WA's conservation, parks and wildlife magazine

LANDSCOPE

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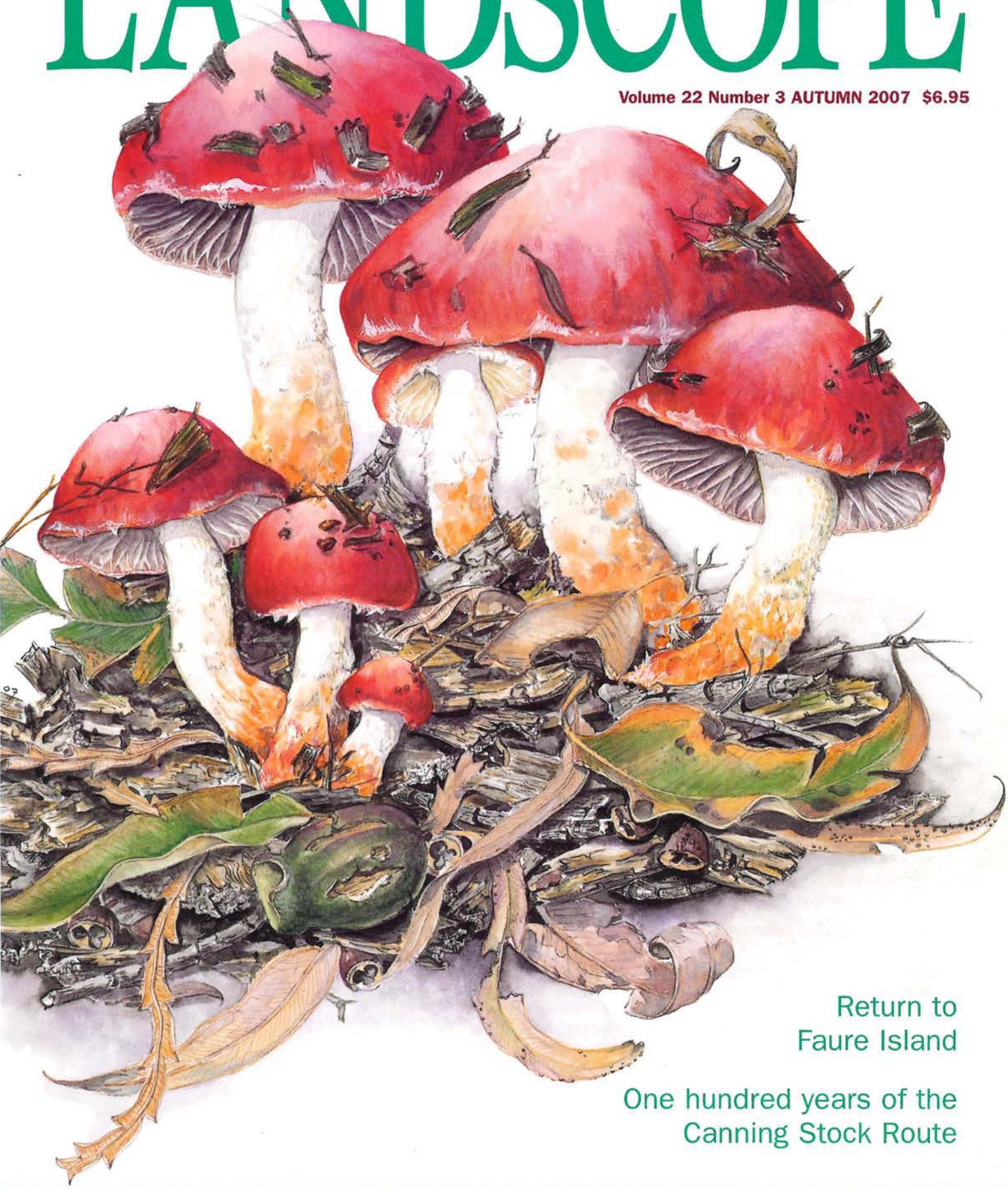


