DESERT FISHING LESSONS

ADVENTURES IN AUSTRALIA'S RIVERS

ADAM KEREZSY

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Adam Kerezsy is an aquatic ecologist for Bush Heritage Australia and a regular radio commentator on fish- and flooding-related matters. In 2010 he completed his PhD on the distribution and movement of fish in the isolated rivers of western Queensland and the Simpson Desert. This is his first book.

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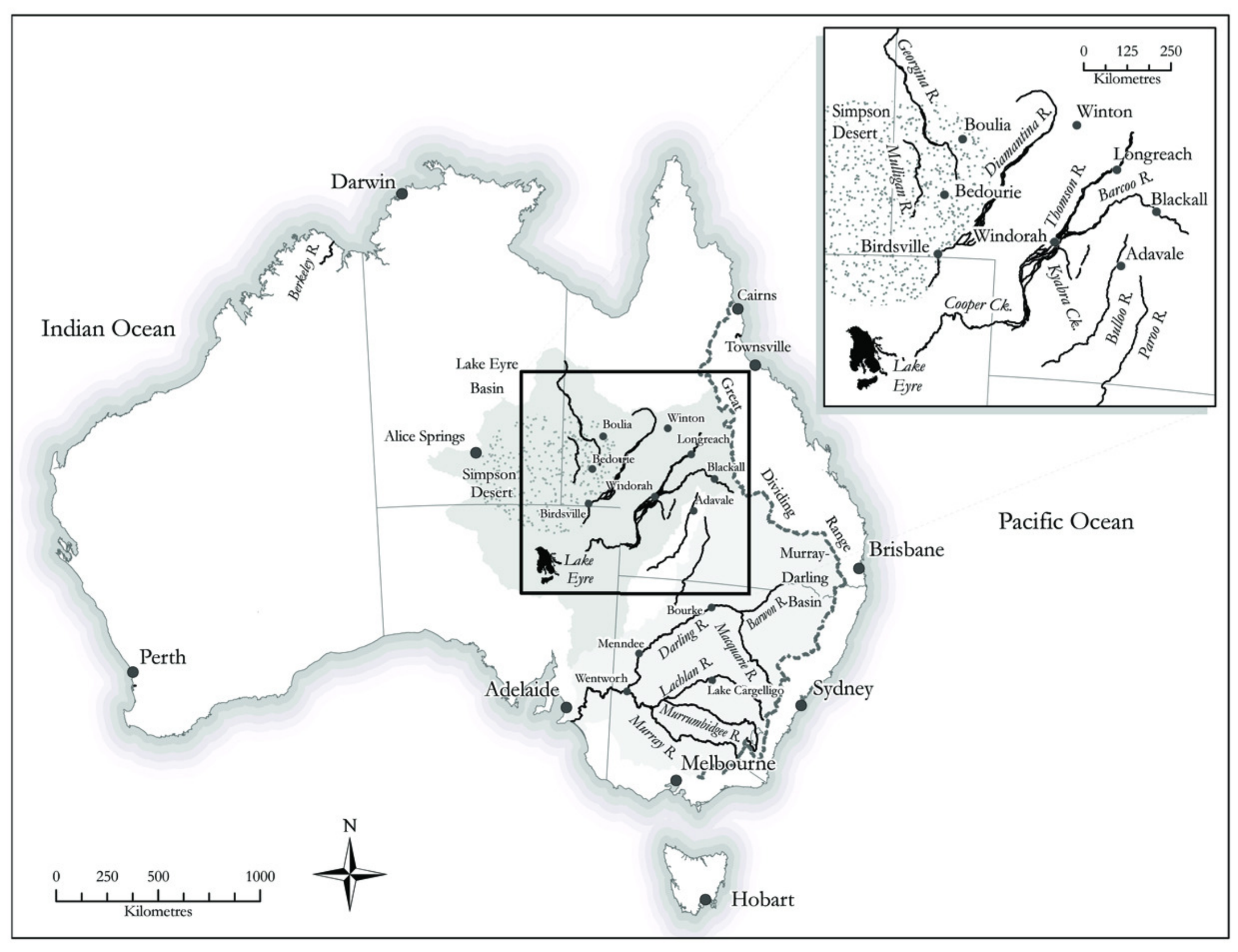
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Pacific Ocean
Darwin
Berkeley R.
Perth
Adelaide
Alice Springs
Simpson Desert
Lake Eyre Basin
Cairns
Townsville
Brisbane
Sydney
Melbourne
Hobart
Great Dividing Range
Murray-Darling Basin
Boulia
Winton
Longreach
Bedourie
Blackall
Windorah
Birdsville
Adavale
Lake Eyre
Bourke
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Mulligan R.
Diamantina R.
Thomson R.
Barcoo R.
Cooper Ck.
Kyabra Ck.
Bulloo R.
Paroo R.

For my father Jenö,
and on the occasion of his 85th birthday

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INTRODUCTION

I'm a water person, a river person, a fish person. I spend an inordinate amount of my time grubbing around in the bottom of muddy waterholes and rivers, thinking about the why and how of fish that live in particular areas. It wasn't planned, it just happened. I've always been fascinated by how living things get by on the planet, but this interest has manifested itself in the mysterious world of things living under water. And this fascination has narrowed further over the years, and now focuses on fishy things within the driest bits of the driest inhabited planet on Earth. Fish and deserts are unusual bedfellows, but that's the way it is.

Growing up in the 70s and 80s, I was born into the east coast middle-class culture that valued hard work and success. Happily, this east coast culture also included the coast itself, which was wild and free, and allowed us youngsters to explore it and, in my case at least, begin a long and fishy journey that continues

to lure me to remote parts of Australia. No matter where I go, I still find myself peering into the water and wondering what might be going on.

I remember on Boxing Day 1985, schoolmates Marty, Alan and I drove up to Bateau Bay on the New South Wales central coast. We unloaded the car, pulled on backpacks, picked up bundles of fishing rods and then traipsed around to the rocks at the southern side of the smaller beach. Dropping our packs and tins of spaghetti, we scuttled out to the only platform high enough to fish from. As we reached the spot, the rain set in so we beat an expletive-filled retreat back to the small clearing where we had made camp throughout the year, something that driver's licences and borrowed station wagons had made possible. Improvements in both our fishing tackle and techniques for landing gamefish from the rocks meant our targets had gradually become bigger, faster and stronger. Back then we ate, slept and breathed fishing.

We sat in the rain and became miserable. We never took tents, preferring to put a sleeping bag out in the sand. We figured that if it was too wet to sleep, it was probably too wet to fish as well, so we'd just go home. On this occasion though, we'd only just arrived and so we waited a little longer. Soon the rain disappeared, leaving a humid east-coast afternoon, a washed and scrubbed rock platform and a rainbow hovering over the rolling Pacific Ocean. We headed back out to the little ledge and – luckily – landed a small pike on the second cast using a small metal lure. (A pike is an elongated, missile-shaped fish with a fearsome set of teeth that prowls around the coast looking for smaller prey – they resemble a mini-barracuda.) There was only about an hour of light left so I quickly rigged up

a live-baiting outfit. Using the jargon we loved so much at the time, we were going to 'float out a livie on a cut-down Snyder MT9120 with a roller tip and a Sealine 50H with 400 metres of 10 kilo'. What it meant in English was that we were using a strong rod with a roller tip to minimise line friction, and a suitable reel spooled with a 10-kilogram breaking strain line. The pike was a mean-looking beast about 40 centimetres long. Anything that was going to eat it was going to be substantially larger.

Live-baiting is exactly as it sounds, so it's important to get the 'bait' back in the water as quickly as possible. I threaded the line through the ten guides, tied on a swivel, then two metres of 60 kilogram trace, a polystyrene bobby cork and an appropriate hook. I pushed the hook just behind the pike's head but above its lateral line, and then lowered it into the swell lapping at the rocks. If you're lucky, the fish will swim away from the rocks, and the current will assist in drifting the impaled fish into deeper water. If you're not, the bait ends up banging against the rocks and the line snags on whatever's handy. That afternoon everything went according to plan, and the water was so clear we could see the pike dragging the float out to sea.

Slowly, I peeled line from the reel, making sure not to let too much out and risk the line catching on a submerged rock while allowing the disabled fish to go wherever it tried. Within a couple of minutes the pike was at least 50 metres away and showed no sign of stopping – if anything, it seemed to be speeding up. The line kept being taken from the spool; not rapidly, but fast enough for me to tell Alan and Marty that something was going on. By the time they both stopped what they were doing to have a look, it was obvious that our pike

had transformed into something bigger. As the line sped up, the most difficult part of the exercise – setting the hook – had to be attempted. This is when most people lose their fish, because the hook is often incorrectly positioned to become embedded in a fishy mouth. I lowered the rod tip and tightened the drag mechanism of the reel. I clamped my thumb over the spool and, as the line tightened, raised the rod in a slow but constant arc. It felt like I'd just hooked a huge piece of wet carpet, but I was pleasantly surprised when – again – the line began peeling from the reel more quickly than before. I repeated the setting procedure at least twice more to remind myself what to do next, and then methodically began to fight the biggest fish I've ever hooked.

We suspected from the start that our hungry visitor was a yellowtail kingfish. Kingfish are built like a torpedo, and this one struggled in wide arcs and more than once dived for the rocky bomboras that dotted the ocean floor. In the end, it took an hour and fifteen minutes to bring it in, by which time a small crowd had gathered. Alan edged down the broken rocky shoreline, and with one swift and risky manoeuvre gaffed the fish. It left the ocean in a brilliant shimmer of iridescent purple, green and yellow, only fading to ghostly silver a few minutes later as it lay in a nearby rockpool.

We spent that night eating the fish and reliving the fight, and looked forward to the morning in the hope there'd be similarly co-operative pike and similarly large gamefish waiting to eat them. A kingfish over a metre long is a great catch anywhere, but it's especially memorable when landed from a small rock platform in fading light by a small group of enthusiastic teenagers.

Back then I loved the technical aspects of fishing, but more than that I loved the freedom of the rocks and the ocean, the fact that once you were there you didn't need to look at a watch, and the feeling that anything could happen. Everyone who fishes knows this 'I wonder what'll happen today?' feeling. For people like me who have never stopped fishing, although the equipment and technical aspects have changed, the feeling remains the same.

Twenty-five years after landing the kingfish at Bateau Bay, Max Tischler and I are sitting in the cab of a Landcruiser and heading to the most unusual fishing location you could find in Australia – the desert. We're a reasonably odd couple, doing reasonably odd things. Max is into birds, reptiles and mammals, is younger than me and still has hair – quite a lot of it – which he keeps in long dreadlocks that apparently make him irresistible to a large percentage of the female population. In contrast, friends tell me I resemble a bikie or a criminal, my hair fell out a few years back and, unlike Max, I count fish not cute little marsupials.

The fish of the temporary rivers of the Simpson Desert don't grow as big as the pike-eating kingfish of Bateau Bay, but they're definitely as tough, and their here-today-gone-tomorrow lifestyle has fascinated me for several years. For both Max and me, the 'what's going to happen today?' thing is the biggest constant in all the remote fieldwork we do. Each morning, we crawl out of our swags, warm up next to a little gidgee fire, have a cuppa, have a laugh, and then go and empty traps and nets with at least a smidgin of the same enthusiasm I had back in 1985.

There has been a massive flood in central Australia and 2010–11 is looking like 1974 as a weather period to remember.

On both occasions Brisbane floods and cyclones wreak havoc across northern Australia. And on both occasions central Australia – the driest part of the driest inhabited continent – receives massive rainfall and the normally-dry rivers run like runaway trains. Max and I are lucky, because we've been scurrying around the desert for a while and we've experienced dry years, proper drought years and wet years. Now we're taking samples following the biggest flood either of us will probably ever see.

We empty Max's pitfall traps and there are native rodents down on the claypan and then two species of lizards, a frog and a dunnart up in the sand dune. It's a freezing August morning – in fact, it's surprising the frogs and lizards are even getting around. We measure, weigh and sex the little critters and take a few pictures before releasing them. Back at the fire I climb into a wetsuit before sucking down an extra cup of coffee: water in the desert gets down to about 10°C in the early morning, and fish samples take a long time to collect, especially after a big flood in a waterhole that only fills every now and again. The waterhole is a reach of our favourite river – the Mulligan – which is almost always the last dry channel before Queensland turns into the Northern Territory.

I jump in the two-metre-deep water and gasp. I mumble to Max about the advantages of having kids prior to immersing one's testicles in freezing water for extended periods, but he's preoccupied with binoculars and a couple of thousand ducks. The waterhole is several kilometres long and about 50 metres wide. Along each side, lignum, a tangled viney plant, chokes the shore and provides hiding places for pigs and birds and snakes. The water is a little salty; it's noticeably clear and has that

Desert ecologist Max Tischler with a plump spangled perch from S-Bend Gorge in the upper reaches of the Mulligan River.

pristine, healthy feel about it. I wade out and drag a wing of one of the big funnel-shaped fyke nets in to the shore. In the nets are up to eleven species of fish – about a thousand individuals with a total weight of about 20 kilograms – plenty for a waterhole that's almost always dry. The sample includes a small fish called hardyhead that we've only recently worked out inhabits the ephemeral – or temporary – waterholes of far western Queensland, and the most northerly Mulligan record for yellowbelly, the big, iconic inland species that everyone loves to catch. I'm struck, as always, by just how healthy and intact the desert water habitats are: no rubbish, no pollution, no invasive species.

The mere presence of fish in the Australian arid zone is fairly remarkable, especially when some of our inland rivers like the Cooper and Diamantina possess the most variable hydrology

– or flows – on Earth. This suggests that fish populations can hang on in remote waterholes, then breed and swim like crazy as soon as the rains come.

We release the fish, which will become food for birds or will die as the waterhole recedes or becomes ever more salty. You can, however, bet your last cent that as soon as the next flood comes down their kin will take the plunge and swim up the river to a similar uncertain future.

Australia is the biggest island in the world and home to over 300 species of freshwater fish. This number is chicken-feed compared to other big continents like South America and Africa, though it's worth remembering that Australia is second only to Antarctica as the driest continent. Our nation is more or less a big desert with a few creeks and rivers around the edges, and that's where the majority of the freshwater fish are to be found. Two of our best known are the primitive Queensland lungfish, which has been around for about 100 million years and has evolved a 'lung' – or more correctly a modified swim bladder – that allows it to extract oxygen from the air as well as from its gills, and the impressive barramundi, a big perch that sustains recreational and commercial freshwater fishing in Australia's north. But there are, of course, plenty more weird and wonderful creatures swimming in Australia's rivers. There are primitive eel-shaped fish called lampreys that have a toothy oral disc instead of a mouth; there are strange hump-headed creatures called nurseryfish; and there are archerfish, so named for their amazing ability to 'shoot down' flying insects using a well-aimed jet of water.

The majority of our freshwater rivers flow for relatively short distances from higher country to the coast. A coastal

draining river starts off fully fresh, becomes brackish, and then ever-more-salty as it reaches the sea. It should come as no surprise, then, that most of our 300 or so freshwater fish species live in these systems. Fish that are only capable of living in fresh water – like lungfish – live in the headwaters; those that live in the sea – like kingfish – don't travel as far up as the fresh, and then there are species that inhabit the middle zone and have a bet each way. Up north, plenty of sharks, rays and sawfish make use of freshwater areas as hunting grounds or nursery habitats; down south common species like bream and whiting don't mind a bit of fresh with their salt either. The same thing happens all over the world – just think of a David Attenborough doco with salmon jumping past hungry bears and up cascading rapids to breed. Barramundi, however, work the other way around – the adults live in the fresh, and then head down to the sea to breed each wet season.

Generally, the further north you go the more species you're likely to find. Consequently, the rivers that drain Cape York, the Kimberley and into the Gulf of Carpentaria are home to more fish species than those in south-west Western Australia and along the eastern seaboard. In each area, there are fish that people know about because they catch them on lines (like Australian bass) or because they're visible (like eels), but most fish species are small and go unnoticed, except by those of us who are paid to think about such things. In any east coast river between Brisbane and Sydney, small fish, with names like gudgeon and glassfish, form vital links in the food web that sustains Australian bass, and similar species inhabit the rivers further north that end up in the bellies of barramundi.

Of the 300 or so freshwater fish that call Australia home,

I'm fascinated by the 60 or so species that reside not in coastal draining rivers but in the big, snaky muddy tendrils of Australia's inland waterways. It's in and around these long and unpredictable murky highways – the Murray and Darling, Cooper and Diamantina – that much of our outback folklore and culture has evolved and developed, and it's in these rivers that fish like Murray cod and yellowbelly – just as familiar as lungfish and barramundi – have swum for millennia.

Cod are massive. They've been recorded at over 100 kilograms and nearly two metres long. Yellowbelly don't get as big, but they're all over the place. From Victoria to South Australia, up through New South Wales and Queensland and all the way out into the desert. They get called different names – callop, golden perch – depending on where you live, but they're the same fish. In drought years, when the outback rivers have dried back to waterholes, big yellowbelly up around the 60-centimetre mark still hang in there. And as well as the big fish, there are a host of smaller arid-zone specialists – catfish with whiskers, glassfish you can see through, brightly coloured rainbowfish – that somehow survive in the puddles and billabongs that are left when the floods and flows recede and the land is once again baked and hot.

This story focuses on these tough-as-nails critters – the ones that reside in the occasionally watery arteries that bisect our arid inland – and what we can learn from them.

PART 1
DOWN BY THE RIVERSIDE

1

A LITTLE HISTORY

Most Australians have heard of the Murray–Darling Basin even if they have no idea what it actually is. A 'basin' in natural-resource speak is not that different from a basin in kitchen or bathroom speak – it's just an area that drains water. Australian basins are areas where run-off from rainfall converges into catchments like creeks and rivers and flows to a particular area, like the sea or a big inland lake. Australian basins include the North-east Coast and South-east Coast, and they almost always occur across several states, which naturally complicates things because it gives rise to the concept of 'ownership' of the water. So a river or catchment in the South-east Coast, for example, is one that rises somewhere in the Great Dividing Range in either New South Wales or Victoria and then flows east before emptying into the Pacific Ocean.

Despite the fact that the majority of Australian catchments (and therefore basins) drain to the sea, vast tracts of the inland are

similarly divided into drainage areas due to topography. Indeed, the largest drainage basin in Australia contains no big river channels at all and is known as the Western Plateau. It covers huge areas of Western Australia, the Northern Territory and South Australia. One of the smallest Australian drainage basins also drains into the 'desert' (or more correctly 'semi-arid inland') rather than the sea, and is known as the Bulloo–Bancannia; it is elongated and straddles the Queensland–New South Wales border about a thousand kilometres or so west of Brisbane.

The Lake Eyre Basin lies between the Bulloo–Bancannia and the Western Plateau and covers about 1.2 million square kilometres. It occupies parts of Queensland, the Northern Territory, South Australia and a narrow north-western strip of New South Wales. As its name suggests, the Lake Eyre Basin (LEB) drains not to the sea but to the vast and temporary Lake Eyre. The major catchments within the Lake Eyre Basin – the Cooper, Diamantina and Georgina – are unpredictable and fickle like the big lake itself, the difference being that permanent waterholes are found along their lengths. Importantly, its muddy rivers and catchments behave roughly as they would have prior to the appearance of Anglo-Europeans, and this is because they haven't been regulated. This situation contrasts sharply with the rivers in Australia's most famous drainage basin, the Murray–Darling.

The Murray is Australia's biggest river, despite the fact that it's a baby compared to the Nile, the Amazon, and countless European and Asian waterways. The Murray rises in the Snowy Mountains – also not particularly Earth-shattering as far as mountain ranges go – and then flows west and forms the border of New South Wales and Victoria. The Darling system comes

down from Queensland and flows through the semi-arid bits of New South Wales – Brewarinna, Bourke, Wilcannia, Menindee – before joining the Murray at Wentworth. The Murray–Darling Basin occasionally drains to the sea – just east of Adelaide in South Australia. But in dry years when water fails to make it to the river mouth there's plenty of controversy regarding why there should be water in the lower reaches of the river. This is where political map lines (states) and science map lines (drainage basins) don't line up, and it's where the trouble starts, for this system covers parts of four states and includes the Australian Capital Territory: it doesn't take Einstein to work out that if you live at the bottom of the Basin (South Australia) it's likely that there'll be less water than there is at the top (Queensland or the New South Wales highlands), because people need it for everything from growing food to generating electricity.

The Murray–Darling Basin (MDB) is particularly interesting from a social and economic point of view because it's where much of Australia's rural development has occurred, and also because it's literally just over the hill (Great Dividing Range) from the east coast, which is where the vast majority of the population lives. Consequently, the meat and grain and wine and fruit that Australians consume as they lazily watch the Pacific drift by is frequently grown on or in the soils within the Basin, and has been ever since Blaxland, Wentworth and Lawson first bush-bashed their way across Mount Victoria. A great number of quintessentially Australian things therefore originate in or from this large area, from sheep grazing to cereal cropping to bushrangers, and in many cases when Australians think of the bush, they probably think of a romanticised bit of

the MDB that includes a few sheep hanging around a section of river, the odd eucalypt, plenty of grass, a kookaburra in the eucalypt…you get the idea.

Beneath the thin veneer of loveliness and tranquillity, however, it's become obvious that the Murray–Darling Basin is in poor environmental nick. So, along with all the happy rural connotations, it is now known as the spot where Minister Penny Wong bought an irrigation farm (Toorale) up near Bourke so that the water could go back to the river rather than into big storages; where the biggest irrigation property of them all, Cubbie, is almost always in the news; and where the conflicting interests and/or wobbly alliances of farmers, conservationists and governments become big, convoluted issues that seem to have no solution.

Way *way* back, of course, it wasn't quite as complicated. About 500 000 years ago (give or take), a massive lake existed in south-eastern Australia. It was called Lake Bungunnia, and stretched from Menindee down to Mildura and then south and west nearly to Adelaide. Think of those big meandering red cliffs on the Murray down in South Australia and you're in Bungunnia country. Back then, inland Australia was a lot wetter. Lake Bungunnia was huge, and would have facilitated colonisation of most of the area covered by the current Murray–Darling Basin rivers by a common suite of fish species and other aquatic creatures like turtles and crayfish. Consequently, with a few local variations, the native species we find today in the Murray we also find in the Murrumbidgee, the Lachlan, the Macquarie and so forth, and it'd be a fair bet that similar species swam about in Bungunnia.

We're not entirely sure what happened between the heyday

of Bungunnia and the present but there are a few clues. Our biggest mammals, such as diprotodons and giant kangaroos, became extinct at around the same time – give or take a few thousand years – as humans first moved to Australia. It seems highly likely that the arrival of a new and efficient super-omnivore might have heralded the beginning of the end of the megafauna, but it's interesting that some of our more arid-adapted large mammals, such as red and grey kangaroos, have hung on and either become or remained the dry-country specialists they are today. Nevertheless, out-size goannas, pythons and land crocodiles drifted into extinction, so it's tempting to think that, way back in the waters of Lake Bungunnia, there might have been mega-cod cruising the shallows searching for giant frogs, and whopping archerfish shooting down low-flying super bugs. The point is, we don't know how many species have become extinct from the suite of fauna that swam about in Lake Bungunnia, but you could put money on the fact that everything native that's getting around the Murray–Darling now has a skerrick of Bungunnian ancestry.

Humans have been present in the Murray–Darling Basin from about 40 000 to 50 000 years ago based on fossil evidence from Lake Mungo in western New South Wales. Shell middens and fish bones are also common at Lake Mungo, suggesting that water in that part of the world was far more plentiful than it is today. It's interesting to consider that the first human inhabitants of the MDB may also have thought about and spoken about the changing seasons and the resulting changes in catch rates and species in their traps or on the ends of their spears. It's conceivable, too, that they may have noticed subtle differences in the appearance of fish species or turtles from Lake Mungo

as they headed east, back along the Lachlan River towards the mountains, or instead migrated south to the Murrumbidgee or north to the Darling.

Fish evolution – like all evolution – is a work in progress. The fish species that we encounter in our inland rivers today are the descendants of their relatives from yesteryear and the ancestors of the species that will inhabit what is left of the planet long after *Homo sapiens* also becomes extinct. Accepting this continuum is tricky when you're a conscious being that lives for less than 100 years, but it's necessary in order to realise the fluid nature of natural systems.

Australia's first people entered from the north and eventually colonised the entire continent, including Tasmania. They certainly had an impact on the native fauna and landscape, and would have contributed to the extinction of a number of species, but this happened comparatively slowly. In contrast, the Anglo-Australians – a mixed bag of ex-cons and settlers – turned up quickly and more or less set about doing the place over in record time. Australia was seen as a land to be subdued rather than a comfy place to live. Consequently, the early phase of colonisation or invasion – depending on your point of view – was the exit point for vulnerable native species, the entry point for a host of noxious alien species, a time of great suffering for the first human inhabitants of the country and the beginning of some serious landscape 'adaptation' by people who knew little of the havoc they were wreaking in the name of progress. In terms of geological time it all happened in a quarter of a heartbeat or so. It's taken us about 200 years to realise just how stuffed some bits of Australia are, and now it'll take a long time and plenty of money to begin reversing the big mistakes.

The narrow coastal strip of eastern Australia was never going to contain the colonists/invaders for long, especially once the Great Divide was breached and the grassed and subtly rolling country to the west beckoned. It was good country. Dry enough to grow cereal crops like wheat, barley and oats, and – as long as water was close by – perfect for running sheep and cattle. Soon enough, thousands of human feet and animal hooves radiated inland. Millions of acres were cleared and cropped, grazed, cropped again, grazed. Into Australia's wild and ancient ecosystems came modern domesticated large placental mammals and modern domesticated food crops from other distant parts of the planet. Within a hundred years most of eastern and southern Australia had undergone an incredible transformation, and the sheep's back was making the country rich and fat.

The biggest obstacle to on-going fatness and commensurate richness was the dependability of water. Rivers on the eastern side of the Great Divide like the Hawkesbury behaved a little like European rivers since they received comparatively frequent rainfall, but the rivers west of the range were a different proposition entirely. It's difficult now to imagine a posse of bewildered explorers manhandling heavy boats along dry sections of the MDB or LEB rivers, searching in vain for the mythical inland sea, and it's amazing to think that they persisted.

We can assume, however, that climatic unpredictability has always been an issue for humans in Australia. The first human inhabitants neatly circumvented this problem by remaining nomadic and relying on their hunting and gathering skills, but this was never going to work for those of European stock. For

those who liked to stay put, the unpredictable rivers became a problem to be solved.

Then, as now, the solution to environmental unpredictability was sought through engineering. The problem was that although the rivers seemed to be reliable most of the time, if the winter–spring rains failed, the rivers might stop running in summer, and might stay that way for the following year as well.

Makeshift weirs and dams were used extensively by the early white settlers in country Australia, and the remains of many structures survive today. Then as now, stockpiling water could mean the difference between a good and a bad year, or even a bad and a terrible year. In the late 1800s, the first tentative steps were taken to start an irrigation industry in western New South Wales. From this time on, river regulation became a big business rather than an ad-hoc pursuit.

Downstream from Condobolin on the Lachlan River is a small town called Euabalong, and a little further downstream from Euabalong was where the regulation of New South Wales' inland waterways had one of its shaky starts back in 1902. An unusual starting point, it must be said, given the *very* ad-hoc nature of flows in the Lachlan over the last 10 or so years, but not so difficult to understand on learning that in 1902 the Lachlan stayed dry for a record 291 days.[1]

Lake Cargelligo, an ephemeral wetland that is easternmost of the extinct Willandra Lakes, was the focus of the work conducted back then. By excavating three short channels linking existing low-lying lake/swamp areas, the engineers of yesteryear worked to create a 5000-hectare shallow lake by diverting water from the Lachlan River. The additions of a short levee bank to prevent the water draining away to the south-west and some

excavation of a small creek to drain water from the Lake back to the river completed the system. Next, regulator gates were installed on the inlet channel and the outlet creek and, bingo, the water was tamed, the town could prosper and farmers could try everything from soy beans to cotton all the way down to Hillston and beyond. In the spurt of development that followed, dams, weirs and levees were erected all over the Murray–Darling Basin to emulate and improve on the Cargelligan enterprise. Before anybody really took the time to look back over their shoulder, the dams were getting bigger, the dollars bigger still and the sheep's back was being chased by a full-blown irrigation industry. The climax was the Snowy Mountains Scheme, which began in 1949 and resulted not only in massive employment, massive amounts of electricity and massive dams (Hume, Burrinjuck, Eucumbene, Jindabyne, Blowering), but the simultaneous 'creation' of irrigated farming centres such as Griffith and Leeton in the Murrumbidgee Irrigation Area.

At the time, the Snowy Scheme was thought of as a great engineering masterpiece akin to the waterworks of ancient Rome. It's taken us a while to realise that – unfortunately – damming and diverting rivers in Australia often creates more problems than it solves. In a nutshell, successive governments worked out that irrigation was a great way to 'insure' agricultural production and therefore make money so they promoted it heavily. Plenty of people were willing to take up the irrigation blocks as many of them had just been laid off once the key at the Snowy Scheme was turned to 'on'. Everybody benefited fairly quickly, too, because suddenly Australian agriculture's climate-associated problems were minimised. As a consequence, the dam-irrigation-population model was adapted for many inland

areas where a river existed. With cheap water everywhere, irrigated horticultural industries like citrus and grapes blossomed, and alongside them broadacre blocks grew everything from rice to cotton and corn.

It took until well into the second half of the twentieth century for us to realise that the gung-ho approach had some negative implications. In certain areas, paddocks that were irrigated every year became non-productive and saline. In others, where catchments had been cleared, rainfall events eroded riverbanks, and the rivers themselves became choked with sediment. Non-native plants and animals appeared to thrive, but native species often declined. In the rivers, where previously there had been yellowbelly and cod, there were infestations of carp. In an attempt to find solutions, ecologists started looking to new branches of science like restoration ecology for answers. But, in order to restore something – anything from an old tractor to a river system – you need to know what it used to be like before it was broken. You need what's known in the trade as 'reference' areas – in this case places that haven't been dammed, pumped, farmed and infested by ferals. In the Murray–Darling there are, however, precious few reference areas, so any restoration involves a little guesswork.

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BIG NASTY: THE CARP STORY

On a typically over-hot, over-humid February day in early 1993, my partner Alison and I drove a three-tonne truck and all our worldly goods westwards over the Blue Mountains to escape the size and dirtiness of Sydney. At the time, I don't think it crossed our minds that we were beginning an extended stay in a drought-prone, water-starved, feral animal-infested drainage basin that stretched from Queensland to South Australia. We were just searching for a change.

We set up house close to the little town of Lake Cargelligo in the mid-Lachlan catchment, arguably one of the most broken rivers in the broken Murray–Darling Basin. We were still blissfully ignorant of most of the problems on our doorstep, but over the next decade, perched on the shore of a drying wetland in the middle of New South Wales, I had a front row seat to a weird and lengthy play that exemplified everything that has gone wrong in the MDB – over-allocation of water, river

regulation, greed and stupidity. And there, literally swimming at my feet, were outsize carp – an introduced fish species from Europe and Asia – that for a lot of people encapsulated and signified the whole messed-up situation.

It had been a full ten years since I'd last seriously hurled lures at the Pacific Ocean or drifted live bait out under floats to catch unseen fishy monsters. As a matter of fact, I'd lost interest. But by degrees I became fascinated by the big lake, by its relationship with its parent river the Lachlan, and by the Lachlan's status within the Murray–Darling Basin. In between going to work – I was teaching music in the local schools at the time – and raising a couple of kids I made two quiet promises to myself. The first was to try and understand what was going on in the murky waters of the Murray–Darling through the prism of a degraded bit of the Lachlan River, and the second was to try and work out just how broken the place really was, and how it should have been, or could have been, before we came along and broke it.

In the back of my mind an idea began to take form that would ultimately lead me to desert waterholes a long way from anywhere. I think I realised early on that understanding Australia's inland water systems required objective eyes cast over intact and unaltered areas rather than jaded eyes focused on degraded rivers. But that said, it was the degraded rivers that caught my attention, because there I was, literally, right in the middle of one of them.

Prior to 1902, Lake Cargelligo was a temporary swamp. Afterwards, the plan was that it would be a shallow lake. A rock weir stretches across the Lachlan just south of the inlet channel excavated over 100 years ago: this means that the river – when

it flows – banks up behind the weir, allowing water to be drawn down the inlet channel to create the 'Lake'. And if you ever go there 'Lake' or '*the* Lake' is the correct placename; locals never say 'Cargelligo'.

The Lake when even a little bit full is a pretty place by virtue of the fact that it's a big sheet of water in the middle of a farming district. There is a small mountain range – curiously called the 'Ural Range', though it's very un-European – that frames the Lake to the west, but other than that the surrounding topography is western plains flat. The main part of the Lake is about seven kilometres long and there's no evidence of trees, so it's a fair bet that it's been a swamp or lake for a fair while. When the Lake is full, the big sky, narrow horizon, pelicans, cormorants and turtles create an idyllic and peaceful place, and provide an idea of what inland Australia may have been like post-Bungunnia but pre-people.

On summer afternoons there was nothing better than grabbing a couple of beers and jumping in the flat-bottomed boat that I kept down at the water's edge. Anyone who has sat in a tin boat on a completely hot, completely still summer's afternoon as the sun ever so slowly loses itself over the western horizon will know the feeling. A waterway in inland Australia is not like a coastal river – it is quiet. Except on the busiest holiday weekends, there is little to disturb the tranquillity. At different times of the year the air out on the Lake would smell like the damp soil being worked by farmers in the district, or occasionally in summer like a fire or an impending dust storm, but there was always plenty of time to think because there were no interruptions. Indeed, the idyllic setting was really only spoiled by one thing. Whenever the boat drifted close to shore there was

Carp (top) and a feral goldfish (bottom). Both species were introduced to Australia in the 1800s and are now widespread throughout the Murray–Darling Basin.

a sound: a slurping, gargling sound like a combination of large raindrops hitting a roof and the swish of a horse's tail. It was – and is – a most obvious sound, and a most unpleasant intrusion into quiet, contemplative afternoons on inland waterways. And unfortunately, the constant sucking sound that emanates from Australian riverbanks comes from one of our most successful invasive species – it is the sound of the working mouths of countless tonnes of carp.

Ever since the 1970s, the Lake – and plenty of other rivers and areas in the Murray–Darling Basin – has been overrun by carp. The term itself can cover any of a large range of species belonging to the massive (over 2000 species worldwide) Cyprinidae family. Australia, New Zealand and South America are the only places where Cyprinids don't naturally occur.

Cyprinids include highly adaptable and resilient species, and because there are so many of them, they have evolved to fill most of the available ecological niches in most of their native

habitats. Carp and Australia were never meant to co-exist, and were it not for the intervention of humans it's hard to see how they could have. After all, it's a pretty big island and they don't like salt water, so swimming here wasn't an option.

The first carp were released close to Sydney in the 1850s. Then they were released in 1876 in the Murrumbidgee, and then again in 1961 – yep, *19*61 – at Mildura. That's the official story, but it seems likely that 'carp' found their way into Australian waterways by various routes over the last 160 years or so. After all, common goldfish, koi carp, goggle-eyed looking things that can hardly swim, and the aquarium fish collectively known as 'barbs' are all Cyprinids – all 'carp' – and it's important to emphasise that the carp we hate for living in our rivers and the goldfish we love for decorating our living rooms are close relatives. Indeed, commercial fishermen setting nets in the Murrumbidgee and Lachlan drainages have reported catching hybrids of carp and goldfish: giant 60-centimetre-long versions of pet shop goldfish with carp-derived barbels hanging from either side of their mouths. Every time a kid buys a goldfish, gets sick of the goldfish, then asks their parents to get rid of the goldfish (which they do, often by releasing it in a creek rather than treading on it), another 'carp' gets liberated in an Australian waterway. Carp have acquired a filthy reputation in Australia – most people don't eat them and they're considered dirty, largely due to their blatant sucking/slurping behaviour in places like Lake Cargelligo. They've also been blamed for just about everything that's wrong with Australian rivers, particularly in the MDB.

