito Creek. Gambusia was in low abundance or absent from cool flowing habitat or areas with high seasonal variation

Rainbow trout: only recorded at three sites in the Angas and Bremer Catchments, but undoubtedly under sampled and more wide-spread given stocking in the region (e.g. recent records in Tookayerta Creek near the Strathalbyn to Goolwa Road, various reports of stocking into instream dams). Found in larger pool environments displaying a mutually exclusive distribution with galaxiids that either occurred at nearby sites or in different pools or microhabitat (see table 5.7.2). Small fish and various macroinvertebrates were found as components of stomach content (see Table 5.7.3)

Brown trout: found in larger pools in higher rainfall areas (Finniss River and Tookayerta Creek), and as with rainbow trout is likely to be more wide-spread (see distribution figure). Most positive sites were permanent pools or other larger refuges (e.g. spring fed stream stretch).

The presence of varied size classes and small juveniles at site ML03-44 on Blackfellows Creek is an indication that recruitment in the wild occurs in the area.

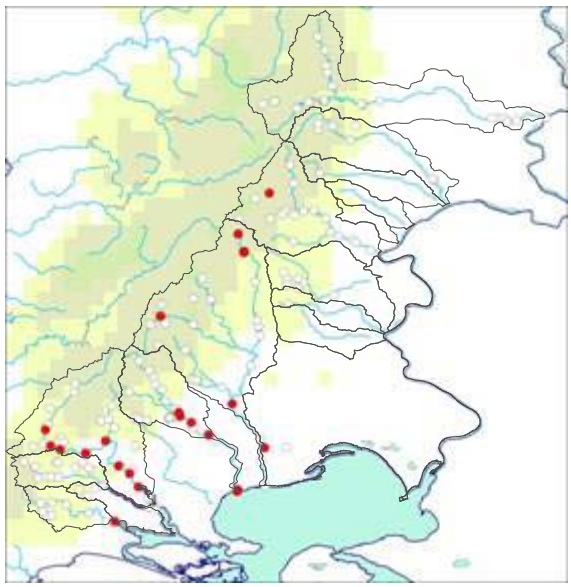


Records of brown (red dots) and rainbow (orange dots) trout from the Inventory. Maroon shapes represent additional areas where trout have been and/or are still being stocked based on inferred locations of habitat suitability from broader records (Morrissy 1967; Fulton 2004) as well as personal communication with landholders.

Juveniles (n =2 <100mm TL) co-occurred with galaxias and carp gudgeon in lower Bull Creek, however, at six other sites there was a clear separation in either local presence or microhabitat between brown trout and small native species (especially mountain galaxias, but also southern pygmy perch) (Table 5.7.2), and small fish were found in the stomach content of brown trout (Table 5.7.3). There were additional sites where similar patterns occur but with the additional presence of redfin (likely that both species could be influencing local patterns).

Redfin: a wide range and occurring in sections of most catchments, with recent records in others where they were not captured (e.g. Tookayerta Creek and Marne River catchments: Appendix 3; Wedderburn 2000). As with Gambusia, there were areas where redfin appeared absent or in low numbers preventing easy detection, and this may relate to possible environmental conditions such as seasonal variability or flow.

Redfin were found in larger deeper pools (generally >1.5m) with medium levels of submerged cover (20-30%) and water conductivities ranging from 620-8030µS. The size of captured fish ranged from 89-380mm TL, with ripe female fish often noted.



Varied patterns of species occupancy at sites were noted, but redfin rarely occurred in the same pool as small native fish, especially southern pygmy perch – the level of submerged and emergent cover seems important (Table 5.7.2). The species clearly predate on native fish at times as stomach content analysis revealed mountain galaxias, flathead gudgeon and dwarf flathead gudgeon (including large adult specimens) (Table 5.7.3).

Table 5.7.2. Species composition (minus wetland taxa) for sites where introduced predators were recorded in the Eastern Mount Lofty Ranges. * Indicates suitable habitat but native species not recorded or excluded from suitable habitat due to introduced predators. X = historic records.

Site Code	Waterway	Rainbow trout	Brown trout	Redfin	Common galaxias	Mountain galaxias	Southern pygmy perch	Yarra pygmy perch	River blackfish	Congolli	Carp gudgeon spp.	Flathead gudgeon	Dwarf flathead gudgeon	Gambusia	Comment
ML04-57	Angas River	12				30*									Galaxias in shallow pools only
ML99-01A	Dawson Creek	1				*	*				6				Native species recovered since removal
ML04-111	Bremer River	1			*						1	32	4		Common galaxias downstream
ML03-44	Blackfellows Creek		60			4*									Galaxias in one small pool only
ML04-40	Bull Creek		2			244					116				The two trout where juveniles
ML04-41	Bull Creek		15			300*			X						Galaxias in pools without trout
ML04-47	Finniss Creek		3			13*						2		60	Trout ds, galaxias us road culvert
ML03-51A	Finniss River		1			20*	117*					15*			Natives in shallow sub-section of pool
ML04-27M	Finniss River		P	2		1*	3*		X			22			Pygmy perch and galaxias in shallows only
ML04-36	Finniss River		2	7		6*			X			7		50	Galaxias in small pool in riffle only
ML04-49	Finniss River		P	2		*	*					3		100	Suitable galaxiid and pygmy perch habitat
ML04-35	Meadows Creek		3	6		*	4*					5		100	Pygmy perch in a small isolated pool only
ML02-36	Tookayerta Creek		5			1*									Ideal mountain galaxias habitat
ML04-26b	Tookayerta Creek		4			*			*						Suitable galaxias and blackfish habitat
ML04-01a	Currency Creek			6	65			X		1		150	6	25	Lowland habitat
ML04-16	Finniss River			13		*	P*					3	1	10	Pygmy perch in winter only
ML04-38	Finniss River			27		*					1	38			Suitable mountain galaxias habitat
ML04-43	Finniss River			3	25	5				8			10		Lowland habitat
ML04-44	Finniss River			1	40	5			X	2		10	70	20	Lowland habitat
ML01-51	Angas River			4		7			4		14				Rocky pool
ML04-143	Angas River			3		18			X	X	163		3		Natives all from ds pool, redfin us pool
ML04-144	Angas River			1	19		P			1		17	23	30	Lowland habitat
ML04-71	Angas River			2		2*	7*				176				Only two pygmy perch in pools w redfin
ML99-06	Angas River			3					3		50			25	V. deep pool
ML99-08A	Angas River			8		*			X	X	2*		1		Low numbers small natives
ML99-10A	Angas River			3	14						2	4	1	28	Lowland habitat
ML99-11A	Angas River			1	7					5		3			Lowland habitat
ML01-10A	Bremer River			2		23					1	2			Most galaxias from a smaller pool ds
ML01-11A	Bremer River			1		6			X		13				
ML02-159A	Bremer River			1		23					30	50			
ML04-112	Bremer River			2	5					1		30	7	200	
ML04-145	Bremer River			P	3					1		20		10	Lowland habitat
ML04-90b	Bremer River			31								2			Instream dam
ML04-78	Bremer River			6								X			Swamp
ML02-160A	Mt Barker Creek			7		40			X						Co-existing
ML04-107	Bryce Creek			2											Suitable mountain galaxias habitat?

Table 5.7.3. Stomach content data for introduced predators collected from stream habitat. Data for numerous other specimens with nil recordings not shown.