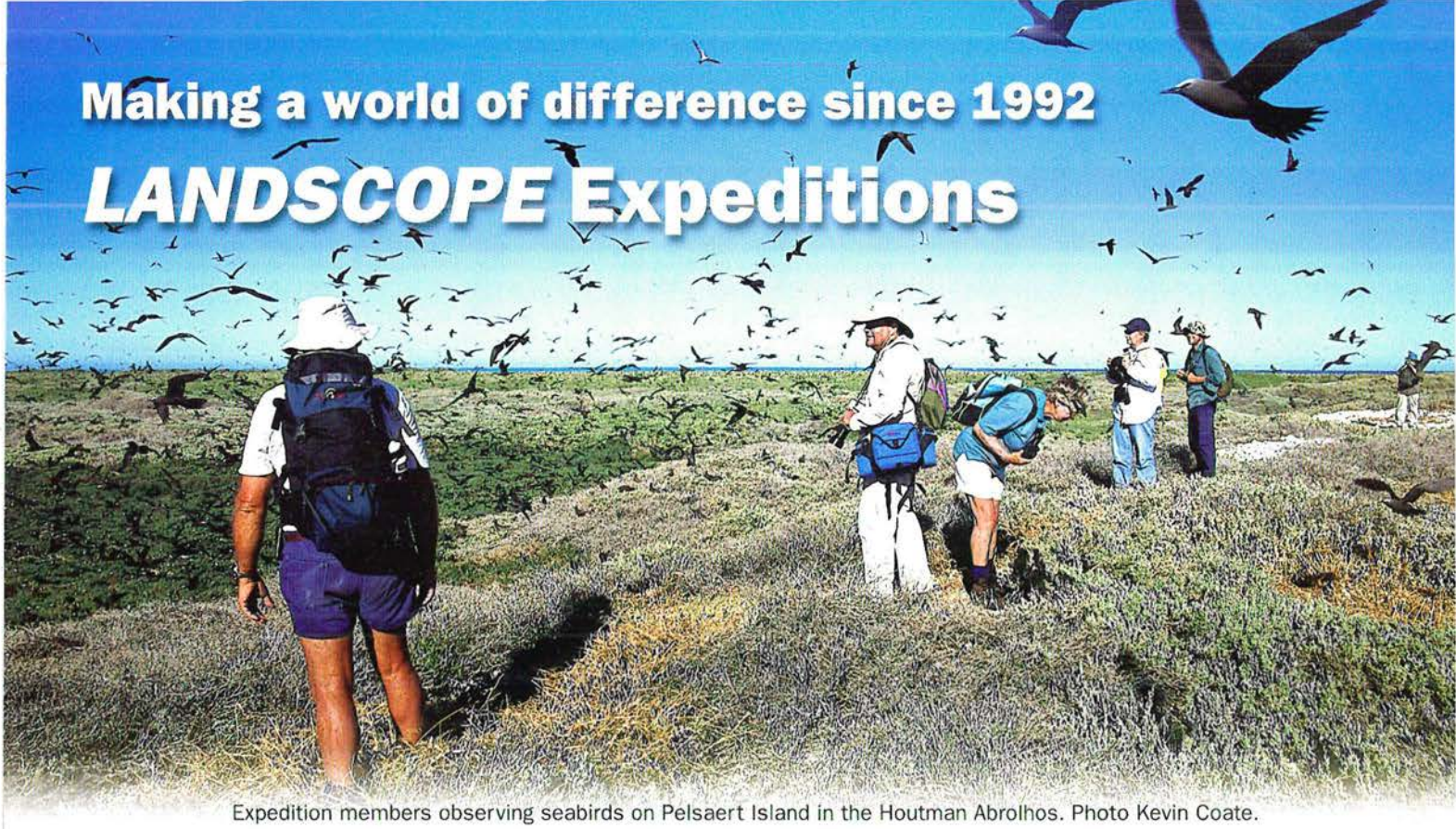
Return to Faure Island

One hundred years of the Canning Stock Route

Shark Bay Marine Park **'Tigers' of Carnac Island** Researching forest predators

Making a world of difference since 1992

LANDSCOPE Expeditions



Expedition members observing seabirds on Pelsaert Island in the Houtman Abrolhos. Photo Kevin Coate.