The carp snuffling under the boat, and the carp gurgling and darting along the canal next to our tiny farm started to

interest me as I spent more time on or near the water. For those first few years, though, I was a snob. I considered kingfish and tuna *real* fish, and anything that lived in the mud inferior and not worth worrying about. Like everyone else, I hated the carp just because they were there, without giving the issue any more thought. It was probably only because I was pumping a bit of water to keep my orchard going and forever in and out of the water priming pumps that I started watching the fish with more than a cursory, disgusted glance. They were noticeably big, and noticeably *everywhere*. Indeed, I wondered how anything else could live in the same patch of water. I started searching around for information on fish in the Lachlan and in Lake Cargelligo specifically. Not surprisingly, there was very little on the Lake. I cobbled together a loose list of species that were supposed to be in the Lachlan from surveys conducted in 1983 and 1997, and that was when I decided to get serious about finding out what actually lived on my doorstep.[1]

In Australia, the carp that everyone loves to hate is known as the 'Boolara' strain of *Cyprinus carpio*. These are the large, smelly, bulky golden models that snuffle and gulp throughout the Murray–Darling and in coastal rivers of the south-east. They occasionally grow to over a metre in length, and because they break the surface of the water and feed in the shallows it's easy to get the impression that carp are the only fish species present in billabongs and backwaters. In most cases they're probably not, but when lakes dry down it's not unusual to find hundreds – or thousands – of dead carp and nothing else. The Boolaran carp are themselves considered hybrids.

When T. C. Roughley wrote *Fish and Fisheries of Australia* back in 1951, he summed up the carp situation as follows:

> There are three species of carp free in Australian streams and lakes – the crucian carp (*Carassius carassius*), the goldfish (*C. auratus*), and the common carp (*Cyprinus carpio*).
>
> The crucian carp is most widely distributed, although the goldfish, which in the streams has reverted to its ancestral form, is probably more widespread than at present suspected...The 'common' carp does not appear to be free in anything like the numbers of the other two species; it can be distinguished by the presence of two barbels on each side of the mouth.[2]

But that was before 1961. Grab a fishing rod or a line, dig up a few worms or steal some cheese from the fridge, then head out to any nice flat billabong in the MDB on a summer afternoon. Bait your line and sit back and enjoy the pelicans or dirt-bike riders. If you get a bite and it's a long, slow, bulldozerish type of bite, the chances are you've hooked a carp. Put down your beer or similar poison and reel in your fish. I guarantee that it'll have barbels just as Roughley described. If it's particularly fat-looking, you might like to kill it (in the trade the term is 'humanely euthanase') and cut it open, for I'm also willing to bet that the fish is a female and loaded with millions of orange eggs. In fact you should kill it rather than leave it on the bank to die; just because they're an Asian-European species that has been stupidly introduced doesn't legitimise making the poor things suffer. If you choose to kill your carp by the time-honoured method of whacking it between the eyes with a stout branch, you'll also notice how tough their heads are. This helps with bulldozing, and probably deters waterbirds' attentions – handy when you

like to forage with your head out of the water.

The Boolarans are descendants of the introduced populations of 1961 with a bit of hybrid vigour courtesy of the 1876-ers. From their southern stronghold they radiated quickly throughout the Murray–Darling Basin, aided by a few good flood years and, according to Roughley, the fact that 'the most useful purpose they served in Australian streams was to provide live bait when fishing for Murray cod'.[3] One shudders to think how many carp were liberated from buckets on the banks of the Murray, Darling, Murrumbidgee, Lachlan and Macquarie back when the lads went a-fishin', got bored when there were no bites and turfed the bait to go to the pub. The shuddering gets even more severe on realising that people still do it today. And it's worth emphasising the rapidity of the Boolaran expansion. The Murray–Darling covers most of New South Wales, a substantial part of southern Queensland, most of northern Victoria and a bit of South Australia. It took whitefella Australians the best part of a century to fill up all the nooks and crannies – carp did it in about a decade.

The Boolaran carp found the Murray–Darling Basin much to their liking: they loved the temperature, they loved the backwaters and, for the first few years at least, they loved the abundance of aquatic vegetation. Carp are omnivorous – they don't generally eat other fish, but they love sucking up mud and filtering out any worms and crustaceans for food, and in doing so they uproot plants and disturb the substrate.

The scientific literature gives us little indication of the great expansion of the Boolarans, predominantly because prior to L. C. Llewellyn's fish survey of 1983, there had been no widespread survey of the freshwater fish fauna. Even then, Llewellyn

only considered New South Wales. Looking back, it seems very shoddy that Australians – governments, organisations, all of us – were so fascinated by irrigation, the Snowy Mountains Scheme and *progress*, but didn't get around to working out what lived in our rivers until the latter part of the twentieth century. Instead, we know most about the Boolaran advance from anecdotal records and oral histories; one of the best of these is *Listening to the Lachlan* by Geoff Sainty and Jane Roberts.[4]

In the 1990s Roberts and Sainty interviewed people who live throughout the Lachlan catchment, many for their entire lives. In almost all cases, the interviewees draw a correlation between the arrival of carp and the decline of native fauna and flora. I've had the same conversations with the same people: 'Before the carp you could go out and catch cod/yellowbelly/catfish. After the carp you had to fish all day and you *still* might not get anything.' 'Before the carp, the river was clear. After the carp you couldn't see the bottom.' 'Before the carp, there was weed everywhere. After the carp it disappeared in a couple of seasons.'

The problem is, despite these observations, we're not exactly sure how destructive carp are in an Australian river. In a pond-based experiment undertaken by Jane Roberts in Griffith in the New South Wales Riverina, it was demonstrated that if carp are stocked at high densities (450 kg per hectare), turbidity (or muddiness) increases and some – but not all – plant species get uprooted.[5] Studies such as this provide good indicative data, but we should still resist the temptation to pin all the Murray–Darling's woes on the Boolarans. We need to remember that at the same time carp became part of Australia's fauna, there were a host of other changes occurring in the Murray–Darling Basin

that might also have contributed to the declines in native species and aquatic vegetation, and an increase in turbidity.

From as early as the mid 1800s, inland commercial fishing targeted the same species anglers noticed declining in number – the big noticeable ones like Murray cod, yellowbelly and catfish. Countless gill nets were strung across countless rivers, and we'll never know how many adult cod, perch and catfish were taken from the rivers of the MDB. The official figures quoted in a 1997 report by NSW Fisheries indicate that all species dropped out of the commercial equation.[6] They just weren't there to be caught. And, once *illegal* fishing is factored in, it's easy to see how the critical mass of breeding age fish could be severely depleted.

We also need to recall that by the time we realised that native fish were declining and that carp were all over the place, river regulation had reached its zenith. All the major MDB rivers were – and still are – 'controlled' by the use of large headwater reservoirs such as Hume, Burrinjuck, Burrendong and Wyangala. This means that the rivers weren't flowing as they would have naturally, and that flows were released to satisfy the requirements of a burgeoning irrigation industry in summer rather than when winter and spring rains traditionally fell in the catchment areas. If native fish reproduction and life cycles were linked with the natural flow regime, they may have been disrupted, and the presence or absence of the Boolarans would have made little difference apart from them gobbling fish eggs, which they surely do as part of their snuffling/filtering process.

Furthermore, as the process of turning inland Australia into a food bowl continued apace throughout the twentieth century, substantial changes were made to the land itself. Widespread clearing of agricultural land and the denudation of riparian

zones (streambanks) meant that a great deal of topsoil found its way into waterways, as well as nutrients and chemicals that had been applied to such areas. So again, it's likely – probably *highly* likely – that the Boolaran carp played a role in wrecking the Murray–Darling Basin, but it's unlikely that it's their fault alone. What we know for sure is that by the time we woke up and realised the MDB was wrecked, there were an awful lot of carp about.

From about 1993 onwards my good mate Mick Brigden and I used to enjoy the none-too-subtle hobby of carp archery on lazy Sunday afternoons. We'd jump in the boat, cruise over to the shallow part of the Lake, and then 'stalk' (sort of) through the 30°C water with compound bows at the ready and a quiver of makeshift 'arrows' over our shoulder or suspended on the bow itself. Arrows, they weren't. We had learned that using expensive aluminium-shafted target arrows on big carp was a dumb idea: if you hit them in the head the arrows would bounce off or break; if you hit them in the body the arrows would usually pass straight through; and if you were lucky enough to have the arrow hold, it would be bent beyond recognition once retrieved. Instead, we cut dowel down to the right length, Araldited a cut-off used centrefire rifle shell to one end and a nock in the other. No fletching, no line. Nothing fancy. Stalk, sight, pull back, sight again, drop about five centimetres to allow for the parallax error created by some combination of the sun and the water and hope for the best. We were remarkably successful on some days. Dean Gilligan, a scientist-in-charge at what used to be called NSW Fisheries later informed me that it's completely illegal, by the way, so consider this before rushing to the nearest waterhole with a compound bow and your camo gear.

A recent study of carp breeding down in the Barmah–Millewa wetland on the Murray found that carp breed early (around September down there, probably August up at the Lake), and they just love the big wetlands that fill up in summer.[7] This means they get the jump on any native competitors, and then the youngsters can get a good start and disperse to their hearts' content. In November 2005 some water came back into Lake Cargelligo after about a year of no inflows at all. I put some small fish traps in, expecting to pick up the usual assortment of small native species that call my corner of the Lake home. All I caught for three weeks straight were juvenile carp. Over 100 in each trap, and every day there were more.

The Boolarans are doing very well in the warm and quiet waters of the Murray–Darling and are a fantastic example of how successful an invasive species can be. But as delightful as it would be to remove all the carp, they are certainly not the only fishy villains lurking in the muddy waters. The others are often less visible – smaller, or less inclined to feed near the surface, or turn up on fishing lines – and yet they are just as bad.

3

THE ALIEN INVASION

In science fiction writing and old black-and-white movies, aliens arrive quickly, disperse rapidly and then proceed to destroy the Earth, its inhabitants or both. And although science fiction *is* fiction, there are hundreds of terrifying examples of alien impacts around the globe, because if native flora and fauna can't withstand the impacts imposed by the arrival of aliens, extinction is the inevitable result.

One of the best known extinct Australian animals is the thylacine. Until recently, thylacines were the largest modern marsupial carnivores and occupied a similar ecological niche to wolves. Along with the Tasmanian devil, thylacines were present on the Australian mainland until about 3,500 years ago, where they had presumably co-existed for up to 60 000 years with the only other large semi-carnivorous mammal, man. Prior to that there was probably more competition at the top of the Australian food chain from the giant snakes and lizards

and the odd marsupial lion. Within the last few thousand years, the introduction of the dingo, probably combined with the intensification of human habitation, resulted in the extinction of thylacines and Tasmanian devils on the Australian mainland, however both species survived into the twentieth century in Tasmania, the island state that dingoes could not reach. Unfortunately, the thylacine's geographical stay of execution did not prevent it from taking the odd sheep or lamb from the farms of new Anglo-European settlers in Tasmania, and once labelled a sheep killer, thylacine extinction became a matter of time rather than chance. The last wild one was shot in 1930, and the last remaining animal died in captivity in 1936. At about the same time, on the mainland, a number of smallish native marsupials such as the lesser bilby and the pig-footed bandicoot became extinct for the same reason: alien invaders – foxes, cats and rabbits – had rapidly colonised the continent, and just like in the old movies and Tasmania, the natives didn't stand a chance.

The arrival of alien animals in Australia was particularly catastrophic for local ecosystems because Australia had been separated from the other continents for so long. For over 30 million years – excepting comparatively recent biological additions like humans and dingoes – Australian biota existed, evolved and became extinct in isolation. From about 1800 onward, this slow-and-steady system was rapidly eroded through the introduction of alien fauna and flora. Like all good colonising species, these animals were – and are – hardy, able to reproduce rapidly, capable of tolerating a wide range of habitats and in possession of generalist feeding traits. For pigs, goats, camels, cane toads and rabbits, Australia's fickle seasons were only a small deterrent – in dry years they hung on, and in wet they

exploded. It will therefore come as no surprise to learn that similar invaders appeared in Australia's freshwater systems.

Believing the native fish fauna of Australia to be inferior, the early colonists were keen on improving the situation by importing (and liberating) a range of fish species commonly sought after by people from the northern hemisphere. These species included several species of trout and salmon, the English perch or redfin, and a variety of fish from the Cyprinidae family that includes carp, roach, tench and goldfish. The majority of these species were first introduced to our waters during or before the 1860s.

Animals known as salmon or trout belong to a family called Salmonidae. They are all large-bodied carnivorous fish from the northern hemisphere, and all were originally introduced to Australian waterways for people to fish them out again.

In Australia there are two species of salmon (Atlantic and quinnat) and three species of trout (rainbow, brown and brook char). They are all elongated bullet-shaped fish with plenty of teeth. Salmonids like cool water with plenty of oxygen, so are most successful in the high country and the big deep reservoirs. Think of Lake Burrinjuck or a dam in the middle of Tasmania on a winter morning and you get the idea. 'Wild' populations of salmon and trout are frequently sustained or supplemented by hatchery-reared fingerlings, some of which are bred and raised in government-run facilities.

Salmonids are top-order predators, so their climate-induced range restriction isn't a bad thing for native fish, frogs, insects and aquatic invertebrates. If they could adapt to the warm and slow-flowing inland rivers Australia offers it is likely that there would be very little else left alive, especially given the fact that

some species can grow to more than a metre in their native environments. Remember there are no bears waiting to flick migrating salmon onto the riverbanks and rip them to bits in Australia – just a few thousand fly fisherfolk in waders.

Salmonids form the basis of a lucrative and popular recreational fishery, and it's easy to see why because trout are a great fish to catch. I remember wading up the Turon River near Sofala in central New South Wales back in 1987. As the afternoon light dimmed, the rainbow trout would rise in the clear and rocky river and pounce on any insect that landed – or even came a little too close – to the water's surface. By casting a small Celta or similar bright metal lure in exactly – and it has to be *exactly* – the right place, I was rewarded with two or three one kilogram trout, each one jumping, head-shaking and crashing the surface in an attempt to dislodge the treble hooks.

Salmonids also make up a hefty piece of the Australian finfish aquaculture pie, so when you buy a portion of smoked salmon from Woolies, chances are the fish lived, died and was subsequently smoked in a coastal environment of Tassie, whereas if you buy a small trout to grill or barbecue it probably came from a fish farm in inland Victoria.

Culinary and sporting attributes aside, anyone with even a rudimentary appreciation of ecology could draw the arrows on a food web between a large-bodied toothy critter like a Salmonid and *anything* smaller swimming in the same reservoir or river, so keeping these beasties in Australian waterways is not ecologically clever. Trout have certainly been implicated in the decline of smaller native species, particularly members of the Galaxiid family, in streams where they co-exist.

Given the popularity and economic value of all Salmonids, it seems likely that climatically suitable rivers and lakes will continue to be stocked with them, and that Salmonid aquafood industries will continue to expand. Indeed, one of the more uncomfortable facts of life for Australian freshwater fish ecologists who are genuinely interested in preserving and enhancing our native fish populations is that Salmonids are here to stay, primarily because the recreational fishing, tourism and aquaculture industries have varying degrees of economic clout. So we're not about to remove all the trout and salmon, and we're not about to embark on a rehabilitation project to restore all the high country streams. The best way forward is to accept all this, live with trout and salmon, enjoy eating them, and try to manage their wild populations carefully. We have a small climate ace in this regard: Salmonids simply can't live in warm water, so their range is not likely to expand. In contrast, most of our fishy invaders are nowhere near as fussy and can survive pretty much anywhere.

Goldfish – the close relatives of the big Boolarans – are all over the Lake system, all over the MDB, and basically anywhere where little Johnny or Jane pesters their parents long enough to allow them to get hold of a few in a bowl. Goldfish, like carp, and like most invasive species, are quick breeders, are hardy and are tolerant of less than perfect water quality. Grouping goldfish with the other first invaders makes good sense: they've undoubtedly been in Australian waters for a very long time, but there's still a good deal we don't yet know about goldfish.

Goldfish in the wild resemble carp – a few individuals retain the bright orange colouration, enlarged eyes or flowing fins of their pet-shop brethren but most revert to a general golden

colour. They don't get as big, and their body shape is usually deeper (less elongated), but in most sampling work undertaken in the Murray–Darling, in coastal rivers and even in some places out west in the Lake Eyre Basin, goldfish turn up. You won't catch a goldfish on a line, and you won't see a goldfish snuffling. Goldfish don't have barbels, and they don't (yet) have the repugnant reputation of their cousins, but it's likely that they're having some kind of negative impact on Australian systems. We don't really know what it is, simply because we haven't tried to find out. In a similar way to trout, goldfish are currently 'tolerated'; fisheries agencies and management bodies aren't throwing money at developing 'daughterless' gene technology for goldfish, though they are for carp, or spending years trying to eradicate them from certain waterways. Indeed, if anyone reading this fancies spending a few impoverished years researching the life history of *Carassius auratus* in Australian waterways you would be doing a great service to freshwater ecology. Any takers?

There are a couple of other Cyprinids that have shown up from time to time in Australian waterways. Like goldfish, they've never made it to the main stage like carp. Roach and tench were first invaders. It seems roach never really made it out of the Yarra in Victoria, whereas tench have a slightly wider distribution in the southern Murray–Darling. Given that they've been here since the 1860s and haven't gone ballistic yet, it seems unlikely that they will (but then that's what Roughley implied about *Cyprinus carpio* in 1951). Further north, rosy barbs have been found around Brisbane. These aren't first invaders at all, but populations derived from comparatively recent aquarium releases/escapees. The fact that the majority of aquarium species are tropical suggests that if they're ever going to go on a

rampage, south-east Queensland and any place further north will be the battle ground.

People are surprised to learn that there are feral goldfish in Australia. I guess they imagine cute little orange critters swimming about in rivers as they do in tanks. When it is pointed out to them that goldfish are pretty much the same as carp, they are even more surprised. Some don't believe it. This is nothing, however, to the reaction of some people when they are told that redfin are also an alien fish. I've nearly had fist-fights over reddies.

Redfin perch, or English perch, are up there with carp as our most successful first invaders, but they don't have the same reputation, and this is because – like the Salmonids – they're a good angling and eating fish. Redfin are a greenish colour with dark vertical bands along their sides, a large and fearsome mouth and red or orange fins. Redfin can be considered 'big' when about a kilogram in weight and 30 centimetres long. They have dry white flesh – much drier than yellowbelly or cod – and they're impossible to scale, so most of us just skin them. They were imported into Tasmania in 1862, into Ballarat in 1868, and by 1888 they were heading towards, or had already reached, the Murray. They now inhabit the waters of the southern Murray–Darling, and other cool areas in New South Wales, Victoria, Western Australia and Tassie.

It's thought that temperatures at or above 31°C limit the range of redfin, and given their southern distribution in Australia this is probably true. Nevertheless, I've caught plenty of reddies in water over 27°C, so it's probable that the redfin cruising around in Australia – like the trout, carp and goldfish – are becoming 'Australian' versions of their parent stocks. Over 150

A healthy redfin from the Murray–Darling Basin: if carp are the rabbits, redfin are the foxes and cats of the MDB rivers.

years might not be quite long enough for a new species to evolve, but it's probably long enough to develop tolerances to local conditions. And tolerance of Australian temperatures would be a good start, because even in southern Australia, summer can be hot, and summer in shallow water, if it's too hot, can be deadly.

Redfin are visual predators. This means that if they can see you, and they're bigger and faster than you, they're probably going to eat you. The fearsome dentistry and wide gape come in handy, too. But again, I'm not entirely convinced about the end-point of this line of reasoning; theoretically, if a redfin has to be able to see you to eat you, you should be safe in some of the turbid water of the Murray–Darling. From my observations, however, redfin don't seem to be disadvantaged by turbid water. Back at the Lake, we would wait until the rare days when the water cleared (a bit) before trying to catch them on lures, but when I did some formal fish sampling using nets in January

2005, the visibility was less than 10 centimetres and the water was like soup. Nevertheless, I caught well over 100 juvenile redfin, as well as several adults, and they were spitting out smelt – a small native species. Further, they were all fat, which suggests that the turbid water wasn't really compromising their feeding efficiency at all.

As an alien species with a 150-year Australian lineage, redfin have been very successful, so we need to think about the consequences their presence has had on natural systems, and whether we need to start lumping reddies in with carp as equal public enemy number one.

Nearly all of our large native freshwater fish species, like the cods, yellowbelly and barramundi, hunt in a similar manner. Roughly speaking, they find a suitable alcove or overhang, and wait until something edible – or apparently edible – swims past within striking range. That's why all lure fisherfolk look for logs or other potential cover in the water, because that's the most likely place for their quarry to be hanging out. When you're a lone ambush-type, you don't need a body built of muscle – like a tuna or a marlin – because you spend most of your time hanging around waiting. That's why cod and yellowbelly get fat as they get older – too much sitting around waiting for something to happen.

Redfin are different from these similar-sized (and larger) native predators in one important respect – they school. A school of redfin hangs around together – much like a school of tuna or a pride of lions or a pod of killer whales – and no doubt strikes justifiable fear into the fishy hearts of the smaller denizens of their home patch. Schooling behaviour can be highly successful provided there's plenty of prey and the predators are mobile

enough to find it. When you're trolling a lure and you hook a reddie, make sure you mark the spot, or at least get yourself a landmark, because they seldom live alone. My brother-in-law took his tinnie with an outboard motor all the way around Australia chasing fish. He caught a few – barramundi here, trevally there – but when he turned up at our place his overall assessment was that the fishing wasn't up to what he'd been expecting. The following morning, the Lake was looking a deep green – a real contrast to its more normal faded brown – so we launched his boat. We found redfin in about 10 minutes – all big, all fast and all hungry. Every time our lures hit the water in the right place we caught a fish, and within a frenzied 15 minutes we landed about 30. As we puttered back home, he begrudgingly admitted that, having travelled around Australia looking for exciting fishing he had finally found it at – of all places – Lake Cargelligo, smack-bang in the middle of the Lachlan, smack-bang in the middle of the MDB.

Schools of tuna or other piscivorous (fish-eating) marine fish, along with the schools of baitfish upon which they feed are known as pelagic fish. Pelagic means 'of the open ocean' rather than inshore or inland. I've heard the term used to describe freshwater species too, which doesn't really make sense, except in the absence of a term for 'freshwater species that roams about in the middle of the channel or out in the middle of lakes'. I guess it's at least slightly descriptive, so for the purposes of our discussion here, pelagic means 'lives in the open water' not 'lives in the open ocean'. Very few Australian freshwater species live like this though; most are either benthic (they live on or near the bottom), mid-water foragers or ambush predators.

So why haven't inland systems in Australia evolved big

pelagic-style predators like redfin, trout and salmon? The answer might relate to our erratic rivers. To maintain a high-octane schooling pelagic life, you need to keep constantly on the move, and feed every day. To do this you need access to oceans, or big deep lakes, or at the very least constantly flowing rivers – rivers that aren't likely to enter a drought cycle. There are really only two – possibly three – Australian families from the inland that qualify as pelagic in our adapted definition, and none are piscivorous. Smelt and hardyhead are both less than 10 centimetres in length and both are silvery grey. The possible third species that could be grouped as inland pelagic would be a species called bony bream that lives on detritus and algae. They're always about, often in massive numbers, and they seem to occupy all levels of the water column.

In a natural Australian system, it's important to note that schools of fast-moving hardyhead, smelt or bony bream would be at greater predation risk from birds than fish, despite the odd individual being seized as the school passed a waiting cod or yellowbelly. But this balance could certainly be upset by the introduction of a non-native species that feeds on fish and hunts in packs. Like, for example, redfin in the southern Murray–Darling, Tassie and south-west Western Australia.

Hardyhead live high in the Murray–Darling water column rather than close to the substrate, and are in decline. It's a fair bet that redfin may be responsible. In fact, in an experimental trial in New Zealand, redfin were removed from ponds containing a suite of native fish, and the survival rates of the native species – unsurprisingly – increased.[1] In another redfin experiment in Western Australia, small trout were introduced into a waterway containing reddies and within a day the trout were pretty much

Hardyheads are small schooling fish. These Lake Eyre hardyhead were sampled in the Mulligan River in 2009, the first time the species has been recorded in Queensland.

gone.[2] It wouldn't be difficult to replicate these kinds of experiments, so if you live anywhere near redfin territory and feel inclined, go and catch one and put it in an aquarium. After a few days, get some smaller fish – goldfish rather than native fish – and pop them in too. Then watch what happens. My money's on the redfin attacking any introduced beastie as soon as it notices they're there. In the wild, it's not unusual to pull fish – often smaller redfin – up to *half* the size of the predator from redfin stomachs. So they're big, frequently cannibalistic, schooling exotic fish; they have a high energy demand because they're always on the move, and they live in areas where we *know* there has been a decline in the populations of smaller natives such as hardyheads and species of a similar or larger size, like Murray cod. By concentrating our research and management

dollars on the perceived number one enemy (carp), we might be neglecting an equally if not more problematic pest, because if carp are the rabbits of the rivers, reddies are the foxes and cats.

That pretty much covers all of the first invaders. Carp are probably still the runaway winners – especially the Boolarans – due to their ability to colonise quickly, breed like rabbits, survive in harsh conditions and grow to a size that prevents even pelicans eating them. Redfin are a very close second, primarily due to their carnivory and pack behaviour. Goldfish are like an accident waiting to happen, but we don't know enough to know what kind of an accident. Brown and rainbow trout (and salmon) decimate native species in the cooler rivers and reservoirs where they live, and they're probably here to stay. Certainly it's time everyone became a bit more honest about the Salmonids. At the end of the day, we're still putting large carnivorous animals into ecosystems where they don't belong, to the detriment of local species. The 'it's an adapted/modified ecosystem anyway so it doesn't matter' argument is also a little flawed, because we still have assemblages of native fish species in our inland systems, and it should be our job – and priority – to try and look after them.

A more recent invader is the gambusia, or mosquitofish. Unlike the first invaders, gambusia only grows to four or five centimetres, they're American, and they were introduced from the 1920s when governments and citizens began liberating them into streams and rivers in order to control mosquitoes. The theory was that gambusia would achieve this by eating all the larvae. A few years later, in 1935, a similar process occurred with cane toads – also American, and also introduced in order to provide a biological solution to a biological problem (in this case cane beetles on sugar cane farms). Unfortunately for

Australian ecosystems, animals like gambusia and cane toads are now widespread and thought to be responsible for numerous declines in native fauna, and unsurprisingly, both mozzies and cane beetles remain common.

Gambusia, like carp, are a highly successful invasive species. They can eat anything – no doubt including the odd mosquito larvae, but also the eggs of native fish – they breed like the clappers and they can live nearly anywhere.

Experiments that have been conducted on gambusia certainly suggest that this species has the potential to destroy or at least negatively impact populations of native fish. In one tank trial, it was demonstrated that gambusia are capable of eating larval native species (as well as their own offspring)[3], and in another, gambusia exhibited aggressive behaviour such as fin and tail nipping towards some small native fish called blue-eyes.[4] For this reason, gambusia are frequently described as 'aggressive' or 'pugnacious'. A lot of cichlids are called 'aggressive' in the aquarium trade for the same reason. It's unlikely that gambos are any more malicious than the next fish, it's just that, like carp, they're visible, and the great mozzie eradication experiment of the 1920s and 1930s was a dismal failure: we used to love them but now we hate them.

Gambusia belong to a family called Poeciliidae and, along with their relatives – guppies, mollies, platies and swordtails – are distinct among Australia's current fish fauna in that they give birth to live young. This means that when the females are about to drop they resemble little beach balls, with a big black patch on their bellies (the young); in contrast the males remain slim and have a pointed reproductive appendage, which is a modified anal fin called a gonopodium.

A pregnant gambusia or mosquitofish, a species introduced from America in the 1920s. This fish gives birth to live young, whereas all native freshwater species lay eggs.

Giving birth to live young is a tremendous competitive advantage in Australian waterways. Junior gambos hit the ground running – usually in spring and summer, which is also the time a lot of native fish breed – and are able to start feeding on large prey such as their native neighbours (as eggs and helpless fry) straight away.

Because of where they're from, gambusia like their water warm, slow and sluggish. Like carp, they adore the backwaters of the Murray–Darling, but they're also widespread in coastal drainages from Adelaide all the way up to north Queensland, in rivers of the Gulf, out in the desert and in the south-west: gambos, unfortunately, are everywhere. The most common explanation for this is that they have colonised widely during floods and other flow events from small founder populations originally liberated early in the twentieth century, but it's also possible that they keep turning up in consignments of aquarium fish shipped in from overseas. Their close relatives – particularly platies and swordtails – are widely distributed in waterways

close to cities and big towns, and their populations are definitely established by people who can't quite bring themselves to flush their unwanted pets down the toilet so release them in the local creek. Like goldfish, after a couple of generations in the wild they revert to dull old gambo colour (a pale olive green). But it doesn't matter what – exactly – they *are* in terms of species, because they all live the same way. If it's got a gonopodium, we don't want it.

And if anyone's wondering, every time I walk into a pet shop where there is tank upon tank filled with livebearers and goldfish, I get the same shudder as when I think of the fishermen of yesteryear using carp as live bait. They're always the cheapest fish in the shop, and there are always thousands of them. It's pretty obvious how so many of them end up getting liberated in our rivers.

These 'newer' alien species found all over Australia represent a new development in the battle our native species face against foreign invaders. One of the specific problems with gambusia is that they are small enough to live anywhere, so the colonisation possibilities are virtually limitless.

Peter Unmack, who has done a fair bit of work on Australian desert fishes, has taken to calling them 'damnbusia'. Like many others, he sees the gambo threat as a potentially fatal invasion for some of Australia's most unique and endemic fauna in the arid zone.[5] Gambusia, unlike carp or redfin, are already present in the waters of the Lake Eyre Basin, and when it floods out there, the colonisation possibilities are massive. Gambusia, in the course of one decent flood like 2010–11 could colonise water from Longreach in Queensland all the way down to Lake Eyre. Then, when the systems dry down to discrete waterholes once

more, they can set about reproducing. Remember, when the floods stop it's pretty much always hot, slow and sluggish, just the way they like it.

Thankfully though, and with the exception of a couple of specific areas, gambos haven't yet managed to flourish throughout the Lake Eyre Basin. It could be because even by their standards it's just *too* hot. In many Lake Eyre Basin waterholes the water temperature in summer frequently stays above 30°C for days at a time. It could also be because the erratic flooding and drying is just too unpredictable, or because the native fish fauna out there has remained intact, and they may be better at repelling an alien invasion through predation. Or we could be wrong, and this year, or next, or the one after that, the gambos will be *everywhere*.

Getting rid of gambusia will be pretty much impossible. And remember that there are other Poeciliids out there too, all just as busy with their gonopodiums and cloacas. They are too small to fish out in most areas, and to a degree, they fit into the same category as goldfish and redfin – we know they're there, we've got an idea they're up to no good, but we would benefit from knowing what seems to trigger infestations and/or keep small populations under a semblance of control.

Our most recent fishy freshwater invaders are species that have reached Australian waterways as a by-product of our affluence. People in poor countries don't keep fish in tanks as ornaments for their living rooms or offices – they're more likely to go and drag them out of rivers and put them in plastic bags and foam boxes and ship them offshore for cash. The recipients are us. As anyone who has ever kept tropical fish knows, it can be a highly rewarding hobby, and there's

nothing intrinsically wrong with it, except that the majority of tropical fish are non-native and, therefore, a potential threat to Australian ecosystems if they get away. Despite the warnings in aquarium-related books, most fish that are capable of surviving the shipment process are also a lot tougher than the authors would have us believe, and, if they find a suitable environment, can quickly establish feral populations. Candidates include the relatives of Siamese fighting fish from Asia, anything even vaguely related to a carp or a gambusia and all the African and American cichlids. Indeed, a family of African cichlids collectively known as Tilapia are already present in many coastal rivers in Queensland and could be just as destructive as the established pests down south.

Perhaps luckily, the key word here is 'tropical'. Most tropical fish are imported to Australia from hot areas in the Americas, Africa and Asia. If these species find themselves swimming free in a Tasmanian creek the odds are it'll be a fairly brief encounter with freedom. But – on the other hand – Australia has more than its fair share of warmer waters too, and consequently aquarium escapees pose a constant threat.

Thankfully, the Australian aquaculture industry has so far concentrated on native species, along with Salmonids (first invaders), and this means that, unlike many other countries, we're less likely to experience inadvertent releases of food fish, which are often carp. Nevertheless, there are specialist ornamental fish breeders who grow live-bearers and the various carp derivatives, and plenty of hobbyists, most well-meaning, who grow and breed a diverse array of exotic beasts from all over the world. Accidental releases of these and hatchery-reared native fish are both undesirable.

Australia's long isolation has resulted in the evolution of our wonderful and unique native fauna, but it also underpins our vulnerability to alien invasion. It's essential for us all to realise that any non-native animal has the potential to become a feral pest in Australia.

4

HANGING IN THERE: NATIVE FISH IN THE MURRAY–DARLING

As of 2011, there are about 46 species of native fish known to occur in the Murray–Darling Basin, and around half that number further inland in the Lake Eyre Basin. It's sensible to use the word 'about', because some species have only recently been recorded, and scientists who busy themselves with genetics continually name new species and sub-species.

The magic number comes from the most recent guidebook published by the Murray–Darling Basin Commission (now an 'Authority') back in 2007.[1] The author of *Fishes of the Murray–Darling Basin: An Introductory Guide* is Mark Lintermans, who, with a band of merry helpers in the nation's capital have made it their business to make sure that one endangered MDB species, the Macquarie perch, will avoid extinction at least in the short to medium term. The amount of effort these scientists have invested is disproportionately large, especially for an Aussie species, and even more especially for a fish, and the ten-plus years

they've been doing this is proof-positive that linking research dollars to short political terms is problematic. Macquarie perch, aka maccas, are a blackish, deep-bodied fish, occasionally with a golden sheen or mottled, and they seem to inhabit the higher, cooler streams of the MDB. They're also found east of the Great Divide in the Hawkesbury and Nepean rivers but they're never common. Maccas are a threatened species due to their limited range, and everything from introduced species to commercial fishing and habitat alteration (such as weirs) is thought to have contributed to a reduction in their numbers.

Maccas belong to the family Percichthyidae – perch-like fishes. The vast majority of the bigger freshwater native fish that people fish for in southern Australia are Percichthyids. Other family members include bass, estuary perch, yellowbelly, Murray cod, trout cod and a couple of other coastal species. In terms of relations, their closest cousins are yellowbelly in the MDB and bass and estuary perch down on the coast.

'Cod' and 'perch' are generic fishy names that were bestowed upon the above-mentioned species by humans around 1788 or soon after due to the similarity of their body shapes to familiar fish from Old Blighty. Australian 'cod' are the biggest freshwater fish we have, and yellowbelly are very widely distributed. All of our Percichthyids are long-lived, carnivorous ambush predators and they're generally the toughest characters in the neighbourhood. However, to demonstrate just how tough the last couple of hundred years has been on Australian freshwater fish in the MDB, there's no better example than this family.

The Percichthyids are an ancient family in Australia, and the ancestors of yellowbelly, maccas and bass have been present since comparatively shortly after the break-up with Antarctica

over 30 million years ago. It's likely they've always played an important role up near the top of the food web. Back in Lake Bungunnia, we can assume there may have been toothy reptiles capable of catching, killing and eating a 50 kilogram cod, but soon after the time humans reached Australia, it's fair to say that once a cod reached 30 kilograms and a yellowbelly 15, they were reasonably safe from most predators except outsize pelicans and crafty *Homo sapiens*. By this time, the megafauna was on the way out, and the country was turning into the wide brown land we're so familiar with today.

The arrival of humans likely had an impact on the numbers of these large-bodied fish species throughout their geographical ranges. Aboriginal art and surviving legends in south-eastern Australia feature cod and perch, and the remains of stone traps at places like Brewarrina in New South Wales suggest that these animals may have played an important role in sustaining the first Australians.

But fortunately for the cod and perch, hunter-gatherers don't tend to camp in one place for too long.

Cod, and to a lesser extent 'perch' (like maccas and yellowbelly) are slow-growing, and they've been demonstrated to have a home range – a deep hole or a patch of snags where they wait for food to drift by or return to after occasionally massive migrations. They are highly regarded as table fish.