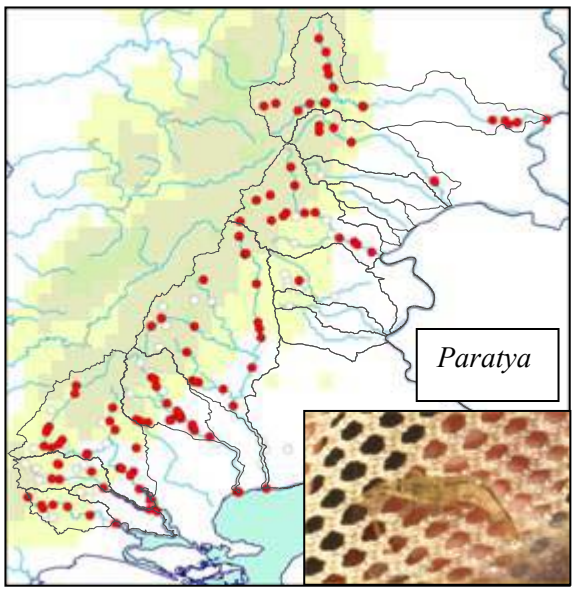
Site code	Waterway	Date	Species	TL (mm)	Stomach content
ML04-57	Angas River	31/03/04	Rainbow trout	404	6 slaters, 1 *Paratya*
ML04-57	Angas River	31/03/04	Rainbow trout	311	Nil
ML04-57	Angas River	31/03/04	Rainbow trout	133	Insects
ML04-57	Angas River	31/03/04	Rainbow trout	399	Slaters, snail, inverts, *Paratya*, yabbies, millipedes
ML04-57	Angas River	31/03/04	Rainbow trout	392	Yabby, 5 *Paratya*, fish pellets?
ML99-01A	Dawson Creek	03/04/99	Rainbow trout	400	2 carp gudgeon, *Paratya*, Millipedes, inverts.
ML04-111	Bremer River	27/04/04	Rainbow trout	306	~80mm fish (partly digested, but resembled a flathead gudgeon) - **C**
ML04-40	Bull Creek	22/03/04	Brown trout	118	3 snails, yabby claw
ML04-47	Finniss Creek	27/03/04	Brown trout	234	Amphipod, inverts, yabby claw, 1 x Gambusia
ML04-47	Finniss Creek	27/03/04	Brown trout	116	*Paratya*
ML04-47	Finniss Creek	27/03/04	Brown trout	249	Yabby, beetle, invertebrates
ML03-51A	Finniss River	07/04/03	Brown trout	310	Small fish (partly digested), yabbies, inverts
ML04-36	Finniss River	21/03/04	Brown trout	420	2 x Yabby
ML04-71	Angas River	06/04/04	Redfin	245	Macroinvertebrates
ML04-71	Angas River	06/04/04	Redfin	380	3 yabbies
ML99-08A	Angas River	17/05/99	Redfin	370	1 x dwarf flathead gudgeon
ML99-08A	Angas River	17/05/99	Redfin	360	Yabby and caddis fly larvae
ML04-16	Finniss River	09/03/04	Redfin	192	Flathead gudgeon (59mm TL) - **B**
ML04-16	Finniss River	09/03/04	Redfin	165	Small invertebrates
ML04-16	Finniss River	09/03/04	Redfin	180	Small invertebrates
ML04-16	Finniss River	09/03/04	Redfin	163	Small invertebrates
ML04-16	Finniss River	09/03/04	Redfin	200	Small invertebrates
ML04-16	Finniss River	09/03/04	Redfin	168	Small invertebrates
ML04-16	Finniss River	09/03/04	Redfin	165	Small invertebrates
ML04-27M	Finniss River	17/03/04	Redfin	244	Flathead gudgeon (81mm TL), yabby, *Paratya*
ML04-36	Finniss River	21/03/04	Redfin	368	Yabby
ML04-36	Finniss River	21/03/04	Redfin	278	Yabby
ML02-160A	Mt Barker Ck	16/5/02	Redfin	220	90mm TL mountain galaxias - **A**, yabbies
ML04-107	Bryce Creek	22/04/04	Redfin	179	Dragon fly larvae

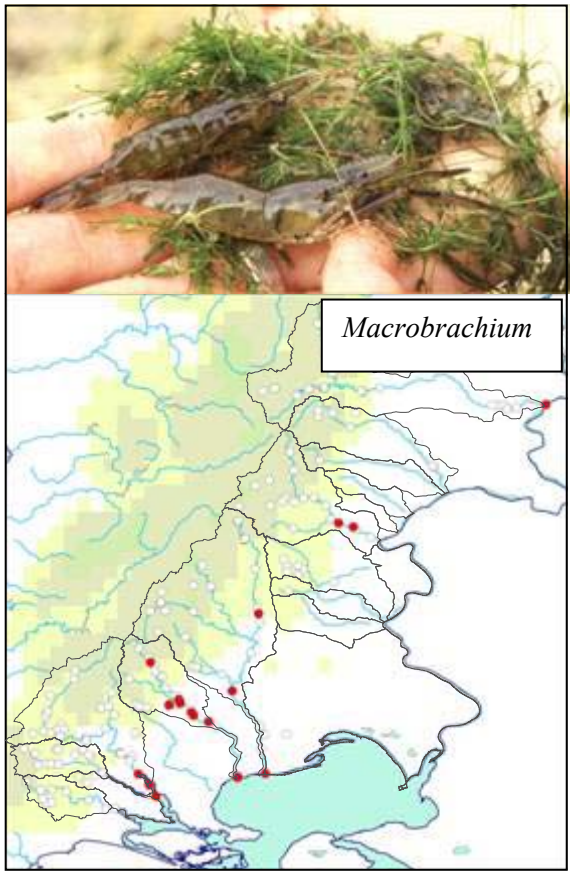
Introduced predators with native fish found as stomach content (photos match details in Table 5.7.3)

6.0 Other fauna

This section provides a brief description of other fauna sampled opportunistically during fish sampling. Distribution maps are shown for three commonly sampled crustaceans: the yabby (*Cherax destructor*), Murray shrimp (*Macrobrachium australiense*) and glass shrimp (*Paratya australiensis*), and Table 6.1.1 highlights other opportunistic samples.

While only supplementary data, information further highlights the diverse local aquatic communities and could serve as a starting point for future studies (e.g. distribution and habitat, genetic investigations). For example populations of *Paratya, Macrobrachium* and freshwater mussels (*Velesunio ambiguus*) occur in isolated areas above barriers and may be genetically distinct, and examination of aquatic snails collected from sites indicate that streams of the EMLR might be the last refuges for some species that are now extinct in the Lower Murray (Keith Walker, University of Adelaide pers. comm.).





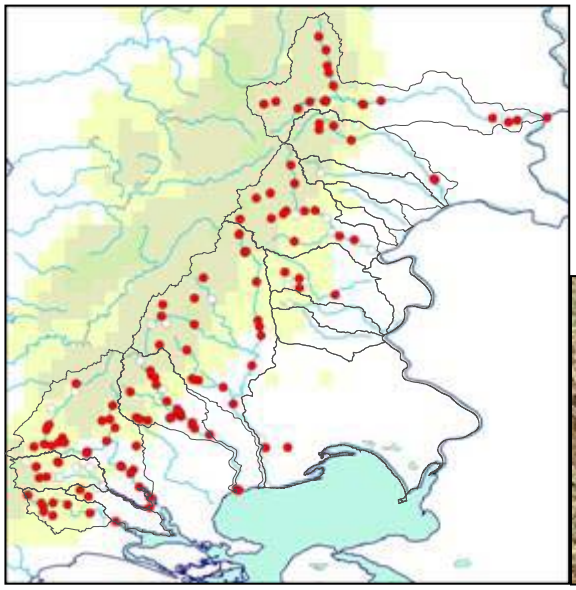


Table 6.1.1. Opportunistic fauna samples.