Loggerhead Turtles of Dirk Hartog Island, Shark Bay World Heritage Area

(a) 7 – 14 January 2008 (b) 14 – 21 January 2008

The sandy beaches of Turtle Bay, at the northern end of Dirk Hartog Island, are key nesting sites for the endangered loggerhead turtle. Expedition members will have the opportunity to observe egg laying and help tag female loggerheads that nest at night on Dirk Hartog Island at the peak of the summer season.

Moon over the Murchison – Astronomical and Botanical Explorations at Mount Singleton

20 – 26 May 2007

Join astronomers from the Perth Observatory at Ninghan Station conducting astronomical experiments and viewing the night skies through portable telescopes. By day, search the region for rare and endangered flora with DEC scientists and learn about the fascinating environmental and cultural history of the area.

Desert Tracks – Plants and Animals of the Canning Stock Route

11 – 22 August 2008

Join a scientific discovery of a part of one of Australia's most remote and historic desert tracks. Expedition members will discover local fauna, record native flora, map fire scars and search for evidence of introduced predators while experiencing the magnificence of the Australian desert. Tag-alongs are welcome on this expedition.

A brush with Nature – The Art of the Flower Hunters

10 – 19 September 2007

Discover the art of botanical painting with Philippa Nikulinsky at Woolgorong, a former pastoral lease in the Murchison region that is being managed by DEC for its conservation values. Expeditioners will also assist in establishing baseline data for the spectacular wildflowers of the Murchison region of Western Australia.

Sanctuaries of the Sea – Wildlife of the Montebello Islands

1 – 8 October 2007

The Montebello Islands are home to many native animals, severely affected by introduced predators which arrived at the turn of the century. DEC has removed these threats to allow the recovery of native species. Join scientists in searching for boodies, mala, golden bandicoots and Shark Bay mice and discover the history of these magnificent marine sanctuaries.

Magenta Magic – Exploring the Biodiversity of Great Southern Nature Reserves

5 – 15 November 2007

Lake Magenta Nature Reserve is an important habitat for a number of native animals and threatened flora species. The success of DEC's *Western Shield* program has seen the return of chuditch, brushtail possums, Mitchell's hopping-mice, red-tailed phascogales, reptiles and frogs. Expeditioners will record animal species, monitor introduced predators and search for rare and threatened flora.

Seabirds and Shipwrecks – Exploring the Houtman Abrolhos Archipelago

11 – 18 December 2007

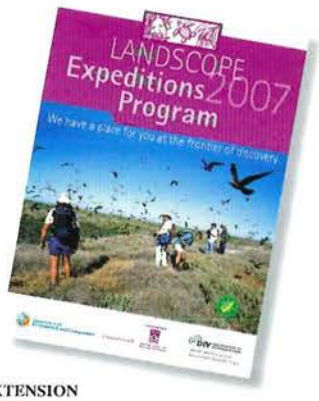
The Houtman Abrolhos Islands off the mid-west coast of Western Australia support the most species-rich assemblage of seabirds in the Indian Ocean. Lying in the path of the warm Leeuwin Current, the islands and the surrounding waters form a unique marine area where tropical and temperate sea life meet. Join an expedition to these islands to record seabird, shorebird and bush bird species at the peak of the breeding season.