The squatting and settlement boom that occurred in inland Australia in the nineteenth century, spreading westwards as it did along the river channels of the Murray–Darling and Lake Eyre basins, was never going to be an easy time for the Percichthyids. Gill nets were easy to construct and deploy across many of the narrower waterways. As soon as fish moved up or down the river

from their home range – for whatever reason – the sharp bits of their outer gills became enmeshed and they eventually became dinner (either for aquatic scavengers or terrestrial predators). Directional nets – usually called drum nets – were even easier to make and deploy, and were set against the flow, thus capitalising on the Percichthyid habit of swimming upstream into incoming river flow. Also, baited hooks – with grubs, shrimp, yabbies, frogs, fish – were and are highly effective capture methods for large-bodied predators like cod and perch.

An inland fishery was established by about the 1880s throughout the rivers of the southern MDB, and tonnes of cod and perch were boated and trucked into Melbourne and Sydney fish markets. There are old and fuzzy black-and-white photos that bear testimony to these big cod and perch hauls – usually a rope strung between two trees, about 30 fish of varying species and sizes and a couple of gleeful fishos with pipes hanging out of their mouths.

Regulation of the inland commercial fishing industry began in what can only be called an ad hoc manner at about the same time, but the populations of Percichthyids that are now listed as endangered – like maccas and trout cod – were likely already in decline by the beginning of the twentieth century. Records collated by NSW Fisheries indicate that the commercial catch of all native species plummeted as the century wore on, and eventually the native fishery finally closed in September 2001.[2]

The genus *Macquaria*, represented in the Murray–Darling by yellowbelly and Macquarie perch, was hammered by commercial fishing, and also by the wide range of impacts associated with river regulation. Yellowbelly managed to hang on, possibly because they are so widespread, whereas maccas have suffered.

A juvenile Macquarie perch. This species has been the subject of a great deal of research and restoration to try and reverse its declining populations in the MDB.

Scientists think that maccas have more specific environmental tolerances than yellowbelly. Maccas like their water cool and clear, and are consequently found in the foothills of the Great Dividing Range rather than out on the plains. But – and it's a big but – is that because it's a habitat choice or is it just that they've been fished to extinction in many other areas?

Maccas seem to need flowing water to spawn. Yellowbelly don't seem quite as fussy, but in the MDB at least it seems that a small or large flow is likely to stimulate a spawning response. Enter dams and water infrastructure during the great growth phase of the first half of the twentieth century. Instead of a series of rainfall-induced flows occurring throughout the year, river regulation meant that for most of the year there were reduced natural flows downstream of large structures (again, think of Hume, Burrendong, Burrinjuck and Wyangala). Additionally, the cold water that gathers in the depths of the big dams and

which then becomes the flow release is also thought to have consequences for some critters. If you consider that the temperature of an inland river in summer is probably over 25°C, and then a massive flow release spews out of a dam at 5°C, it's easy to see how such events might impact upon animals or plants with a low tolerance for massive temperature fluctuations.

If maccas are slow to reach maturity, the removal of adult fish through fishing over the last 200-plus years is likely to have resulted in a smaller number of broodstock, and a range reduction, because populations at the edge of the species' distributional range have probably become extinct. The small populations that were left – from about the 1920s and 1930s onwards – then faced additional hurdles due to the construction of barriers (like roads) across their migration pathways, the impoundment of rivers and consequent loss of local flows (which are cues for breeding). As a final nail in the coffin, fish from overseas like trout and redfin also became established in the cool waterways where maccas hung on. Quite apart from their predatory lifestyle (not good if you're a baby macca), redfin in particular carry a virus which is known to affect the native species and wipe out infected individuals in less than 24 hours.

The multiple impacts that have hit maccas have certainly hurt their numbers. That's why the Canberra mob have been so busy translocating maccas to safe areas, jamming radio-tags in them to work out where they're going and snorkelling around looking for macca larvae in the always-cold waterways of the ACT.

Without doing the research, without trialling techniques and without making the odd mistake, *nothing* would have happened. If nothing had happened, there'd be very few maccas in

Yellowbelly – the big, widespread inland species. When there are no cod or barramundi, yellowbelly is the fish everyone loves to catch.

the Australian Capital Territory – possibly none. Instead, with a bit of luck, Lintermans and his crew have set up a much brighter future for this species.

Of the other three Percichthyids present in the Murray–Darling, only yellowbelly could be considered to be in reasonable shape. Trout cod, like Macquarie perch, were candidates for the title of first known fish extinction in the MDB until a similar restoration and relocation program was undertaken, and Murray cod – the large iconic species – is actually listed as 'vulnerable' under our national endangered species legislation. Thankfully, money is now flowing in the direction of cod threat abatement and habitat restoration. Hopefully, the big, recognisable, fishable species of the Murray–Darling Basin might be around for many years to come. However, there are plenty of other, lesser known species that also require our attention.

I conducted formal fish sampling out at the Lake in 2004 and 2005. I wasn't looking for Percichthyids particularly, but it was something to look forward to if it happened. The term 'formal' in this sense refers to sampling for which you have a research permit and an approved animal ethics agreement, as opposed to basic observational records from Sunday arvos.

We used three different techniques to sample fish, the general rationale being that some species and size classes respond better than others to different gear. So there were two so-called 'passive' techniques, where you set different sizes and types of net in the afternoon and go back and check them in the morning, and an 'active' technique called electro-fishing, which, using either boat or backpack-mounted units, has become a common method for sampling freshwater fish. Basically, an electric charge is pulsed through the water and knocks out anything that gets in the way. Most fish go belly-up, and then they're scooped up with a net. They generally recover.

Undoubtedly the worst thing about electro-fishing – or e-fishing as it's known – is the required garb. Because there's electricity and water in close proximity, it's an OH&S nightmare and apparently a goodly number of technicians in various far-flung countries actually go belly-up themselves. You have to wear a lot of rubber and plastic – boots, gloves, waders – which would probably be OK in a Tasmanian lake but is always uncomfortably hot in any waterway west of Orange. Despite all this, we traipsed around the lakes (there's a big one, a small one, and a shallow one) and the canals that join the lakes, zapping away, and caught a few fish.

Lake Cargelligo is in the mid to lower reaches of a river (the Lachlan) that is considered to be pretty poor, even when

compared to other MDB catchments. The Lachlan doesn't get the big snow melt like the Murrumbidgee or the Murray, and it doesn't drain a quarter of Queensland like the Darling does in a good year. It's just sort of stuck in the middle. Additionally, the lower reaches of MDB rivers are generally where the carp are thought to congregate, so I wasn't expecting a great deal from the Lake in terms of fish diversity. As it turned out, I was pleasantly surprised, as the vast majority – in terms of numbers if not biomass – were descendants of Bungunnians rather than cheap imports.

There is a large freshwater fish family called the Eleotrids or gudgeons. A gudgeon is a mid and bottom-dwelling fish, but not quite as bottom-dwelling as a goby. You can tell a gudgeon from a goby because in the latter the fins on the underside of the fish have fused to form a disc that they rest on (which is what they do for the majority of the time). Gudgeons and gobies are slow, small and steady – the fishy opposite of big flash creatures like marlin and tuna. You most definitely *wouldn't* spend your weekends camped on a rock ledge eating out of cans to catch a gudgeon (although I do know at least one bloke who is pretty besotted). Gudgeons are quite common in Australia and some – like the purple-spotted gudgeon – are pretty and cute in a gudgeony kind of way as well.

Most aren't. They're just drab brown fish, only a few centimetres in length. There are plenty of species of gudgeons, but there's also conjecture regarding just how many and how to tell them apart. So if you're emptying a net or zapping fish with an e-fisher at a place like Lake Cargelligo you'll definitely be catching some Western carp gudgeon (which, incidentally, are nothing like a carp), but you might also be catching some

Midgley's carp gudgeon or possibly some Lake's carp gudgeon and maybe even some Murray–Darling carp gudgeon.

The interesting thing – given that the Lake is a Murray–Darling Basin wetland with plenty of invasive species – is that the carp gudgeon are going gang-busters. Indeed, it would appear that river regulation, despite all the things it may have wrecked, has been particularly kind to this group of fish. Long after the Lake study I was running some demonstrations for science teachers in Brisbane and found that carp gudgeon – or at least their close relatives fire-tailed gudgeon – were similarly going gang-busters in a big pond at the University of Queensland, apparently oblivious to the fact that shopping trolleys, condoms and Coke cans weren't part of their natural habitat. I'm not sure why carp gudgeons like regulated watery places as much as they do, but it's probably to do with the fact that in these areas the water is often still and flows are rare. If you're three centimetres long and you like hanging around near the bottom of the water column waiting for a small bug or bit of zooplankton to float by, chances are still water will be more to your liking than a big flow.

I emptied about a kilogram of carp gudgeons from the small box traps one morning in Lake Cargelligo, about 1500 to 2000 individuals. A leading candidate for top carp gudgeon predator in the Lake would be their larger cousins the flathead gudgeon. These beasts are reasonably long (up to about 12 centimetres or so), have a compressed flathead-type head and – just like saltwater flathead – stay on or near the bottom and wait for things to happen.

Flathead gudgeon have a bit of character about them, though. They're not just drab brown fish; indeed, they're generally a

A carp gudgeon from Lake Cargelligo. Local populations of this small fish can be considerable despite the impacts of river regulation.

mottled brown colour. In fact, flathead gudgeon have the same mottled brown colouration shared by many Australian animals – from carpet snakes to geckoes. And they're true pugs. Occasionally I would put a few in a fish tank to have a better look at them and get a half-decent photo. On the odd occasions that a few carp gudgeon were in the net at the same time they enjoyed a brief stay in captivity as well, except it always ended badly. The flathead gudgeon would roll their beady little eyes in their flat little heads and spy the drab little brown fish haplessly swimming just above them. Then the flathead gudgeon would flap its big pectoral fins (the ones on each side) and wriggle a bit closer. A few more minutes of eye-rolling and flapping and it was all over. They always took them head first, and the size of the prey didn't much matter: several times I observed a flathead

gudgeon seize a carp gudgeon of nearly the same size and then swim around with the poor creature's tail hanging out of its mouth for an hour or so as it tried to swallow. Life's tough if you're a carp gudgeon – I think it's courtesy of being stuck at the bottom of the food chain.

A couple of other notable species also turned up in the Lake. One of these is the unspecked hardyhead. Why go to the bother of saying something is *un*specked? Good question. There are two bits to the answer. The first is that hardyheads, like gudgeons, are a family of fish and there are many variations on a theme. There is a species of hardyhead in Lake Eyre, a species in the south-west, a species in the Finke River in central Australia, several species in northern Australia, and marine and estuarine species – they're all over the place. So just calling them 'hardyheads' isn't enough. For a long time a species that occurs in the Murray–Darling Basin was called fly-specked hardyhead due to the broken lines along its sides. Some would say they were quite pretty. But in the lowland, or bottom reaches of the big rivers, most of the fly-specked hardyheads weren't quite as 'specked', so they became 'unspecked'.

Hardyheads share the top and middle area of the water column with another schooling specialist – the Australian smelt. Smelt – like hardyhead – congregate near the surface in big schools and are targeted by fish from below and birds from above. They're silver in colour and quite small – a 10 centimetre smelt is Godzilla. We'll meet them again further west but for the time being it's just nice to know that they exist in the Lake.

Having Lake Cargelligo on the doorstep was a great way to discover what lived there, and my Honours thesis documented some of the spatial and temporal differences in fish distribution

and abundance. Although the place was stuffed to the gills with things that shouldn't have been there – carp, redfin, goldfish and gambusia – a variety of native species were capable of maintaining populations, which naturally raised a few questions.

The most obvious was whether the redfin were outcompeting formerly present piscivores such as yellowbelly and cod. Possibly, I thought, but then I sampled a few yellowbelly too – admittedly not many – but enough to indicate that they were still there. Additionally, I sampled, and then subsequently angled, another species called silver perch as well. These animals aren't Percichthyids but another family of fresh and saltwater perch-shaped fish called Terapontids. They are known more colloquially as grunter or black bream. Like anything else in the Murray–Darling Basin that grows big enough for the table, they were commercially fished, and they've also been affected by river regulation, by competition with alien species and by disease carried by alien species.

I thought it was pretty neat that there were silver perch – a vulnerable native species – swimming around in the mostly murky Cargelligan shallows, obviously capable of doing so despite schools of redfin nipping their fins, the odd goldfish giving them ulcers and hordes of gambusia gobbling up their eggs. It was curious because it tended to suggest that the Lake was doing OK for a place that should have been pretty stuffed.

A further surprise was that Mick Brigden and I also trapped a very healthy adult catfish – the eel-tailed variety that is native to the Murray–Darling – despite local reports that there hadn't been a catfish caught in the Lake for years and that the carp killed them all. Catfish in the MDB are usually a dark, mottled colour, and the literature suggests they can get up to 90

Lake Cargelligo in a dry year. During 'normal' years the Lake supports a diverse ecological community and provides water for the town's 1300 residents.

centimetres long.[3] Nobody that I know of in the Lachlan or anywhere else has ever seen one that size, but on that sunny morning the fish Mick and I carefully removed from the net was around the 40 centimetre mark, and it was easy to see why they would have been such a popular eating fish back when they were more common. The catfish made a characteristic grunting, croaking sound as we quickly posed him for a few photos, being careful to avoid the three sharp and poisonous spines on his back and sides, before releasing him back into the cloudy water only a few hundred metres from my front door.

Catfish – like silver perch and the Percichthyids – were hanging on in the Lake. Their populations have definitely diminished, however, and since they build big circular nests in the mud it's thought that carp are the prime culprits because

they disturb the nests and hoover up all the eggs. Yet despite the carp, catfish were present. And despite the redfin, silver perch and yellowbelly were present. And despite the gambusia, many of the small species – gudgeons, hardyheads and smelt – were present.

It struck me at the time, as it still occurs to me now, that the native fish in the Lake and more widely in the Murray–Darling Basin are the tough ones – the ones that have weathered the storm of alien invasion. There are a few small species that we didn't find in the Lake – fish like the Murray hardyhead, a brightly coloured species called a rainbowfish and a translucent one called a glassfish. Perhaps they'd been in the Lake earlier? Maybe they'd be back again in a really good year? Or maybe they simply couldn't get along with that many aliens, or had never been there in the first place? I couldn't answer those questions for the species I didn't catch, but for the ones I did – they were, most likely, toughing it out and they'd probably been doing it for some time.

Given that the Lake was still drying, I put together a naïve little plan that I then shopped to the local Catchment Management Authority and the relevant government agencies. I suggested that we pull the carp, the goldfish and the redfin out of the Lake from the isolated drying sections using whatever means necessary – big nets, electro-fishing, anything – and that before the water returned we build screens and/or cages at the inlet and the outlet regulators so that anything – native or alien – that wanted to get back in could be 'assessed'. It was a bit like the Australian government's immigration policy.

In any event it didn't go ahead despite a brief meeting towards the end of 2005 – and that's when I started thinking

how different a totally 'natural' Australian inland river system would be from a place like the Lake. To envisage this was tricky because pristine inland catchments are thin on the ground in the central west and Riverina of New South Wales.

I did a bit of reading and checked out a few maps. In the north and west there were rivers where there were no weirs or other stuff-ups. Out there the rivers either flowed naturally or didn't flow at all. I figured if fish could get by out there, they could probably get by anywhere. And, to top it off, the Lake Eyre Basin rivers weren't overrun with aliens, so there was no better place to go to observe how a natural system in the Australian inland operates.

I accepted a PhD scholarship at Griffith University's Centre for Riverine Landscapes (later to be renamed the Australian Rivers Institute), and we moved to Redcliffe, just north of Brisbane. The kids had the same blue tracksuit-style school uniforms they'd had at the Lake, except the gold emblems were different. There was even a puddle of water a few hundred metres down the road – just like there had been at the Lake – except it was Moreton Bay. We'd moved to the city, but the idea – ironically – was to get out into the country as often as possible over the next few years and try and get a handle on what made the Lake Eyre Basin tick, and what made it different from the Murray–Darling Basin down south.

PART II
WAY OUT WEST

5

SOMETIMES WET, MOSTLY DRY, ALWAYS UNPREDICTABLE

December's not prime-time for travelling in outback Queensland. Whenever you drive anywhere there are mirages on the horizon, and whenever you stop the heat hits you like a general anaesthetic. A few years ago Smithy and I had just finished a 'quick' trip, sampling fish in the Cooper Creek catchment. Smithy, whose first name is Tim, is a diesel mechanic and farmer from Lake Cargelligo and an ideal fish-sampling assistant when working in such inhospitable conditions. He oozes commonsense and capability, can always see an easy way to solve a problem or improve an invention and he leaves it up to me to complain about the heat and the flies. It was our last stop – about an hour west of Blackall on the Barcoo, so we had the kind of bone-weariness that comes from two weeks of outdoor living in summer in the outback.

Many of the smaller waterholes had dried to nothing since my visit in September. Given that the entire country (more

or less) was also in the grip of a five-year-long drought, it was a fairly extreme dry – but then again in outback Queensland, although summer rains are the norm, sometimes they don't come. It had been above 45°C for the entire week, and the day we called in at Windorah it was 47°C.

Sitting under the coolabah trees on the Barcoo it seemed just as hot, but it was starting to smell a bit different – a bit like rain. Looking back, the clouds had been building up for the entire week. A couple of mornings earlier, at our established five o'clock wake-up time, there had even been a few drops of rain on our swags in the 15-minute window between wake-up and fly arrival. Not enough to call 'rain', but enough to indicate that it might have been on its way.

We'd reached the last waterhole in good time, and the nets were all set and water quality readings taken. We busied ourselves straightening out the winch cable (I'd bogged the truck a few days earlier) and attending to chores like clothes-washing for the return trip to Brisbane the following day. Smithy then had another 1200-kilometre truck ride to get back home to the Lake, which at the time was as dry as a chip. I scrambled down the steep-sided waterhole to check on the weather. Our western outlook was obscured by thick ti-tree scrub, so we couldn't quite see the low sky from our campsite. It looked a bit dark, a bit grey – just a little bit. I scrambled back up, suggesting that rain was a possibility, but Smithy dismissed my concerns. 'Rain? Doesn't rain here, mate. We'll be right.'

Blacksoil country in inland Australia makes for smooth driving because you're usually going across a floodplain or claypan. Sometimes it can get a bit lumpy really close to a creek or river, but mostly it's the best surface to drive on – heaps better

than gibber. That's why when it's dry, everyone drives on the smooth side-tracks, and they only use the formed, capped road when it's wet. You can't successfully drive on blacksoil when it's wet – even a little bit wet – because the clay sticks to everything, especially rubber tyres connected to a three-plus-tonne vehicle. Our biggest concern was that if it rained we had 100 kilometres of black country to churn through before we hit the tar near Blackall. Generally, if stuff-ups are going to occur it's better if they happen near the beginning of a trip. Once you're on the way home, you want to keep moving in that direction, not camp for two extra days waiting for the road to dry.

The little gas burner burbled away as the sausages sizzled in the pan and we arranged our mouldy bread and other bits and pieces for our makeshift tea. Perhaps fortuitously, we were pretty much out of beer, but the couple we had left we enjoyed while waiting for the fat to drain out of the snags. The clouds kept building up, and even Smithy was starting to change his mind. Maybe it *would* rain after all.

Leading sampling trips in the outback is fairly easy most of the time – it means calculating distances and times to ensure that we can get nets in the water well before dark, then out again the next morning so the process can be repeated at different waterholes or in different catchments. Apart from that, it means provisioning trips, organising vehicles, gear and personnel and generally making sure the trip has a chance of achieving its aims, which in my case means being in the best areas – or at least representative areas – to catch and measure (hopefully) plenty of fish. Although a 'nil' sample – where you get nothing – is still a sample from a scientific point of view, it doesn't provide the best raw material from which to draw pretty graphs.

A net in the water is the best way to go fishing in the muddy waterholes of central Australia. Although some people prefer shorter sampling times, I always leave the nets in overnight, because it's the easiest way to standardise the samples from a time perspective, and it encompasses sunset and sunrise, times many of us suspect are the most conducive to fish movement. Setting the nets is a laborious affair, and retrieving them even more so, but the last thing any researcher wants to do is 'lose' a sample by pulling the nets early, stuffing up the setting process or having to break camp to out-run a storm.

But if the storm clouds look big enough, and there's 100 kilometres of blacksoil roads, and it's the end of the trip, and it's been over 40°C for a week, these priorities can sometimes shift. Quickly.

As the first big droplets fell I wolfed down my mouldy sausage roll-up in double-quick time, scrambled down the steep bank and heaved the big fyke nets in faster than ever before, opening the cod-ends and spilling the captured fish back into the waterhole before I even had a chance to look at them. I'd asked – probably instructed – Smithy to do everything else, like stow the cooking gear, pack all the loose equipment and prepare us for take-off; the clouds by then were big, black and everywhere, and if we stayed one night we'd likely have to stay two or three. We heaved the wet nets up onto the roof rack of the Cruiser, hastily tied them down and then slid out of the campsite as the rain intensified. On the road to Blackall lightning cracked low on the horizon in what seemed like every direction. Although we paused briefly to fashion a fuse out of some foil for the driving lights, we only had one objective – to get out of the mud and onto the tar. As it turned out, we made

A flooded creek in the Diamantina catchment in late 2008. Rain transformed this dry creek bed into a flowing river overnight.

the right decision: 35 millimetres of rain fell in Blackall that very night.

Rain changes everything in inland Australia. When it rains in the west – properly rains – it's as though everything resets. People huddle on verandahs or indoors, guessing at how much rain might be falling. Maybe they'll get an inch? Maybe two? Or maybe it'll settle in – nice and slow – and soak the (usually) dry ground for a couple of days. Or maybe it'll just be a little spat – gone before it really starts. The first thing you notice when it rains out west after a dry spell is the smell. It's as though the whole place is refreshed, and there's always a strong, gritty, earthy smell. In any area where there's heavy soil – essentially more clay than sand – a walk or a drive soon after a decent rain will have a textural component as well; boots and tyres become

clogged with clay. If you're fortunate enough to be standing under a corrugated iron roof and the rain's heavy enough, you won't be able to hear much else, while if it's only light rain all sleeping disorders are likely to be overcome by the most comforting sound you'll ever hear when you're nodding off.

You can smell it, feel it, hear it, see it. Rain changes everything, and it drives ecosystems and landscapes.

In January and February 2007 big rains came to some of the western parts of Queensland after a prolonged absence. Towns like Boulia and Bedourie, accustomed to making the news for their dryness, suddenly had television news crews filming people boating in the main street. Low pressure systems in the Gulf had brought storms to the Queensland–Northern Territory border country, and outback rivers like the Georgina changed from a series of dry pools to a meandering flood-front snaking its way towards the heart of the continent. People even started talking about Lake Eyre filling.

It all started back in December 2006 – around the time Smithy and I dashed back to Blackall. But it was patchy, as usual. In the east, the Bulloo River, which starts south of Blackall and ends up down past Thargomindah and into the Bulloo overflow, and the Paroo, the most north-westerly MDB catchment, received plenty. If you're driving west across Queensland, depending on the road you take, you'll cross a noticeable but low range west of Charleville, which is the basin boundary. A drop of water that falls east of that range has a chance – albeit a tiny one – of ending up in the Darling, the Murray and ultimately the Southern Ocean. But if it falls on the western flank of that small range it'll pretty much end up in the Bulloo

Getting bogged – and getting out again – is an occupational hazard when working in the western rivers.

overflow, with no chance of an extended holiday to the South Australian coast.

Once you get to the Barcoo River (to the west of the Bulloo) you've entered the Lake Eyre Basin. The lucky water drop in the Barcoo would never see the sea, but in exceptional years it might just end up evaporating in the saltpans of Lake Eyre.

The Barcoo flooded that year, which was slightly unusual because the Thomson River (the Barcoo's neighbour to the west) hardly flowed at all. The Thomson comes down through Longreach, and meets up with the Barcoo 30 kilometres or so upstream of Windorah. Once the Thomson and the Barcoo meet, they go by the legendary name of Cooper Creek down

through the rest of Queensland and then into South Australia – and, ultimately, into Lake Eyre. The flows going down the Barcoo were enough to get a fair bit of flow moving at Currareva waterhole – where the big bridge crosses the Cooper east of Windorah – and the flows kept going as far south as Nappa Merrie on the Queensland–South Australian border.

But the way the 'channel country' works, even a big upstream flood gets redirected, diverted, soaked up and evaporated many times before it moves 100 or so kilometres. Aerial photos of the channels in flood show this – the floodplain is like a big wide spongey mosaic. When it finally gets water, it wastes no time in soaking it up, so there has to be plenty of water before there's serious run-off.

Heading further west, the Diamantina River, like the Thomson, wasn't in any danger of being flooded into non-existence in summer 2006–07. Although there were a few within-channel flows that joined up and filled up some waterholes, the country remained predominantly hot and dry, and the windswept mesas and jump-up, just like the flatter plains surrounding them, stayed stark and devoid of regrowth.

West of the Diamantina, as mentioned before, the Georgina had a fair-dinkum flood, and west of the Georgina, the Mulligan, which is basically the eastern edge of the Simpson Desert, also flooded. The water filled dry waterholes in both catchments, and out in the desert there were pools and lakes between dunes. The floodplain and river valley just east of the Simpson dunefields reminded me of paddocks in the south after a big rain when I drove through them in April 2007, only a month or so after the flood receded. It was the greenest 'desert'

you could ever imagine.

This little summary of where it was wet and where it was dry in western Queensland in the summer of 2006–07 serves as a good example for the inland as a whole. Rain's patchy – plenty of landowners have stories of the rain gauge at the house registering nothing, but the gauge down the paddock or in town registering 10 or 20 millimetres. If you're not under the cloud, you miss out.

The biggest constant in inland ecosystems therefore is unpredictability, and the further west you go, the more unpredictable it gets.

Today human beings have a hard time dealing with unpredictability, largely because the societies we've developed rely on predictable supplies of everything from food to electricity. We've never really grasped the idea that a 'harsh' environment is only harsh because we are unable, or unwilling, to adapt to it, and consequently prefer to alter the environment to suit our version of 'normal'.

The rivers in western Queensland are fascinating because they haven't been altered. In terms of rivers behaving as they did prior to the rapid colonisation of Australia by Anglo-European human beings and the host of fauna and flora that accompanied them, the rivers of western Queensland, along with the Kimberley, the Gulf and Cape York are the best examples we have. Isolation has certain benefits. Their most obvious feature is their variable hydrology. If you pull up next to a creekline or dry river channel, you'll notice evidence of run-off – even in the smallest gullies. It's not hard to work out why, for when water hits the stony country it doesn't soak in, it runs. The run-off

Smithy, aka Tim Smith, drags in a big fyke net full of Georgina River fish in April 2008.

accumulates in the gullies, the gullies hold the water for variable amounts of time depending on erosion and substrate composition, and plants have a better chance of succeeding if they make their play for survival in a depression with a clay bottom (which holds water for longer) than a stony hill underlain by sand. The bigger the gully, the more run-off, the better the chance of plant survival. Rainfall is the fuel that makes the engine of desert systems move from idle to acceleration, if only briefly. Perhaps if we think of a river in the arid zone as a gully harvesting rainfall we might get a better handle on what makes the rivers tick.

The biggest gullies out west – those with names – have sections within them that are often deep, steep-sided, with low enough elevation to function as sumps. Some of these sumps can be several kilometres long and many metres deep even at the

end of a dry spell, so they hold a lot of water. Some in the trade call them 'refuge' waterholes, but most landowners just stick with the term 'permanent'. When the rain comes, it accumulates in these sumps, and a string of sumps (or waterholes) in the same valley usually ends up with a name with 'river' tacked on the end. However, the similarity to coastal, temperate or tropical rivers is fairly tenuous, because for much of the time Australian arid-zone rivers exist as a series of waterholes – a series of low-lying sumps. And if it stays dry for a long time, the sumps dry up too.

When it rains, the gullies flow and the sumps are resupplied with water. If there's sufficient rainfall and run-off they may become connected with the next sump in the gully, or perhaps a sump located somewhere else on the floodplain. When this happens, what's in the sump can *move* – it has a chance to disperse and to colonise new areas, or other sumps. And if it keeps raining – if the engine gets fed with more and more fuel – everything becomes turbocharged. The sumps are still there, but they're submerged beneath tonnes of water that spreads out across all low-lying areas. Where there was a series of isolated waterholes, there is now a more traditional river or a submerged floodplain. If you're lucky enough to see it, take a photo, because it doesn't happen regularly. But it's normal. It's *most* normal for Australian arid zone rivers to be a series of drying waterholes, it's normal for them to occasionally dry up, and it's equally normal for them at times to flood like crazy.

The differences between the rivers of the western Murray–Darling Basin, like the Darling, and the rivers of the Lake Eyre Basin, like the Diamantina, are not easy to pick if you haven't spent a fair bit of time in each. It's always hot in summer,

the river heights vary incredibly in response to rainfall and evaporation, and the isolated towns are tiny. The topography doesn't change much either – it's mostly flat as a tack.

There are, however, three big differences between the Darling and the rivers of far western Queensland. The first, as discussed above, relates to drainage patterns. A drop of water in the Darling has a slim chance of ending up in the Southern Ocean, a similar drop in the Diamantina has an even slimmer chance of reaching Lake Eyre. The second difference is the geography (or more correctly geomorphology) of the river valleys. In the Darling it's mostly one big channel all the way down. Up in the Diamantina it isn't – in fact, sometimes it's nearly impossible to pick the main channel. On some stations they name the channels by number. In other words, in some places the Diamantina 'River' is a floodplain maybe 10 kilometres wide, with seven or eight channels. Most of the time there'll only be puddles of water in one or two – sometimes none. When there's a big enough flow, the channels might run, and the deeper parts might be recharged. Then, if there's a flood, the Diamantina might become 10 kilometres wide at that particular spot for a week or two. Not so in the Darling. The banks of the Darling are deep and steep, and when it flows there's room between its banks to accommodate all but the biggest floods. So when people talk about the 'channel country', they're mainly talking about the Cooper, the Diamantina and the Georgina.

The third difference between the Darling and the rivers of western Queensland is – of course – river regulation. I had first-hand experience of this back in 1993 when Mick Brigden and I loaded a couple of kayaks on his old Ford XD ute, with the intention of paddling down the Darling. We had a rough

plan – leave from Bourke, take a few maps, have a few beers in Louth on New Year's Eve, and finish up at Menindee around the end of January. Bourke to Menindee. Everyone reckons rivers run three to one; in other words, for every kilometre you travel along a river on a road, the river does an extra two. That meant Bourke to Menindee was 1000 kilometres, give or take.

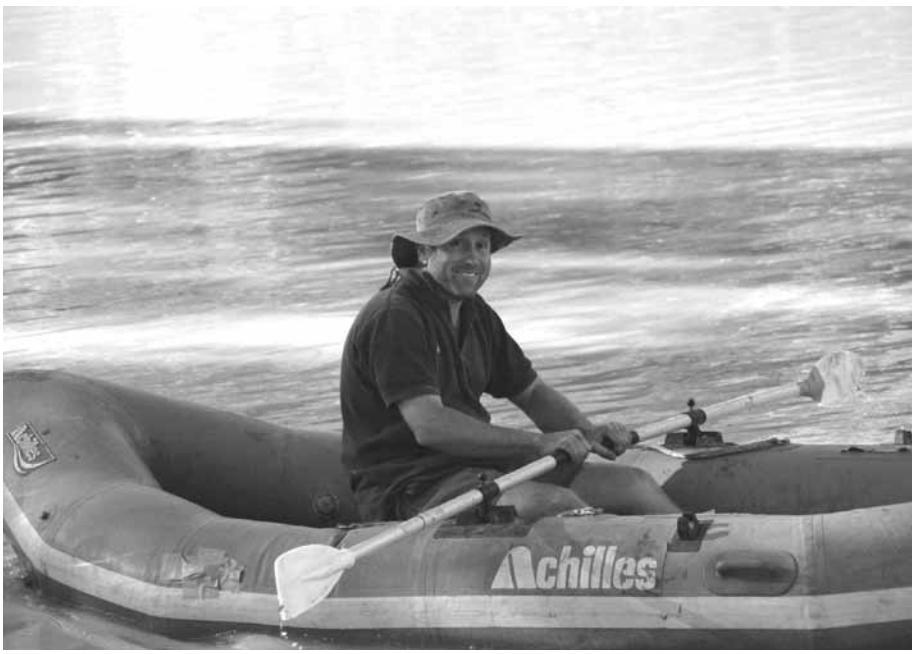
On Christmas night, Mick piloted the XD *around* (mostly) the 5,000 or so skinny roos that seem to call the bitumen home as we drove up through the Macquarie cotton country to Bourke. Next morning we jumped in the boats just below the Bourke weir and away we went.

The Darling was pretty low in 1993, and there were plenty of times on that trip when we were carrying or dragging boats and provisions rather than paddling them. After a few river miles we paddled past the first irrigation pumps – big ones. And those pumps were working – sucking the Darling up and over the deep steep banks and out to storage impoundments or spread at once over summer crops. You didn't need to be a rocket scientist to work out that if the big pumps kept pumping eventually the river'd be stuffed. A few years later it most definitely was.

There's no doubt the big drought at the beginning of the twenty-first century had a massive negative effect on water levels in the Darling, just as it did on all other rivers in south-eastern Australia, but the bureaucratic snafu that has resulted in over-allocation of all the water meant that it was already punch-drunk and ready to be knocked out before the drought really took hold. We saw it as we swore and paddled and fought our way from Bourke to Menindee in '93. In the years that followed it became common knowledge, as catchment after catchment dried and towns started making the evening news as

they ran out of water. Paddling down the Darling was like paddling down a great canyon. On either side were these massive steep muddy banks, and right down the middle – if we were lucky – was a thin sliver of river.

Different drainage basins, different geomorphology, and different degrees of human-created interference. That's pretty much it, except for the latitudinal differences, and these don't have as big an effect as you head towards the middle of Australia anyway. It's the outback – hot, dry and flat. Ironically – I'd argue – the perfect place to work on Australian native fish.



Mick Brigden heads off to retrieve nets in the Thomson catchment in 2009.

6

LITTLE FISH, BIG DUNEFIELD: THE MULLIGAN RIVER IN THE SIMPSON DESERT

To the best of my knowledge, nobody fished the Mulligan River before April 2007. A photograph I have of Mick climbing a sand dune carrying nets summarises why – it is, after all, the Simpson Desert and one of the driest bits of Australia you could imagine. In January 2007, the big rains in western Queensland resulted in big floods in the Georgina River, and the Mulligan – a normally dry rock-and-sand thoroughfare on the edge of the Simpson dunefields – copped it too. For a few short weeks, there were lakes between dunes and flowing water in the desert.

Mick and I took fish samples in the Bulloo, in Kyabra Creek, in the Cooper itself near Windorah and then in the Thomson up near Stonehenge before heading west. On the Thomson I do some of my fish work on land owned by Angus Emmott. Angus is one of the best natural historians in Australia. He's even got the round glasses and moustache that make him *look* the part, but that's where the Dr Livingstone similarity ends. Angus

Angus Emmott, natural historian, museum collector and tireless advocate for the Lake Eyre Basin, holds a legless lizard from the east Simpson Desert.

seems happiest in a pair of thongs chasing hopping mice around in the glare of headlights, and his encyclopedic knowledge of the critters that inhabit western Queensland has been acquired over a lifetime of poking about, keeping his eyes open and scraping the odd bit of roadkill from the highway. Angus is an obsessive collector, and his specimens fill museum shelves in Australia and across the world. In between collecting, chairing the Lake Eyre Basin Ministerial Forum and a few other boards, yapping to ministers and government heavies and lobbying on behalf of inland Australia, he also runs a cattle enterprise and even milks a couple of cows each morning.

We set our nets at two waterholes on Angus's place and then returned to the homestead for a regroup for the next phase of our April trip – as a result of the flooding we were heading west to the Mulligan to fish in the desert.

In recent years the eastern Simpson Desert has become well known as a location for terrestrial biological research. This work has been done by Chris Dickman's team from the University of Sydney and has centred on a property called Ethabuka, about an hour and a half west of the small town of Bedourie. Max Tischler, he of the dreadlocks and small furry animals, is a graduate of the 'Dickman lab'.