Site Code	Habitat type	River System	Other animals
ML01-50A	Stream	Bremer River	Leech
ML04-84	Stream	Bremer River	Long and shortneck turtle
ML00-01	Instream dam	Angas River	Longneck turtle
ML04-83a	Stream	Bremer River	Longneck turtle
ML04-95	Stream	Bremer River	Longneck turtle
ML02-15, 21	Stream	Marne River	Longneck turtle **(A)**
ML02-21	Stream	Marne River	Longneck turtle
ML02-28A	Stream	Marne River	Longneck turtle
ML04-137	Stream	Marne River	Longneck turtle
ML04-116	Stream	Salt Creek	Longneck turtle
ML04-130	Stream	Saunders Creek	Longneck turtle
ML04-104	Stream	Reedy Creek	Longneck turtle, interesting snail
ML04-145	River Channel	Bremer River	Longneck turtle, *Velesunio ambiguus*
ML04-99	Stream	Bremer River	Mosquito larvae
ML04-27M	Stream	Finniss River	Rare snails
ML04-16	Stream	Finniss River	Shortneck turtle **(B)**
ML04-53	Instream dam	Tookayerta Creek	Snail, pobblebonk tadpoles
ML04-109	Stream	Bremer River	Snails
ML04-89, 90a	Stream	Bremer River	Snails
ML04-18	Stream	Currency Creek	Tadpole
ML02-14	Stream	Marne River	Tadpole
ML04-103	Stream	Reedy Creek	Tadpole **(C)**
ML02-37	Stream	Tookayerta Creek	Tadpole
ML04-92	Stream	Bremer River	Tadpole (large black)
ML04-38	Stream	Finniss River	Tadpole (speckled in colour)
ML04-06	Stream	Currency Creek	Tadpoles
ML04-17	Stream	Finniss River	Tadpoles
ML02-07, 17, 22	Stream	Marne River	Tadpoles
ML04-132	Stream	Saunders Creek	Tadpoles
ML04-88	Stream	Bremer River	Tadpoles, lot snails
ML04-23	Stream	Deep Creek	Tadpoles, spotted grass frog
ML02-170	Stream	Finniss River	Tadpoles, *Velesunio ambiguus*
ML04-07	Stream	Currency Creek	*Velesunio ambiguus*
ML04-44	Stream	Finniss River	*Velesunio ambiguus*
ML99-04	Stream	Angas River	*Velesunio ambiguus* shells
ML04-144	River Channel	Angas River	*Velesunio ambiguus*, spotted grass frog
ML99-07	Stream	Angas River	Water rat
tML04-125	Stream	Reedy Creek	Water rat

7.0 Implications and management

This section draws together key aspects of regional habitat and species patterns to provide perspectives for the significance and management of EMLR fishes. In applying this broad-brush approach some local messages may be overlooked, and hence in specific cases interpretations should be made from the catchment summaries in Section 4.

Species richness: looking at overall figures, 28 species (16 captured) in EMLR catchments represents a high number of species occurring or previously known compared to the overall state total (58 species: Hammer and Walker 2004) and for the Murray-Darling Basin as a whole (41 fishes: Appendix 1).

Streams provide habitat for several state threatened species while wetlands at stream termini generally had a diverse species composition including a large portion of the Murray range of the nationally 'vulnerable' Yarra pygmy perch. The Finniss River recorded a particularly high species richness (15 native species) with values in strictly stream habitat also comparatively high (>3 native species) in this catchment, as well as the Angas, Bremer, Marne and Tookayerta catchments.

Significant habitats: concentrating on stream fauna, three species, namely southern pygmy perch, river blackfish and mountain galaxias, are currently supported in distinct outlier habitat of the Murray-Darling Basin with the next closest populations of these species occurring considerable distances upstream (e.g. Loddon River, Ovens River, Upper Murray).

Within the EMLR, the Tookayerta, Finniss, Angas, Bremer and Marne are of special significance considering the representation of the endangered southern pygmy perch and/or river blackfish. Other isolated populations of mountain galaxias and/or dwarf flathead gudgeon also occur in these catchments as well as Currency Creek and Reedy Creek.

The Tookayerta Creek catchment stood out from other catchments due to its contrasting and unique habitat (especially swamps and permanently flowing sections), its water quality and the wide representation of threatened species compared to rather patchy distributions elsewhere. That said, each catchment had particular and distinct geomorphic and hydrological character (e.g. rocky nature of the Finniss, deep pools of the Angas, permanent pools in an otherwise parched landscape in Salt Creek) comprising a blend of different habitat types worthy of protection individually and collectively as an interesting and distinct region. Areas with permanent base flow (spring fed pools) were regional features both in terms of water availability and the types of ecosystems they supported, often representing localised hotspots for fish diversity and threatened species.

The Eastern Mount Lofty Ranges offers a rare habitat type (regional and state level) and serves as outlier habitat and refuge for species at the terminus of an ailing River Murray. The following discussion concentrates on issues and priorities for protecting this habitat.

7.1 Characteristics of the EMLR fish fauna and aquatic habitats

Intermittent streams can be harsh environments considering seasonal extremes in temperature, flow (or no flow) and pool level, and resultant fluctuations in the condition and availability of habitat. It appears that as a result of such variation steam habitats of the EMLR generally support few native species especially higher up in catchments where the most variable environments occur (often only supported mountain galaxias or had no fish). However, natural variation seems to be an important factor in maintaining species rich fish assemblages at wetlands on the lower reaches of streams. Further down in catchments the disturbance of stream flow provides variation in the spatial and temporal nature of wetland habitats that contrast to the stable lentic conditions of the highly regulated lower River Murray, and stream flow likely represents a key factor in the richness and composition (including threatened species) of wetland fish communities (e.g. lower Finniss and Tookayerta).

A few wholly freshwater species had distributions strongly aligned to stream habitat and they persist either by occupying specific stable habitats (e.g. river blackfish) and/or by having life history characteristics and population dynamics that are suited to variable environments (e.g. mountain galaxias, southern pygmy perch). Other species appeared to occupy niches in both streams and wetlands, and this requires a broad tolerance covering the lower extremes of environmental variability (e.g. gudgeons). Some migratory species appear to colonise the lower areas of streams opportunistically based on connectivity from larger population reservoirs when conditions are favourable (e.g. common galaxias). But this is not to say that stream habitats are not utilised for breeding and recruitment (e.g. congolli?).

The species patterns observed in preceding sections suggest a number of broad predictors as to the fish composition (or lack of fish) in a catchment. These include natural isolation, catchment area, elevation and rainfall, and availability of long term refuges. These appear to act independently to exclude species from otherwise suitable habitat (e.g. barriers), as well as being related or cumulative (e.g. isolation across intermittent stream lengths due to low stream flow) and work over short time frames (e.g. local migration of diadromous species) or longer evolutionary periods (e.g. access to source populations over time). At finer scales however (i.e. sections of a geomorphic reach), casual patterns were harder to identify owing to the often highly variable nature of habitats and the extremely localised nature of fish distributions, especially threatened taxa such as river blackfish and southern pygmy perch. This could be aided by more in-depth analysis of the data (e.g. GIS modelling), and does suggests that the intensity of sampling could be increased in the future for important areas or habitat types.

Identifying the influence of isolation is important in many aspects of management and conservation. Fishes isolated in particular regions are prone to genetic differentiation, potentially accompanied with ecological and behavioural adaptation to local environments. Hence isolated populations or communities represent significant and discrete natural values for protection (e.g. genetically distinct sub-populations, core remaining habitat), and given their often insular and restricted nature are extremely vulnerable to anthropogenic change.

Seasonal isolation also occurs commonly in stream sections due to summer pool contraction (especially low rainfall years), where fish habitat often becomes limited to small stretches or isolated pools, particularly in upper catchment areas and regions with lower average rainfall. These refuge habitats form the basis of local metapopulations (groups of smaller populations that experience some gene flow or exchange of individuals) where some populations may be lost but in the long run a species persists via an interchange of individuals from source areas or a mosaic of patches that might shift during the course of time (Burgman and Lindenmayer 1998).

Seasonal flow extremes: *top* – highly contracted summer pool on the mid-Finniss River, *middle* - winter flow on the North Rhine River and *bottom* Currency Creek waterfall in flood (3/8/04)

7.2 Historic conditions and environmental change

In general, comparison of current and historic fish records suggest that several species were once more wide spread and in far greater abundance (especially river blackfish, also southern pygmy perch and mountain galaxias) and that some have potentially been lost from the region (e.g. Murray cod, purple-spotted gudgeon). There have been general and often significant reductions in species richness from lower stream reaches and wetlands (drastically so at the Marne Mouth wetland, also at the Finniss River). Remaining species distributions are being whittled away too: there is evidence of continuing local extirpations at locations like Dawson Creek on the Angas River and the Black Hill Springs on the Marne River.