Send for your copy of the *LANDSCOPE* Expeditions 2007 brochure:

call (08) 6488 2433
fax (08) 6488 1066
email extension@uwa.edu.au

or write to *LANDSCOPE* Expeditions
The University of Western Australia
35 Stirling Highway
Crawley, Western Australia 6009

or visit www.naturebase.net



Department of Environment and Conservation

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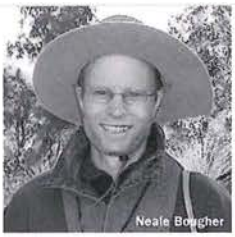
Ken Leighton


Neale Bougher

contributors

Ken Leighton started his career as a Surveyor with the Department of Lands and Surveys (now Landgate) in 1970. For many years he carried out mapping and boundary surveys throughout regional and remote areas of Western Australia. In 1985 he began managing the Rangelands resource mapping project in partnership with the then Department of Agriculture. He has extensive experience in mapping the landscapes of the Murchison, Goldfields, Pilbara and the Nullarbor. He has an interest in early WA exploration and mapping and is currently compiling a book on Robert Austin's work as a surveyor and explorer. Ken works for Landgate as a manager of remote mapping projects.

editor's letter

Delving in to history can bring out some fascinating anecdotes—and I hope you will find them great reading as you turn the pages of this edition of *LANDSCOPE*.

One of the most intriguing stories comes from Carnac Island, an island off Fremantle. The feature 'L'île des Serpents' looks at the island which is home to a remarkable population of tiger snakes. It has attracted interest from researchers who are investigating the origins of the snakes and why so many of them are blind.

Does the explanation lie in the history of 1920s snake showman Rocky Vane? Did he let his snakes free on the island or are they descendants of snakes marooned by rising sea levels thousands of years ago? What is it in the ecology of the island that enables about 5 per cent of the snakes to survive even though they are blind?

History underlies our feature on the Canning Stock Route and its origins in the early Kimberley cattle industry. This year sees the start of a range of programs to mark the 100 years since Alfred Wernam Canning first surveyed the track. The historic route crosses four deserts and is now one of the world's top four-wheel drive adventures, providing extraordinary natural contrasts throughout the journey.

Mystery takes over from history in 'Surprises in the sand', a look at the life that thrives in the sand patches in shallow areas between offshore reefs and Western Australia's shoreline. Some fascinating marine plants and animals with names such as Ludwig's sea cucumbers, heart urchins, sand dollars, pebble crabs, purple feather duster worms and wavy grubfish, have adapted to the relatively inhospitable environment.

Hidden wonders are also highlighted in our cover story 'Perth's fungi forever'. A crucial part of our bushland vegetation, the incredible diversity of fungi found in WA, is attracting growing interest. Stunning photographs of some the species hidden in our bushland show what we could see if we took a closer look around us.

Another island off the WA coast provides the setting for establishing and monitoring new populations of threatened mammals. 'Return to Faure Island' looks at the extensive work on the island from the time when it produced sheep and goats as a former pastoral lease, to today when it is home to a range of threatened native mammals including djoongari, boodie, banded hare-wallabies, western barred bandicoot and greater stick-nest rats.

The feature outlines the success of the work—from completely removing feral cats from the island to the successful translocation of native mammal species.

Feral cats are also part of the puzzle in 'Will curiosity kill the cat?', which looks at the research examining fox and cat interactions in five sites in south-west WA. Estimating fox and cat density is central to the research and a variety of techniques are being used—including sophisticated DNA-based monitoring.

It's a diverse selection of stories that I hope, combined with our regular features, will provide you with hours of pleasant and encouraging reading.

Kaye Verboon
Executive Editor

Neale Bougher joined the Department of Environment and Conservation's (DEC's) WA Herbarium in 2006 as the first Mycologist (fungi scientist). He is also an adjunct Associate Professor at The University of Western Australia. Previously he was a CSIRO Scientist and Fulbright Scholar studying fungi world-wide for about 20 years. His extensive publications outline research to understand and raise awareness about the roles of fungi in ecosystems and include dozens of fungi new to science. He aims to build and communicate an improved information base about WA's vast but poorly known fungi, and help improve the documentation, conservation and restoration of our biodiversity.

Jacqui Richards has worked as a Regional Ecologist for the Australian Wildlife Conservancy for the past two years in Perth, managing research projects on predator control and threatened mammal reintroductions in WA in partnership with DEC. Before this, Jacqui worked in a similar role as a Research Scientist for CSIRO Sustainable Ecosystems with a focus on the Heirisson Prong project at Shark Bay. She has recently written recovery plans for DEC for threatened mammals in the Shark Bay region.