My involvement with the Mulligan began when the owners of Ethabuka – a conservation company called Bush Heritage Australia – wished to conduct a broad-ranging ecological survey of another property called Craven's Peak, which sits on the Queensland–Northern Territory border about two hours west of Boulia.

We left Angus's place for Ethabuka in a small convoy of two Toyotas before sunrise and rolled back through Stonehenge and Jundah to Windorah before heading west. The Thomson country hadn't received the January rains, and with the exception of the neat lawns in the main drag of Windorah, the view was endless rocky terrain overlain by gidgee trees and occasionally broken by the odd claypan.

It takes more than three hours to get from Windorah to Bedourie, and that's clipping along at 110 kph. It took until well after crossing the Diamantina for the country to start showing signs of transformation by rainfall, but once shiny ironstone paddocks began to disappear under new carpets of the greenest grass, Mick and I acknowledged how lucky we were to be seeing outback Australia in a wet year. As we closed in on Bedourie and inspected debris piled high against the pylons at King Creek, we realised just how powerful the flood had been.

The gradual change from semi-desert to desert starts east of

Navigating the Mulligan River is a rare experience as most of the time all the waterholes are dry.

Windorah, for it's there that travellers in outback Queensland first notice occasional sand dunes by the side of the road, often hauntingly marked by the graves of pioneers. Every time I come across a grave on a dune I get a mental picture of a pioneering family huddled together in their Sunday best, Bibles in hand and dripping with sweat as the dust and wind and birds of prey create an eerie backdrop. It would have been one of the harshest parts of Australia to endure back in the 1800s – it remains that way in the twenty-first century too. Heading west from Bedourie, the dunes are grouped closer together, until, by the time you reach Ethabuka, they're only a couple of hundred metres apart. Once you're at Ethabuka, the dunes glow red in the afternoons, the days alternate from hot and still to hot and windy, there are lizards on the tracks and falcons overhead – once you're at Ethabuka you're in the desert.

The Mulligan River is entirely ephemeral and has no permanent waterholes. There are, however, several semi-permanent waterholes that retain water for up to a year after a flooding event, and one of these is Pulchera, situated in the eastern section of Ethabuka.

In terms of a desert oasis, Pulchera is a classic Australian example – a bright blue expanse of water about 200 metres wide and over five kilometres long, sandwiched between two desert dunes. The land is expansive and flat, from a distance the water is a startling blue and the sky is – simply – huge. The 'bigness' of the sky is one of the ever-present aspects of central Australia – no matter how beautiful parts of the coast can be, they'll never be as impressive as it is out west, because the air is always clearer, the mornings are always crisper and the colours are always sharper.

The rainfall and flooding throughout the Mulligan and Georgina catchments in early 2007 meant that Pulchera was at full capacity. Scott Morrison, who managed Ethabuka at the time, had told us that only three months earlier, Pulchera had been bone dry. This immediately set us up for interesting results, because it meant that any fish we caught had most likely travelled upstream from the confluence of the Mulligan and Eyre Creek (where permanent waterholes exist) in – or immediately after – the flood. And given that Pulchera is more than 100 kilometres upstream of Eyre Creek, it meant a lengthy migration.

Animal behaviour is littered with examples of the mass movement of juveniles to premature death – sea turtles and lemmings flip-flopping down the beach are a good example. The utilitarian explanation is that these species produce plenty

of young in order to enable a small proportion to make it to adulthood. In some fish, the utilitarianism, fecundity – whatever you prefer to call it – is extreme. Certain fish species can produce millions of eggs or spawn over an extended timeframe. As with all reproduction, the goal is to keep the species moving by keeping representatives alive. If a fraction of the millions of eggs hatch, and then a fraction of the hatchlings live for more than a week – and so on and so on – then perhaps two or three might become old enough to become involved in reproduction themselves.

A significant aspect of this reproductive behaviour relates to where the juveniles go. Go they must – especially in desert rivers – because when the flow stops it's a little bit like a game of musical chairs at a kid's birthday party. After the mad scramble, fish that have moved to a deep waterhole that has a chance of lasting until the next rain or flood are the lucky ones – they get a 'chair' until the music starts again. Those that are still moving get stranded. They might last a week, but more likely it'll only be a couple of days.

To standardise my fish samples I'd trialled and decided on gear that could be easily deployed throughout the sampling area (the Queensland section of the Lake Eyre Basin) with a minimum of trouble. I chose two 'large' fyke nets – essentially whopping 1.2 metre diameter funnels covered in netting with two eight metre 'wings' at the entrance, two smaller fykes for catching juveniles and a conical larval net made out of very fine mesh (less than one millimetre). Once we got to a waterhole we set the fykes, dragged the trawl net around and took water quality readings such as temperature, dissolved oxygen and salinity. Then we either packed up and moved to the next site

All hands on deck: setting nets in a Simpson Desert waterhole in an upstream–downstream pattern.

or made camp. But at Pulchera – a beautiful big, unsampled, unstudied lake – I decided to put in two 'sets' of nets in two different places to increase our chances of catching whatever had migrated there.

We untied the crusty ropes and then manhandled the nets down from the roof of the wagon in a shower of dust. Fyke nets are ungainly objects to carry. Even when they're folded up like a big basket, hanging on to one is like grabbing either side of a steering wheel made for a giant. Stretched out in the water the main funnel section is about five metres long, and the wings make the whole contraption at least that long again depending upon the angle at which they're set. Mick and I loaded up a folded fyke each and a few thin poles from which to suspend them once we reached water of sufficient depth. Then, barefoot,

we squelched and tripped, struggled and traipsed our way out about 70 metres through the sticky black mud, occasionally dropping poles or net hoops and then cursing as we tried to regain them from the silty water.

Breathing heavily with the effort, we jammed a central pole in the soft substrate in water about a metre deep, and then each of us methodically unravelled a net ensuring they faced in opposite directions. With our extra poles, we staked open the big wings, so that any fish, of any species, that happened to swim into the 15-metre entry area would end up being diverted through a series of funnels and hoops such that they couldn't easily escape again. As we trudged back towards shore we ducked our heads under the water to cool off; we were both extremely excited about Pulchera – a great big waterhole in the middle of nowhere that nobody knew anything about.

We moved the vehicle a kilometre further down Pulchera to set our second group of nets, and came across a dune grave. A young girl. A young girl who didn't quite make it through the 1912 season out in the Simpson. 'Tootles' accidentally drowned in the waterhole when she was only 13, and as we quietly inspected her headstone Mick and I muttered to each other about how tough it would have been living that far from anywhere else back then, and how difficult it must have been to have to bury your own child.

Early next morning – just after sunrise – we were back in the water, and this time it was significantly colder. Emptying fyke nets entails closing the wings, preferably dragging the entire net ashore and then shaking the contents down to what is known as the 'cod-end' before opening the net into a bucket of water. Lots of things can go wrong, from the net becoming

untied on the way back to shore (which means the sample is lost), big yabbies ripping holes in the net (which means most of the sample escapes) or inadvertently twisting the net during the setting process, which means nothing is trapped. On this occasion all went to plan. The nets all came in full of fish, the fish all flopped neatly into the buckets, and we had the first ever sample of Mulligan River fish to process as the sun climbed high over our campsite.

As it turned out, plenty of pioneering fish took their chances on the floods in January 2007 and left the Georgina catchment for an adventure in the great north-west. They swam against the flow – into and around the flood – and pushed out into the desert gutter called the Mulligan – a river you can drive over most of the time without even realising you have. Scientifically, the results from Pulchera in 2007 demonstrate that seven species are likely to move upstream into new and unknown territory when it becomes available, and that these species are likely to travel over 100 kilometres to do so. The behaviour of these 'speculative colonists' is all the more awe-inspiring when you consider that many adults are only 40 to 50 millimetres long.

When we hauled the nets in that morning the catch was dominated by four species: glassfish, bony bream, spangled perch and a smallish catfish known as a silver tandan.

Glassfish are small perch-like fish, and there are several species in Australia that fall into the 'not much really known' category. This is because little fish aren't as edible, economically important or noticeable as big fish. Everybody's heard of barramundi and Murray cod, but only fish-freaks realise that these monsters are likely to dine on glassfish. There are glassfish in the MDB and they're on the vulnerable species list. It's probable that

A glassfish from the Mulligan River catchment. Glassfish numbers are declining in the MDB but seem healthy in central Australia's rivers.

river regulation and the long list of impacts – altered flows, alien fish, barriers to movement – have knocked them around. The glassfish out in the desert might be a slightly different species, but whatever the case, the fish we measured that morning at Pulchera were the biggest, fattest and prettiest glassfish – mostly up around 50 millimetres and glowing iridescent purple, blue, green and yellow. We'd trapped over a hundred in our nets, yet our nets only covered a tiny fraction of the waterhole. We wondered aloud about how productive these desert waterholes could be.

Bony bream is a herring rather than a true bream. Again, 'bream' is a generic fishy name like 'perch' and 'cod', and this is why there are so many bream, perch and cod scattered throughout

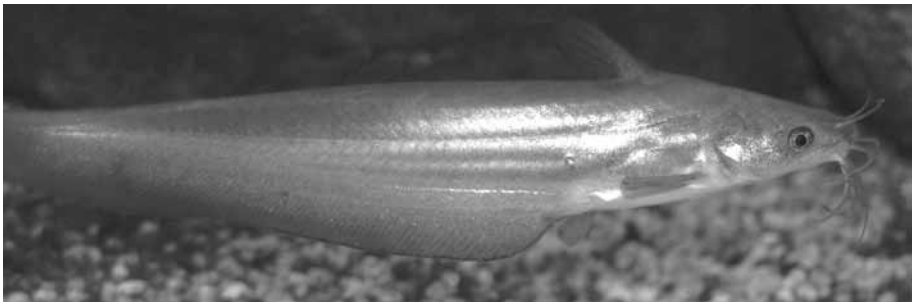
Bony bream – a driver of Australia's inland aquatic ecosystems. Although themselves vegetarian, bonies provide a food supply for everything else in the western rivers.

the waterways of the world, and even in the ephemeral rivers of the Australian desert. Along with two other members of the Lake Eyre Basin fish fauna this species has the widest geographical range of any Australian freshwater species, and can be found from the Pilbara, across the north, and down through the western rivers in both the Lake Eyre and Murray–Darling basins. Bonies can be thought of as the engine room of aquatic systems in Australia; they get by on algae and detritus, so unlike most Aussie fish they're not carnivorous. The sad flipside for bonies is that turtles, birds and fish eat them as often as possible. Without bonies, inland aquatic ecosystems – that's everywhere from Lake Cargelligo to the Simpson Desert – would probably grind to a shuddering halt.

The bony bream is slim, silver, with a tiny mouth, a prominent forked tail and an elongated ray or 'hair' on their dorsal fin. Whenever we empty a net full of bonies scavengers from all over the outback – aerial, aquatic and terrestrial – come in close for an easy feed. Although bonies can grow to above 30 centimetres, the majority in Pulchera were half this size or smaller, indicating that it was adolescent to young adult fish that migrated.

Like crocodiles and big goannas, spangled perch have a 'take no prisoners' attitude and an aggressive streak. If you put a spang in a tank with anything else, the anything else will endure constant fin-nipping and general harassment. Spangled perch are often called bobby cod – fishermen don't like them because they'll take a carefully prepared bait earmarked for something bigger and more valuable. They're toothy, stocky, muscular and often have a light or dark spattering of orange spots. My erstwhile (and very patient) sampling companion Smithy calls them 'specklies' and occasionally less pleasant things when they jump off the measuring board or when a fin or gill cover is embedded into a fleshy part of his hand. Spangs have been noticed swimming in wheel-ruts after rain, and allegedly fall from the sky in storms. They've been recorded up to 30 centimetres in length, but out in the Lake Eyre Basin I've rarely caught them over 20 centimetres. Nevertheless, that day at Pulchera – way out in the Simpson – our biggest spang was 22 centimetres long, a testimony perhaps to swimming ability and the persistence associated with being a tough fish in tough conditions.

Along with the glassfish, bony bream and spangled perch were a couple of hundred small catfish called silver tandan. The words 'catfish' and 'tandan' are interchangeable when talking about the Australian eel-tailed varieties. We might assume that a catfish is a solitary mud-sucker sitting on the bottom of a river, yet silver catties are schooling fish that utilise all water depths using the barbels protruding from their snouts and chins to detect anything edible. Silvers, like spangled perch, are big at 20 centimetres. This is a handy maximum size to attain given their distributional haunts, which are frequently prone



Unlike many catfish, the silver tandan is a schooling species rather than a solitary bottom-feeder.

to shrinking and heating and are therefore not conducive to growing large-bodied, long-lived aquatic animals.

Silver catties are true central Australians – they only occur in the rivers of the Lake Eyre Basin, in the Bulloo, and maybe a couple of rivers in adjoining catchments such as in the Gulf of Carpentaria. They are members of a catfish family called the Plotosidae, or eel-tailed catfish, and have plenty of relatives in other parts of Australia, including the freshwater catfish of the Murray–Darling we sampled back in the Lake. As discussed previously, the Murray–Darling cattie excavates a nest in the substrate, which becomes the family home until the eggs hatch and the youngsters move out, but the introduction of carp may have seriously affected the success of this strategy.

Silver catties have a couple of advantages over their big cousins, because they live in the remote inland where – thankfully – carp haven't been found (as yet), and they are more likely to be egg-scatterers than nest-builders, meaning not all the babies are in the one crèche.

Like most of their kin, silver catfish have venomous spines in their fins that are capable of inflicting painful injuries on the fingers and hands of people trying to measure them, but apart

from that they're harmless foragers – eternally busy Centralians snuffling around for a feed. We measured about 200 as the sun climbed higher over Pulchera and the flies started to camp in our eye sockets. Not one was under 70 millimetres or greater than 80; they were all juveniles.

One of the most common beliefs about Australian freshwater fish is that they breed on a flow, and it makes sense to make the most of flow conditions in variable rivers, because that's when food is likely to be available over a larger area and when migration pathways will be open. It's the 'boom' time of boom-bust ecology. People living along the rivers worked out years ago that when rivers that don't usually flow suddenly do, it's clever to throw a net in because all the 'breeders' will be trekking upstream.

But there's a problem with the 'breed on a flow' theory in the desert, because there might not be a flow, and sometimes there might not be one for several years. And if there is one, in most cases it won't be a major flood like the one that occurred in far western Queensland in January 2007, or the even bigger floods of summer 2009–10 and then 2010–11. In other words, if a fish has a life cycle that is cued to reproduce *only* in conjunction with flow events, it's not likely to be the most successful species in central Australia. Instead it seems more likely that central Australian fish – and there's nothing more central than a silver cattie – have a breeding cycle geared towards maximising the migration possibilities afforded by flows, because if they wait for a flow to spawn, the eggs may well all be swept away downstream – possibly into a salty, drying lake. Given that up around or just above the Tropic of Capricorn (which is where Pulchera is) the rain is most likely to fall in summer, this means

having the vast majority of young *before* the flow is most likely to arrive. Then if it does, the fish can take advantage of it by swimming upstream to colonise recently inundated areas and munch anything edible.

We hypothesised that the silver catties were all born at about the same time (they were a *cohort*), because of the similarity of their lengths, and that they all migrated to Pulchera by swimming upstream through the floodwaters in mid-January, which gave them about two months to attain their maximum length of eight centimetres. We further hypothesised that they probably hatched sometime in early or mid December, and were fortunate enough to become free-swimming by the time the rain hit. If the rain *hadn't* hit? Well, then 99.99 per cent of them would have been consumed by something else as either eggs or hatchlings back in the familial waterhole – probably by Mum and Dad. As it was, the flood enabled a large number of the cohort to survive, become juveniles, and seek the rich bounty out yonder.

Gaining corroborating evidence for such hypotheses is the tricky bit, because samples taken at one time only reveal one temporal set of data (unless back-dating techniques involving body tissue and specimen death are used). In other words, silver catties *probably* migrated north-west into the Mulligan from a homeland in the Georgina/Eyre Creek catchment and were *probably* spawned in early summer.

Luckily, I had enough evidence to support this hypothesis from other places and other times within the Lake Eyre Basin rivers. I had caught silver catfish on every sampling trip and in every catchment, from the Mulligan east to the Georgina, Diamantina, Cooper and Bulloo, and in most individual

waterholes. Fish larger than about 110 millimetres were sampled throughout the year, whereas smaller fish were most common in autumn and winter. This evidence supports the idea that silver catfish mostly breed in summer, and the large cohort from Pulchera tends to indicate that if there *is* a flood, more juveniles are likely to live a little longer and travel a little further. In addition, adult female silvers sampled in late spring and early summer in *any* catchment displayed tell-tale signs of imminent reproductive activity, as their bellies were distended with eggs. This never occurred in autumn or winter.

When I returned to Pulchera in August 2007 – three months after the first trip – I also sampled silver catties, but this time their average length was between 80 and 90 millimetres. This had to be the same cohort because Pulchera is such an isolated waterhole, and it suggests that once the weather cools down this species' growth slows down to two or three millimetres per month. The fact that juvenile silvers (in smaller numbers) were also caught in catchments that hadn't experienced a major flow or flood reinforced our observations: they breed in late spring and early summer.

As Mick and I dragged in our nets, emptied their contents into buckets, identified, measured, counted and released, our travelling companions – Angus and his mate Bill Wilkes – and Ethabuka managers Scott, his partner Sajida and their young son Thor, had trekked down from the homestead 20 kilometres to the west to take a look at the operation and become acquainted with the desert fish of the Simpson.

They were all amazed at both the number of individuals and the number of species emerging from the shallow desert lake, and so were we. Indeed, whenever I've emptied a net

full of fish in the middle of a scorching hot day somewhere in the middle of very non-fishy-looking country, any onlookers seem genuinely interested. But on this particular day there was something else – it had caught my eye when we first emptied the nets, and as I rummaged in the muddy water of the bucket and counted and measured the bonies, glassfish and catfish, I kept a lookout out for the unusual creature.

It was a catfish, but it was a full three centimetres shorter than any of the others. It was the same colour, but it was squat, with a snub nose and a totally different body shape from the other silvers. It didn't fit any catfish description from either central Australia or the rest of the country, so we christened the creature 'the X cat' and gave ourselves permission to become excited. Angus knows this feeling well, and has a goodly number of animals already bearing his moniker in their Latin names, but for the rest of us it was a completely new experience.

I sat down in the soft sand of Pulchera, contemplating the possibility of a new species of catfish from the Australian desert. I resolved to spend another night sampling Pulchera just in case our X cat was more than a mutant.

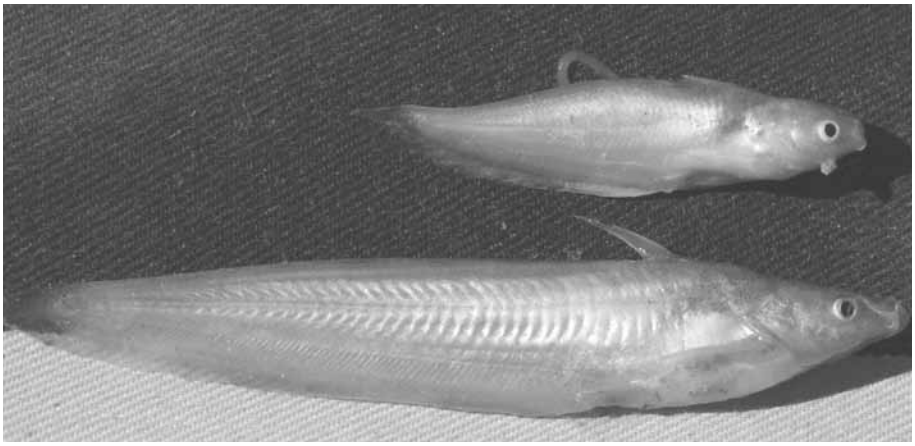
That afternoon, Mick, Angus, Bill, Scott and I used every net we had in an upsteam–downstream pattern to trap what we all hoped would turn out to be *Neosiluris* or *Porochilus mulliganensis*. With all hands manhandling nets and poles, we figured we were giving it our best shot, and by the time we were finished we had at least half the width of the waterhole bisected by netting.

We then headed west to drop Scott off at home, but Angus's Toyota had problems. Ethabuka, as may be inferred, is not the best place to suffer a major vehicle breakdown. Every time he tried to engage a gear – any gear – there was

a sputtering-crunchy-metal-whizzing sound and nothing happened, except for the kind of swearing you hear when five blokes are trying to work out what's wrong with a car. After spending time inspecting underneath in the sand, looking in from the bonnet or through from the wheel arches, we defaulted to Plan B, which involved a snatch strap and a 10-kilometre drag back up the sandy tracks to the workshop in the Ethabuka house yard. Plan C, which involved spanners, sockets, hammers and more swearing was a little like the ABC television series 'Bush Mechanics', where a group of Aboriginal men in similarly isolated places use spare tyres stuffed with spinifex and rip bonnets off old cars to use as sled-like trailers.

When a vehicle is broken in the desert, two people is a good number to have on hand to try and fix it. Three is also good – two to get dirty and one to pass the tools around and offer moral support. Five is overkill. As night fell, and it became apparent that the vehicle was going nowhere, Mick and I excused ourselves from the workshop and decided we'd be better off camped next to the nets for an early start.

Mick and I have done a lot of things together since 1993, not just paddling down the Darling River or shooting carp with bows and arrows in Lake Cargelligo. But Pulchera – the big, magic, majestic waterhole on the Mulligan – was the most interesting place we'd been to together, and sampling the fish that lived there was the best reason to roll our swags out next to it and gaze up at the shooting stars. It wasn't the X cat possibility – it was just the entire experience. It was a vindication of the way I had been thinking for over five years, along the lines of 'Well, if these inland rivers in the south are so stuffed, what should they be like?' After emptying the nets on that first April



The X cat (top), with a 'normal' silver tandan. In a bountiful year, survival of the not-so-fittest occurs, albeit for a short time.

morning at Pulchera, I knew I could, one day, have a decent go at answering that question. I've been back to Pulchera many times since – when it was totally dry in 2008, after it filled again in 2009, flying over the top of it when it was a few kilometres wide after the big 2010 rains – but it's never been the same as that first trip back in 2007. That's when I realised that the desert fish stuff really was as fascinating as I'd hoped it would be.

One by one, we dragged the big nets in the next morning; plenty of silver catfish, quite a few glassfish and spangled perch, and some bony bream. But there were no X cats. The X cat was – after all – just a lucky mutant. It makes sense when you think about it. Mum and Dad silver cat spawn 2000 or so eggs. One per cent of them are a bit dodgy – they have a bent spine, or they're short, or long or twisted in some other way. Under 'normal' desert flow scenarios the mutants don't make it, but when there's a cracker flood, they just might.

With my curiosity satisfied regarding strange catfish in the desert, we heaved and hauled the wet nets back on the roof of the Cruiser, jammed our personal gear and swags wherever

they'd fit and then trundled back up the track to tell the others the not so Earth-shattering news and hear the latest instalment of the Toyota diaries.

Pulchera was a jewel for gathering data relating to fish activity in the Australian arid zone. Not only did we have a species list for a previously unsurveyed area, the data also shed light on breeding and migration patterns. Without a doubt, a conclusive way to measure fish movement is to go to a place that was once dry and which then becomes wet. And without a doubt, one of the best ways to study the breeding habits of fish is to find an isolated waterhole that has recently filled, and then keep an eye on it as it dries out. If anything's going to breed you'll learn about it when the juveniles appear. And, contrary to fable and rumour, fish need one thing to survive and that's water – they don't have drought-resistant eggs. There may be odd occasions when wind storms pick up fish and drop them in 'rains'; there may be even rarer occasions when a fish is transported by a bird, but these occurrences, even if they were measured and verified, could not account for the similarity of the fish fauna between distant, isolated habitats in the desert. The way it happens – quite simply – is that they are perfectly adapted. When it rains and the migration pathways open, they go. If we needed any convincing, it happened on the way to Craven's Peak the next day.

Fifteen kilometres north of the Ethabuka homestead, way out in the middle of a dunefield and nowhere near a river, Mick and I watched the brake lights jolt into action and then saw Angus bolt out of the vehicle cabin ahead of us. I'd seen him do this kind of thing before, usually for snakes. Remember – he collects. As we got closer, however, it became apparent that

Angus wasn't head-down in a clump of spinifex, but cavorting around a very wet – though very shallow – claypan chasing something.

The water was about five centimetres deep, and Dune Pond, as we christened it, was circular with a radius of about 15 metres. We watched for a couple more seconds until we understood what the object of his desire actually was, as he lunged, grabbed, regained his composure and then held the quarry aloft. In his left hand Angus held a very stubborn and possibly cranky fish – a spangled perch 15 centimetres long.

We all wondered what the hell it was doing way out in the dunefield.

The January floods had spilled out in uneven tendrils, reaching up through the swales but not over the dunes. The fish – especially this particular spangled perch that now gasped and struggled in Angus's grip – had followed the floods, presumably as far as possible. We honestly thought that no fish would be bold enough to migrate that far from 'real' water and end up stuck at the base of a dune as eagle fodder but we were wrong, and the desert fishing lessons were coming thick and fast.

When we let him go, this incredibly tough animal swam off in typical spang fashion, darting and dashing all over the evaporating pond as if reasserting his dominance of the highly temporary territory. The swimming in wheel-ruts and rains of fishes stories started to ring a little truer – spangled perch really *were* the toughest, most adaptable fish in Australia, as evidenced by this fighting individual that probably only had a couple of days to live.

Evolutionary adaptations such as a tolerance of high temperatures, high salinities, low dissolved oxygen, wide food

preferences (pretty much anything), handling and presence in strange places like Dune Pond have obviously worked for spangs. Indeed, if it wasn't for their apparent aversion to cold water they'd probably be widespread in southern as well as northern Australia. Even so, their presence in central Australia alongside far more 'peaceful' species such as silver catfish and glassfish raises some interesting questions. Spangs are hard to kill. Like carp, they can spend a bit of time (probably about a minute) out of water, gills flaring, without apparent harm. So it's reasonable to assume they *should* be the dominant fish in desert waterholes, because they grow bigger than the other fish, are more hardy and more aggressive. Nevertheless, even in small waterholes, as well as spangs I've always caught plenty of smaller fish – potential 'feed' fish like glassfish and small bony bream – and these species are usually found in higher numbers. Perhaps evolution by natural selection for spangs is aligned with the maximum viable population size for a given waterhole. In other words, if all the small species are consumed by spangs there'll be little left to eat and the population will crash, so instead the population of piscivores is regulated by another means – perhaps avian predation or cannibalism – to achieve equilibrium. These are interesting things to think about but difficult to test in the fickle waters of the Mulligan.

We were heading for Craven's Peak, a place that once was a pastoral holding and was then purchased by Bush Heritage Australia in 2005. Land that is managed by private conservation agencies (reserves) is similar to land that is managed by government conservation agencies (national parks) in that both wish to preserve biodiversity and control feral plants and animals if it's practical. The main difference is that the private conservation

companies can decide when – or whether – people can visit, and this has some advantages. For a start, they don't have to maintain camp grounds and toilets for the benefit of a stream of tourists. Additionally, they can avoid some of the intense public scrutiny that parks sometimes receive. There was much controversy, for example, surrounding the aerial culling of brumbies (wild horses) in the Guy Fawkes National Park around ten years ago by the NSW National Parks and Wildlife Service. It wasn't because they shot a lot of brumbies, but because they winged a few. Then the word got out to the media and all hell broke loose. There are similar-but-different issues on many parks that receive high visitation: on Fraser Island the Queensland agency walks a dingo tightrope, with some people illegally feeding them while others bay for blood if they come too close to their campsite. The private agencies can be a bit more discerning about who comes to visit and what they do once there, and there are two such companies that are a similar size in Australia – Bush Heritage Australia, which was founded by Greens leader Bob Brown, and the Australian Wildlife Conservancy.

Bush Heritage wanted a biological inventory of Craven's, which resulted in the normally quiet dunefields crawling with four-wheel-drives and boffins of every description. It was our job to look after the fish, and our first stop was a place called Kunnamuka Swamp. Kunnamuka, like Pulchera, sits between typical Simpson dunes and it had filled during the January rain and flooding. But unlike Pulchera, it doesn't hold water for long, so we had another unique opportunity to go fishing in the desert.

Our companions for the next two days were Don Cook, a tall bloke from Rockhampton who was a boss in the EPA; Alun

Hoggett, a computery-mappingy type from Desert Channels Queensland; Al's girlfriend Vanessa Bailey, from the EPA in Longreach; and Joan Powling, a self-described 'algae woman' from the University of Melbourne. Meeting people in outta-the-way places means that because you have to live with them you need to get along from the start. There's not much point deciding whether or not you actually like somebody, because they'll be with you anyway, and if something goes awry – which it often does – you'll probably be pulling each other out of bogs. With this in mind, Mick and I extricated some welcoming cans of Fourex Gold from the fridge and offered them to our new buddies. Joan and Vanessa both politely declined, possibly because it was only about one o'clock, and also because Joan was busy scooping algae out of Kunnamuka Swamp and peering at it through a portable microscope. Every now and then she'd shriek with excitement or make a proclamation about something algae-related.

Vanessa and Alun were incredibly organised, and by the time we had found a campsite on top of a big dune overlooking the main swamp and set our nets, they had erected and laid a camp table with a tablecloth, bottles of wine and even plunger coffee for the morning. Mick and I had our dirty old swags, a couple of steaks and spuds and a few cartons of Goldies we'd picked up in Bedourie. Like yobbos everywhere we eschewed the gentility of the porta-gas stove for the non-environmentally friendly campfire, wrapped the spuds, warmed the hotplate and sat back to watch the sun set over a lake in the desert. We were extremely happy to be in the Simpson, for it contained all the things we loved. There were big shallow lakes that smelled fresh and earthy, there were bright red sand dunes to scramble up

and over and explore. And to top it off, there was just the right amount of driving up and over the big dunes to risk getting stuck going from place to place.

Before long, the smell of the barbie had ignited something primeval, carnivorous and possibly 'Austrayan' in the others, and by and by, unsatisfied with their lentils, most asked if we had a spare spud or a piece of steak or sausage. As the sun slipped behind a distant dune at Kunnamuka we all realised how lucky we were, for it doesn't get much better than the desert in autumn after a wet summer, good company and good tucker.

Despite the fact that in terms of surface area Kunnamuka, for a brief week or three, was bigger than Pulchera, there were no fish in our nets as we stumbled through the thick red sand and waded out into another perfect outback morning. Fish like the spang at Dune Pond can swim up swales and get to unusual places but they can't jump over ten metre dunes: Kunnamuka is just a little too far west of the Mulligan to allow fish colonisation.

We packed up and then helped Alun dismantle and store the table, coffee plunger and other knick-knacks that characterised their luxurious camp, before sliding back out over the dunes and heading north for the Mulligan River itself and a place called S-Bend Gorge. Along the way we pulled up a couple of times to look at diminutive white toadstools that grew straight out of the sand, a wedge-tailed eagle's nest low in a gidgee tree and the 'classic' desert lizard – the moloch or thorny devil – slowly ambling off the track. This is how desert travel is; impossible to rush. It's a timeless place, delightfully devoid of deadlines, and jangling and bouncing through it at 20 kilometres per hour is the only way to do it.

S-Bend Gorge is like a great scar that truncates the dunes on the Craven's Peak boundary. To the north-east, the country changes and first becomes the flood-out channels and gullies of the Georgina, and then – eventually – the folded, rocky, broken country up towards Dajarra and Mount Isa. After a flow, S-Bend retains enough Mulligan River water for fish sampling because it harvests all the run-off from the surrounding hard country. But unlike settled areas there is no bitumen road that loops down to the bottom of the Gorge – there's just a hellish 40 degree rock-strewn goat track.

Mick and I arrived at the top – or lip – of the Gorge fairly late in the afternoon. It was a fascinating, mysterious place, for ancient rock walls and scree now replaced the rolling dune-field we felt so familiar with. But, in order to get nets in the water we had to get down to the bottom – a drop of about 100 metres.

I engaged low range four-wheel-drive in the wagon, chose first gear and, with a jolt and a few more revs than was needed, started heading down. Mick held on to the 'Jesus bar' – the handle that is sometimes mounted directly over the glovebox. (When you're a passenger in rough country it's smart to hang on to the bar, and when the vehicle hits an unseen gully or pothole 'Jesus!' is a common – but by no means the only – exclamation.) We skittered and slipped, and the tyres scratched and scraped across the big sharp stones. On more than one occasion we bounced a little too high, or a little too far to the left or right, and crashed into the small acacia trees that were trying to make a go of it halfway up the steep slope. That's when I'd jam on the brake and clutch, before letting the engine slowly lower us down the hill yet again. We were travelling at about walking

pace, so it felt a little like abseiling. About halfway down, Mick remarked that, yes, we'd definitely get *down* – eventually – but would we ever get *up* again? But as I wrestled with the steering wheel and the bulk of the Landcruiser on the narrow path I was really only interested in the first part.

Once we had the nets set in two separate waterholes the camp was full again, the barbie was cranking and Mick and I thanked our foresight at over-supplying on the beer front. S-Bend sits about 30 kilometres east of the border between Queensland and the Northern Territory. The riverbed consists of coarse red sand overlain by rocks dislodged over millennia from the towering gorge walls on either side. Along the river channel a line of stately white-trunked eucalypts is reminiscent of Albert Namatjira paintings – obviously there's just enough water at just the right time to sustain them, even though S-Bend is usually dry. Again we were incredibly lucky that the rain and floods had come to the Mulligan eight weeks earlier. In the fading light Mick and I scaled the big boulders on the side of the canyon to take a few quick snaps of the sunset before retiring to the comfort of camp, silly conversations and smelly swags.

One of the main reasons for me sitting around the campfire at S-Bend was to gain some field evidence that might help us test theories to do with ecosystem function. In the freshwater ecology world, a conceptual model called the Flood Pulse Model, first published by Dr Junk and others in 1989, originally held a lot of sway.[1] The FPM states that biological processes like fish recruitment (breeding) are facilitated by and regulated by regular overbank flows (floods) and that without them most fish would be cactus. This makes a lot of sense, especially if you're Dr Junk and you've done all your fish work in the Amazon (where

there's a regular monsoon) or in Europe (where the climate is similarly predictable). Unfortunately, it doesn't fit as well for Australia's inland rivers because they're so erratic. About ten years after the FPM was posited, Dr Paul Humphries – an Australian – came up with another model for certain fish in the lower Murray–Darling and he called this the Low Flow Recruitment Hypothesis.[2] In it he showed that fish like drab little brown gudgeons bred regardless of flows and flooding. From an Australian inland perspective, the LFRH makes perfect sense if you're a species that wants to hang around for a few millennia, because if you live in unpredictable systems, waiting for a flow could mean a *long* and extinction-inducing wait.

Around the same time Humphries published his hypothesis, another Australian – Jim Puckridge – was testing Dr Junk's theory in outback South Australia at Coongie Lakes, part of the Cooper catchment.[3] Jim decided that in Australian outback rivers any flow event – no matter how small – was likely to result in biological and ecological responses. Puckridge – now rightly recognised as a pioneer of arid zone aquatic ecology – also demonstrated just how unpredictable our inland rivers are; on a global scale, the Cooper and Diamantina were clear winners in the 'most variable hydrology' department.[4]

The evidence Mick and I were collecting in 2007, and the evidence I've kept collecting in the intervening years in the desert, supports the work – unsurprisingly – of Puckridge and Humphries more than it does the original Flood Pulse Model. Even in a drying waterhole, a place where the eventual extinction of all local fish is a no-brainer, we've recorded juvenile spangled perch and bony bream shortly before the water evaporates.

Nevertheless, one of the things these models don't consider in detail is the how or why of fish movement and migration. Consequently, after the post-flood April trip I spent a fair bit of time reading to find out more about animal behaviour in variable environments. The best explanation I found was the so-called Source-Sink Theory.[5]

The idea behind this is that the population sizes of animals go through ebb and flow, but that *source* populations – those that are important for maintaining the species over the long term – are located in reasonably safe environments. In other words, a species of fish that occasionally inhabits the Mulligan, like spangled perch, would have source populations in the permanent waterholes of the Georgina and Eyre Creek. Then, when conditions are right – for example when there's a great big flood – these source populations produce plenty of offspring. The offspring and adults can't all live in the same waterhole, so when migration pathways open many get out and either find other source habitats or end up hundreds of kilometres upstream in a drying waterhole – a sink habitat. Then, when there's another big flow, the process is repeated, thus preventing massive in-breeding and overcrowding at the same time. And if – and only if – there's an exceptional year when it rains in winter and the sink population can eke it out, they themselves become a source population for other sinks out in the wilderness.