The trend of decline is likely much greater than that realised due to the relatively low level of historic information available, and considering drastic change in the current condition of local environments. The region has been extensively cleared of its native vegetation (>90%), implying significant changes to hydrology, water quality, salinity and sediment input/geomorphic stability. Interlinked pressures based on landuse (significant urban areas, wide spread agriculture and ever increasing viticulture) have also for example reduced the amount and nature of flows, delivered pollutants (point source or broader impact), damaged riparian areas (stock) and provided other localised habitat destruction (see Section 4). Perhaps the most pressing current issue is decline in stream flow witnessed with recent levels of dam development and other water use (see 7.3). The combined effect has been one of reduction in the extent and quality of permanent refuges and overall core fish habitat, thus suppressing the natural ability of populations to be buffered from or respond to natural disturbance (e.g. occasional severe floods and drought). For example, there were numerous cases of currently dry stream reaches that historically contained permanent pools or flow, including areas that had only recently dried for the first time in living memory.

Examples of **continuing habitat destruction** in the EMLR: *clockwise from top left*- in-filling of Mt Barker Creek during works (ML04-87); significant physical alteration of a stream stretch during bridge works at Harrogate (ML02-159A); large causeway constructed across the mid-Finniss River and stock access – still common along EMLR waterways

7.3 Environmental water requirements

Left - **riffle connecting** large pools on a spring fed section of the Finniss River (ML04-30M) and *right* - once permanent, spring fed pools at Christian Reserve, Marne River (springs dried in 1997)

Within the variable seasonal and interannular nature of stream flow in the EMLR there are particular extremes that likely provide significant points of stress or physical processes that shape the distribution and dynamics of fish populations. For example under natural seasonal or longer term periods of low rainfall the amount of available habitat contracts at microhabitat (e.g. water level), site (refuges) or regional (stream connections) scales and species that persist in the region must be attuned to flow cycles. However, increasingly the natural flow regime of streams in the EMLR is being altered and this has and will affect the ability of species to respond to disturbance such as persistence during drought or recolonisation following local extirpation (e.g. drought, destructive flood or artificial problems such as pollution). In a more general sense local fish are likely attuned to natural patterns of flow for successful recruitment.

Aspects of environmental water requirements are noted in relation to refuge maintenance, connectivity and natural disturbance. Different types of habitats would have different considerations due to complex and variable patterns of stream flow over different spatial and temporal scales (e.g. upland environment compared to larger lowland pools and spring fed areas versus naturally dry habitat).

Refuge maintenance: the condition and availability of refuges is linked to aspects of flow:

- The overall availability of pools→ impacted by length of period of no flow and the timing of the seasonal onset of flows, also groundwater and potentially aspects of flow volume or frequency (e.g. winter 2004 delivery of fresh water (~1000µS) to the Black Hill Springs),
- Water level is often linked to the degree of structural complexity (e.g. water may drop below emergent and submerged cover) and reflects cover in refuges that may be important to allow a variety of species to co-exist with concentrated conditions, especially where non-native species have been introduced→ as above also potentially buffered by vertical connections to groundwater,
- Water quality with concentration can reach levels that stress fish causing direct mortality or declines in condition, a particular problem for species attuned to spawning soon after the onset of seasonal flow (e.g. Inventory observations on mountain galaxias). Mountain galaxias, southern pygmy perch and river blackfish all have relatively low thermal tolerance (e.g. Harasymiw 1983; McDowall and Fulton 1996) → affected by the length of time between flows, summer top ups or freshes and spring feeding.

Connectivity: important on a number of levels, especially for the colonisation of biota into or between habitats such as:

- The upstream migration of diadromous or other migratory species into catchments→ attractant flow and then appropriate time period of connection to allow migration,
- More localised movements of species with population expansion or migration facilitating recolonisation and gene flow→ sufficient time of smaller or low velocity flows,
- Lateral connections to edge and floodplain habitat that might be important areas for recruitment (e.g. southern pygmy perch) or otherwise might maintain healthy riparian habitat as cover→ even rise and fall in water level, appropriate length of time of inundation.

Disturbance: important for physical processes and potential biological response such as:

- Regular habitat maintenance→ decongest thick reed areas, flush silt and salts,
- Flushing exotics like Gambusia which appear to lack an innate response to flooding,
- Variability to wetland areas in an otherwise stable (regulated) environment of the lower Murray and Lakes (regular flushes of sufficient magnitude).

Capture of surface water in dams is significant in the Eastern Mount Lofty Ranges, with particularly high levels of development (Fig. 9). For example stream modelling in the Marne River Catchment (Marne River Environmental Flows Technical Panel 2003) identified farm dams to have:

- Increased the length of no flow periods in the wettest subcatchment from 20% to 73% of days, and in Marne Gorge from 13% to 45% of days,
- Decreased the median annual flows out of the wettest subcatchment by 76% and through Marne Gorge by 25%,
- Reduced the volume and frequency of, or completely removed, summer freshes,
- Delayed the onset of winter flows by capturing flows during the break in season,
- Reduced the frequency, height, duration and, hence, coverage of low, medium & high flows.

Modelling for the Finniss River (Savadamuthu 2003) also identified significant changes to stream hydrology including a reduction in overall runoff, especially during dry years (potentially > 25%) and over summer (potentially up to 72% for the study area). Both studies also predict that impacts will increase if farm dam development continues.

Such alterations to the volume and timing of flows, particularly smaller flows, via farm dam abstraction as well as the relatively unquantified use of groundwater is a key threat to local ecosystems (i.e. availability and condition of refuges as well as the nature of connections and disturbance). Significant signs of stress are already evident in the condition of habitats and summer refuges, with an overall accentuation of naturally dry periods being of particular concern. There is some urgency to address the protection of important natural values that are under immediate threat (e.g. drying of Black Hill Springs, Rodwell Creek and Dawson Creek).

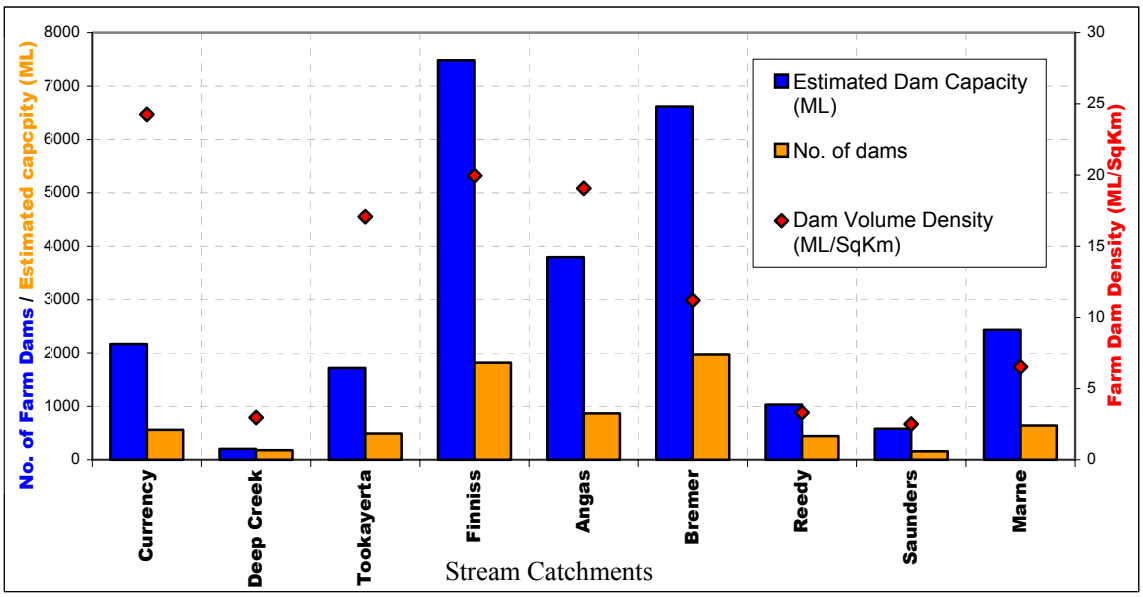


Figure 9. Farm dam data for stream catchments of the Eastern Mount Lofty Ranges (DWLBC 2003) (e.g. data for the Finniss River catchment = 1819 dams with a storage capacity of over 7000 megalitres and a density of 20 megalitres per km^2 of the catchment). Note these figures are for levels of development in 1999 and are initial estimates only and there has been considerable development in some regions over the ensuing five years.