Paul de Tores is a Research Scientist at DEC's Wildlife Research Centre in Woodvale and Dwellingup Research Centre. Paul began work with CALM (now DEC) in 1988 at Harvey and Bunbury and transferred to the Science Division in the early 1990s. He has a longstanding interest in research and in transferring research findings to management operations. His is particularly interested in conservation management of the western ringtail possum, the quokka and the woylie. This has necessitated considerable involvement in pest animal control, particularly foxes and cats, and developing and refining translocation and monitoring techniques. Paul is also an Adjunct Professor at the Institute of Natural Resource Management, The University of Notre Dame Australia.


Jacqui Richards

Also contributing ...

Ian Herford, David Pearson, Xavier Bonnet, Oliver Berry, Sue Morrison, Carolyn Thomson-Dans, Mark Maddern, Verna Costello and John Hunter.

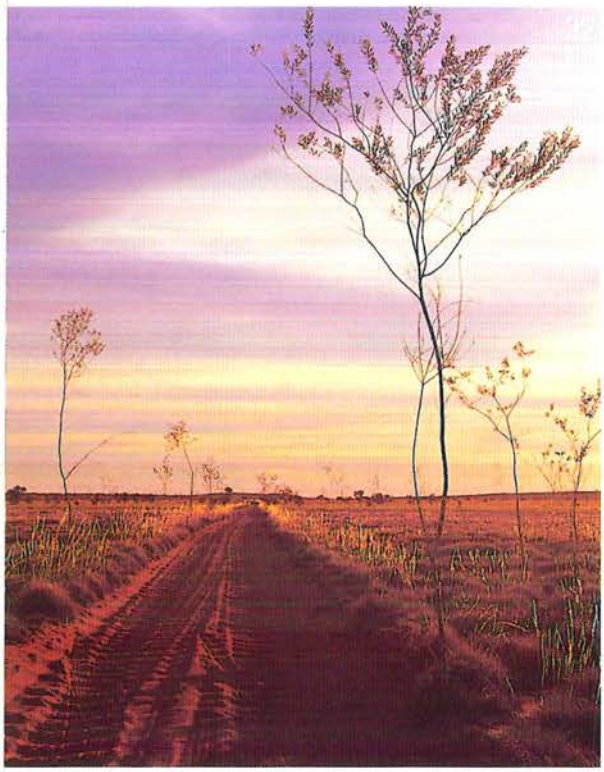

Paul de Tores

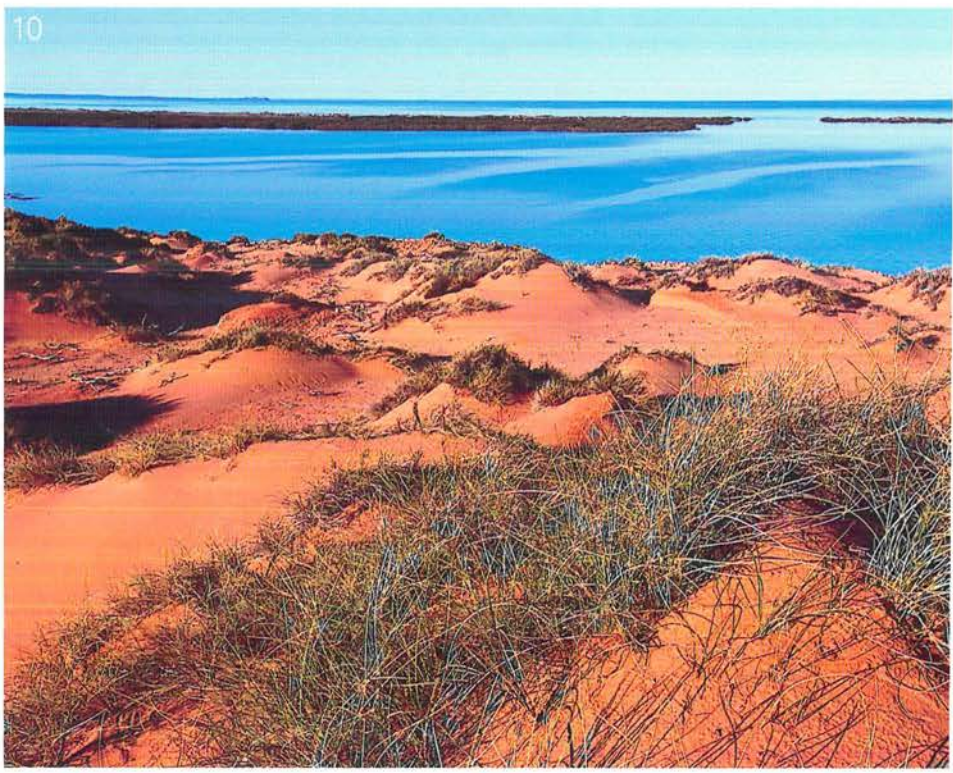
Cover illustration by Philippa Nikulinsky
The red woodchips fungus (*Stropharia aurantiaca*) grows in large troops in woodchips, sawdust, lawns and gardens in parks and gardens around the Perth region, throughout Australia and in many other parts of the world.