The Source-Sink idea is particularly relevant for S-Bend, as it's 300 river kilometres away from the closest real 'source', which is the confluence of the Mulligan with Eyre Creek south-west of Bedourie. So whatever we pulled out of the nets at S-Bend had swum a long way to an extremely uncertain future.

Like Pulchera, S-Bend contained big glassfish, big spangled perch and a few medium-sized bony bream. Unlike Pulchera, our haul didn't contain many silver catfish, suggesting that most migrating catties didn't travel as far as the spangs and glassfish. Also unlike Pulchera, we found the waterholes up at S-Bend full of rainbowfish.

Australian fish often have brilliantly descriptive names: glassfish have translucent bodies, bony bream are full of bones and rainbowfish are multi-coloured. They are small (80 millimetres is a whopper) schooling fish found in the upper layers of the water column. They have an upturned mouth, though not as pronounced as a saratoga or archerfish, and dietary studies demonstrate that they're happy to feast on unlucky terrestrial insects that land or fall in the water as well as on aquatic prey. There are plenty of species of rainbows as they are widespread in both Australia and New Guinea.

The desert rainbowfish is the least colourful, no doubt due to the waterholes in which it lives being a murky soupy brown. But the rainbows at S-Bend were different from anything else I'd seen or caught in the Lake Eyre Basin. Instead of being drab and silvery, they were vividly striped with orange, purple and yellow on their sides, and we were measuring and counting hundreds of individual fish from 30 to 70 millimetres in length. I thought of where the Mulligan rainbows might have come from given that the waterholes we were fishing had been dry in 2006 and only filled in January 2007. At that stage it seemed there were two explanations: either they migrated from down south during the flood (along with the bonies, spangs, catties and glassfish), or they were derived from some local population hiding out in a waterhole nobody knew about high on the

Mulligan. Every local I could find – and there are precious few – told me emphatically that there was no hidden waterhole anybody knew about in the border country. In essence, this suggested that the colourful rainbows of the upper Mulligan were the longest-ranging colonists of all, bypassing Pulchera and travelling an extra 150 kilometres all the way to S-Bend. It also suggested they may have been the dopiest, for Blind Freddy could see that S-Bend would dry up long before Pulchera without another rain.

It wasn't until November 2007 that a third explanation surfaced. Smithy and I had returned to Pulchera, and I was still scratching my head and wondering out loud about the whereabouts of the mysterious Mulligan River rainbowfish when Scott Morrison, who was to leave Ethabuka soon after our visit, suggested we take a bumpy cross-country drive to Dribbler Bore, a flowing water source on the eastern boundary that boasted a small dam around five metres in diameter. Permanent water in the desert. Some volunteer workers had found a dead spangled perch there in winter, so Scott was interested to see if the population had lasted.

By this stage Smithy was a three-trip fish sampling veteran so knew exactly what piece of equipment was appropriate for taking a quick sample of a bore pool in the middle of nowhere, and before I had time to ask the seine net appeared from the back of the vehicle. We put our feet into the two loops at the bottom corners of the five-metre-long net, then our hands into the loops at the top. Between us, we now had a 'wall' made out of two-millimetre mesh about a metre high. We dragged the net through the water, changing it from crystal clear into a black soup by disturbing the long-settled substrate. Although

On the edge of the Simpson Desert is Dribbler Bore, where an isolated population of desert rainbowfish survive.

our seine was too slow to catch any spangs, we found plenty of rainbowfish – and not just any old drab rainbowfish – these were the colourful Mulligan purple and yellow models, the same as I'd sampled in S-Bend. This was a great discovery, for it solved the most pressing Mulligan River fish mystery.

It appears that rainbowfish have been living for years at Dribbler Bore in a small population – one derived from ancestors that battled and fought their way up the flooded Mulligan decades earlier. Over generations, the mostly-marooned Dribbler rainbows became brightly coloured as a result of the clear bore water in which they lived. It seems conceivable and likely that this 'source' population benefited from the January 2007 floods and had juveniles in the water ready to move when migration became a possibility. Then, they moved upstream (but maybe

not back down to Pulchera) and colonised the upper Mulligan during the flood. The 'discovery' of the Dribbler rainbowfish population demonstrated that desert fish are extremely tough and adaptable, and that such species will seize any opportunity to maintain a population. Presumably, whenever the Mulligan floods and the Dribbler Bore swale receives an overland flow, hundreds of rainbowfish leave home. Most expire, but some make it to the main channel, and a few make it all the way up to S-Bend, over 100 kilometres north.

By August 2007 – and only seven months after the flood – the Mulligan was back to the sand-and-rock gully it remains for 90 per cent of the time. Fishing with Angus this time, we found only a single pool at S-Bend, which was 40 metres long, five metres wide and no deeper than 40 centimetres. To our surprise, however, we retrieved nets loaded with rainbows, glassfish and spangled perch. We released them, but knew that each and every one was destined for an extremely brief life; S-Bend dried out completely two weeks after we left.

By November, long after S-Bend had dried, the big lake at Pulchera still had a fair bit of water, and there was an impressive array of ducks, spoonbills, swans and pelicans too. But things were getting tough. The bonies, spangs, glassfish and a solitary silver cattie were hanging in there, but the deepest water was only about 70 centimetres. Without a summer rain or another flood, Pulchera, like S-Bend in September, would evaporate, the fish would all disappear, and no more would be found until another random hydrological event.

Intrigued, Smithy and I again headed west from Bedourie to see whether any fish had survived the summer in Pulchera in March 2008. There had been no rain that summer, so we knew

the chances were slim. We were in separate vehicles this time, and each of us had a wife and two kids for immediate company. We dodged the graders and tractors of the Diamantina Shire just out of town, and then skidded across the gibber as we left Kamaran Downs and drove through Sandringham – the big property at that stage still owned by the Kidman company. It wasn't looking particularly watery – an observation our families made frequently – but I held out a little bit of hope. Maybe there had been a shower out at Ethabuka. Or maybe there was a deep hole right in the middle of Pulchera I hadn't noticed on earlier trips.

Scott, Sajida and Thor had left Ethabuka the previous Boxing Day, and they hadn't been replaced. Working full-time at a place like Ethabuka has its difficulties: it's hot, it's isolated and you're pretty much on call 24 hours a day. To do the grocery shopping Scott used to take off on a two-day trip to Mount Isa with an 80-litre Engel car fridge for company, so it ain't for everyone. With no staff on site, the only way I could find out about the water level in Pulchera was to get someone to fly over it, or drive out to it myself. I chose the second option because I loved the place – I just wanted to go back. If it was dry – well, I'd have a quick look at it dry.

Where the bonies, glassfish, spangs and catfish used to live was a cracked lake bed and a posse of black kites hovering overhead; the magical place I'd told the kids about no longer existed. Pulchera had lasted about a year, and in March 2008, it didn't look like it would fill again any time soon.

We drove back up the dusty track, past the twisted gidgee-posts of the old stockyards and back over the first few dunes

of the Simpson. I was slightly annoyed that I'd driven 300 kilometres to find a dry lake (though not as annoyed as my family), but my overriding feeling was of gratitude; privileged to have witnessed and recorded a full year of the boom-bust-busted ecology of the water country in the desert.

7

GRASS CASTLES AND WATER WARS: THE RIVERS OF THE COOPER CATCHMENT

Patsy Durack's words about being a king in a grass castle that could be blown away any minute were no doubt uttered around the kitchen table at Thylungra, the vast spread he battled his way towards from Goulburn in New South Wales way back in the 1860s. It's not a bad analogy for the boom-and-bust life cycle of all animals and plants out in western Queensland. In the arid zone life is like a one-legged bird perched precariously on a skinny wire, and it doesn't take much to knock it off.

From the dampish south-eastern highlands, Durack, along with the Costelloes, Scanlans, Hammonds, Tullys and other poor-arse Irishmen, made his way north around 150 years ago. Many descendants are still there today. The distances these men travelled are mind-blowing, especially given they took their wives, kids, cattle, horses, wagons – everything. And they made their way not towards lush forests or fertile grasslands but into the heart of Australia, through stony plains and spinifex; out

into the outback, where even in winter it's still about 30°C most of the time.

North-west of Quilpie the road straightens out for 150 or so kilometres until you reach some sand dunes. Air-conditioning in the car makes it easier, so I can only sympathise with the Duracks and the other families who battled their way over the gullies, up the jump-up, through the mulga; the flies in their eyes and the creak of wagon wheels and hooves over the polished ironstone. The sand dunes are significant because Kyabra Creek – where the Duracks and Costelloes initially called home – starts to the north-east of the dunes, then does a big U-turn and heads back up towards Windorah.

Durack stayed on the Thylungra waterhole, while John Costello made camp on the big lake further down at Kyabra. This is where they paused, settled, and built their vast empires, which would eventually stretch across to the Kimberley and back down to the Lachlan in New South Wales. It's odd that Kyabra Creek – rather than the Cooper itself – was where white settlement first occurred in far western Queensland, because Kyabra's small, it doesn't flood often and it's not that far east of the Cooper channel country which contains both more water and better pastures.

My first trip to the Cooper in August 2006 was a reconnaissance mission, minus nets and flash equipment. As usual, I had a companion not from academia but from a farm down south. Peter 'Spider' Tyack had moved up to Brisbane a few years before us and had set himself up as a panel beater. This meant that when it hailed he became frantically busy. August, however, wasn't hail season, and Spider put his hand up for a little drive. Spider is originally from Tullibigeal in western New South

Wales and I'd taught his kids, so we knew each other fairly well. Once we'd moved to Brisbane, we felt part of the same tribe – people from the country living in a city – and when I suggested to Spider that he grab a swag and come along he didn't hesitate.

We took my old Toyota Hilux and crawled about at 90 kph for ten days from Adavale to Quilpie, to Eromanga, to Durham Downs, back up across the floodplain, to Windorah, to Jundah, Stonehenge, and then home. There's nothing quite as easy as coasting through central Australia when there's just two blokes, a couple of swags and a trayback ute. You can't do it on the coast, because either gear or your ute would get nicked – at the very least everything would get pretty damp. Spider and I gossiped about home and watched and noticed the way the land changed as we explored and mapped the oddest fishing locations – a drying channel down on the Kidman-owned Durham Downs, the big crossing east of Windorah, a narrow ghost-gum channel high up on the Bulloo. We negotiated multiple dog fences, eventually reaching the conclusion that, as well as the 'real' dog fence, some of the stations seemed to construct their internal fences in the same fashion – posts eight feet high strung with chicken wire in various states of disrepair.

One morning we pulled up on the inside track that bisects the floodplain south of Windorah. A ewe had given birth to twins the night before and six wedge-tailed eagles formed a circle on the ground around her and the lambs. When the ewe moved to defend a lamb, a wedgy on the opposite side of the circle took an ungainly flap-hop inwards. When she moved to defend the other lamb, a similar flap-hop was taken by a wedgy on the opposite side. The circle was gradually closing, flap-hop by flap-hop, and the ewe was becoming increasingly stressed.

Another eagle arrived, this time alighting on a nearby gidgee stump, and crows began to turn up as well. The birds were in no hurry, for their war of attrition was destined to be successful.

We didn't hang around and didn't interfere. We knew that even if we tried to chase the eagles off they'd return, and we reasoned it was probably best that she lost one lamb quickly – at least that way she might have a chance of looking after the remaining youngster.

There had been a little 'run' in the Cooper prior to our visit, and as we neared Windorah the contrast between the dry country and the floodplain was extreme. As soon as we dropped from the harsh, mulga-dominated ridges, the channels of the Cooper were covered in a blanket of green. This was Cooper clover, named because of its similarity to other legumes, and it was growing thick and knee-high in the table-drains through all the Cooper channels. Its fresh, fragrant smell pervaded the cabin of the ute, prompting Spider to grab a handful and place it on the dashboard for round-the-campfire examination. It was, as far as we could discern, very like lucerne, and a few days later – as it dried – produced a sweet, aromatic smell that reminded me of health food shops and market stalls. The Cooper clover was as lush and verdant as any irrigated crop down south, and its presence demonstrated why the channel country was so good for fattening cattle. When rain or flows occur here, the country comes spectacularly to life and the desert becomes an oasis. If a grazier or manager had stock to move in to a big paddock full of the sweet-smelling plant, they'd surely do well.

We rolled out our swags under a massive red gum in the dry bed of the Cooper just near the Windorah crossing. It was then I realised that I'd chosen well – even if I never finished a PhD,

I could learn a lot about western Queensland and love doing it. Once country gets under your skin it's impossible to ignore. Within six months of that first trip with Spider I'd completed three fish sampling trips throughout the Cooper catchment – including two in the middle of summer – and increased my sampling area to include the entire Lake Eyre Basin in western Queensland and the smaller Bulloo River to the east, which meant every catchment west of the Murray–Darling and east of the desert.

Within the three main Lake Eyre Basin catchments (the Cooper, Diamantina and Georgina) are plenty of smaller creeks and waterways, of which the ephemeral Mulligan is a good example. It's a stand-alone catchment, that, when it floods, links up with Eyre Creek, and becomes part of the 'greater' Georgina catchment. The Cooper is a bit different, originating as it does from the confluence of the Thomson and Barcoo rivers. Sturt named it a creek because he didn't think it was quite reliable enough to call it a river. Given that he was carting an upturned boat on his expedition to find the inland sea I guess he was looking for something a little more substantial, though he didn't find it. Kyabra Creek is also part of the 'greater' Cooper, but it's a lot smaller than either the Thomson or Barcoo, and doesn't flood as often.

Apart from being historically important, the Cooper – specifically the area around Windorah – made news in the mid-90s because some cotton people tried to start irrigated agriculture in the district. They might have succeeded, too, if it hadn't been for a few colourful locals supported by some sympathetic scientists and greenies. Perhaps the most vocal opponent to these developments was Dr Bob Morrish.

Bob is a passionate man, with a full head of silver hair and a head full of ideas wrapped up in a sometimes hilarious, occasionally furious socialist-commie package of anecdotes, stories and yarns. The 'Dr' title is genuine – he's a sex psychologist by profession – but thankfully he likes to talk about many other topics as well. He becomes incredibly fired up and involved in issues that affect him and his bit of the planet.

Outside and patrolling around Bob's modest home, which is not far from the big Kyabra waterhole where John Costello settled, there are at least 25 half-bred/in-bred blue or red heelers – all with their own Shakespearian name – that jump on any living thing that strays into the yard. Mick found this out the hard way on one visit. He confidently patted and swooned over Macbeth and Iago for a few minutes but then made the fatal mistake of electing to relieve himself in their territory. Horatio and a few others took exception and the upshot was that Mick ended up with his trousers down at the Windorah clinic being dabbed with Betadine. Luckily he was back in the water a day or so later.

The interior of Bob's house contains mountains of books courtesy of his deep and abiding interest in everything from natural history to poetry to all things sexual, and an array of local wildlife – frogs, insects, rodents – that appear to be marooned courtesy of the aforementioned hounds.

Bob and a few other locals were the ones who saw the cotton farmers coming, put two and two together and worked out that pumping the unpredictable Cooper up and over the banks MDB-style was a recipe for a wrecked river. They mounted a successful counter-attack and corralled the media, local landowners and scientists together in order to stop the

cotton-growers from activating two 'sleeper' water licences close to town. Stories from the cotton wars – particularly the colourful language directed towards a state government minister by well-known Windorah local Sandy Kidd – have become the stuff of folklore in and around the little town. Consequently, despite the dogs, frogs, bugs and God-knows what else, most people in the district recognise the important role Bob played in keeping cotton out of the Cooper. If the Windorans and their allies had lost, and water had been pumped under licence, it is possible that the Cooper would now be on a trajectory similar to that started in rivers like the Culgoa and Darling many years ago.

Biogeography is the study of what lives where and how and why it might have got there. It becomes really interesting once you know a bit about what we like to call species' boundaries or distributional ranges. The general idea is that, barring translocation by humans, living things on the planet have slowly evolved, spread, become locally extinct, changed into something else in the next valley, and so on.

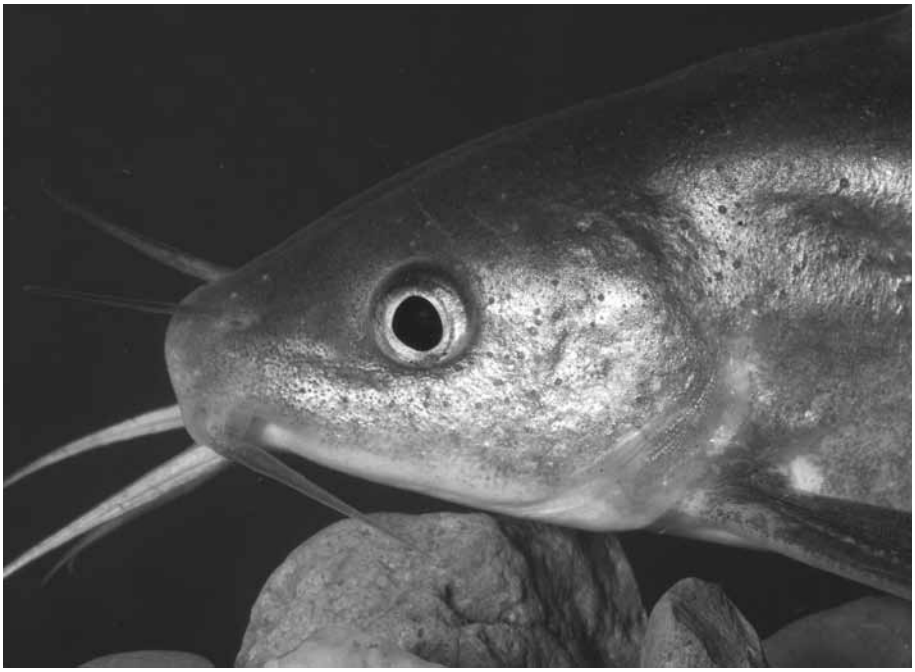
In terms of the fish species from the Lake Eyre Basin, the common, widespread species like bony bream, spangled perch, rainbowfish and silver catties are found all the way across western Queensland from the Mulligan to the Bulloo. There may be slight genetic differences between a population in the west (like the Georgina) and the east (like the Bulloo) but they are all the same species. When the rains come and the rivers flood they disperse and colonise, just as we found in the Mulligan.

But biogeography also highlights questions. Silver catfish, for example, are found in the Georgina, the Diamantina, all

the rivers of what I term the 'greater' Cooper (the Thomson, Barcoo, Kyabra Creek and Cooper Creek itself), the Bulloo and up in some of the Gulf of Carpentaria rivers. But that's more or less it. It's weird, because the north-western rivers of the MDB, like the Paroo and the Warrego, are very similar to the Bulloo in the way they look. They share muddy water and even the riparian (riverbank) vegetation. Yet the basin divide (between the Paroo and the Bulloo) – a ruptured, slightly higher bit of mulga than the rest – is an insurmountable hurdle for a fish. Consequently, critters that live in one catchment don't necessarily live in the next.

If we stick with catfish for a little while – and we're talking about the eel-tailed varieties like silver catties – there is only *one* species that is widely distributed in the entire Murray–Darling, and this is the freshwater catfish that is thought to have been so disrupted by carp and river regulation (the species Mick and I found in Lake Cargelligo). Another species is the freshwater cobbler which is limited to far south-western Australia. But in the Lake Eyre Basin there are *three* species that live in the rivers (silver tandan, Hyrtl's tandan, Cooper Creek catfish) and a fourth confined to springs in South Australia (the Dalhousie catfish). That's a lot of catfish species for a desert, and biogeographically the desert catties are worth thinking about as a metaphor for everything else.

Australia was wetter half a million years ago – there was Lake Bungunnia and another ancestral lake called Dieri further north. It's likely too that there were plenty more fish species than there are currently in the Lake Eyre Basin. It's almost impossible to imagine now, but back then you'd be bogged on a rainforest track rather than a dry creek. We can assume that the



A large Hyrtl's tandan from the Thomson catchment. Poisonous spines in the dorsal and pectoral fins of this and other catfish species need to be treated with respect.

drying phase the continent entered slowly started to erode the species list, with the number of aquatic species declining along with available habitat.

By the time the Cooper, Diamantina and Georgina catchments had become physically separated (the Diamantina and Georgina still join up every blue moon at Goyder's Lagoon in South Australia), it's reasonable to assume that the suite of species living in each river was similar to what's there today. However – and it's an important however – geographical isolation is what science writer David Quammen calls 'the flywheel of biogeography'.[1] In other words, funny things start to happen once an area becomes cut-off from other places.

Throughout the Lake Eyre Basin there are springs, which are areas where artesian water rises to the surface and sustains an

aquatic habitat. One of the most extensive spring complexes is Dalhousie in South Australia, and it's where the resident catfish species grows no bigger than 10 centimetres and is named after John Glover (*Neosiluris gloveri*) – pretty much the first person to go out into the Australian desert and catch fish. The Dalhousie catfish has a close cousin, Hyrtl's tandan, and this species, along with the silvers, are the two most common catfish you'll find in central Australia. Hyrtl's are stocky and yellowish; silvers are skinny and silver. Unlike silvers, Hyrtl's have a big distributional range across northern and north-eastern Australia, and they're also in the Murray–Darling Basin. In fact, behind bonies and spangs, they are the third most widely distributed freshwater fish in Australia. They're pretty tough too – certainly tough enough to eke it out in the deeper waterholes of the Georgina, Diamantina and Cooper, and wait until the right time to breed and move.

The fish species that live in Dalhousie have been on an unusual trajectory since the springs stopped being connected to any other watery habitat. The catfish have evolved – probably from Hyrtl's or similar ancestral stock – into the version that swims in the springs today. Hyrtl's themselves can get quite big for a desert fish – over 25 centimetres long, and a far cry from the 10 centimetre Dalhousie catties. It's ecologically sensible for local variants in tight situations – like remote desert springs – to evolve into something *smaller*, because that way bellies become fuller more quickly and life cycles can be completed in a shorter time. There's not much point reaching sexual maturity at 25 centimetres if there's not enough food to allow you to grow that big, and – even more fundamentally – there's not much point reaching a large size in a small waterway, because before you

starve you'll run out of space and possibly oxygen. Dalhousie catties are among the most endangered fish in Australia because no amount of adaptation can alter or ameliorate the fact that they live in a very small area in a very big desert. If the springs fail or are destroyed, the fish go extinct.

In the bigger catchments silver catties and Hyrtl's catties seem fairly happy together, and it's not unusual to pull in a net with plenty of each slithering around. None of these catfish species is a solitary mud-sucking type that sits around on the substrate; these are busy schooling fish. Silver catties prefer to eat stuff directly in front of them whereas the Hyrtl's mouth points down a little more. Silver catties actually have trouble picking food from the substrate and have to become almost vertical in the water column to do so. Australian eel-tailed catfish don't have scales like the other fish they share waterholes with – just skin – and despite the fact that many people find their appearance distasteful, catfish are probably the best eating fish swimming in the inland. Straight from the river, two or three biggish Hyrtl's tandan barbecued in garlic butter would rival the most expensive seafood in an upmarket restaurant.

Catfish can be difficult to pick up because their skin is quite slimy, and I guess if a fish lacks a protective covering of scales, slimy skin is a sensible predator avoidance measure. Trying to measure several hundred of them by the side of a waterhole when the flies are camped in your eye sockets and both hands are covered in slime can be frustrating and the language colourful. But the slime and the general handling difficulties are only the beginning – catties have still more tricks in their tails in order to avoid predation and harassment.

In January 2007 I was counting and measuring fish at a waterhole close to Angus's place. It was bloody hot, and Smithy and I had – for some unfathomable reason – dragged the families along. So the wives were uncomfortable and a bit pissed-off, and the kids – four altogether – were mostly happy when they were in the water and sometimes grumpy when they weren't. I was counting, measuring and calling out numbers, the rest of them were swimming and having a pretty good time, Smithy was writing down fish lengths and Angus was taking pictures of a turtle. Without giving it much thought, I began 'releasing' the fish close to my partner Alison's head. She was swimming in the water, I was throwing fish – the sort of lovin' behaviour you'd expect after twenty years and two kids, I guess. It wasn't in the animal ethics statement or the permit, but it was the kind of troppo thing you start doing on summer fish sampling trips in the middle of nowhere. Al would dive under the muddy water, and then – whoomp – I'd try to land a bony right next to her as she surfaced. As my ammunition altered from bonies to catfish, I started picking up the slimy Hyrtl's by the tail. So now I would scoop up some catties, grab one by the tail, drop him, swear at him, grab another one, repeat the last three steps, get him on the measuring board, call out the figure and – like a small boomerang – flick him in the same general direction. In fact, I soon found that cattie-flicking was more accurate than bony-tossing, and that I could get the poor animals to within a few inches of Al without too much trouble.

The game went really well for a while, but, like most dumb kids, I kept at it just a little too long. As I flicked out a particularly large catfish, Al must have moved. Instead of hitting the water

Measuring big samples of fish can become dirty and frustrating, especially once the flies set up camp in your eye sockets.

next to her, the fish hit her first. Now, if it had been a bony everything would have been OK – sort of. But all Australian eel-tailed catfish have three venomous spines. The first one is the first ray of their dorsal fin, the second and third sit on either side of their bodies as the first rays of their pectoral fins. When catfish become irritated they lock their three deadly fins in the 'attack' position so that anything that comes into contact receives a sharp puncture wound and a bit of stinging juice. The bigger the catfish, the bigger the sting. The bigger the catfish, when thrown like a boomerang at an unsuspecting swimmer, the bigger the force of impact. I'm not sure how many spines connected with Al's shoulder and hand but she was in a lot of pain and I felt like a real wanker.

We rummaged in the first aid kit for the Stingose, which was a bit like taking a Panadol instead of morphine. Unfortunately those catfish stings *really* hurt and time is the only cure. After an hour or so Al was fully recovered, but I still get reminded of catfish day on the Thomson every now and again.

Catfish really are interesting fish. In many species the tails (caudal fins) have fused or merged into the anal fin on their underside. In some cases, the second dorsal fin has also become part of one large tail-fin apparatus that forms the perimeter of the entire posterior section of the fish. This is why, if you hung around with catfish taxonomists, you would hear much talk of caudo-anal and caudo-dorsal fins, barbels and spines. Another word that you may hear from such a scintillating conversation is 'anguilliform'. Strictly speaking, it means 'eel-like': to my way of thinking, silver catfish are a little more anguilliform than Hyrtl's; they're a bit thinner, and when they wriggle and struggle in a small net it looks and feels like a small eel trying to squirm and weave its way to somewhere better. There is, however, a fourth species of catfish from central Australia that wins hands down in terms of size, general oddness *and* anguilliformity. The Cooper Creek catfish (*Neosiluroides cooperensis*) is probably the strangest denizen of the Lake Eyre Basin and lives only in the waterways of the Cooper system.

Cooper Creek catties grow big. Along with yellowbelly, they are the biggest fish in the back country waterholes and frequently reach over 40 centimetres in length and a couple of kilograms in weight. Not only that, they're *thick* – as round as a fit man's upper arm. They're usually a speckly grey colour all over, but sometimes are almost black. Unlike silver catties the

The unusual Cooper Creek catfish is capable of swimming backwards like an eel.

mouth points directly downwards, signalling them as mud-grubbers that feed on snails and other bottom-dwellers. Unlike both silver and Hyrtl's catties, they don't seem to float around in mid-water schools but prefer to hang out solo on the bottom, and unlike most other fish – eels excepted – they seem to swim as happily backwards as they do forwards.

Cooper Creek catfish are a locally endemic species – a species with a limited distributional range – and are therefore susceptible to extirpation; if the Cooper/Thomson/Barcoo were to dry, or became infested with alien species, that could mean species extinction. As an endemic species restricted to a central Australian catchment Cooper Creek catties are special, and potentially as vulnerable as local endemics from other drainage basins (such as Mary River cod and Clarence River cod). Because they only live in a remote part of Australia,

Cooper Creek catties have not yet been labelled 'threatened' or 'vulnerable', though it makes sense to find out more about them. We do know that Cooper catfish produce far fewer eggs than most other catfish species and that they grow bigger. These two facts taken together suggest they breed less frequently than Hyrtl's and silver tandans, and that they may not reach sexual maturity until a few years old. To support this, in seven sampling trips to the Cooper rivers between September 2006 and March 2008 we only ever sampled small Cooper Creek catfish once – after the flood in 2008 – and even then we only found about 40 of them.

The rivers in the Cooper system have deep permanent waterholes dotted along them that old-timers can't ever remember going dry. They've all got names, the most curious being Murken, which is probably *not* named after a pubic wig, but just might be. Smithy and I set the nets at Murken in November 2007 during a small rise in the river caused by earlier rain in the upper catchments, and then spent about an hour tying them off with ropes to trees on the shore. There was a method in the madness. The water seemed to be rising slowly, only a few centimetres each hour, and we were interested in whether the flowing water would make a difference to the sample. We skedaddled back to other sites near Windorah and repeated the process. We camped by the big waterhole at the crossing that night, and as we washed clothes and prepared our steak'n'spuds tea we noticed the normally still Cooper transforming into the so-called 'mighty' Cooper by the second. The flow was gaining momentum and we were a little concerned about our nets. What if the river came up too fast overnight? Then again, that's

why we'd tied them off to the trees. We satisfied each other that any difficulty in retrieving the nets in the morning would be compensated by the size and composition of the sample; we were expecting all the big, adult fish to be moving upstream into the flow.

From the campsite we could hear the road trains rumbling along the bridge and see the headlights of traffic – such as it was – moving between Quilpie and Windorah. At about nine o'clock, which is bedtime on sampling trips, we noticed some headlights moving very slowly, and remarked that we hoped it wasn't somebody with a spotlight and a .22-250 who was keen on taking potshots at fish geeks. It wasn't, but they were coming to say g'day whoever they were. As the muddy banks of the Cooper tumbled and crashed into the surging current below us, a police Troopcarrier edged closer and closer to camp and, eventually, an officious-looking chap called Jim emerged from the cabin.

Coppers in outback towns either take it easy and become good at turning a blind eye, or they take their job very seriously. Jim belonged to the latter category. Six months earlier, during a conference held at Windorah, we had a big 150-person barbie at the same place and Jim had parked on the road out of town and breathalysed everyone going in or out. The rest of his time is spent doing a lot of other government work like handing out pension cheques and helping people pay their bills, though occasionally things get exciting, like when a chopper pilot found the body of a wayward European cyclist 40 kilometres west of town. The poor bloke died about 200 metres off the highway – within easy-hearing distance – so we're all baffled as to why he didn't just walk or crawl out there and get a lift. But then, the

outback attracts unusual people.

That night it took us a while to convince Jim that, yes, we were fishing and, that no, we weren't fishing illegally and that yes, researching fish in the Cooper did involve the use of big nets that crooks would love to get hold of, but that we weren't crooks. Eventually he believed us and joined us at the fire.

Jim works symbiotically with district fishing inspector Gary Muhling to prevent people from fishing illegally in the western rivers. Sounds easy in theory, though in practice it's a nightmare. Western Queensland is big, with plenty of waterholes. There are rumours around the west of unscrupulous types coming up from places as distant as Adelaide, committing their crimes and taking the booty – big hauls of yellowbelly – back to city markets. So it's good that Jim and Gary are trying to stop this sort of thing, but I'm glad it's them and not me. Gary – otherwise known as the Wombat to the cubs and scouts he looks after, is a community-minded chap who lives in Longreach and drives all over western Queensland throwing the book at dodgy fishos. I was told about Gaz by other researchers back when I first started my PhD, and the general consensus seemed to be that he was an obstructionist rule-enforcer who didn't like illegal fishos and absolutely *hated* nerdy scientific research types. Nevertheless, there is a rule that says you have to notify the district inspector when you're fishing in their area, so before my first sampling trip to the Barcoo, I did just that.

It was May 2006, and I'd picked up Leanne Faulks – a genetics researcher – from Brisbane airport and headed out to Blackall. That was the first time Faulksy and I had met, and we've been good mates ever since. Just out of Blackall we met up with a fish farmer called Bruce (they're mostly called Bruce)

who was to be our guide and companion and who lived for the entire week in a two-man tent on a diet of tinned food (just tins – nothing else). Bruce had two French students in tow, who were working with him for nothing in exchange for aquaculture wisdom. A good week was had by all, though I suspect the French lads may have had a few illusions shattered regarding outback Australia, Australian scientists and the Australian aquaculture industry.

Bruce piloted us in to a deep waterhole, where he set about netting the place to catch broodstock for his fish farm while Faulksy and I tried out different methods to catch larvae and juvenile fish.

Gary the Wombat turned up a few days later in a Cruiser bristling with aerials and communications gear. I don't think he had a gun but he might as well have, and the fishing inspector uniform is police-blue, so you get the picture. Gary's a big man, too. Although he knew Bruce, he didn't know me and was keen to assert his authority. At the time I was up to my knees in deep grey mud.

Gaz cast his eye over the permit, over the nets and over Leanne and myself, and presumably realised that we weren't quite the geeks he was expecting. We shared some damper and coffee, and then he went net-checking with Bruce. After that he hassled me about not having a label on every tiny box trap I had on the bank, to which I think I suggested he do something auto-erotic to himself. At the very least, I thought it. Yet from that day on we've been good mates and every time I see him – no matter how remote the location – he always seems to have a sticky bun from the Longreach bakery as a gift. Taking people how you find them and not listening too closely to the

opinions of others is a handy attribute when living and working in the more isolated bits of Australia. Everybody has a story or an opinion about everyone else, but it's better to trust your own judgement.

Back on the banks of the Cooper, with the fire crackling away, Jim hung around for another hour or so, which in retrospect was unfortunate, because an early night would have been more sensible.

The following morning we were up at daybreak and in the water ten minutes after that. The river had risen 1.5 metres overnight, the nets were submerged beneath the murky soup of the Cooper and – at $750 each – we had to get them out. After a prolonged period of duck-diving we accomplished this task, and then processed the enormous sample as quickly as possible. As predicted, the big flow had cued every yellowbelly and every catfish to head upstream, which meant our downstream-facing net was overflowing with adult fish keen to move. Throughout the retrieval exercise we were aware that the nets at Murken – ten or so kilometres downstream – would also be a problem, so we counted, measured and released a little faster than usual.

At Murken things were worse. The river was two metres higher than the previous afternoon and it was flowing like a freight train. We dived and dived again for the nets, hanging onto logs to prevent being swept downstream by the current and gasping for air as we resurfaced. We could feel the taut netting with our feet, and then when we duck-dived we could find it with our hands, but the cumbersome nets were tangled with sticks and other debris. And the water was still flowing – faster – and still rising. When Smithy stayed down for an unusually long time I had visions of Royal Flying Doctor Service calls

from crackly radios and satellite phones, news reports and coroners, and that's when we stopped. There was no way we could retrieve the nets. We'd have to leave them, do the sampling in the western rivers and retrieve whatever was left of them on the way home. So we found Jim, told him what had happened, then rang Gary, told him what had happened, and within a couple of days, with the Cooper still rising, headed to Bedourie and the Georgina. There was no flood out there that year and we could fish without having to worry about the river stealing our equipment.

It transpired that the Cooper stayed 'up' for four months. Beneath it, at Murken, I had visions of those big fyke nets gradually being torn to pieces by the slow flood, by the yabbies, by the water rats and turtles, and being strewn in pieces from Windorah all the way to the South Australian border.

But I was wrong. When we returned at the end of March 2008, our ropes – miraculously – had done their job, and though a little worse for wear the nets were where we had left them. We dug the wings out of the black mud and untangled the branches or cut them free. Hundreds of fish and yabbies that had been trapped since the previous November were liberated that day, and I was very relieved that my nets hadn't become moving death traps further down the Cooper. With a few stitches and patches, and a bit of bending of the squashed hoops, the fykes were once again useable.