7.4 Restoration and enhancement

The scope for restoring and enhancing aquatic habitats has been set largely in previous discussion of the significance and characteristics of regional habitats. The ever-increasing concern shown by the community for protecting regional biodiversity is also a strong factor (e.g. the strong representation of Catchment and Landcare groups and general involvement of the community in the EMLR). Encouragingly a strong focus on catchment restoration does exist in the area (e.g. see Hammer 2002b), and this forms a good platform for more dedicated programs. Importantly such works and environmental changes need to be well documented to identify positive environmental response, best practice and ensure change does not inadvertently negatively affect remaining natural values (e.g. broad-scale willow removal often leaves barren, exposed habitat unsuitable for fish).

Protecting water resources for the environment is the major broad regional conservation issue for the future, however field observations during the Inventory suggest that localised projects are likely to have a positive influence on the quality and quantity of habitat for aquatic fauna and flora, especially the protection and enhancement of refuges either as important local habitat and/or specific areas for threatened species. This could include habitat improvements such as stock exclusion and revegetation, reducing other threats such as introduced fish or pool pumping, and identifying and addressing point source pollution (e.g. road and stormwater runoff & point sources of pigeon faecal matter - a particular problem noted at several bridges in and above Strathalbyn as well as Rodwell Creek at Woodchester).

As naturally wet areas, habitats respond rapidly to stock removal with visual and functional improvements (e.g. more submerged and emergent fish (and frog) habitat, shade, stabilised sediments and banks). Other benefits including:

- Improved water quality for the environment and stock (less parasites and disease risk).
- Stock management benefits- easier to move.
- Possible financial gains with concentrated management of productive land types, reduced erosion and loss of land.
- Biodiversity benefits: return of native birds and other wildlife.
- Aesthetics (visual improvement) as green healthy areas look good!
- Provides a sense of achievement and ownership.

On these benefits, enhancement of virtually any area is possible with even small steps or practices. It is important to consider seasonal variations (e.g. flood levels) when providing riparian buffers as observations on the nature of habitats. Some indications of fish behaviour during winter 2004 suggest that when water levels and stream velocity are high, habitat at stream edges becomes important shelter. The continuing incidence of significant habitat destruction (e.g. Finniss and Bremer rivers) also indicates a strong need for education and proactive approaches with new developments.

Left - **Fenced section** of Dawson Creek (ML04-72b) and *right* - a modified flow gauging weir in the Marne Gorge designed to improve conditions for fish passage

7.5 Introduced species and management

The current study provides evidence to support broader patterns of impact and local concerns that introduced predatory species (i.e. redfin and trout) are a problem in intermittent streams of the EMLR (e.g. Crowl *et al.* 1992; Hammer 2000, 2002b; Morgan *et al.* 2002). Sampling identified examples of site and microhabitat exclusion of native fish by redfin and/or trout and also identified small native fish in the stomach contents of these predators. The predators that reach sizes much larger than the maximum size of native fish which have evolved in the region (i.e. >30cm) also occupied or are stocked into some of the best over-summer and long-term refuges - larger pools (e.g. Finniss River) or spring fed stream sections (e.g. Bull Creek, Tookayerta Creek), reducing the value of these habitats for native fish which are potentially forced to more marginal and unreliable habitats (e.g. shallow pools more likely to dry). Dedicated fine-scale investigations would probably identify that these impacts are greater than that observed from opportunistic observations as part of broader sampling.

Interestingly some natural barriers appear to provide protection for native fish such as a population of pygmy perch above but not below the waterfall on the Finniss River (redfin and trout recorded below) and some man-made barriers also appear to provide protection (e.g. small road culvert on Finniss Creek with mountain galaxias above and brown trout below). It is thus important to recognise this habitat separation (or isolation: see 7.1) as a consideration for any projects to remove or modify instream structures.

The wide-spread and often abundant Gambusia undoubtedly has an impact on native species distribution and abundance through competition and aggressive interaction (e.g. see Lloyd 1987). Observations that certain environmental conditions seem to suppress their abundance such as flow, cool winter temperatures and winter flow disturbance imply that natural variability in flows might be a key to protecting native fish populations (e.g. for southern pygmy perch that co-exist at some sites in Tookayerta Creek with Gambusia and occur above the distributional limit of Gambusia in the Angas River Catchment). Similarly there appeared to be some conditions limiting the distribution of redfin where they were absent from some pools or present only in low numbers.

Hence a key management objective is to maintain natural variation in EMLR streams and enhance habitats (e.g. structure such as riparian vegetation and snags as cover) to potentially suppress introduced fish and to cater for the requirements of native species to allow resistance to negative interactions (e.g. strong native fish recruitment). It follows that if environmental conditions deteriorate further, increased exposure of native species to introduced fish will occur (e.g. loss of riffles that currently allow habitat separation between trout and mountain galaxias; increased Gambusia and carp abundance with degradation).

Temporal monitoring at sites where larger predators have been removed (rainbow trout from a pool on Dawson Creek, redfin from Middle Creek) provides circumstantial evidence that native fish numbers and species richness increased following removal of the exotics. Hence direct control measures might be useful in confined environments like stream pools and targeting larger exotic fish in waterways is an option for active community participation (e.g. redfin fish-outs). Preventing avenues for introduction is an obvious management control that requires a wider level of public education concerning: (a) identifying that species such as trout and redfin are in fact not native as some people believe, (b) the impacts of such species can be significant in small stream environments, especially for species with already small and restricted distributions, (c) it is illegal to introduce species to waterways without permit (e.g. fingerling sales of angling species to the public), and (d) dams within catchment that can overflow into natural waterways are a potential avenue for introduction (e.g. several dams with carp in the Angas and Bremer catchments). In general a broader recognition of the problem is required fitting in with control programs for other pest species in terrestrial environments to achieve holistic outcomes. The same message applies for species native to other areas of Australia that might be translocated to the region (see next section).

Redfin from the Angas River – note the large jaw gape that can easily accommodate most adult native fish of the region

Carp collected from the Angas River (ML04-143)

7.6 Fish and farm dams

In addition to problems with exotic fish in farm dams, there are issues with a number of the larger native fish of the Murray-Darling Basin bred in commercial aquaculture facilities interstate (i.e. likely different gene pools to Lower Murray fish) and made available for sale as fingerlings to the general public. On-ground communication with landholders indicates that these are commonly stocked into farm dams in the Eastern Mount Lofty Ranges, often without the required permit from PIRSA. There is a potential for fish to escape from farm dams (those which are not isolated from catchment areas) into waterways during high flow events, posing ecological and genetic impacts to local ecosystems (e.g. they are large predators). Problems with the previous escape of exotic species such as carp and redfin were mentioned by local landholders (Appendix 3).

There was also an indication of strong interest and demand for small native fish alternatives in dams either as food for larger fish or in the view of increasing biodiversity. While this is at least partially positive (i.e. instead of sourcing exotics) such stockings need to be done carefully and with the required permits to limit un-natural range increases that could erode genetic diversity (e.g. strong structure at the catchment level) or introduce competition to small vulnerable populations.

An example of this problem was demonstrated for an instream dam on Doctors Creek (a tributary to the Angas River that joins upstream of Strathalbyn) which was reported to have been recently stocked with golden perch and flyspecked hardyhead (the later could refer to several species). The source of these fish would assumedly have been from interstate hatcheries (possibly not even in the Murray-Darling Basin for the hardyhead) and if these fish escaped during high flows they could easily end up in the Angas River or Lake Alexandrina causing potential genetic pollution of local golden perch and hardyhead. They could also occupy habitat where they do not naturally occur (e.g. golden perch is a predator and might be a threat to the highly restricted southern pygmy perch population).

A management plan discussing translocation and options for sourcing small native fish for farm dams is required.

7.7 Research and monitoring

The EMLR Fish Inventory provides the first comprehensive survey of the area and provides valuable baseline data for future programs of research and restoration. Specific regions that could be targets for more detailed investigation have been covered in Sections 4 and 5 (see also Hammer 2002b, 2004), with the more detailed investigation of the range of threatened species and further identification of refuge habitats a logical next stage of Inventory sampling.