It is easily recognised by its bright orange-red caps and white stem, which is orange-red on the bottom half. The intense red colour of its caps does not fade with age, unlike many other brightly coloured fungi.

Back cover photo Dennis Sarson/Lochman Transparencies
After rains, jarrah forest in the Perth hills is a haven for fungi.

Features





Volume 22 Number 3 Autumn 2007

contents

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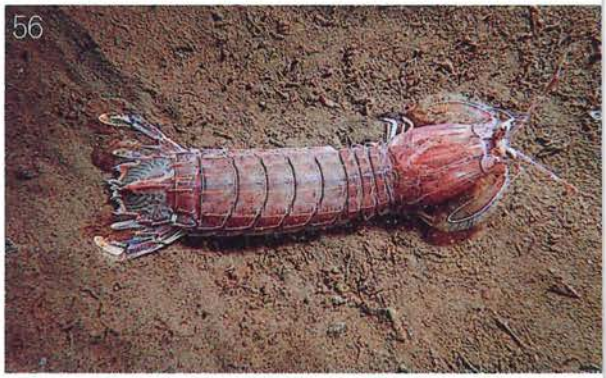
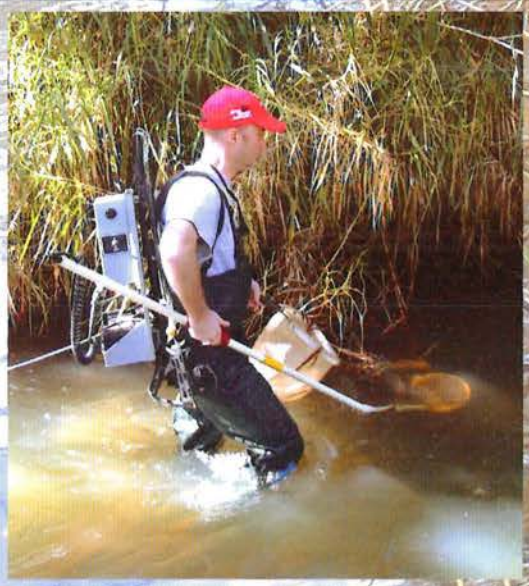


One-spot livebearer

by Mark Maddern



An invasive freshwater fish —the one-spot livebearer— is having a detrimental effect on native fish species around waterways in Perth and the south-west.