Big waterholes like Murken are home to bonies, catfish, spangled perch and yellowbelly, but curiously few rainbowfish and glassfish – certainly nowhere near the numbers in the Mulligan. Instead of these species, or perhaps alongside them, the Cooper waterholes contain another small-bodied species

– Australian smelt. Smelt are common in all the coastal draining catchments of the south-east and the MDB, and they breed in winter – not spring and summer like most of their neighbours. It's rare to catch a single smelt – you either catch a couple of hundred or none, and it all depends on where the schools of smelt are and where the nets are. If the two coincide, there's counting to be done.

There are no smelt in the Georgina and Diamantina, yet there are plenty in the Thomson, in Kyabra Creek, in the Barcoo and in the Cooper itself. There don't, however, appear to be any in the Bulloo; the Bulloo is east of the Cooper but west of the most north-western rivers of the Murray–Darling Basin, like the Paroo and the Warrego, but there are smelt in these Murray–Darling rivers too. You might need a map about now, because the inevitable biogeographical question is – if smelt got into the Cooper from the east, why are there none in the Bulloo?

The answer might be that smelt in the Cooper came from the south rather than the east, and this has been demonstrated by Michael Hammer, a genetics researcher from Adelaide.[2] Then again, Hammer and other geneticists think there are up to *six* species of smelt scattered around Australia, but DNA is the only way to tell them apart because but they all look the same. Non gene-plumbers like me just call all of them smelt and don't become too stressed about what micro-variety they might be. Looks like a smelt, smells like a smelt (and they do have a distinctive smell – a bit like a cucumber), is a smelt. It's still curious though, because if southern populations managed to colonise the Cooper, why didn't they also get into Warburton Creek and the Diamantina, given that both Warburton and Cooper Creeks

empty into Lake Eyre on odd occasions?

The Cooper's still in pretty good shape, but it's the most vulnerable of the three big outback systems for reasons which all relate to people. Towns like Blackall, Barcaldine and even Longreach aren't big by Australian standards, but they're big for the back country, and more people always means more impacts. In November 2007 Smithy and I pulled two overgrown goldfish out of a waterhole downstream of Longreach called Waterloo. How did goldfish – which are basically carp – get into the Thomson? Who knows, but imported live fishing bait and liberated pets are the most plausible explanations. We've caught them in the Barcoo as well – between Blackall and Isisford. The Cooper, Thomson and Barcoo rivers are accessible, and people love to access them, especially in winter when the weather's pleasant.

Grey nomads from all over Australia line the banks of waterholes from April to September, reading papers, boiling billies, taking pictures and wetting lines in the hope of landing big yellowbelly. Local communities welcome them, and tourism is becoming big business in outback Australia, albeit on a fairly low level, since most of the retirees drag their tin homes behind them, turtle-style. Councils have been quick to organise fishing competitions and other events designed to make them stay longer and spend more money. But it's up to everyone – locals, government officials, grey nomads and even European cyclists – to stop and think before they cart live bait around or release Grover the unwanted goldfish, because the Cooper rivers still have a chance of remaining in reasonably good ecological condition.

8

KIDMAN COUNTRY: THE GEORGINA AND DIAMANTINA CATCHMENTS

Sid Kidman developed his 'three rivers' idea early on during his grand land acquisition activities. It was based around the notion that a bunch of properties spread throughout the Cooper, Diamantina and Georgina river systems was a good way to insure against drought. His rationale was that because the northern monsoon fed the rivers, there was a good chance that in any given year at least one would get a flow or flood, and the clay-lined channels would be inundated and spring to life. It wasn't a bad idea, and in seasons when it worked fat cattle made him plenty of money. But rivers in inland Australia are unpredictable beasts, and plenty of SK cattle also perished during drought years when none of the three rivers ran.

It's easy to see why Sid and others became enchanted with the magical channel country. The rivers themselves are different from both European and southern Australian rivers, because apart from their deeply incised 'permanent' waterholes, they are

really a series of dry, tree-lined channels waiting for something to happen. When it does, the water follows some channels but not others, breaks the banks in some places but not others, rises, falls and then disappears again, leaving the same waterholes and maybe adding a few more.

The first bit of magic is the flow irregularity itself. It can be a hot, clear central Australian day, and you might be cooling off in a waterhole that seems as though it hasn't had a flow for years. You get out and decide to make camp in the creek bed, or very close to it, to grab some shade under the ti-trees or coolabahs. Although you've heard that there was rain far upstream two weeks ago, everything seems as dry and static as usual. But if you put a stick in at the water's edge – and this only works if there *has* been a bit of rain upstream – you might notice that the muddy water is slowly climbing the marker as the hours pass. The rain might take up to a week to turn into a flow further downstream as it's 'stolen' at every juncture by more channels, new channels and diverted channels, but if there's been enough rain the rivers will rise, so if you're camped in one, move. As mentioned earlier, on sampling trips we've experienced overnight rises of up to two metres that have come from out of nowhere, and have seen still water at 4pm turn into a torrent by midnight.

The second magical aspect of the channel country is that it's situated smack-bang in the middle of some of the most other-worldly land you could ever imagine. In a dry year, travelling west from Windorah or Winton is an exercise in little more than patience. The moonscape spreads out to the north and south, broken only by a fenceline, the odd herd of cattle held in a mirage around a water point and the occasional twisted and dehydrated carcass of a kangaroo or emu. Then, the almost

endless hard-baked ironstone plains dramatically give way to a jagged rocky outcrop or a worn and eroded hillside – and then, even more amazingly, a wide green floodplain that sits like a fat snake between the barren stuff.

These channels and waterholes are true oases. Some of the waterholes are properly big – kilometres long, hundreds of metres wide, really deep – and totally unexpected. At the end of a long, windy and dusty day, there's nothing better than cresting a rise and noticing a creekline or a line of trees in the distance; that's when you'll find a shady tree and pull up.

The most extraordinary thing about the channel country is how quickly it's transformed after a flood. In April 2007 I drove east from S-Bend Gorge – way out near the Territory border – only two months after floodwaters had subsided out in the Georgina. The rain in January and February had turned the far western edge of Queensland into a lush and verdant savannah, and the tracks were dust-free and still held the odd pool of water. Mick and I knew what a good wheat or barley crop looked like down south – row upon row of deep green plants fighting for space in the chocolate-brown earth. We also knew how irrigated crops looked – the same busy sea of green only bigger, more dense. But the desert country, replete as it was with grass over a metre high that crowded the narrow track on either side, trumped all our analogies that April. There were bees and butterflies attending the vivid yellow, white and purple flowers at every turn, and massive locusts perched inelegantly on stalks, flopping and falling to the ground or into the windscreen. I slowed down, for it felt like we really were meant to be there, driving along at 30 kph and soaking up as much of the strangely green outback as we could.

We navigated north-east for about an hour, through a couple of paddocks the size of Canberra with their names painted on old windmill vanes. Glenormiston, the property we'd entered upon leaving Craven's Peak to the north-east, is owned by the North Australian Pastoral Company (NAPCo), and we were impressed by the quality of the roads and the fat cattle that hovered around bores and – begrudgingly – moved their arses off the track so that we could pass.

We crossed Pituri Creek, which flows into the Georgina at the terminus of a long section of channel called Lower Lake. We paused and looked north; a wide expanse of blue drifted up and out of sight, and hundreds of egrets and ducks appeared from nowhere and disappeared into the lignum and coolabahs. Feeling like old salts who knew exactly what they were doing, we reckoned the place looked pretty fishy, and were keen to set our nets in the hope of snaring another weird catfish like the mutant from Pulchera a few days earlier.

Glenormiston is probably not as picturesque after a long dry spell when all the waterholes are gone, but the homestead, workshops, stables and quarters, perched as they are on a hill overlooking Lake Idamea, and at the confluence of Pituri Creek and the Georgina River, remain impressive under any conditions. The place is managed by Stephen and Narda Bryce – operators who understand the back country and how it works. Before I'd met him, Steve made it clear that he didn't mind us working on Glenormiston if we were organised but that he wouldn't tolerate fools. I appreciated his approach and have been back many times since. Some people think that Ludwig Leichhardt's bones may be on Glenormiston, and a former ringer named Bruce Simpson has spent time trying to relocate

some relics (old iron and leather) he thought he saw many years ago. To date, his search has been unsuccessful, but it seems entirely plausible that Glenormiston – including as it does the gorge country of the upper Mulligan – would have been a suitable spot for Leichhardt to camp and survive, and enthusiasts would be well-advised to have a poke around in the jagged ranges that straddle the Queensland–Territory border. My bet is that if his bones are in western Queensland, that'd be the area.

The shallow lakes on Pituri Creek – Idamea and Lower – had filled during the 2007 flood. Fringed by a low line of trees, and with a backdrop of azure skies and bright sunshine, the place was reminiscent of Lake Cargelligo on lazy Sunday afternoons, except there were no snuffling outsize carp. After the bigger flood in March 2010, Max and I flew over exactly the same spot; the Glenormiston homestead was by then just a pimple – an island in a sea of floodwater that stretched all the way from Queensland, down the eastern side of the Simpson and into South Australia.

With nets set at both Lower Lake and Lake Idamea, Mick and I puttered away from the fleet of new trayback Landcruisers, the new-looking grader, the freshly washed trucks and the general not-a-thing-out-of-place-ness of Glenormiston and made camp about five kilometres to the east, pretty much where the Donahue Highway crosses the Georgina River on its way to Alice Springs.

Small fish samples can sometimes be good fish samples; there's no need to rush, there's time to take pictures, and the data sheets are often easier to understand once you extricate them from under the car seat three weeks later. As we ate breakfast and the sun climbed over the sandy banks of the Georgina,

Mick and I thought our sample would be small because we were fishing in a shallow and ephemeral pool. In fact, we were both *hoping* our sample would be small because we had a suspicion that the samples at Lake Idamea and Lower Lake, a task for later that morning, would be time-consuming. We were wrong. The big fyke nets had trapped every living thing in the main channel of the Georgina that morning and 'processing' was looking like a major operation.

Halfway through clearing the first net we realised that 'sub-sampling' was necessary. This is when only the first 50 specimens (or a similarly tolerable number) of each species is measured and then the rest are counted. It's not particularly accurate, but it's unavoidable if you want to save the lives of 700 bony bream, as they don't survive the bucket experience for any longer than about ten minutes. So away we went – one of us identifying, measuring and releasing and the other writing down numbers, hastily drawing extra columns, sharpening pencils and asking questions: 'Was that a bony or a rainbow?' or 'Hang on, what came after 55, 60 and 65 for spangleds?'

'Bony 60, rainbow 45, glassfish 40, spangled 70, bony 50, bony 50 – another five bonies at 50 and – hang on – what the fuck's *that*? Jesus, Mick – I think we've caught a flathead gudgeon!'

We hadn't, but we were excited.

Ever since the Pulchera catfish adventure we'd become attuned to the idea that something interesting might happen. Australia has a poor record when it comes to general knowledge about its ecosystems, and the Georgina catchment is one of the country's biggest biological black holes. What I had in my palm was a smallish, speckly-brownish cylindrical creature with

stargazing eyes and a big wide gob. Down south, the similar-looking flathead gudgeon sits on the bottom in Lake Cargelligo (and other places) and waits for anything smaller to come within range before gulping it down.

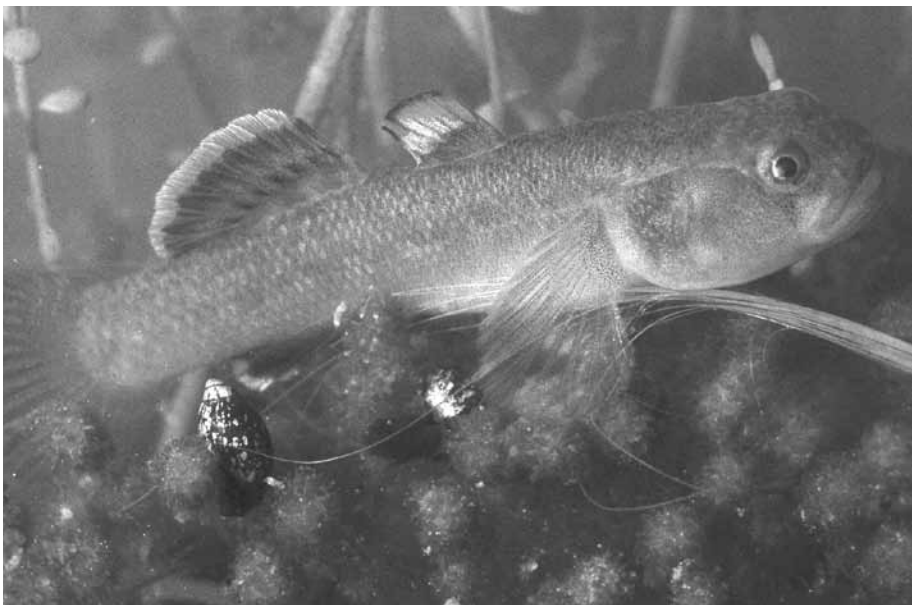
I looked, and looked again. Mick put down the pretty pink folder with all the numbers in and he looked and looked again. We'd fished all over the Lake Eyre Basin – in the Thomson, the Cooper, the Barcoo, even the Mulligan – but we'd never seen anything like it. It was a bit like a flathead gudgeon – same body shape, same mottled colour – but its head was a different shape with a far more elongated snout. Then, when we turned the beastie over, we noticed that the pelvic fins were fused to form a circular podium – obviously the perch-point for long hours spent bottom-sitting waiting for a feed – and this meant it wasn't a species of gudgeon, but a species of goby.

Gobies are the biggest fish family in the world. Most species are coastal, all have fused pelvic fins and eyes on top of their head, and an awful lot of them sit around on the bottom just like flathead gudgeon. Mudskippers are gobies – those funny little greeblies who crawl up trees and flip-flop around on the mudflats – and it seemed we had our own goby on that April morning out in the Georgina. Rather than being scientific about it and calling them 'goby species', we did what all people do who are high on enthusiasm, low on knowledge and relatively pedestrian with regard to nomenclature and christened our new fish 'monster' on account of its large mouth and fearsome appearance. Two more monsters turned up in the ensuing half-hour, and one was bigger – about 10 centimetres – so our name seemed to fit. Out came the cameras, on went the speculation, and – eventually – on went the counting.

Forgetting the monsters for a moment, it had been a busy morning processing. Hundreds of bonies, rainbowfish, glassfish and spangled perch. The desert fish were doing well in the Georgina two and a half months after the flood, and it was obvious where the Mulligan colonists had come from. When the rains came, and the Mulligan changed from a dry channel to a watery highway, the fish had swum from the Georgina and Eyre Creek to places like Pulchera and S-Bend: 150 kilometres to Pulchera, 300 to S-Bend. Not bad when your average length is about 50 millimetres.

We threw muddy nets on roof racks and dirty buckets in the back and jumped in the car. Our 'small' sample had taken three hours and we still had two more locations to check. At Idamea and again at Lower we moved a bit faster, but the absolute numbers were even greater. A couple of ringers from Glenormiston came down to the water's edge at Idamea as it was a Saturday. They were dressed in jeans, boots and hats while we were covered in fish slime and mud as we dragged nets and processed buckets of fish. There were 'monsters' in Idamea that were even bigger than those in the main channel. To protect our awesome discoveries, I slyly put them in a separate bucket rather than letting them swim free in the big lake. To be honest, the chances any of the ringers were interested in the difference between a monster and anything else were slim, but I thought it was essential not to let on that we'd found something unusual.

As we closed the folder and tied on nets I put four or five unlucky gobies in plastic bags into the freezer compartment of the fridge. I've never enjoyed taking fish samples but I figured these were special and needed to end up in the Queensland



The unique and endemic Edgbaston goby.

Museum or somewhere similarly important. After repeating the lengthy net retrieval process again at Lower Lake, and again encountering monsters, we packed up for the last time that trip in the Georgina and headed east.

The Elizabeth Springs complex, where we camped that night, is situated right in the middle of gibber plains and the endless treeless flats Angus so lovingly calls 'rat country' on account of the occasional plagues of long-haired rodents that appear – as if from nowhere – from the cracking clays during wet years. The ancient water from the Great Artesian Basin percolates to the surface at Elizabeth Springs and a few other places in the Lake Eyre Basin, such as Dalhousie in South Australia. At each spring complex, endemic species have evolved in the isolated environments. The number of endemics is highest at Edgbaston – another Bush Heritage property – near the small Queensland town of Aramac where up to 14 species of snails and two species of fish are unique to the area. Even at Elizabeth

Springs, only a hundred metres or so from where we stopped, there is a small endemic fish – ironically a goby – which only reaches about five centimetres and shelters among the vegetation in the shallow spring vents. It's quite different from our monsters, but from the same family.

We rolled our swags out on the cooling, polished pebbles close to the springs and lit a small gidgee fire to cook our steaks. Unsurprisingly, the talk revolved around massive fish samples, the rich bounty of the Mulligan and Georgina rivers and – of course – the monsters. Our curiosity had to be satisfied so I unpacked the phone, set it up on the bonnet of the car, watched the small LCD screen while it located a couple of satellites, and rang Angus. Sadly, it turned out that our monster enthusiasm was a little misplaced, and that a species of largish goby had previously been recorded from the Georgina catchment.

Currently the total goby count for the Lake Eyre Basin comprises six species, but it's really five closely related small species and then the bigger, distant relative we'd encountered that morning. There is the small endemic species from Elizabeth Springs and similar localised populations at Edgbaston, at Dalhousie, and in the Finke River in the Northern Territory. All of these fish are related to a more widespread species known as the desert goby that is found throughout arid South Australia. These fish are all adapted to living in shallow, occasionally salty water that is frequently low in oxygen. But as weird as these desert-adapted little fish are, the monsters – big riverine gobies, not small spring gobies – are just as curious.

For a start, we didn't know whether they were golden goby (*Glossogobius aureus*) or flathead goby (*Glossogobius giurus*). Both

grow to similar sizes, look the same and live in coastal draining rivers in northern Australia. Fish taxonomy is tricky, and thankfully I don't claim to be particularly good at it or this story would bog to the axles. Some people really like counting scales and fin rays and other morphological features and deciding that something is or isn't the same as something else. Others then come along – usually geneticists – and say that such-and-such a population is a different species or sub-species. Leanne Faulks, for example, has spent a fair bit of time attempting to work out just how different the Lake Eyre yellowbelly is from the Murray–Darling mob, where the Bulloo crowd fit in and how different they all are from their relations up in the Fitzroy. To me they're all yellowbelly except the fish from out west come out of the water white because it's muddy and the ones from clearer waterways are greener. Still, I'm interested in what people like Faulksy have to say, because every man and his dog seem to want to stock every puddle with hatchery-reared fish, and if they're the 'wrong' variety they could cause problems for the locals.

Once back in Brisbane, I defrosted the monsters, took their pictures and sent them to museums in Brisbane and Darwin. I also looked up all the books and research, but couldn't find much on golden or flathead goby, particularly in Australia and even more specifically in the desert.

We returned to the Georgina in August. This time Lower Lake was nearly dry and yielded a total of only seven fish compared with the 2,000 Mick and I had sampled in April – that's how quickly things can change. Idamea was shrinking fast as well, and in the main channel the water was low and most of the holes were dry. If April was the boom, August was the bust,

and it was also interesting that the sampling in August produced no monsters. In the end, monsters only showed up again as the weather warmed, and we finally trapped a decent number – about 40 – a year after that first 'monster moment' by the banks of the Georgina. Today, we know a bit more about golden goby and here's our summary:

- The monsters are all golden goby – not flathead goby. I sent a couple to Australian goby-guru Helen Larson in mid-2008 and she made the identification based on tiny bumps called papillae and the way they're arranged on their cheeks.
- Golden goby from the Georgina River are massive compared with populations in northern Australia. I've caught them up around 20 centimetres in the Georgina, whereas the biggest they get up north is about 12 centimetres.
- Golden goby up north (and throughout the Indo-Pacific) seem to access the sea as larvae or juveniles and return to the freshwater later on. Monsters in the Georgina can't do this, so it seems the inland populations have a different – or at least adapted – life cycle that allows them to live, die and breed in freshwater alone.
- Perhaps most interesting of all, golden gobies are *not* restricted to the Georgina catchment in the Australian inland, because Mick and I subsequently found one in the Diamantina catchment.

Biogeographically, it seems most likely that the golden goby population in the Georgina originated from populations swanning about in the coastal catchments to the north. In a wet year it's possible that the basin divide around Camooweal or

somewhere similar was breached, and that a number of gobies crossed into the desert system and found their way down and into the large permanent waterholes. With no way of returning to the sea to breed (if indeed this *is* a requirement for this species), monsters in the Georgina managed to breed OK anyway. It's interesting to note that many of the Georgina waterholes are salty, which may have helped.

The Diamantina, however, isn't salty at all. And although golden goby may be uncommon in the Diamantina, they're still there; in November 2008 I went back and caught another one just to make sure.

It's possible that golden goby colonised the Diamantina following flow events linking the Georgina and Diamantina at Goyder's Lagoon in South Australia. Possible, yes, but I know of no-one catching golden goby downstream in the Diamantina or Warburton Creek. Also, Goyder's Lagoon is a long way south of the sites where we've found them in the Diamantina, and golden goby are unlikely to race 1000 kilometres upstream – as we know, they sit on their fused pelvic fins and wait to gobble stuff as it comes within range of their cavernous mouths. So if the species didn't reach the Diamantina from the Georgina, it may have crossed the basin divide to the north in a similar way to the very hypothetical Georgina explanation, or it may be a far more ancient species that has been there all along whose range has contracted. Whatever the explanation, the golden goby have been the topic of many conversations as we've traversed the dusty highways and back roads of western Queensland since that exciting day in April 2007.

The eroded mesas that are prominent in the Diamantina catchment conjure memories of Clint Eastwood and Lee van

Cleef in the western *The Good, the Bad and the Ugly*, or the Utah canyon where adventurer Aron Ralston famously amputated his arm and lived to tell the tale: there are few trees, little water, ironstone plains with the odd dry gully, a couple of soaring eagles and towering flat-topped hills surrounded by the rubble and scree that has been dislodged over millennia. It's an ancient, eerie, windswept place that for some reason reminds me of explorer John McDouall Stuart. Stuart was a proper bushman. To think of him riding into the desert with scant provisions and plenty of instinct and cunning, willing to take his chances and live on mice and pigweed, is awe-inspiring to anyone who has spent time out in the isolated bits of central Australia.

For some reason I've got a genuine affection for the rough-as-guts country, and the Diamantina's as harsh as it gets. North of Diamantina Lakes there's Brighton Downs, Verdun Valley, Old Cork; east there's the full-on high country on Mount Windsor, and west there's the flat dinosaur-ridden plains of Springvale and the other treeless blocks on the way west to Boulia. Normally I drive through there at 80 or 100 kph, but as soon as I'm back in Brisbane I wish I'd taken an extra month and just poked along at 50. Maybe Stuart was right. Seeing the country – as harsh as it is – from horseback would have definitely left the rider with no illusions as to the true nature of central Australia.

The first time I worked in the Diamantina was when Mick and I headed east in April 2007 following the 'discovery' of the monsters. Like all good tourists, we followed the signs and stopped at Hunter's Gorge waterhole in Diamantina Lakes National Park, where we grabbed cameras and climbed the craggy peak on the northern shore to get a better look. When

we returned, the ranger-in-charge, Andrew Kingston, was waiting to see whether we were really research people or just dumb poachers, so we did what everybody does and stopped for a chinwag.

Although it may not make immediate sense, national parks can be difficult places to conduct research. They're a tourist destination, and the public campsites are almost always situated right where the fish sampling would be best, like a big fat waterhole. I'd be a lot richer if I had a dollar every time a grey nomad has said something like 'Hope ya got a permit for those nets', 'Nah, ya won't get yellas this time of year' or 'What the fuck are *youse* fellas up to?' The other reason I'm not keen on national parks is because, unlike working on private property, you need to jump through more governmental hoops than usual to get yet another permit for the dubious privilege of dropping your nets in next to Barney and Meryl in the big van with the noisy generator.

Nevertheless, Hunter's Gorge looked fishy, and running into Andrew was fortuitous. He was interested in my research, keen to welcome some fish sampling to find out what lived there, and keen to encourage some of his rangers to get their feet wet, so in August 2007 – when it was cold as buggery and there were nomads aplenty – Angus and I camped next to Hunter's Gorge, with nets in, a comfortable campfire flickering and Angus pointing his Canon at the pelicans and shags.

By the time the seven or so ranger-bears turned up the next morning I was climbing into a wetsuit and sculling down coffee in an attempt to warm up before I really cooled down. Angus had no intention of getting into the water, and neither did anybody else.

There had been no flood in the Diamantina in the summer of 2006–07, and little water as far south as Diamantina Lakes the following year. This made quite a contrast to the Georgina and Mulligan floods of January 2007, and the Cooper rivers, that flooded from December 2007 through to February 2008. So although I was expecting, and then retrieved, a small winter sample at Hunter's Gorge that cool and foggy morning, it was interesting – to me as well as to Andrew and the rangers – as it contained not only bonies and catfish but the biggest prize in the western rivers – yellowbelly.

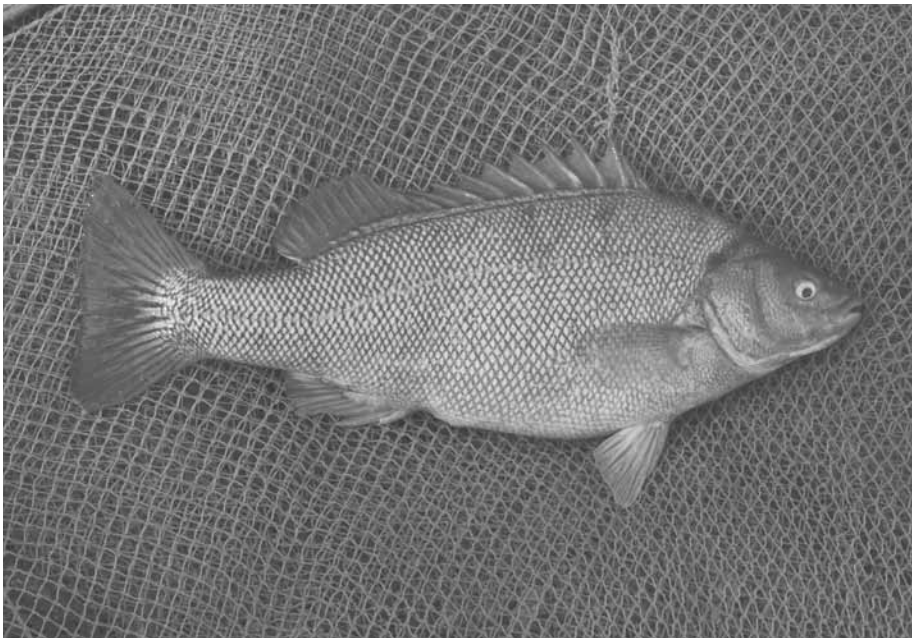
Despite the continual dry conditions, ongoing evaporation and shrinkage of waterholes, yellowbelly was the species that always surprised us – they're everywhere. When people fish in areas where there are no cod or barramundi, they fish for yellowbelly, and in the western rivers I've sampled them from all the river systems up to the 50 and 60 centimetre mark. What is more interesting though, is the fact that, no matter what the season and no matter what the waterhole condition, juvenile yellowbelly are almost always present. This contradicts theories relating to yellowbelly flow-reliance developed down south, because it seems that this hardy, ancient species is able to grow, breed and survive in anything from a desert waterhole to a deep river channel.

From the earliest white settlement of inland Australia, yellowbelly were sought after, and they were commercially fished throughout the Murray–Darling from the 1880s to the 1990s.[1] While catch rates for yellowbelly, cod, catfish and silver perch all dropped fairly dramatically in the second half of the twentieth century, yellowbelly evinced the least population decline, even

in heavily fished rivers with weirs that had plenty of carp, redfin and trout. Tough fish? Definitely – one of the toughest.

About 40 years ago, Australians finally began to realise that if you take all the fish out of a river pretty soon there'll be none left. At the same time, the Australian aquaculture industry expanded to include native species. People started experimenting using tanks and worked out that if they raised the water level (increased flow) native species like cod and yellowbelly would spawn.[2] In the 1980s a study tagged a yellowbelly way down in Victoria and recaptured it in Queensland, thus demonstrating the fish can migrate up to 2,000 kilometres or so when flows occur.[3] It seemed the evidence was in: yellowbelly spawn when there's a flow and migrate long distances to do so.

But just because one yellowbelly went for a long swim in 1983 doesn't mean they all do, and just because yellowbelly spawned in conjunction with rising water levels in an experiment doesn't mean they all do in the wild. Without carefully watching many yellowbelly for a long time across their massive geographical range it's over-generalising to say that flooding is the key determinant influencing their reproduction, and the results from the Diamantina suggest that for that particular catchment – especially in a no-flow year – it might have very little to do with it. In Hunter's Gorge, for example, there were at least 15 yellowbelly; the biggest at over 20 centimetres was a small adult, but the smallest was only four centimetres long, and most of them were new recruits. In all seasons, there were always plenty of juvenile yellowbelly, but there wasn't a flood. So it doesn't appear that yellowbelly need a flow to stay alive in the Diamantina, which is just as well, because in some years there isn't one.



A large Welch's grunter from the Georgina catchment that, together with its relatives the Barcoo grunter and silver perch, is also often called bream or black bream.

Yellowbelly are the undisputed kings of the western rivers, but there are a couple of other species that come close in terms of size, and which also figure in the riverbank catches of grey nomads with lines and of researchers with nets. These are the grunters, so named for the croaking sound they make when removed from the water.

Barcoo grunter and Welch's grunter are big fish for the western rivers, and both frequently grow to around 30 centimetres. Out west – all over the west – 'bream' and 'black bream' are the names locals use for Barcoo grunter and Welch's grunter in the LEB rivers and silver perch in the Murray–Darling. All three are similarly sized, similarly shaped large-bodied grey fish (however not one is related to bream that occur in Australia's coastal and estuarine waters). The Barcoo grunter usually has irregular dark spots or blotches and is a greeny-silver colour,

though sometimes it can be nearly black. Like yellowbelly, its body colouration depends upon the turbidity of the water; light coloured fish in muddy water, dark fish in clear water. The Barcoo grunter has a small head with prominent ridges on its gill covers, and their body shape is deep – almost round sometimes. Aquaculture people who grow them in tanks call them 'jade perch'.

Welch's grunter is a longer, more slender species, especially when young and they don't get the black spots. Both fish are found throughout the Lake Eyre Basin and they're reported to be present in the Bulloo, too. Unlike the majority of desert fish species, for Barcoo and Welch's grunter reproduction *does* seem to be related to movement and flow.

The day after our long campfire chat near Windorah with Jim the policeman, Smithy and I discovered plenty of big, healthy adult Barcoo and Welch's grunter in the net facing downstream. They were all swimming against the flow, keen to get somewhere upstream of where they had come from. Then, following the floods of 2007–08, we sampled a small and shallow outflow channel close to Windorah and found a group of small Welch's about eight centimetres long, similarly battling upstream and into the main waterhole. Max and I gained some supporting evidence for this 'move and breed on a flood' hypothesis after the big flood of 2009–10 out in the Mulligan. In all the big waterholes there were plenty of Welch's and Barcoo grunter – a few big ones, but mainly juveniles. We guessed that when the music stopped in the game of fishy musical chairs, they were already a long way upstream of their familial waterhole and destined to live out their lives in the remote waterholes of the Simpson Desert.

The banded grunter is widespread in northern Australia and found in arid rivers like the Georgina and the Mulligan.

All grunters – including Barcoo and Welch's, silver perch from the MDB and spangled perch from almost everywhere – belong to a family called the Terapontidae. Within this family, the greatest amount of speciation has occurred in the coastal draining rivers of northern Australia, so there are multiple species of Terapontids – grunters – in the Gulf, the Northern Territory and the Kimberley, with the sooty grunter perhaps the best known. A smaller northern species, the banded grunter, like its waterhole neighbour the golden goby, almost certainly entered the Georgina River from the north, found the desert to its liking, and stayed.

So named for the black vertical bars that decorate its sides, the banded grunter does not attain the size of Barcoo or Welch's and is big at 15 centimetres. In the Lake Eyre Basin rivers of Queensland, banded grunter are common in the Georgina and

occasional further west in the ephemeral Mulligan, but we're yet to catch one in the mid to upper reaches of the Diamantina or any of the Cooper rivers.

The banded grunter is a busy fish that darts about all over the place. In April 2008, as a big Georgina waterhole was drying down to a series of pools, Smithy and I set some nets in a deep section, and then, noticing a thin white crust covering the mud and logs on the shoreline, took off upstream with the water-quality testing gear. We found water half as salty as the ocean in a separate pool a few hundred metres away, and tell-tale sulphuric-smelling mud and slime to go with it. A little further we found another break, and then another, shallower waterhole. Drying down even faster, this puddle registered roughly the same salinity as sea water. The Georgina's funny like that – most of the aquifers are salty, but some aren't, despite the fact that the distance between a salty bore and a fresh bore may be comparatively short; indeed, some of the locals can take you to places where salty and fresh groundwater can be found within a few hundred metres of each other.

At the saltiest site, the water depth was only about 40 centimetres, yet we decided to put in our spare set of nets just on the off chance we'd retrieve something.

To our surprise, the next morning we measured over 500 bonies, a few rainbows, one very unlucky yellowbelly with eyes sunk back in his head like the potato-headed Sonarans in *Doctor Who* and 2,493 banded grunter. So a bit of salt doesn't bother them, and neither does the fickle nature of ephemeral waterways in the desert. The fact that bandeds have also been found in the Neales River way down near Oodnadatta and in waterholes out in the Western Plateau bears further testimony

to their preference for any place warm and wet, no matter how isolated. Like spangled perch, they are capable of breeding under sub-optimal conditions, migrating to distant waterholes and living in highly saline water – yet another perfectly adapted Australian fish species.

9

STUCK IN THE MIDDLE: THE BULLOO CATCHMENT

I'd been curious about the Bulloo for a while. It's all by itself, a narrow, elongated catchment sandwiched between the vast Lake Eyre and Murray–Darling basins. The Bulloo rises in narrow gorges south of Blackall, and then trickles and meanders its way down to north-western New South Wales – through Quilpie, Thargomindah and then, in a wet year, out into what's known as the Bulloo overflow. When you drive west of Charleville, you cross the Langlo River – which is still the MDB – and then start climbing over a low and undulating range, and that's the divide. By the time you've come down the other side there are 'three stubbies to go', 'two stubbies to go' and 'one stubby to go' signs erected in the trees, and – before long – you're crossing the river as you enter the vast metropolis that is Adavale.

Vin Richardson thinks Adavale needs 'a lift', and it's difficult to argue with him. Built on a floodplain, it has a population of about 20, is only accessible by dirt roads, and whenever the

Bulloo River floods it gets cut off from everywhere else. The black roads stay soggier and mushier for longer than the red ones, but it's never easy. All the houses are on stilts, which looks a bit weird at first because most of the time the place is characteristically back country hot and dry. You can get there from Charleville, or from Quilpie, or you can come down from Blackall, but whichever route you choose, make sure you've got enough fuel to get back again, 'cause there ain't none there. It's harsh mulga country, eaten out by rabbits and sheep decades ago, and most of the time, the occasionally lush channel country is a long way west and the more arable farming country a long way east. That said, small communities are good communities and the Adavale locals wouldn't live anywhere else. Furthermore, they've also had some good seasons recently.

I'd first met Vin in June 2006 – a chance encounter at the BP roadhouse just south of Blackall. Faulksy and I had concluded our week of fishing gear experimentation on the Barcoo, and after bidding farewell to Bruce the fish farmer and the two French students, headed east. Vin's a portly chap who looks a bit older than he actually is. He was covered in dirt, hanging on to the business end of the diesel bowser and dragging a Dingo digging machine in a box trailer behind a trayback ute. I had no idea who he was, but he seemed interested in me once he eyed the wagon, the nets, the mud and our scruffy appearance; we were probably pretty dirty, too. I dropped from the cabin, gave the then-stranger a simple 'G'day mate' nod and murmur, to which he replied, far more enthusiastically, 'How's it goin? I think I wanna know you.'