Monitoring is also a high priority to track the condition of habitats (e.g. Conallin and Hammer 2003) and the response of species to variation in environmental conditions and positive or negative change such as restoration or threatening processes, especially with respect to environmental flows. Some specific areas for future research and monitoring include:

- Specific scientific investigations into species requirements for long-term viability (e.g. detailed range mapping and ecological studies for River blackfish, mountain galaxias and dwarf flathead gudgeon),
- Investigations to increase understanding of groundwater hydrology, especially in key habitats, and identify and control water usage that could threaten dependent ecological communities (especially Rodwell Creek, Black Hill Springs, lower Finniss River, Meadows Creeks, Tookayerta Catchment),
- Further investigations into environmental water requirements to maintain and enhance fish populations at varying scales – local habitat management, preservation of metapopulation dynamics (connections) and terminal wetland maintenance,
- Initiate community based projects that involve detecting ecological response following restoration initiatives such as fencing, introduced species removal or environmental flow improvements, or decline such as habitat destruction or river abstraction (with expert assistance with fish monitoring, at least in the initial stages),
- Identify particular points of stress for important habitats (e.g. summer low in water level) and look to develop safe guards and actions to protect existing natural values (e.g. increase habitat, return environmental flows),
- Investigation of the species boundaries and spatial genetic structure of different fish and aquatic biota across contrasting EMLR catchments,
- Temporal replication of fish surveying to further knowledge of fish and ecosystem dynamics in local intermittent streams.

Promoting fish as an indicator of aquatic health may help the incorporation of these recommendations as components of programs such as Waterwatch, the focus of school projects and within the priorities of regional management and planning.

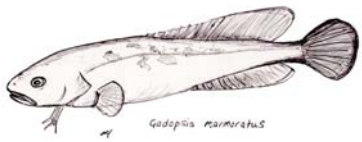
Flooding on the lower Finniss River (Winery Road) in August 2004: understanding the role of disturbance and flows to the health of local catchments is a key focus for future research and management such as: protecting and restoring habitats like terminal wetlands and summer refuges; exotic species control; and identifying actions for community involvement

7.8 Conclusion

The Eastern Mount Lofty Ranges is often overlooked in discussion of significant habitats at the Murray-Darling Basin level probably owing to its small size. However, the area is rich in aquatic diversity and provides a refuge otherwise isolated from other stream habitats in the Basin. The highly varied habitats of the region support threatened species and communities (fish but also nationally 'critically endangered' (*EPBC Act*) Fleurieu Swamps and associated biota) and have a role in maintaining wetland environments in the Lower Lakes, wetlands recognised as internationally important under the Ramsar Convention. Hence it is imperative to fully catalogue the biodiversity of the region and understand processes that threatened its future persistence. The current fish Inventory represents a first step in this process.

Given large levels of historic change and continuing pressures, especially competing demands for water during dry periods, there are considerable challenges to the conservation of natural values in the EMLR. These values include unique habitat types of spring pools and permanent flow and rare species or isolated and potentially genetically distinct populations of more wide-spread taxa. In variable stream environments the availability and quality of refuges seems central to healthy fish populations, especially in climatically harsh seasons and extended dry periods. Hence identifying and protecting permanent refuges and natural flow regimes is a vital component of regional management, with the area of environmental water requirements a clear priority for the future.

Finally, there is a common undervaluing of stream habitats in the EMLR, with a frequent perception that the river or stream is 'just filled with carp' or is 'dead'. Survey data clearly indicate this is by and large not the case. Further, landholders and others with local interests were often amazed to learn of the local diversity of native fish on their back doorstep, and consequently had a renewed interest and sense of ownership for stream habitat. For effective protection and enhancement of stream habitats, education aimed at a broader awareness of natural values and threats is required. This can in part be aided by the dissemination of information in this report to highlight that there are definitely things left to save in the region.



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Appendix 1. List of native freshwater fish known from the Murray-Darling Basin: 43 species including freshwater landlocked populations of estuarine gobies (a total of 31 obligate freshwater species)

Common name	Scientific name
Pouched lamprey	*Geotris australis*
Shorthead lamprey	*Mordacia mordax*
Short-finned eel	*Anguilla australis*
Long-finned eel	*Anguilla reinhardtii*
Hyrtl's tandan	*Neosilurus hyrtlii*
Rendahl's tandan	*Porochilus rendahli*
Freshwater catfish	*Tandanus tandanus*
Bony herring	*Nematalosa erebi*
Australian smelt	*Retropinna semoni*
Climbing galaxias†	*Galaxias brevipinnis*
Barred galaxias	*Galaxias fuscus*
Common galaxias	*Galaxias maculatus*
Mountain galaxias*	*Galaxias olidus*
Flat-headed galaxias	*Galaxias rostratus*
Murray rainbowfish	*Melanotaenia fluviatilis*
Desert rainbowfish	*Melanoatenia splendida tatei*
Small-mouthed hardyhead	*Atherinosoma microstoma*
Darling River hardyhead	*Craterocephalus amniculus*
Murray hardyhead	*Craterocephalus fluviatilis*
Unspecked hardyhead	*Craterocephalus stercusmuscarum fulvus*
Chanda perch	*Ambassis agassizii*
Two-spined blackfish	*Gadopsis bispinosus*
River blackfish	*Gadopsis marmoratus*
Murray cod	*Maccullochella peelii peelii*
Trout cod	*Maccullochella macquariensis*
Murray-Darling golden perch	*Macquaria ambigua ambigua*
Macquarie perch	*Macquaria australasica*
Estuary perch	*Macquaria colonorum*
Southern pygmy perch	*Nannoperca australis*
Yarra pygmy perch	*Nannoperca obscura*
Silver perch	*Bidyanus bidyanus*
Spangled grunter	*Leiopotherapon unicolor*
Congolli	*Pseudaphritis urvillii*
Western carp gudgeon	*Hypseleotris klunzingeri*
Murray-Darling carp gudgeon	*Hypseleotris* sp. A
Midgley's carp gudgeon	*Hypseleotris* sp. B
Hybrid carp gudgeon	*Hypseleotris* spp. (e.g. Lakes)
Purple-spotted gudgeon	*Mogurnda adspersa*
Flathead gudgeon	*Philypnodon grandiceps*
Dwarf flathead gudgeon	*Philypnodon* sp.
Tamar goby	*Afurcagobius tamarensis*
Western blue spot goby	*Pseudogobius olorum*
Lagoon Goby	*Tasmanogobius lasti*

* likely species complex (Raadik 2001)

† native in SA only, interstate populations appear to be the result of translocation