Opposite page
Main Canning River at Soldiers Road, Roleystone.
Inset top One-spot livebearer.
Photos – Mark Maddern
Inset bottom Mark Maddern electrofishing in the Canning River.
Photo – Leah Delfs

Above A section of Mary Street drain in Maylands, where one-spots have recently been discovered.
Photo – Mark Maddern

The waterways of Western Australia's south-west are home to many native fish and crustaceans found nowhere else in the world. Iconic species such as marron (*Cherax tenuimanus*) are popular targets for recreational fishers and support tourism in regional WA. Native species share these waterways with introduced freshwater fish, such as goldfish, carp, brown and rainbow trout, redfin perch and mosquitofish that may compete with, or predate upon, the natural inhabitants. Unfortunately, new introduced fish, often ornamental species with unknown ecological impacts, are regularly discovered in waterways of the south-west.

Spot the difference

The one-spot livebearer (*Phalloceros caudimaculatus*) is an aquatic invader becoming common in creeks and rivers within the Perth metropolitan area. These small fish (no greater than 60 millimetres long) are native to central South America and were imported into Australia to be kept as pets. Although one-spots have been in Perth for at least three decades, their range has recently expanded significantly. Within Perth, one-spots are found in the upper Canning River around Gosnells and Kelmscott, and in many tributaries including Bull Creek, Lesmurdie Brook and Southern River. They have recently been discovered in drains and creeks leading into the Swan River at East Perth, Maylands, Belmont and Bayswater.

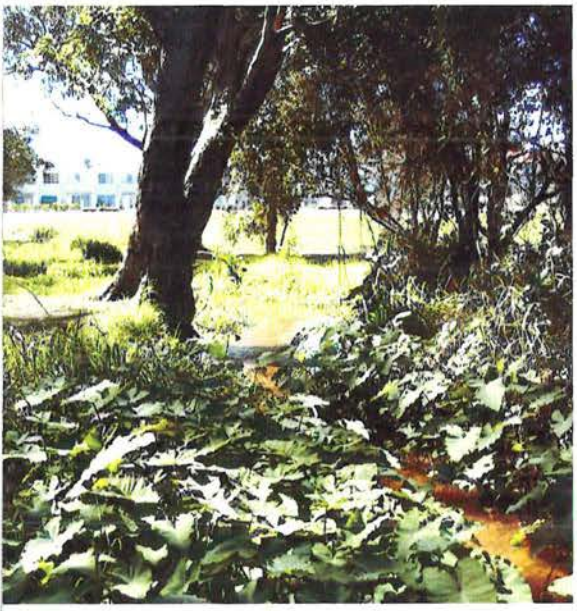
One-spot livebearers are identified by the speckled markings and the yellowish tinge on the body that is particularly noticeable on the fins. They are easily discernible from all small, native species, and may be confused only with the introduced mosquitofish (*Gambusia holbrooki*). The name 'one-spot' refers to wild fish in South America that do not have the speckled markings, but only a single spot on the mid-flank. Ornamental strains were specially bred to have pronounced markings, and it was these varieties that were introduced into the waterways of Perth. Thus one-spot livebearers typically have many spots!

Like many introduced animals, one-spots compete with indigenous species for space and food sources, consuming aquatic invertebrates that are the preferred diet of native fish. They may also predate upon the fry of native fish and small tadpoles. One-spots will also readily consume low quality dietary items such as detritus and algae. The ability to consume a highly varied diet enables one-spots to thrive in a wide variety of environments, including degraded areas such as urban drains that native species will not inhabit.

Survival and spread

As the name 'livebearer' suggests, one-spots do not lay eggs but give birth to live young. Newborn fish are relatively large and are immediately able to swim, feed and escape predators. Therefore, one-spot offspring have a better chance of survival than the offspring of egg-laying native fish, which are much smaller. The production of live young also allows a single pregnant female to start a new population if released in a different waterway. In south-western Australia, one-spots breed continuously throughout the year and grow more quickly than native fish. A flexible diet and live young allow one-spots to readily settle in new environments and compete successfully with native fauna.

One of the most worrying aspects of their spread is that one-spots have dominated waterways in Perth and Sydney that previously contained only mosquitofish. The mosquitofish is the most abundant introduced freshwater fish in Australia, primarily due to its wide release as a mosquito biological control agent since the 1920s. It is now considered a pest due to its aggressive



Above Mosquitofish were introduced in the 1920s as a control agent for mosquitos.
Photo – Babs and Bert Wells/DEC

Left A suburban drain, where one-spots have recently been discovered.