Vin's hyperactive and driven. He juggles at least four jobs at once, including maintaining the gas pipeline, running a road

plant, hiring out the odd bit of gear and running a few cattle. With his wife Jenny he lives on and runs a little place – 70 000 acres, I think – just north of Adavale on the Bulloo. Like a lot of graziers, they need a lot of fencing and general maintenance, but can't afford – or can't justify – the expense. Enter the government. Over the last ten or more years – ever since they first started selling the national communications company Telstra – the government has created pots of money with the takings and called them things like NHT 1 and NHT 2. This is an acronym for Natural Heritage Trust. More recently NHT has transmogrified into Caring for our Country. The general idea was – and remains – that this money be used to improve the Australian environment, and every man and his dog in rural Australia has been chasing it, from irrigation companies to government agencies to stand-alone cockies like Vinny. But – and there's always a but – jumping through government hoops and loops is not unlike banging your head against a large immovable object most of the time, so a lot of people chasing the money – especially stand-alone cockies – often give up because it's too hard.

At around the same time as the government accepted that looking after Australia costs a fair bit of money, there were also massive and far-reaching changes occurring in Australian agriculture. Back in the old days, people like Vin and Jenny and countless others could run their place, run their stock, sell their produce, keep all their receipts in a shoebox, see the accountant once a year and then wait for the wool cheque or the grain cheque before buying a new car or piece of machinery. They all voted for the National Party, presumably because most considered the Nats the least objectionable government types as they also owned farms, wore hats and boots, and were likely

to utter the odd politically incorrect sentence during doorstop interviews. But it's not quite like that anymore.

Nowadays, running a farm is a tricky balancing act, and owner-operators need to be equally adept at managing finance, personnel and natural resources. In managerial speak this is the utterly annoying triple-bottom line. As a consequence, cockies in different parts of Australia now often sit on boards of management and are involved with decision-making at local, state and national levels. If they're particularly motivated, as Angus Emmott is, they end up spending more time in the seat of a plane or a car than they do in a cattle yard. In the long run, it'll be – to quote a former Queensland premier and bulldozer driver – 'Good for Australia, good for you', but the transition process has been shaky, and plenty have fallen by the wayside. Today there are fewer productive properties in Australia than in the 1970s, with fewer people to run them and fewer still to work on them. To stay in the game landowners have to be aware of the bigger picture – what's going on nationally and globally – and to do that they have to keep their ears and eyes open. And that was exactly what Vin was doing in the BP that day. Vin the Dingo driver/pipeline fixer/road plant operator/cowcocky saw the link between a couple of fish researchers in a university vehicle and a bit of government assistance to purchase fencing materials. If he could get the geeks to find out what's in the river, get a report with a fancy letterhead stating what's in the river and then submit it to the government funding mob, he might – with a bit of luck – get bumped further along the queue than the neighbours, who also want and need a fence along the river but don't know the fish geeks.

I said I'd see what I could do about some survey work in the Bulloo, and then Vin headed north to Barcaldine and Faulksy and I commenced the day-long drive back to Brisbane.

When I got home, I dug out the books and papers. Sure enough, the Bulloo was a Georgina-like black hole. Hamar Midgley, a fish enthusiast and author who has done more pioneering work in remote Australian rivers than most, published a small report on the Bulloo, but that was about it.[1] Indeed, the lack of information reminded me of my initial interest in Lake Cargelligo's aquatic inhabitants.

I found it interesting that the Bulloo fish that Hamar found were remarkably similar to those found in the Lake Eyre Basin rivers, despite the fact that the Bulloo was managed with the Paroo and Warrego – both MDB rivers. As examples, there are introduced carp in the Paroo and Warrego, but no records from the Bulloo. There are freshwater catfish (the Murray–Darling variety) in the Paroo and Warrego but not in the Bulloo. And there are smelt in the Murray–Darling rivers but not the Bulloo. All of this constituted a good enough reason to include the Bulloo in my future sampling program, so that's what I did.

The Bulloo flooded in the summers of 2006–07 and 2007–08. It was the only far western catchment that experienced major flooding in those successive years. I was interested in what came out of the nets at Vin's place, not only because of the general lack of data, but also because of its geographical position, as there are alien fish in the catchments on either side (the Cooper to the west and Paroo to the east).

Happily, though, at three sites in the upper Bulloo that I fished a total of four times each, I only ever found native species.

Heaps of catfish – both silvers and Hyrtl's, but especially Hyrtl's. Vin said he'd never heard of catfish in his neck of the woods before, but we found them in their hundreds. There were large numbers of rainbowfish too, and lots of bonies, yellowbelly, spangled perch and glassfish. Around the eddies and backwaters formed by the red gums, we also sampled carp gudgeons, the drab little brown fish I knew so well from home.

In the Bulloo, and in Kyabra, and in the Barcoo and Thomson and Cooper, we always sampled a few gudgeons. Never a lot. Never hundreds, never thousands. Additionally, we always sampled the full range of size classes, from little transparent youngsters to veritable beasts (between four and five centimetres is *huge* for a carp gudgeon). This indicates that regardless of flow and regardless of season carp gudgeon keep breeding. Their consistently small numbers also indicate that in a natural or near-natural system they are probably eaten at about the same rate, though there's a chance that gudgeons are comparatively uncommon out west simply because it's near the limit of their range. Alternatively, it's tempting to consider why the abundance of gudgeons is so variable across the Lake Eyre, Bulloo, Murray–Darling and coastal drainages.

Gudgeon are a prey species. They're small, they don't move around much and appear to live in loose 'colonies' – you usually get a few rather than one. As they seem to breed constantly, gudgeons are likely to figure in the diets of carnivores such as spangled perch and yellowbelly, so in isolated waterholes, as long as there are predators about it's likely they'll keep gudgeon numbers in check.

On the east coast and in the fairly crook Murray–Darling, however, the populations of predators have been compromised

by commercial and recreational fishing and the other factors associated with river regulation. It's feasible that, in the absence of predators, or in areas where the natural ecosystem has been out of kilter for a while, carp gudgeon numbers might explode. In the manmade pond at the University of Queensland, for example, there are *millions* of gudgeons. From three small box traps I put in for less than 30 minutes I counted – with the help of some eager Brisbane students and teachers – well over 500. So maybe the populations of natural gudgeon gobblers either don't exist or only exist in low numbers, and maybe the resident turtles and eels don't play a major role in regulating gudgeon numbers. Maybe there's a hole in the food chain in this highly regulated system, and the gudgeon can exploit it to their advantage. Similarly, in Lake Cargelligo, where I caught kilograms of gudgeon, there were hardly any big native predatory fish in the samples – two or three yellowbelly was about it.

The point is, a small population of predators is unlikely to make a dent in a massive population of gudgeons, so it seems that there may be a correlation between gudgeon abundance and predator absence or rarity, and that the known decline in large predator species in the Murray–Darling may result in population booms of small prey species such as carp gudgeons.

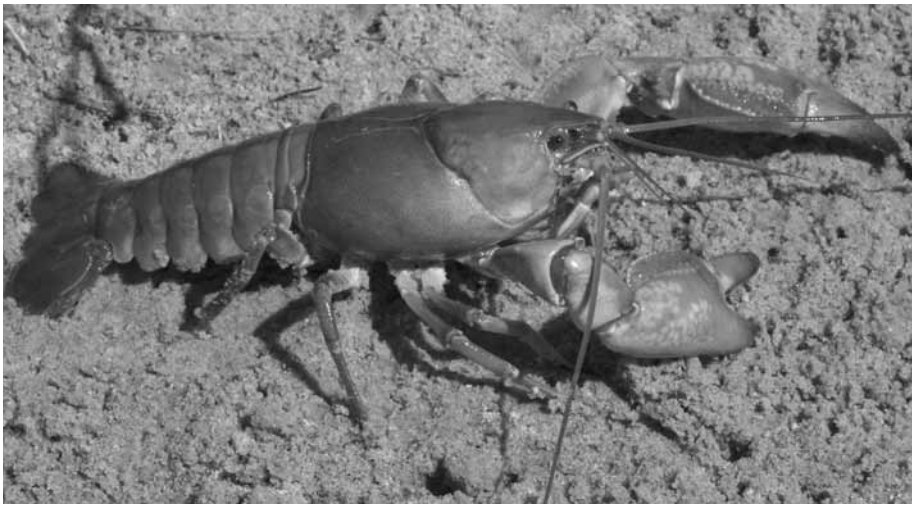
It was extremely satisfying to be able to conclude that the Bulloo, a 'forgotten' catchment in the Australian arid zone, contained an intact native fish fauna and no alien species. Because of its unique position between our two big inland drainage basins, keeping it this way should be the primary goal of management. That means keeping aliens out, resisting the temptation to alter the river and educating the residents and visitors about the good news.

10

THINGS THAT AREN'T FISH

Since opportunism is the key to success in outback waterholes, it's no surprise that scavengers of all descriptions end up trapped and sharing the net with the objects of their desire during fish sampling operations.

The most well known are yabbies. In Australia we use this term for many of our large freshwater crustaceans: elsewhere the generic term is crayfish, whereas out in the ocean these creatures are known as lobsters. The yabbies out west are usually big, bright and blue: they are the common yabby (*Cherax destructor*), its Latin name appropriate given their formidable claws – or nippers – and unfriendly attitude. On more than one occasion while setting nets, I've felt the vice-like crunch of a yabby 'claw' (in reality a modified set of front legs) and yelped in agony all the way back to shore. Unfortunately, once they latch on they're often slow to release and it's not unusual to end up with a yabby claw still connected to a piece of netting, or clamped like a vice



A native blue-claw yabby from the Lake Eyre Basin, now threatened by competition from redclaw.

onto a sampled fish or a human digit. In this respect yabbies are very lucky – they just cut their losses, crawl away and grow another claw.

Yabbies are like amphibious armoured tanks for 95 per cent of the time, and clunk around the bottom of waterholes, sifting through the muck for their food. The remaining five per cent of the time is when they're vulnerable, for that's when they shed their exoskeleton and grow a bigger one. No doubt a fair few unlucky yabbies end up in bird and fish gullets when they have their clothes off.

Yabbies are nearly always present in the waterholes of inland Australia – everywhere from Lake Cargelligo and out to the desert – and many Australians may recall spending a sun-drenched day in their childhood trying to lure the prehistoric creatures to the side of a farm dam using a chop bone tied to a piece of string. Unfortunately, however, *Cherax destructor* has some unwanted competition in a couple of LEB rivers, and yet again, it's our fault.

It's monster morning on the Georgina, and Mick and I have just recovered from the shocked excitement of finding a fish we didn't think was there. Then, out of the bucket looms a bloody great ugly yabby with ridges along its head and big, long thin nippers that don't look like yabby nippers, so we get excited *again*. There are a few of them: one big bright greeny-blue one and a couple of smaller drab models. Like the monsters, they go on ice. When I ring Angus that night and suggest we might have found a super-crayfish *as well as* a new fish, he – again politely – asks whether the said crustacean might be a redclaw. I'd never met a redclaw back then – I know them pretty well now.

Unfortunately, whenever a non-native crayfish becomes established anywhere in the world it seems to do a fantastic job of wrecking the place. It's not hard to see why – broad environmental tolerances, bottom of the food chain, thick skeleton on the outside and nasty claws to crunch the enemy. Redclaw (*Cherax quadricarinatus*) are related to yabbies but in the western rivers they're a translocated species, so not only do they look like aliens, they are.

Redclaw are a tropical species from up in the Gulf and Cape York. Back in the 1980s and 1990s, the Queensland Department of Primary Industries was promoting the idea of redclaw aquaculture. It's most unfortunate that many of these agencies are charged with both promoting production (agriculture, aquaculture) and managing the environment, because juggling the two doesn't seem to work. The spiel was that you could put some redclaw in your dams, they'd breed up and require very little maintenance and then they'd be worth a fortune a few years down the track. Eyewitnesses tell of a particular workshop where the redclaw were dumped in a dam reasonably close

to the Thomson River, and shortly after how they clambered out and started their march – stormtrooper style – straight towards the river channel. The same Thomson River channel had an almost perfect suite of native freshwater fish and yabbies up until then.

Meanwhile, we can guess that the nomads and mad-keen fishos were also carting buckets of live redclaw around so they could impale them on a hook and catch a yellowbelly. I guess some people consider that redclaw have an advantage over the endemic yabbies and shrimp as a form of bait, though I can't imagine what it could be, especially given the fact that they're far more spiky, horny and generally unpalatable looking than anything local.

One of the big waterholes on the Georgina – and salty home of monsters and banded grunters – is Parapituri, half an hour or so west of Boulia. It's probably the most popular fishing spot on the river, too, especially if the piles of garbage and toilet paper that lie strewn about are anything to go by. Perhaps unsurprisingly, Parapituri and other big permanent waterholes along the Georgina are a stronghold of redclaw, with discarded bait the most likely source populations. In April 2008, out of a small waterhole no wider than 10 metres and no longer than 20 metres, Smithy and I easily filled a 20-litre bucket. Hardly any fish. No yabbies. In fact, in April, August and November 2007, and then again in April 2008, we *always* caught redclaw in the Georgina waterholes – sometimes bucketloads – but we *never* caught yabbies. I mentioned it to locals in Boulia and they all reckoned that redclaw had been present in the river for five years or more, but that they seemed to be becoming more common every year, and they (the locals) also hadn't seen a yabby for

ages. The same thing's definitely happening at Longreach on the Thomson – there used to be yabbies, then there were yabbies and the occasional redclaw, now the redclaw outnumber the yabbies ten to one.

In April 2011 Angus was driving home one night, which involves crossing the Thomson River north of the small town of Stonehenge. The river was flowing courtesy of the recent flooding, so Angus stopped his truck in order to see whether any animals had become trapped in the flood debris: remember Angus is a collector, so always on the lookout for things to stuff or preserve. To his surprise, he found hundreds of redclaw clattering and clanking over one another in an attempt to scale the causeway and flicker and flap into the waterhole above it, so it's a certainty – unfortunately – that redclaw are now well-established throughout the Cooper catchment.

When a species or community is ticking along in a natural state, everything exists in a rough kind of balance. Populations ebb and flow seasonally or in relation to climatic variables. If there's a big flood, everything booms. If there's a dry summer, there's local extinction. But the next season – or the one after that – everything returns to normal-ish. The problem is that invasive species upset the rough kind of balance. Instead of having only to deal with the seasonal impacts, native species have to compete with an introduced animal that occupies a similar niche. A good Australian example is the introduction of cats and foxes. Quite apart from decimating our native reptiles, mammals and birds, foxes and cats perform the same carnivorous role as marsupials like quolls. The more foxes and cats, the fewer prey species there are, and fewer prey species means fewer quolls. It seems redclaw may be capable of doing exactly the same thing to yabbies in far

western Queensland: I'm not sure exactly how this is happening, but it's a situation that deserves close study, and soon.

Yabbies and redclaw are not the only armoured scavengers that crawl into nets in the hope of an easy feed. Freshwater shrimps from the Atyidae family are pretty small (less than five centimetres generally), mostly translucent and mostly everywhere. They cart their bundles of greeny-grey eggs around under their tails, and I reckon a fully berried-up female would be irresistible to anything with fins all over the west. Their slightly bigger cousins are freshwater prawns (*Macrobrachium australiense*), but most of us just call these critters shrimp too. These get a lot bigger – up to about seven or eight centimetres – and if you caught enough of them they'd make a decent prawn cocktail. The males develop long ungainly nippers and are adept at using them; it's not unusual to have to remove one from a finger accompanied by a stream of bad language. We've tipped thousands of Macrobrachium shrimp out of the nets and into buckets, and at all times of the year. In fact, there's no shortage of tucker in far western Queensland if you're a fish who doesn't mind tackling nasty-looking critters with shells. The armoury up front is almost certainly the reason that yellowbelly suck them in from behind.

The most interesting crustaceans in the western rivers, however, are freshwater crabs. Similar in every respect to their larger relatives on the coast, in the estuaries and out in the deep oceans, the crabs out west are different in one very important respect: they are adapted to living in a desert environment, so can survive long periods without water. At S-Bend, for example, we trapped hundreds after the floods – we'd shake down the nets and they would tumble noisily into the buckets like a pile

Freshwater crabs spend most of their lives underground, but are abundant when unpredictable rains fall.

of kid's toys being thrown in a plastic bin. Then, when the water evaporated, their little burrows on the banks made the place look like a World War I battlefield.

Water animals in the desert possess adaptations that allow them to survive in such a variable environment. The crabs basically aestivate in their bunkers: they hunker down in their holes and wait for it to rain. Granted it might take a while – possibly a few years at S-Bend – but when it does they can feed, breed and grow in no time and be back down the hatch before the puddle dries up again.

For brine shrimp (or fairy shrimp) and shield shrimp life's short and extremely busy. In the interim there's a great deal of waiting, but it's OK because all the waiting occurs as an egg rather than a busy, bustling creature. Brine shrimp have

Shield shrimp hatch in recently inundated desert claypans and waterholes.

multiple feathery legs and swim on their backs; shield shrimp are reminiscent of the trilobites of ancient seas and have a 'shield' that covers all their vital organs. Both types are considered big when they're over four or five centimetres in size. Out in the ephemeral claypans and low areas of the Simpson Desert like Kunnamuka Swamp it's not unusual to find thousands after a flood, or even after a local rainfall event. This is because, unlike fish, these species, whilst cavorting around during their short lives, lay millions of drought-resistant eggs. Then the claypan evaporates and the shrimp die. Their eggs, however, remain buried under a shallow crust of mud. When it rains again – like magic – there are brine shrimp, shield shrimp, smaller shrimp called conchostracans and even smaller ones called ostracods, and they're all buzzing around everywhere.

We also find insects in the nets, and these can be both large and fearsome. The biggest are the giant water bugs. These prehistoric-looking creatures get to about seven or eight centimetres long and are a worthy surrogate for any alien monster. Like brine shrimp and shield shrimp, their numbers explode when the desert becomes wet, but when it's dry it's as though they were never there. Indeed, the explosion of life that occurs in outback waterways after the addition of water is one of the most enduring and surprising aspects of inland Australia.

The most fearsome insects are about three to four centimetres in size and are known as Dytiscid beetles or predatory diving beetles, and these characters hunt in packs. When we pulled the nets in at the site of the first discovery of golden goby in the Diamantina, it was full of the meanest black beetles I've ever met. Hundreds of them, and all with jaws. They bite so hard and so efficiently that they killed plenty of the sampled fish, including a large yellowbelly. Their eating habits are not unlike those of piranhas, and in the waterholes they perform a similar role: they scavenge in groups, set upon far bigger prey and devour it in rapid time.

Yet another opportunistic scavenger that finds a fyke net full of fish irresistible is the turtle. Angus is mad on turtles. So mad, in fact, that the turtle that lives throughout the Thomson, Cooper and Barcoo now bears his name – *Emydura macquarii emmotti* – the Cooper Creek turtle. I'd frequently ring Angus from far-flung places like Ethabuka and Diamantina Lakes to let him know where we were and that we were still alive. Although he feigned interest in our general well-being, he was always keen to learn if there were any turtles.

Despite plenty of searching, I've not yet located one in the Diamantina or Georgina. We find this strange, because like yabbies turtles possess legs. They've even got lungs. You'd think that in a big wet year, turtles would travel long distances and yet they are conspicuously absent from the upper Georgina and Diamantina. Cooper Creek turtles are the biggest local variety of the widespread Macquarie turtle (*Emydura macquarii*) and we've caught them in the Cooper rivers with carapaces over 40 centimetres long. Once a turtle gets that big, it is usually over 50 years old, with a deep body and sometimes an enlarged head. We'd often have up to ten in each net, and many of them had shells notched by other researchers on previous scientific endeavours. It's a shame such projects are scrapped – whether the funding gets pulled or the researcher moves on – because there's plenty of data that could be collected by people like me: it could be as simple as taking a photo, recording the location and maybe measuring a shell.

The one place we really have caught a lot of turtles – both the short-headed *Emydura macquarii* and also the common long-necked turtle (*Chelodina longicollis*) – is back at the Lake. One morning Mick and I caught 180 – all fairly big, and all struggling to get back in the water. Long-necked turtles are often observed awkwardly crossing roads on rainy nights – frequently it's their downfall – and they exude a strong, musky, sulphuric odour when they're unhappy about being stuck on their back or caught in a net, so it was a fairly smelly exercise as well.

We are yet to trap a snake or a bird – which is good, because getting either out of a net would be tricky. I've spoken to people who've worked up in the Gulf and they've described

The Cooper Creek turtle is widespread throughout all the waterways of the greater Cooper catchment.

the none-too-subtle art of removing crocodiles from fykes, but thankfully that's an experience I've also not yet encountered.

But what we – me and all the people I work with – *have* found has been exciting: up around 100,000 individual fish with the vast majority native to Australia; up around 30 individual trips comprising God-knows how many kilometres. And we've not just focused on the big catchments, but included smaller creeks like the Burke, the Wills and the Hamilton in the Georgina catchment, and the Mayne River in the Diamantina. Every specimen has been identified, most measured, and all from muddy waterholes in inland Australia. The further west we go the more native animals we find. We've contributed the first records of golden goby in the Diamantina, the first records

of up to 11 species in the Mulligan and plenty of useful data about migration patterns and breeding. And – above all – we've gained a great and abiding appreciation for the rivers, the places and the people of far western Queensland.

PART III
RECOVERY ROAD

11

OBSTACLES AND CAUTIONARY TALES

Peter Saunders also works for Bush Heritage Australia, but his job is to manage several small conservation reserves in south-eastern Australia. One of these is Scottsdale, located on the upper Murrumbidgee River in New South Wales, quite close to Canberra and just up the road from the snow. One Friday afternoon he rang me in exasperation.

Peter was attempting to work out why he couldn't *do* anything about the carp that were slurping on his doorstep as they do in Lake Cargelligo and throughout the MDB. He had read the management plans and strategies relating to carp published by the Murray–Darling Basin Authority and the NSW Department of Primary Industries (now bizarrely called the Department of Industry and Innovation). In the plans there was much discussion of community involvement, community awareness, collaboration, education – indeed, every buzzword was present. So Peter thought it would be simple to gather

volunteers, get some help from the said agencies, pull a few thousand carp out of the river and then donate them to his neighbour who was keen to mash them up and use them as fertiliser. As a professional working for a conservation company, he was also – naturally – keen on doing something that might be either relevant to carp management in the MDB or conservation of the upper Murrumbidgee River.

Unfortunately, things are not that simple. It's nobody's fault – it's just the way our legislation occasionally acts like an anchor rather than an accelerator.

For a start, if Peter wants to use specialised fishing gear like electrofishers and seine nets, he needs to get a permit. Given that Peter's section of the Murrumbidgee is in New South Wales, that means getting a permit from the aforementioned department with a silly name. And if Peter wanted to run a monitoring program to measure the effects of sustained carp removal on – say – populations of native fish, platypus and other riverine biota, he would be veering towards 'research', which would mean more legislative hoops. He would need to tick a box that says 'Animal Ethics Approval granted', and the only way to tick that box is to submit an application to an Animal Ethics Committee, which makes judgements on whether animals with a backbone would be treated ethically in the proposed research project. So, if Peter's project was to remove x number of carp from the upper Murrumbidgee River between point y and point z, he would have to detail how the fish were removed, how they were euthanased and what he planned to do if something went wrong. He would also have to give due consideration to the bycatch that might end up getting zapped or trapped, and in that part of the

world the list would include mammals like platypus and water rats as well as fish on threatened species lists like trout cod and maccas.

After preparing and submitting all this paperwork, it is still likely that Peter may have to rewrite and resubmit his project a couple of times before it gets the green light.

The thing is, Peter is a busy person. He doesn't really have the time to write research proposals and ethics applications. He certainly doesn't have the time to rewrite the applications in the hope that after the third iteration and a year or two later he finally gets the go-ahead. Peter just wants to do something about the carp because everything he's read and seen tells him that's what he should be doing.

Poor Peter. He couldn't understand why the government kept banging on about community involvement, yet when the community wanted to do something there were all these obstacles in the way.

The sad fact is that apart from cooking a few snags at carp fishing events and giving out the odd sticker and t-shirt, government officials are pretty hamstrung. They can't invite Peter and other well-meaning types on to their electro-fishing boats, because you need the correct training and experience first. They can't easily direct resources, such as putting staff in the field at Peter's reserve, because the location hasn't been identified as a carp 'hotspot' (despite the fact that there seem to be plenty there). And, even if they could, this would negate the 'community involvement' fairly emphatically – the electro-fishing boat would be blurting and humming in the river and the community would be looking on from the bank, which is not the same as getting in and getting their hands dirty.

The current situation in the Murray–Darling Basin is that everyone wants to do something about carp, but only the relevant agencies are allowed to do much more than drag them in on lines and then whack them between the eyes with a stout stick. Additionally, the relevant agencies are often being eroded in terms of personnel and funding. Although it's good that millions of dollars are being spent on researching high-tech carp-removal techniques such as breeding 'daughterless' fish (by fiddling with genetics to create sterile males) and developing a virus, these solutions are a long way off, and they might not even work. Even if they *do* work, there will then arise the touchy issue of whether or not the public wishes to risk dumping genetically modified and/or virus-ridden fish into the already-ailing MDB. In the meantime, the focus is very much on 'control' as opposed to 'removal' and that's why there's a big push towards building fishways at weirs so the native fish can get up and down, fishing out carp at 'hotspots' like Lake Cargelligo and tolerating them everywhere else – like Peter's bit of the Murrumidgee. The take-home message is that everyone's frightfully busy and that carp are here to stay, at least in the short to medium term.

In addition, there is the sadder issue of whether doing *anything* will make any real difference. Remember, carp are one of the most successful invasive species on the planet and they are perfectly designed to survive. No matter how many we bash and stun and net and shoot, they produce millions of eggs, and it only takes one successful spawning to repopulate an entire river reach. So while pulling carp out of a connected big river like the Murrumbidgee might make people feel better, eradicating carp using physical methods – or perhaps any methods – may well be impossible. The general line advanced by management

agencies now is that a 'combination' of methods is needed, which includes the use of attractants in traps, the use of separation cages designed to capitalise on the jumping ability of carp at weirs and other barriers, and the other high-tech solutions being explored in laboratories as mentioned.

Few of these methods, however, are easy to deploy by well-meaning people like Peter, or by community groups and fishing clubs throughout the MDB. But helping interested local people remove carp from areas where it is possible – such as drying wetlands – may be a smart compromise. It would certainly be an improvement on the current carp-a-thon and carp muster events, where prizes are awarded to participating anglers for the biggest carp, the smallest carp, the most carp, and so on. Following removal, preventing the carp from returning to such areas and monitoring the biological changes associated with carp removal and possible recolonisation could become the responsibility of local groups, especially if they were led by keen people like Peter. Indeed, it may well be worth implementing these kinds of carp projects (where the fish are removed by local people who want to do so), for as long as accurate records are kept these projects may contribute useful data to aid the carp controllers of the future.

In response to the recognition that freshwater fish in the MDB were in a bad way, the first years of the twenty-first century saw the then Murray–Darling Basin Commission release a document called the Native Fish Strategy (NFS).[1] The big goal was and is to rehabilitate native fish populations in the MDB to 60 per cent of pre-European levels after 50 years. It's not a bad idea, if we admit that we don't know *exactly* what the rivers were like all those years ago, and that

it's going to be impossible to remove all of the big headwater dams and alien fish.

The NFS recommends many commonsense measures such as fixing the habitat – throwing the snags back in so the cod and yellowbelly have somewhere to hide – and revegetating the riverbanks so half of eastern Australia doesn't blow into the waterways in the next dust storm. Another step involves trying to control the aliens (hence people in white coats growing viruses and playing God). Protecting the native species and their habitats through formal listing under the Environment Protection and Biodiversity Conservation Act and associated recovery planning may also help, and is mentioned, as is ensuring that stocking and translocation have beneficial outcomes. At first glance, the idea of breeding native fish in captivity and then releasing them into the Murray–Darling Basin might seem like a no-brainer; at first glance, it seems like a great way to control aliens and restore some natural order. But in the real world it isn't that easy.

Pressure to restock Australian river systems comes from fishing groups eager to ensure catchable fish, from individuals trying to do the right thing, from aquaculture wanting to secure markets, from conservation types attempting to reinstate natural fish assemblages, and from governments with the varied aims of conservation and tourism. The result is that, in many Australian waterways, thousands of native fingerlings are released each year, though we have very little information on where they go, what they do and what impacts they might have.

The prevailing ideology that hatchery-bred fish are native, therefore Australian, and are *meant* to be cruising around in Australian rivers misses the main point, which is that anytime

The sleepy cod is a translocated species in the Lake Eyre Basin that has been recorded from the Thomson River upstream of Stonehenge since late 2008.

something is put into a river – whether it comes from Australia or Asia or Africa – there is a risk that the animals and plants already in the river might suffer as a consequence. This doesn't necessarily mean that all translocation is bad, but it's worth considering some negatives as well as some positives.

Along with barramundi, Murray cod are the best known freshwater fish species in Australia. They grow big, have a beautiful mottled-green appearance and live in the snags and deep holes of the Murray–Darling. Everyone fishing in inland Australia wants to catch a cod – they're the duck's guts. Back in 1967, the biologist John Lake determined that if you keep a few cod in a pond, and then raise the water level and the temperature around spring, they'll spawn on the underside of a log, or in an underwater cave.[2] The eggs are adhesive so you

can collect them, along with whatever they've been laid on, and then incubate them in aerated water, hatch them and then look after the fry. Easy. As soon as all this was worked out, people began thinking it would be a good idea – and good business – to breed cod (and other natives like yellowbelly and silver perch), and then put them back in the rivers.

Back in 1999 when I was studying aquaculture, I spent a couple of weeks working at a cod hatchery in the NSW Riverina. It was springtime so the cod were busy in broodstock ponds spawning in the only structures available – mesh cages with removable shadecloth inserts. We would jump in the ponds – which were still a bit cold as it was September – and swim down to the cages. Once there we would feel around the shadecloth for evidence of spawning: looking wasn't an option due to the turbid Murrumbidgee water. If we found eggs we would quickly remove the cage, race up to the hatchery in the old Toyota, carefully remove the shadecloth, cut it into manageable-sized strips and place the strips in incubation tanks. Once there the eggs were given a daily bath in a weak formalin solution to help arrest fungal growth, and they were kept aerated. Within a week or so they would turn pink, and eventually most of them would hatch. Keeping the fry alive, however, was substantially more difficult than hatching the eggs. Larval fish are prone to disease – especially fungus – and it wasn't unusual to inspect the newly hatched fry in the mornings, only to lose hundreds by nightfall.

The trend in modern aquaculture is to hatch eggs, nurture larvae, raise juveniles and grow the fish to adulthood – or at least market size – under one roof in large indoor recirculation systems. These enterprises are so named because they pump

water to multiple tanks (which are full of fish), and then recycle the water through gigantic filters. The farm I was at bucks this trend, and instead, once the young fish are large enough to fend for themselves they are released back into outdoor ponds.

All cod breeders employ similar methods for hatching and raising the fish each spring, though the process is vulnerable to stuff-ups. Birds, turtles, yabbies, rats, disease, poachers, cash flow and fluctuating markets are all threats that each fish farmer must manage each year.

In aquaculture the aim is to hatch the greatest number of eggs and produce the greatest number of fish from each spawning, which is then sold on. This production model is fine if the fish are destined to be sold at the fish markets as food, but it might not be such a good thing if they're going to be released back into the wild, because if a fishing group, farmer or government purchases a consignment of cod fingerlings, they may be buying a large number of siblings. This doesn't happen in the wild, of course, where – except in unusual circumstances like large floods in the desert – few larvae survive to become juveniles, and fewer juveniles make it through to anything approaching adulthood.

Additionally, most broodstock held on farms is sourced locally (which makes sense, as transporting big fish long distances is problematic). This means that a fish farmer in the Murrumbidgee is breeding 'Murrumbidgee' Murray cod, a farmer on the Murray would be breeding 'Murray' Murray cod and so on. This is as it should be given the difficulties in corralling a large number of cod, yellowbelly or silver perch from different catchments on one fish farm and keeping track of them.

The problem with the 'catchment-of-origin' doesn't arise until farmed fish are liberated in rivers far away from where their parents hailed – and a good example would be taking yellowbelly bred in a hatchery in the MDB and then releasing them out in the Cooper or the Diamantina. This has certainly happened, though it shouldn't have, because Faulksy and others before her have demonstrated that yellowbelly in the Lake Eyre Basin are slightly different from their MDB relatives.

And even within the Murray–Darling the rivers don't all join up. There is hardly any chance, for example, that there would be genetic transfer between fish populations in the headwaters of a Queensland river like the Condamine and the headwaters of an isolated catchment like the Lachlan in southern New South Wales. This means that in some areas – and the Lachlan is a great example – the fish, such as the local cod population, have been on their own single-catchment evolutionary trajectory for some time.

So if or when a fishing club on the Lachlan rings up and orders 20,000 fingerlings from a farm on the Murray or Murrumbidgee, although they're ordering the same species as the one that survives in the Lachlan, they're also potentially introducing new cod genetics into the Lachlan that may result in the extinction or at least alteration of the local genetic variety.

Again, Australia's aridity plays an important role here. When there is no real connection between river systems, there can be no inter-breeding of populations. That's why the Mary River cod from coastal Queensland and the Clarence River cod from coastal New South Wales have evolved as different species from Murray cod west of the mountains. And if Australia stays dry, it's just as conceivable that in a few thousand or million years the

Lachlan River cod will be a different species from Murray cod found in more connected areas of the Murray–Darling Basin. This means that there is always the chance that translocating native fish to rivers might have a negative effect on the genetic integrity of the fish that are already there, but there are also other potential problems.

In late January 2005 I received a phone call from John, whose property adjoins the Lachlan River in the vicinity of the Lake Cargelligo weir. He said there were dead fish floating in the weir pool (the section of river immediately upstream of the weir) and suggested I take a look. I reached the site within half an hour, expecting to find a few dead fish. What I *wasn't* expecting was to find the entire river, for a distance of about a kilometre upstream, littered with the corpses of thousands of animals. Some of the dead cod were up to a metre in length. We quickly discussed what might have happened and what to do next, but John was already way ahead of me: Harry and Greg were bringing a boat, and a NSW Fisheries officer was due to arrive in about four hours. We needed to survey the dead fish to determine whether the cause was likely to be environmental (suggesting a problem with water quality) or species-specific (suggesting a disease). So once Harry pulled up with the boat, we wasted no time and collected representative samples of all the species affected by the fish kill. A small downstream 'flow' had resulted in most of the fish lying entangled in snags or vegetation within 100 metres of the weir itself, and it was obvious that whatever killed the fish was comparatively local – either directly related to that stretch of river or from slightly further upstream.

Our first sample was a massive cod, so big it took three of us to lift it into the tinny. The cod didn't smell too good, and

all the fish were in a similar state of decomposition, suggesting that they'd all died at the same time – probably a day earlier. We probed the riverbanks for an hour and collected about twenty more cod (of various sizes), as well as plenty of yellowbelly, a few silver perch and an even smaller number of bony bream. By the time we returned to the bank and arranged some of the corpses for photos, other residents were starting to congregate; the word had got around via telephones and two-way radios that something fishy was going on at the weir.

The largest group of dead fish had become trapped at the regulator gate that fills the Lake Cargelligo system, about 500 metres upstream of the weir itself. Using poles, a long-handled net and then our hands, a few of us began clearing the stinking mess, moving each fish from the water to the bank about three metres higher. Again we arranged them by species, and again, found only cod, yellowbelly, a few silver perch and a couple of bony bream. The Fisheries bloke had told John the most likely cause was an oxygen inversion, where oxygen-depleted water 'turns over' in the water column, thus making the said water column too oxygen-unfriendly for fish to survive. But, if that were the case, why were only four species of fish affected? Why were there no dead catfish, carp, goldfish or redfin? Why were the dead fish predominantly Murray cod and yellowbelly? It was about then that my befuddled brain kicked into gear and I remembered when I'd witnessed something similar.