Appendix 2. Site details and summary of survey methods

Site Code	Date	Easting	Northing	Landuse	Pool condition	Seine net	Dip net	Fyke net	Bait trap	Efishing	Night obs	Day obs	Angling
ML99-01A	03/04/99	306500	6095950	Fenced	Bank level	+	+						
ML99-02	10/03/99	301100	6107700	Road side	Low level	+	+		+			+	
ML99-03	17/03/99	303900	6102800	Fenced	Bank level	+			+		+		
ML99-04	17/05/99	305800	6099400	Grazing- light	Bank level	+	+		+			+	
ML99-05	07/05/99	307600	6097800	Grazing- light	Bank level	+	+						
ML99-06	21/02/99	310250	6095100	Fenced	Bank level		+				+		
ML99-07	21/04/99	310650	6093850	Fenced	Bank level		+		+		+		
ML99-08A	17/05/99	313200	6092600	Fenced	Bank level		+		+		+		+
ML99-09	17/05/99	314500	6091500	Fenced	Bank level	+	+		+				
ML99-10A	25/03/99	318400	6081300	Fenced	Bank level	+	+						
ML99-11A	25/03/99	318300	6080950	Grazing- light	Bank level	+	+						
ML00-01	13/02/00	306400	6095900	Fenced	Low level	+	+		+				
ML00-02A	13/02/00	306500	6095950	Fenced	Bank level		+		+				
ML01-08	03/12/01	350682	6146134	Reserve	Bank level	+	+	+	+		+		
ML01-10A	20/10/01	318500	6130700	Road side	Bank level		+				+		
ML01-11	20/10/01	318400	6130600	Recreation	Bank level	+	+				+		
ML01-12	25/10/01	308200	6096300	Recreation	Bank level	+	+		+				+
ML01-13	26/10/01	290700	6085300	Fenced	Bank level		+						
ML01-50A	04/01/01	311100	6103850	Fenced	Bank level	+	+						
ML01-51	11/02/01	308300	6096300	Recreation	Low level	+	+		+				+
ML01-52	11/03/01	318050	6081400	Grazing- heavy	Low level	+	+		+				
ML02-05	25/02/02	369657	6159363	Recreation	Bank level	+	+	+					
ML02-06A	25/02/02	363088	6158313	Fenced	Bank level				+		+	+	+
ML02-07	26/02/02	341205	6162387	Fenced	Bank level	+	+	+	+				
ML02-08	25/02/02	361500	6159100	Reserve	Dry							+	
ML02-11A	02/03/02	298100	6085800	Fenced	Low level	+	+						
ML02-12	07/03/02	326972	6160538	Grazing- light	Bank level	+	+						
ML02-13A	07/03/02	323155	6161928	Grazing- heavy	Low level	+							
ML02-14	07/03/02	321113	6161343	Road side	Low level	+							
ML02-15	07/03/02	331706	6162321	Grazing- light	Low level	+	+	+	+		+		
ML02-16	08/03/02	331688	6162061	Reserve	Bank level	+	+				+		
ML02-17	08/03/02	332966	6165363	Grazing- heavy	Low level	+	+						
ML02-18	08/03/02	331569	6172765	Fenced	Low level	+	+						
ML02-19	08/03/02	331822	6169483	Grazing- heavy	Bank level	+	+	+					
ML02-20	10/03/02	330286	6175502	Road side	Low level	+							
ML02-21	10/03/02	328966	6161995	Grazing- light	Low level	+	+		+				
ML02-22	08/03/02	332100	6168100	Fenced	Low level	+	+	+					
ML02-28A	26/02/02	338164	6161572	Grazing- heavy	Low level	+	+		+				
ML02-33	16/03/02	360357	6159102	Fenced	Low level	+	+	+					
ML02-36	30/05/02	287905	6083211	Fenced	Bank level		+		+		+		
ML02-37	30/05/02	282000	6086383	Horticulture	Low level		+						
ML02-158A	16/05/02	331500	6162200	Grazing- light	Low level	+							
ML02-159A	16/05/02	318500	6130500	Fenced	Concentrated	+							
ML02-160A	16/05/02	304500	6117000	Urban area	Bank level					+			
ML02-170	17/05/02	290100	6101000	Grazing- heavy	Concentrated	+	+						
ML02-172	17/05/02	287500	6086400	Fenced	Bank full		+			+			
ML03-44	19/01/03	288712	6091079	Fenced	Concentrated					+			
ML03-51A	07/04/03	292400	6088600	Grazing- light	Concentrated		+		+				
ML03-53A	07/04/03	298300	6085800	Fenced	Bank level				+				
ML04-01a	24/02/04	297670	6074300	Recreation	Low level		+	+	+				
ML04-01b	01/03/04	296200	6074200	Fenced	Dry							+	

Site Code	Date	Easting	Northing	Landuse	Pool condition	Seine net	Dip net	Fyke net	Bait trap	Efishing	Night obs	Day obs	Angling
ML04-02	24/02/04	287600	6079400	Fenced	Low level		+					+	
ML04-03	24/02/04	285259	6077117	Fenced	Bank level	+			+				
ML04-04	01/03/04	284938	6077779	Road side	Concentrated		+		+				
ML04-05	01/03/04	285950	6075080	Fenced	Low level		+					+	
ML04-06	01/03/04	286937	6075263	Grazing- light	Low level		+		+				
ML04-07	01/03/04	293241	6075865	Grazing- light	Bank level		+	+	+				
ML04-12	04/03/04	272898	6064111	Grazing- heavy	Low level		+		+				
ML04-13	04/03/04	273971	6064387	Road side	Bank level				+				
ML04-15	09/03/04	300431	6085062	Grazing- heavy	Concentrated		+		+				
ML04-16	09/03/04	298040	6085831	Fenced	Low level	+	+	+	+				
ML04-17	10/03/04	300798	6090023	Road side	Bank level		+		+				
ML04-18	01/03/04	285352	6076056	Grazing- light	Bank level		+		+			+	
ML04-19	11/03/04	286899	6077900	Grazing- light	Low level	+	+		+				
ML04-20	11/03/04	289391	6077579	Grazing- light	Low level		+		+		+		
ML04-21M	11/03/04	295420	6081662	Fenced	Bank level				+				
ML04-22	11/03/04	294300	6081200	Grazing- heavy	Low level		+					+	
ML04-23	11/03/04	292873	6079404	Grazing- light	Bank level		+					+	
ML04-24M	17/05/04	292374	6088407	Grazing- light	Low level				+				
ML04-25M	17/03/04	292530	6088631	Grazing- light	Bank level		+		+				
ML04-26a	17/03/04	285683	6083257	Fenced	Bank level		+		+				
ML04-26b	17/03/04	286600	6083300	Road side	Bank level		+				+		
ML04-27M	17/03/04	292448	6088247	Grazing- light	Low level			+					
ML04-28	18/03/04	294874	6095120	Fenced	Low level		+					+	
ML04-29M	18/03/04	296194	6095462	Road side	Bank level		+		+		+	+	
ML04-30M	19/03/04	298353	6085776	Fenced	Bank level				+				
ML04-31M	19/03/04	298446	6085658	Fenced	Bank level		+		+				
ML04-32	21/03/04	290288	6102727	Grazing- light	Bank level	+	+		+				
ML04-33	21/03/04	286126	6097518	Road side	Bank level		+					+	
ML04-34M	21/03/04	285574	6093563	Fenced	Low level				+				
ML04-35	21/03/04	285432	6093018	Fenced	Low level		+					+	
ML04-36	21/03/04	286410	6089682	Grazing- light	Bank level		+	+	+		+		
ML04-37	21/03/04	285860	6094085	Reserve	Low level		+	+					
ML04-38	22/03/04	295700	6090900	Fenced	Concentrated	+							
ML04-39	30/03/04	287610	6090459	Grazing- light	Bank level	+	+						
ML04-40	22/03/04	297115	6093715	Grazing- light	Bank level		+		+		+		
ML04-41	22/03/04	296600	6098300	Grazing- light	Bank level						+		
ML04-42M	24/03/04	303327	6077319	Fenced	Low level				+				
ML04-43	24/03/04	299945	6084246	Fenced	Bank level		+	+					
ML04-44	24/03/04	301499	6081528	Fenced	Bank level	+	+	+	+		+		
ML04-45	25/03/04	303373	6079330	Grazing- heavy	Bank level	+	+						
ML04-46	25/03/04	288602	6090503	Fenced	Bank level				+		+		
ML04-47	27/03/04	285117	6090025	Fenced	Bank level	+							
ML04-48	27/03/04	283397	6089481	Fenced	Concentrated	+			+				
ML04-49	27/03/04	288008	6088987	Fenced	Bank level		+		+		+		
ML04-50M	27/03/04	287700	6086300	Fenced	Bank level				+				
ML04-51	27/03/04	291480	6080734	Grazing- heavy	Low level		+		+				
ML04-52	30/03/04	293334	6084940	Fenced	Bank level		+		+				
ML04-53	30/03/04	291990	6086259	Forestry	Concentrated		+						
ML04-54M	30/03/04	292976	6085382	Fenced	Bank level		+		+				
ML04-55a	30/03/04	283763	6085240	Fenced	Low level		+						
ML04-55b	30/03/04	283908	6085345	Road side	Bank level		+		+				
ML04-56	30/03/04	284470	6083029	Fenced	Bank level		+						
ML04-57	31/03/04	303063	6104706	Grazing- light	Bank level		+				+	+	
ML04-58M	31/03/04	302851	6105691	Urban area	Bank level				+		+		