While working at the fish farm I often had to patrol the ponds to scare off cormorants. Sometimes this just involved scare guns or driving around in a vehicle, and sometimes it involved potshots at 100 metres with a .222 rifle. Either way was effective

and a welcome diversion from cleaning eggs and siphoning fry. On one particular morning, we were driving around the last pond in a block of ten or so and noticed a few dead cod floating on the surface. As we got closer, we saw there were *hundreds* of dead cod – in fact, we'd dropped (that's the aquaculture term) the whole pond. An entire pond full of cod, each about 500 grams, had gone belly-up overnight. Temporarily distracted from terrorising the birds, we drove back up to the hatchery with a couple of specimens to show the boss. The culprit, he explained, was a protozoan parasite – *Chilodonella* – that gets on their gills, multiplies like crazy and, basically, suffocates them. We were quickly instructed to load up the tractor mounted spray unit with a deadly cocktail of chemicals, and then we drove back down to the pond and applied it. Anything that might have remained alive in there – fish or protozoan intruder – was soon taken care of.

Back at the riverbank in early 2005, the *Chilodonella* light went on inside my brain, and it made sense because of the limited range of species affected. Most of the onlookers could follow the logic since most were also farmers. If you have crook water, all your animals get sick, but if you get a disease outbreak, it's likely to affect a limited range of susceptible species, varieties or individuals. A couple of blokes, however, strenuously challenged my disease hypothesis: they were members of the fishing club, and had supervised the release of cod and yellowbelly fingerlings (from the Murrumbidgee) into the Lachlan only a week earlier at *exactly* the same place. They could see where I was heading with the disease hypothesis – if a disease caused the fish kill, where had it come from? Possibly just a natural outbreak, but far more likely to be imported with foreign animals.

Chilodonella has been found in both wild and captive populations of Murray cod, yellowbelly and silver perch, and it has also been implicated in fish kills of bony bream. The Fisheries bloke sent some tissue samples off for testing, but unfortunately they were too decomposed to do anything with. The Fisheries summary of the event was more-or-less 'Dunno, but it's probably to do with oxygen/water quality'. And it may well have been but unfortunately we'll never know.

In the incident report the fish stocking event was not linked to the fish kill in any way. This is totally understandable from NSW Fisheries point of view, because they juggle the three-headed monster of aquaculture, recreational fishing and environmental stewardship – and try to keep everyone happy. But to this day I reckon that if the cause of the fish kill *was* a disease and not related to water quality, then there is a high likelihood that the presence of the disease was linked to the liberation of foreign fingerlings in the same general area. And as anybody involved with aquaculture knows, disease – bacteria, viruses, fungus – is common, and usually results in mass mortality.

At the very least incidents such as the stocking event at the Lake Cargelligo weir should force all of us to question the wisdom of further tampering with our rivers. First, we need to decide whether we need to import fish at all. If we then decide we want to stock our rivers, we need to ensure that what goes in is the right genetic variety, and that only healthy animals are released.

It's even more important to ensure that, as much as possible, we prevent alien species and non-local natives from being deliberately released into our rivers, but unfortunately we're

slow learners. As an example, between 1988 and 1989, the then Queensland Government Freshwater Recreational *Enhancement* Program (my italics), administered by the Department of Primary Industries, released over 7,000 Murray cod in the Thomson River around Longreach.[3] You may recall that cod are not naturally present in the Lake Eyre Basin rivers. You may also recall that the initial reason for trout and the other first invaders coming to Australia was along the lines of 'these local fish are crap, so let's get some better ones'. We can only assume a similar attitude prevailed in western Queensland towards the end of the 1980s, hence the need for 'enhancement'. But this was the *1980*s, not the 1880s! This event (three stocking events in total), and the fact that the same agency, at the same time, was promoting redclaw aquaculture in the district, exemplifies why such agencies cannot always be trusted to act in the best interests of our rivers, and again highlights the gulf that can exist between the priorities of recreational fishing, aquaculture and conservation. In essence, recreational fishing wants good numbers of the big, catchable species in the rivers, aquaculture wants to grow and provide the same, and conservation wants to hang on to the suite of native species that already exist.

There is at least one other translocated species in the Cooper catchment – a stout, coastal gudgeon that grows up to about 30 centimetres called a sleepy cod. According to a reliable source, these were also plonked in a dam quite close to the Thomson River a few years back. Then – presumably – they spread out during a big flood that connected the dam to the river, because I caught one halfway between Longreach and Windorah back in 2008 and another was brought in to the government offices in Longreach and now resides in the fish tank in the foyer.

These are the kinds of dumb activities that have to stop if we're to have a chance of preserving the western rivers, and obviously government, as well as the general population, must shoulder its share of responsibility.

Fish stocking has become increasingly common because native fish stocks are fast declining and we feel we need to supplement them with hatchery-reared stocks. This has certainly helped certain fish, and were it not for captive breeding programs the survival of endangered species like trout cod and Mary River cod could not be assured. Nevertheless, the overwhelming majority of releases are more common native species such as bass, yellowbelly, Murray cod, and undertaken to satisfy the demands of recreational fishers. Alien trout and salmon continue to be released for the same reason. We don't have to stop doing it, but we do need to be more prudent in our rationale. Certainly translocation can be justified for species that are struggling, or for species that exist in such small wild populations that captive breeding programs are necessary to ensure their survival. Silver perch, freshwater catfish and a fair few smaller species are all declining in the Murray–Darling Basin, for example, so reasonable cases could be made to enhance the populations of all these species through the careful reintroduction of hatchery-reared animals. But *careful* needs to be the operative word here. Once mistakes are made in Australian freshwater systems they are often impossible to reverse.

12

LESSONS FROM THE BIG SKY COUNTRY

It's May 2008 and I'm back in Windorah for a conference. It has been organised by the Cooper Creek Protection Group and the Australian Floodplain Association. What that means is that Professor Richard Kingsford, an environmental scientist with a high public profile from the University of New South Wales, is running the show, and that a bevy of disgruntled graziers from hotspots in the MDB like the Culgoa, the Darling and the Macquarie Marshes are both the speakers and the audience. It's being held in Windorah because the ten-year management plan is up for renewal – it's ten years since the cotton war was fought and won. At first, the disgruntled cockies from south of the border were sceptical about why they've come so far from home, but they're all impressed – nay, gobsmacked – by how much better the Cooper is than they had expected. With no river regulation, no big weirs, no big dams, no irrigation, no stuff-ups, the Cooper works roughly as

it did before cattle and people arrived.

Richard Kingsford is affectionately known as 'Dr Duck' by the participants and he has put together slideshows for the speakers who don't have a computer or who haven't yet been privy to the wonder that is Microsoft PowerPoint. Scientists seem to love PowerPoint, possibly because it can turn a dull speaker into a passably interesting button-presser. So as the overhead fans buzz and whirl in the little hall, a grazier from the Bulloo or the Culgoa tells his story while Dr Duck keeps up with the slides. Unfortunately, this is the kind of conference that many 'real' science-types don't go to, and it's a shame, because there are very few forums where people who do totally different things with bits of land or water get a chance to hang out together for a couple of days and swap yarns.

The message the floodplain graziers delivered at Windorah was clear. These people used to graze stock on periodically inundated country before the places upstream of them were sold to big irrigators. They used to have a good lifestyle and a productive property, but then it turned to crap: the floodplains had been dry for years, the river never broke its banks and consequently their businesses and lifestyles were at least affected and in some cases completely wrecked. To make matters worse, most of them had had frustrating encounters with government water agencies and they were cynical about pretty much everything.

I knew how they felt, because I called the crook Murray–Darling home too. As I sat and listened to sad tales of drying floodplains, falling bank balances and desperation, I thought of my tenant's goats chewing on the bluebush up my driveway and the little canal that feeds Lake Cargelligo receding to its putrid little trickle. As a slide flashed up of the Warrego River, about

four metres wide, meeting the Darling about ten metres wide, I think we all realised that the Murray–Darling Basin will remain eternally compromised. When we stopped for morning tea shortly afterwards, a local summed up the mood fairly poignantly: 'We have bad years – sometimes we have plenty in a row – but at least we know that eventually there'll be a flood. These fellas are buggered. I had no idea it was that bad down there.'

As we know from the mid-1970s and 2010–11, big floods occasionally occur in the MDB too, and they perform exactly the same function as they do in the LEB – they reset the ecosystems and kick-start production. The problem is that today our ecosystems are under so much pressure that by the time a big flood comes, the dams are already nearly dry and the towns out of water. In the Murray–Darling Basin, we forgot about extended drought when times were good and over-allocated the water in our rivers. In contrast, out in the Lake Eyre Basin rivers, prolonged dry spells have always been more common and accepted, so we've learnt to live with – rather than adapt – the variable environment.

A couple of months after the Windorah conference I'm camped next to the Lachlan at the historic Merri-Merrigal station with a good mate called Alby Hutton. Alby grew up there and he spends a few days each week doing odd jobs for the owners and a bit of farming. The Lachlan's been one of the biggest basketcases in the MDB for years, and is a classic example of the over-allocation of water and the effects of drought, but it's pretty much an analogy for the Basin as a whole. On this crisp July afternoon the river level is unsurprisingly low at Merrigal, and the water is far clearer than usual due to an extended period of zero flows. As the afternoon light reflects off the river and

the imposing red gums that staunchly line its banks, Alby and I, like most people who live along watercourses in the Australian inland, discuss the river level, the management of the river, the stuff-ups and the consequences.

Wyangala Dam near Cowra is where the westward-draining catchments from the Great Dividing Range are corralled in order to manage the Lachlan. In addition to Wyangala, Lake Cargelligo and Lake Brewster are also used to re-regulate the lower river, the idea being that excess flows in big years can be stored and then doled out when the creek gets dry, and that flows from the big dam (Wyangala) can be stored mid-river. This sounds good in theory but there are some problems, even when there's water in the system.

Brewster is a large and shallow bit of occasionally drowned country to the south of the river between the Lake and Hillston. To put the size of these storages in perspective, a megalitre is the volume of a 50 metre pool: Lake Cargelligo, when full, holds 36 000, Brewster is over four times bigger and can hold 153 000, and Wyangala has a capacity of about 1.2 million. Although Cargelligo and Brewster are small fry, they can be handy. The problem with Brewster – apart from evaporation, which is unavoidable in the hot and dry inland in shallow lakes – was that once water was stored there, it was difficult to retrieve because it pooled in sumps below the level of the outlet gate. In 2007 work commenced to convert Brewster into a series of 'cells' replete with buffering wetlands rather than just one big puddle. The cost of the exercise was about $13 million that, depending on your point of view, is either another adventure in speculative engineering or a realistic long-term attempt to make the Lachlan more reliable.

Further back up the river, Lake Cargelligo experiences similar evaporation issues and also 'transmission losses', because the water has to travel a fair way to get into it – well in excess of 10 kilometres of channels and smaller lakes. State Water – the agency that manages the river – probably wishes that the founding fathers hadn't dug the channels from the river to the lake system back in 1902, because in return for an occasional mid-river water-storage opportunity it cops plenty of criticism. There is no better way to demonstrate the water issues that have plagued the Lake over the last few years than to relate a story from Christmas time in 2004.

The northern half of Lake Cargelligo had dried and the level of the remainder was down around 10 per cent capacity. This meant that the water was about a metre deep, crawling with carp and continually churned up. A few years earlier the Lachlan Shire Council had commissioned and overseen the construction of a new water tower that cost a couple of million dollars and was supposed to solve all the water-delivery problems that had hitherto plagued the little town.

For those who have never been to a small town in inland Australia between November and March you need to imagine 40°C heat, endless sunshine, very little humidity, stillness, a couple of million flies and a climate-induced inertia that affects every living thing. Over summer, the Lake locals would crank up their evaporative air conditioners and turn on their hoses and sprinklers to keep gardens alive. Then the water would run out, the air condoolies stopped, the gardens died and the residents, hot and cranky, blamed the Shire. As it happened, the new water tower appeared to work well when the Lake was full and not choked with mud and the occasional algal bloom –

but this only occurred for about 5 per cent of the time from 2004 onwards. Unfortunately, whenever the Lake got low, the mud caused the filters to block, the backflushing stuffed-up and the town faced the problem of no water.

In Christmas 2004 this is exactly what was happening, so the Shire Council requested water from the Lachlan, but State Water refused, explaining that Wyangala was down to less than 10 per cent; there was even talk of stopping the river upstream at Condobolin. At about the same time, the nightly news was showing footage of water tankers driving to Goulburn in the Southern Highlands, where storages had already failed, and similar water shortages were occurring or predicted all over south-eastern Australia, including most of the capital cities. In the Lake, frustration grew and the townsfolk considered that both State Water and Lachlan Shire Council simply didn't care about their town. They were wrong, however, because a couple of the councillors who lived in the district decided to do something to fix the impending problem.

One morning late in December I came down our dusty drive to see cars parked where the water's edge had been a year earlier. I wandered down, half-expecting someone to be borrowing or stealing something, only to discover two gentlemen deep in discussion: the mayor and a local councillor. They planned to get two graders going the following day – which I think was New Year's Eve – and dig a channel into the dry bed of the eastern perimeter of the lake all the way to town, a distance of over 10 kilometres.

And they did it, too. A few weeks later a woman from the EPA turned up and wanted to have a look at their construction, so I'm not sure whether they had all the correct approvals or

whether the boys out west simply carved a big, long channel in a natural-ish wetland. I do know that the EPA used to jump on landowners for a lot less – like sinking a couple of posts in the riverbank for a jetty: they called it 'dredging'. Whatever the case, the upshot was that a three metre wide, 50 centimetre deep channel was responsible for keeping the town alive that summer, because it enabled the leakage flows dribbling under the inlet regulator to trickle all the way to town.

The Lake Cargelligan drought-amelioration story is a consequence of many of the short-sighted decisions that fuelled river regulation in the Murray–Darling. Despite the fact that rivers were unreliable – remember that in 1902 the Lachlan dried up for 291 days – towns were built and districts settled. There was no real consideration of the future demands on resources as communities expanded, even though there was always the chance of long dry periods. The engineers of yesteryear thought they could solve all the problems by using plenty of concrete and steel, but the real problem is that once a catchment is close to dry, as the Lachlan was in late 2004, the size of the dams becomes irrelevant. No matter how big they are and no matter how expensive, if it doesn't rain there's no water to harvest.

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Back out in the desert, in 2010, after a bigger flood than 2009, which itself was a bigger flood than 2007, we increased our species tally further in the Mulligan after catching a few Hyrtl's tandan, Welch's grunter and yellowbelly. What this illustrates is that our arid zone fish really are completely adapted to dealing with the entirely unpredictable climate in which they live, and that the bigger the flood the more species will take their chances *anywhere*. Indeed, to date the only fish not

sampled in the Mulligan that has been sampled in the Georgina is golden goby, and that's probably only a matter of time. I dare say they're there in a big year, sitting on the bottom on their fused pelvic fins waiting for something smaller to edge within a centimetre of their mouths. We might yet catch one following the big floods of 2010–11 or maybe we won't – maybe it'll take until the next flood cycle.

There are two big lessons learned from the desert fish that are relevant to all other inland systems in Australia, and which might be handy for more settled areas such as the MDB. The first is their adaptability – the flexible breeding strategies and opportunistic migration. The Mulligan was dry in 2006, and it was dry again in 2008. But in 2007 at least seven fish species called it home, in 2009 there were eight species, and in 2010 the number of species increased to 11. They were waiting in the big waterholes down south – waiting for the gate to open to the Mulligan in a big flood – and when it did, away they went. When it dries down again – which it surely will – they'll all die, but the next flood will trigger another set of colonists to make the big trek north. Australian animals are perfectly suited to surviving in Australia – they can handle long droughts and big rains – it's just that in some areas we've changed Australia by doing a number of ecologically silly things. Maintaining biodiversity in the more settled areas is therefore contingent on fixing as many of these mistakes as possible and not doing any more dumb things.

The second big lesson – for want of a more formal term – is toughness. Fish can wait for the good times to come, and they can bounce back. Like the fighting spangled perch in Dune Pond, Australian inland fish are built to survive all but the most

impossible situations. But again, they're not built to prosper when they're up against over-exploitation, or barriers to natural movement, or the introduction of disease, or the impost of aliens and other creatures that aren't meant to share their waterhole or river reach. We stuffed up, and it's now our responsibility to make amends. If we do, odds are the majority of our inland fish will claw their way back, even in heavily modified systems. None of our inland species are inherently fragile – if they were they'd already be extinct. But in some places they obviously need a bit of help.

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There's a lot of thinking time when you're driving a Toyota from Longreach to Boulia. Inevitably, I spend large amounts of time questioning what's going on in the Simpson – and in the Georgina, Diamantina and Cooper rivers – and how different or similar it all is to the Lake and the Murray–Darling Basin.

The biggest and most noticeable difference is that out west there are mostly only native species (except for a few gambusia and goldfish in the Cooper). This in itself is pretty interesting given that the water is generally warm and still and just how gambos like it. In fact, I've only come across two major 'outbreaks' of gambusia so far – one in the springs at Edgbaston, and one down on the Wilson River opposite the Nocundra pub. The main waterhole at Nocundra is probably around four or five kilometres long and represents the most permanent water on the Wilson. On the day we were there, there was plenty of weed in the water, which made hauling even the small seine net pretty difficult. So instead of persisting in the main waterhole we went and found some channels around the edge of it – most waterholes have some skinny water around the edge. As soon

as we dragged the seine we caught gambusia – hundreds of them – you could nearly call it an infestation. But then, when we travelled up to the Kyabra, Cooper, Thomson and Barcoo areas we hardly caught any.

The gambusia story is interesting because under most circumstances they are such a successful invasive species. Presumably an isolated waterhole would suit them just fine, because they certainly don't need a flow to breed. If it's warm enough – and in the Lake Eyre Basin rivers it is for all but a few days each winter – they'll presumably play the gonopodium-cloaca game until the cows come home. They certainly do everywhere else. So it must be to do with other aspects of a natural system – predominantly the presence of an intact food chain. This is not an original idea: Jim Puckridge, who did plenty of pioneering work in the South Australian LEB – predominantly at Coongie Lakes – and the rest of the team that created a report called 'ARIDFLO' in the mid-2000s similarly noticed that there were very few gambos and that the most logical explanation was that the resident fauna could 'control' them under natural conditions.[1] In the water – in the real world – this suggests that if there's a healthy population of piscivorous fish in an isolated waterhole (in the LEB this means yellowbelly and the Terapontids), then an invasive prey-sized species such as gambusia may not be able to establish infestation-level populations. If these predators aren't present – such as in the springs at Edgbaston – gambusia can expand their populations extremely rapidly. I have no real idea what goes on at Nocundra, and why in that particular waterhole there are so many gambusia, but I'd have a bet that absence of predators might have something to do with it. After all, it's a big waterhole next to a pub – one of the few big waterholes

in that neck of the woods. I reckon the place might get fished pretty hard for yellowbelly, and in an isolated system like a back country waterhole, that could be enough to tip the balance in favour of the invasive species.

It's also worth turning our attention to the bigger species, like the grunters. Silver perch are rare in the Murray–Darling Basin and they're now on threatened species lists. They were walloped by commercial fishing, the dams and weirs are thought to have played a role in preventing them migrating, and then to ice the cake along came the aliens. However, if I only considered the populations of their close relatives Barcoo and Welch's grunter out in the Lake Eyre Basin, and only considered the results from dry years, I could also conclude that these species are rare. Basically, when it's dry, and when the waterholes have been isolated and are evaporating, it's unusual to catch a grunter. As soon as there's a flood, however, they turn up in most places, including way up in the Mulligan in temporary waterholes and all through the other channel country rivers. Indeed, the success of some members of this fish family – the Terapontids – seems entirely linked to the occurrence of floods. It's possible that the populations of silver perch, like their arid zone cousins, also fluctuate in relation to season, and that they are naturally rare in dry times. The crucial difference is that silver perch can't bounce back as effectively as the others due to all the disruptions. The more I think about it, it's this ability to bounce back that encapsulates our inland native fish.

The ecological lessons are easy: the rivers out west are currently good – so much better than down south. They retain their natural flow patterns, they haven't been pillaged to the same degree, but perhaps most poignantly, they're not infested

with animals that aren't meant to be there. Unfortunately, however, it's starting. There are a few gambusia and a few goldfish. There are some translocated fish, and there are crayfish from up north. Attempting to control and/or eradicate these known and existing problems – thin end of the wedge problems – is exactly what we should be doing in the Lake Eyre Basin so that they don't become big problems like the ones that have 'got away' elsewhere.

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It's the middle of 2010 and I've walked out of a chilly and bleak Adelaide morning and into the artificial warmth of one of the small city's few tall buildings. It always seems weird that government decisions about the real world – especially the real world I'm most familiar with and comfortable in – are made in such imposing buildings. There is a characteristically friendly woman who has a palmload of swipe cards that enable her to successfully navigate the 13th floor, and I end up in a meeting room with no windows and a bunch of new-looking metal chairs.

The South Australians have been busy writing a scientific report on their Lake Eyre Basin strategy, and they've nicely asked me to review it. One of the big issues lurking within the report is devising a method for determining the environmental water requirements (EWR) for their assets, meaning the South Australian parts of the Lake Eyre Basin. A lot of the LEB is situated in South Australia, but hardly any of the permanent water. Almost all of the thin blue lines on maps in the South Australian arid zone represent wholly ephemeral rivers. The South Australians have proposed a number of methods for determining said requirements, most of them predicated on having good data relating to the hydrology and biology of the

areas of concern (which is mostly non-existent).

But I'm not sure that you can work out how much water a place like an outback river 'needs', because it needs as much as it gets. Some years it gets plenty – other years it gets nothing. Everything that lives there is already adapted. If it stays dry, the brine shrimp and shield shrimp eggs don't hatch, and the crabs stay buried in their World War I-style bunkers. In that particular year or season, their environmental water requirements are nil. But the next season, or the one after that, down comes the water, out hatch the bugs, out crawl the crabs, up swim the fish, and so on. That year they use the water – but they don't *require* it. It's Australia – if it doesn't come that year it'll come some other time. The environmental water requirements – for anything – can't be calculated because they are so highly variable, and because being an organism in the desert is all about being an opportunist.

The whole determination-of-environmental-water-requirements thing has come about because of the ecological problems that affect the Murray–Darling Basin. In heavily regulated rivers it's useful to work out how much water is needed to sustain species, ecosystems and areas, because there are plenty of people who also need the water for growing food and sustaining towns. In those areas, it follows that there should be sharing of the resource, the odd compromise, plenty of argy-bargy and – hopefully – a workable and adequate solution for all. If this sounds a bit Utopian it probably is, and it's worth recalling that when push comes to shove – like when a town's about to run out of water – all the policies, goodwill and fairy-dust evaporate.

Of course we should be doing our best to keep as much water in the regulated rivers as possible, and if we can use science to guide us then all the better. But unfortunately, water allocation

in decades past has created a situation where there will always be a certain amount of ill-will between people who have a legal entitlement to the water, and those who believe that this legal entitlement is trumped by environmental need. Anyone with any lingering doubts about this should recall the angry reaction from the community in Griffith, New South Wales, when the Murray–Darling Basin Authority held a meeting to explain their draft plan in late 2010. The audience – grape growers, citrus growers, rice growers, business owners and townspeople – burnt copies of the guide-to-the-plan (as it became known), and hurled abuse at the chairman, who resigned a couple of weeks later. It wasn't pretty, but it illustrates how important it now is to reduce the growing distance between government bodies delivering processes, protocols, frameworks and strategies and people in communities who scratch their heads and believe it all to be a load of rubbish.

And if you think the dumb things are now done with and pertain only to the MDB, think again. In the 2011–12 Caring for our Country Business Plan, for example, the Cooper catchment in South Australia is eligible for funding but the Cooper in Queensland isn't, despite being the same river with the same ecological attributes.[2] These kinds of decisions are like a red rag to a bull for people who care about the back country. Another dumb thing; another decision that makes no ecological sense.

Hopefully, we've come a long way since the bad old days of intentional carp, trout and redfin introduction to our rivers. And we've definitely come a long way in terms of what we know about our country and its unpredictable climate. But what niggles, of course, is that the path of destruction we've left is so significant and so difficult to arrest or reverse.

We can't 'unregulate' a river that's been regulated, but we can at least try and improve the lot of whatever fish and other native species are hanging on. We can't remove all the alien fish, but we can make worthy attempts – which is preferable to throwing our hands in the air and doing nothing.

We can recognise the species that require specific or extra research and effort, and that require our intervention so they remain part of Australia's biota. We can use our knowledge of the culture of animals to bolster the recovery of endangered species, and we can be smart about how we use this knowledge to restock our rivers. In the MDB, we can even keep chipping away at the vision of the Native Fish Strategy.

But we have to keep a few things front and centre from now on such as commonsense, communication and respect. The key thing here is, of course, involvement. People in towns, on properties, in cities and in government – from different backgrounds and often with opposing views – need to become involved in issues that affect them and work together to make things better. As an example, Max and I get on really well with the neighbours and local people that we hang around with and see in places like Boulia and Bedourie. They're pastoralists; we're working as ecologists for a conservation company, but we all talk the same language, we all know how to sit down and have a cup of tea together at smoko. It's the same trust and respect I have for all my friends at the Lake. It doesn't mean we all agree on everything all the time, but it doesn't matter. Additionally, communities have to be involved when decisions are made that affect them. Otherwise they fight, like they did in Windorah to stop irrigation and like they did in Griffith to try and keep it. A bit more communication with

both groups before things became heated would have gone a long way, and similarly, if the Feds had asked around they would never have issued a plan that effectively says a river has more or less conservation status on either side of a state border as late as 2011.

Given that we pride ourselves on being a smart country, we now need to do things differently and creatively. If there's ever a compelling case not to revisit the stuff-ups of the past it's sitting there – in our faces and under our noses – and it's called the Murray–Darling Basin.

13

FOUR RIVERS

I have – in my mind's eye, every day – an image of a pristine river. It's a coastal draining river, not an inland river like all the others, but it forms a point of reference for all the stuff that's been discussed, and I saw this river back in 1991. There's a waterfall cascading over a twisted and buckled shelf of ancient rock in two stages. Halfway down, in an isolated rockhole, there's the rotting carcass of an unlucky crocodile that didn't quite make it through the dry season; that didn't have enough energy to drop the final three metres into the azure-green pool below.

Ten metres east of the rotting croc, there's a rock overhang with a bit of wallaby poo, and the dishevelled belongings of two crazy young blokes who started walking, paddling and fighting their way down the river over a month earlier. They're exhausted, skinny and overwhelmed by the task they've set themselves: to try and get from one end of a tropical river to the other at the end of the wet season, trying to supplement their

rations with wild-caught food and cover enough kilometres each day to achieve their goal. The one with the orange beard is a bloke called James Woodford, who will end up writing books on wombats and dinosaur pine trees and build a solar house on the south coast of New South Wales, and the scrawny dark one with the scraggly black beard is me, who will end up chasing fish in the desert.

Paul Keating has just ousted Hawke, but we have no idea. We have no idea of anything except that we're very, very hungry and very, very isolated. We're halfway down the Berkeley River in the eastern Kimberley, and the Berkeley enters the sea halfway up from the town of Wyndham, towards Kalumburu. A chopper pilot dropped us in. He was sure he'd come and drag us out, but it doesn't work out like that. We keep fighting and battling on, walking over mountains, crossing the fickle river, paddling our inflatable boat every now and then, shooting the odd feral cow for food. Two weeks later we reach the salt water. Another ten days and we're on a Royal Australian Navy patrol boat – HMAS *Wollongong* – heading east, out across the Joseph Bonaparte Gulf, back to Darwin, back to civilisation, back to the land of rules. We wanted to live with a wild river and that's what we got.

The croc smell drifts over as I lie on my too-skinny Thermarest mattress and swat flies. I wonder whether the 'skinny-ness' of the mattress hasn't changed at all, and I've just become too bony. I sit up and contemplate the next five minutes. Get knife, get fishing rod (what's left of it), get hat – climb down to the pool, try for a fish. I've been thinking about the little farm I'll buy one day, the best rifles to take on expeditions, the best fishing gear to abuse in the Kimberley. Ninety per

cent of my thoughts and plans relate to the best way to procure nourishment, and the best equipment with which to obtain it.

I settle on a .308 – better than the .30/30 I'm carrying because it'd have a tad more grunt and accuracy. James is reading the bush tucker book and jotting down the odd thought in a tattered-looking journal. I let him know that I'm off to catch dinner and then scramble down through the boulders and scree. Croc eyes watch me and then silently slip beneath the water surface. A goanna reluctantly moves further down the pool, pissed-off that I've interrupted his routine. Overhead, a small bird of prey circles and then dives on the other side of the 20-metre-wide waterway. This is what Australian rivers have been like forever.

The sooty grunter has a take-no-prisoners attitude to life that I'll notice years later when I try to measure its relatives – spangled perch, banded grunter – and keep them from flapping off the board. But in 1991 I don't care how long the sooties are, as long as they're big enough to eat. I tie a shiny silver hook on the end of the line – no sinker – and lob it out. A few seconds later a sooty crash-tackles the bare hook, and I smile and mutter congratulatory phrases to myself. The fish have never seen a hook before. It's shiny, and it's in their pool, so they attack it.

Within half an hour I've caught five or six good sized grunter, and I gleefully gut them while the crocs return. There's nothing recreational or sport-fishy about the task at hand. In the Berkeley I'm fishing for a *living*. I call out to James – I called him Woody back then – to get a fire going as I near camp and the sun begins to sink and make the rock walls glow orange. Within minutes the fire roars, then sinks back to embers. Within those same minutes we've jammed a sharpened

Fishing for a living in the remote Berkeley River in the Kimberley in 1991 was mostly successful until the river disappeared beneath a bed of sand.

green stick through the gills of the sooties, suspended it at either end with another stick and we're licking our lips as the coals and flames frizzle the skin and sear the flesh. The scales that don't fall off are quickly scraped off as we juggle the fish between our hands to cool them down. We eat the lot – skin, fins, fillets, cheeks, eyes – and wash it down with a weak cup of tea. The tea runs out three days later, and so do the sooties, because the Berkeley disappears beneath the floodplain: this is what Australian rivers are like. We start walking. Back in 1991 we swore and kicked the offending sand and threw the odd tantrum because we hated the river for not being there, but, more than that, because we were too impatient to understand it.

Fifteen years later – almost to the day – I relate a bit of the Berkeley story to Faulksy the fish geneticist and Bruce the fish

farmer around the fire on the Barcoo. I take five or six smallish Barcoo grunter from the bucket that Bruce has just brought from the river, gut them, and take a small green stick and thread it through their gills. Then I suspend it over the fire between two sticks, and keep yapping. My companions are dubious about my rough culinary approach, but the Barcoo grunter cooks up well and everybody is pleasantly surprised.

The Barcoo is a very different river system from the Berkeley, but there are similarities. In both, native species that have evolved over millennia survive in the absence of major disruptions. In the Barcoo, yellowbelly and grunter and catfish fall victim to fisherfolk wielding lines in winter, but even so, the Barcoo's good – heaps better than anywhere in the Murray–Darling Basin, like the Lake. If you throw a baited line in Lake Cargelligo you'll most likely catch carp and little else. The irony is that the Barcoo and the Lachlan look very similar as you drive over them on a bridge or scoot along the side in a car. It's not until you get beneath the water that you realise that the Barcoo has more in common with the pristine Berkeley, and that the Lachlan really is a poor southern neighbour.

When Mick and I crested the range and slipped down into S-Bend Gorge in the Mulligan back in 2007 it was the closest I'd been to a wild river in 15 years, and it reminded me of the Berkeley. An ephemeral river in the desert. Nobody goes fishing there, hardly anybody even goes there. The cliffs even had the same neat dollops of wallaby poo and orange glow in the afternoons. It struck me that if we'd dropped in to S-Bend 200 years ago after a flood it would have looked exactly the same, and had we a fishing net we would have pulled out a similar sample of silver catties, rainbows, glassfish, bonies and spangs. The really

isolated, inhospitable bits of Australia haven't changed nearly as much as the more settled areas, so it's there that we must look to understand how to repair the broken bits. It's there that we must look in order to understand how Australia works.

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2 Big Nasty

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APPENDICES

Appendix 1. Fish of the Lake Cargelligo system in the Lachlan catchment, Murray–Darling Basin, from surveys undertaken in 2004 and 2005.

Family	**Species**	**Common Name**
Native species		
Clupeidae	*Nematolosa erebi* (Günther, 1868)	Bony bream
Plotosidae	*Tandanus tandanus* (Mitchell, 1838)	Freshwater catfish
Retropinnidae	*Retropinna semoni* (Weber, 1895)	Australian smelt
Atherinidae	*Craterocephalus stercusmuscarum* (Günther, 1867)	Fly-specked hardyhead (un-specked form)
Percichthyidae	*Macquaria ambigua* (Richardson, 1845)	Golden perch, yellowbelly
Terapontidae	*Bidyanus bidyanus* (Mitchell, 1838)	Silver perch
Eleotridae	*Hypseleotris klunzingeri* (Ogilby, 1898), *Hypseleotris* species 1, 2 and 3 (after Allen *et al.,* 2002)	Carp gudgeons
	Philypnodon grandiceps (Krefft, 1864)	Flathead gudgeon
Alien species		
Cyprinidae	*Carassius auratus* (Linnaeus, 1758)	Goldfish
	Cyprinus carpio (Linnaeus, 1758)	Common carp
Poeciliidae	*Gambusia holbrooki* (Girard, 1859)	Mosquitofish, Gambusia
Percidae	*Perca fluviatilis* (Linnaeus, 1758)	Redfin perch

Appendix 2. Fish species of the Lake Eyre and Bulloo–Bancannia basins in Queensland, from surveys undertaken between 2006 and 2011. Asterisks denote range extensions (the first time the species has been recorded from the catchment).

Family	Species	Common name	Catchment							
			Mulligan	Georgina	Diamantina	Thomson	Barcoo	Cooper	Kyabra	Bulloo
Native species										
Clupeidae	*Nematolosa erebi* (Günther, 1868)	Bony bream	•*	•	•	•	•	•	•	•
Plotosidae	*Neosiluroides cooperensis* (Allen & Feinberg, 1998)	Cooper Creek catfish				•	•	•		
	Neosiluris hyrtlii (Steindachner, 1867)	Hyrtl's tandan	•*	•	•	•	•	•	•	•
	Porochilus argenteus (Zietz, 1896)	Silver tandan	•*	•	•	•	•	•	•	•
Retropinnidae	*Retropinna semoni* (Weber, 1895)	Australian smelt				•	•	•	•	
Atherinidae	*Craterocephalus eyresii* (Steindachner, 1884)	Lake Eyre hardyhead	•*							
Melanotaeniidae	*Melanotaenia splendida tatei* (Peters, 1866)	Desert rainbowfish	•*	•	•	•	•	•	•	•
Pseudomugilidae	*Scaturiginichthys vermeilipinnis* (Ivantsoff, Unmack, Saeed and Crowley, 1991)	Red-finned blue-eye				•				
Ambassidae	*Ambassis* sp.	Northwest Ambassis or Glassfish	•*	•		•	•	•	•	•
Percichthyidae	*Macquaria* sp.	Yellowbelly	•*	•	•	•	•	•	•	•
Terapontidae	*Amniataba percoides* (Günther, 1864)	Banded or Barred grunter	•*	•						
	Bidyanus welchi (McCulloch & Waite, 1917)	Welch's grunter	•*	•	•	•	•	•	•	
	Leiopotherapon unicolor (Günther, 1859)	Spangled perch	•*	•	•	•	•	•	•	•
	Scortum barcoo (McCulloch & Waite, 1917)	Barcoo grunter	•*	•	•	•	•	•	•	
Gobiidae	*Chlamydogobius micropterus* (Larson, 1995)	Elizabeth Springs goby			•					
	Chlamydogobius squamigenus (Larson, 1995)	Edgbaston goby				•				
	Glossogobius aureus (Akihito & Meguro, 1975)	Golden goby		•	•*					
Eleotridae	*Hypseleotris* spp.	Carp gudgeon				•	•	•	•	•
Translocated species										
Eleotridae	*Oxyeleotris lineolata* (Steindachner, 1867)	Sleepy cod				•*				
Alien species										
Cyprinidae	*Carassius auratus* (Linnaeus, 1758)	Goldfish				•	•	•		
Poeciliidae	*Gambusia holbrooki* (Girard, 1859)	Gambusia or Mosquitofish				•		•		

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