Site Code	Date	Easting	Northing	Landuse	Pool condition	Seine net	Dip net	Fyke net	Bait trap	Efishing	Night obs	Day obs	Angling
ML04-59	31/03/04	303674	6104282	Grazing- light	Bank level		+		+		+		
ML04-60	31/03/04	305095	6101800	Road side	Dry							+	
ML04-61	31/03/04	307071	6096181	Recreation	Dry							+	
ML04-62Ma	31/03/04	306639	6096087	Fenced	Concentrated		+		+				
ML04-62Mb	31/03/04	306400	6095950	Fenced	Bank level				+				
ML04-63	31/03/04	307723	6096228	Urban area	Low level		+		+				
ML04-64	31/03/04	310239	6094509	Urban area	Bank level			+	+				
ML04-65	31/03/04	302652	6095321	Grazing- heavy	Low level		+		+				
ML04-66M	01/04/04	307734	6097201	Fenced	Dry							+	
ML04-67	01/04/04	307831	6097149	Urban area	Concentrated	+							
ML04-68M	01/04/04	308154	6096930	Fenced	Bank level		+		+				
ML04-69	01/04/04	299524	6101222	Grazing- light	Bank level		+		+			+	
ML04-70	05/04/04	308128	6096850	Vacant land	Bank level			+					
ML04-71	06/04/04	308055	6097135	Grazing- heavy	Low level		+	+					
ML04-72a	06/04/04	300674	6095908	Grazing- heavy	Bank level		+					+	
ML04-72b	06/04/04	301334	6095587	Fenced	Bank level		+					+	
ML04-73	18/04/04	321575	6113335	Fenced	Bank level	+	+	+			+		
ML04-74	08/04/04	325974	6123869	Road side	Concentrated		+					+	
ML04-75	08/04/04	324893	6138618	Grazing- light	Concentrated		+		+				
ML04-76	29/04/04	332317	6137835	Road side	Concentrated		+						
ML04-77	08/04/04	333193	6135001	Grazing- heavy	Bank level		+					+	
ML04-78	09/04/04	322815	6090124	Grazing- light	Concentrated	+							
ML04-79	09/04/04	326548	6090239	Reserve	Concentrated	+							
ML04-80	09/04/04	322248	6087192	Grazing- light	Dry							+	
ML04-81	07/06/04	322070	6091888	Recreation	Dry							+	
ML04-82	09/04/04	310008	6104157	Fenced	Low level		+	+					
ML04-83a	09/04/04	310338	6103970	Grazing- light	Bank level			+					
ML04-83b	09/04/04	311038	6103897	Fenced	Dry							+	
ML04-84	09/04/04	315328	6102524	Grazing- light	Bank level		+	+	+				
ML04-85	14/04/04	304289	6111029	Fenced	Low level		+					+	
ML04-86	14/04/04	305334	6115525	Road side	Concentrated		+						
ML04-87	14/04/04	304600	6117200	Recreation	Low level							+	
ML04-88	14/04/04	304678	6119416	Urban area	Bank level		+						
ML04-89	14/04/04	310052	6120862	Road side	Concentrated		+						
ML04-90a	15/04/04	317394	6134216	Grazing- heavy	Bank level		+	+					
ML04-90b	15/04/04	317446	6134368	Grazing- light	Low level		+	+				+	
ML04-91a	15/04/04	318600	6130664	Road side	Concentrated		+	+					
ML04-91b	15/04/04	318400	6130600	Recreation	Dry							+	
ML04-92	15/04/04	318662	6130751	Fenced	Low level		+	+					
ML04-93	15/04/04	320569	6124470	Fenced	Concentrated	+		+					
ML04-94	18/04/04	311482	6125119	Fenced	Low level		+						
ML04-95	18/04/04	321280	6115200	Grazing- heavy	Concentrated	+	+	+					
ML04-96	18/04/04	313000	6120700	Road side	Bank level						+		
ML04-97	18/04/04	312450	6125200	Fenced	Bank level		+	+	+				
ML04-98	19/04/04	320964	6116472	Grazing- light	Bank level		+						
ML04-99	19/04/04	317504	6127405	Grazing- light	Low level		+				+	+	
ML04-100	19/04/04	317500	6137400	Fenced	Bank level	+	+					+	
ML04-101	21/04/04	322845	6137655	Grazing- heavy	Bank level	+	+		+			+	
ML04-102	21/04/04	326983	6138459	Grazing- light	Low level		+					+	
ML04-103	21/04/04	325366	6139301	Grazing- light	Low level		+						
ML04-104	22/04/04	325969	6148796	Grazing- light	Low level	+	+					+	
ML04-105	22/04/04	326716	6144999	Road side	Low level		+						
ML04-106	22/04/04	320187	6141812	Grazing- light	Bank level	+	+		+				
ML04-107	22/04/04	322565	6142906	Fenced	Bank level			+				+	

Site Code	Date	Easting	Northing	Landuse	Pool condition	Seine net	Dip net	Fyke net	Bait trap	Efishing	Night obs	Day obs	Angling
ML04-108	27/04/04	302816	6115319	Grazing- heavy	Bank level		+		+				
ML04-109	27/04/04	310131	6115412	Fenced	Bank level		+	+	+				
ML04-110	27/04/04	308972	6110076	Fenced	Bank level		+						
ML04-111	27/04/04	320138	6107095	Grazing- light	Bank level		+	+					
ML04-112	28/04/04	317096	6099102	Grazing- light	Low level	+							+
ML04-113	28/04/04	326332	6119966	Grazing- heavy	Dry								
ML04-114	28/04/04	334045	6122040	Grazing- light	Low level		+						
ML04-115	28/04/04	328800	6124500	Grazing- light	Bank level		+				+		
ML04-116	28/04/04	327855	6125292	Fenced	Low level		+	+	+		+		
ML04-117	29/04/04	327902	6123351	Fenced	Low level	+	+						
ML04-118	29/04/04	325982	6125082	Fenced	Low level		+					+	
ML04-119	29/04/04	325372	6126568	Fenced	Bank level		+						
ML04-120	29/04/04	326855	6132968	Grazing- light	Low level		+						
ML04-121	29/04/04	328512	6139332	Fenced	Bank level		+		+				
ML04-122	29/04/04	330312	6139467	Fenced	Bank level	+	+						
ML04-123M	30/04/04	304579	6076969	Vacant land	Bank level		+						
ML04-124	02/05/04	337103	6133488	Grazing- light	Low level		+					+	
ML04-125	02/05/04	334586	6134228	Fenced	Bank level		+	+	+				
ML04-126	02/05/04	331050	6147192	Grazing- light	Concentrated							+	
ML04-127	03/05/04	337623	6132938	Reserve	Concentrated	+							
ML04-128	03/05/04	350531	6146364	Road side	Low level	+							
ML04-129	03/05/04	336231	6154156	Fenced	Low level								
ML04-130	03/05/04	330676	6156244	Grazing- light	Low level	+							
ML04-131	04/05/04	330697	6157512	Grazing- light	Low level	+	+		+				
ML04-132	04/05/04	333153	6157094	Fenced	Bank level	+	+						
ML04-133M	04/05/04	331644	6162341	Grazing- light	Bank level	+							
ML04-134M	04/05/04	323141	6161926	Grazing- light	Low level	+							
ML04-135	05/05/04	337148	6157203	Grazing- light	Bank level		+					+	
ML04-136M	05/05/04	338160	6161579	Grazing- light	Low level	+							
ML04-137	05/05/04	337990	6161657	Grazing- light	Bank level	+							
ML04-138	05/05/04	362492	6159043	Fenced	Bank level		+	+	+				
ML04-139	05/05/04	364585	6158749	Fenced	Bank level			+					
ML04-140M	05/05/04	363088	6158313	Fenced	Bank level				+		+		
ML04-141	22/05/04	340129	6131436	Grazing- light	Concentrated	+	+						
ML04-143	06/06/04	313228	6092606	Vacant land	Bank level			+					
ML04-144	06/06/04	318373	6081222	Road side	Low level	+	+	+					
ML04-145	06/06/04	323069	6082075	Recreation	Bank level	+		+					

Appendix 3. Oral history

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