Below left and right One-spots from South America were specially bred from having a single spot (left) to having speckles (right).

Bottom A brood of fully developed embryos and eggs removed from a pregnant female.

Bottom right A one-spot livebearer at actual size.
Photos – Mark Maddern

behaviour towards, and competition for food with, native fish. Furthermore, mosquitofish are poor consumers of mosquito larvae compared with the native fish they often replace. Unfortunately, much like the cane toad (*Bufo marinus*), while mosquitofish were released with the best intentions, they have become an ecological disaster. It is of concern that a well-established and highly successful invader such as the mosquitofish may have been out competed and replaced by one-spot livebearers.

Control

Now that one-spots have become established in Perth waterways, what can be done to remove or control them? Physically removing or poisoning fish is possible only in small, confined locations and, unfortunately, as one-spots are now established in many creeks and rivers within the metropolitan area this strategy would be unsuccessful. Other potential control strategies may include reintroducing larger, native fish which may prey on juvenile one-spots and help control their numbers. Typically, once introduced species become firmly established it is very difficult to remove them. The most important strategy is to prevent the further release and spread of one-spots around Perth through greater public education.

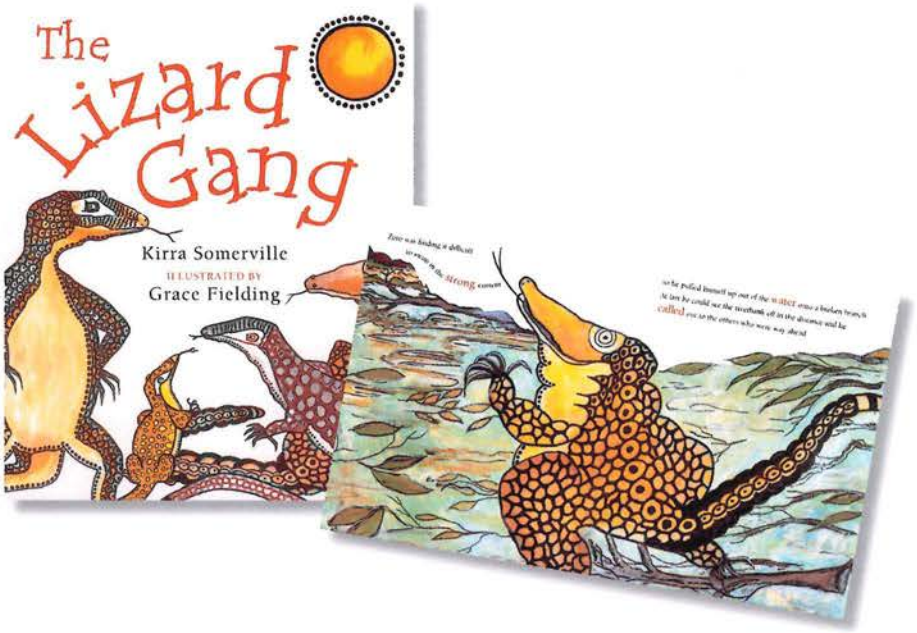
Mark Maddern, from the School of Animal Biology at The University of Western Australia, is conducting research on the biology and ecology of one-spots, and their potential to affect natural ecosystems. If you see one-spot livebearers in south-western Australia please contact him on 0422 068 870 or by email (mark.maddern@gmail.com), or the Department of Fisheries translocation officer on (08) 9482 7205. Mark is a recipient of a Land and Water Australia postgraduate scholarship and acknowledges financial support from Land and Water Australia and The University of Western Australia.

bookmarks by Verna Costello

The Lizard Gang

Author: Kirra Somerville
Publisher: Magabala Books
28 pages, soft cover, full colour
ISBN: 1 875641 89 0
RRP: $19.95

This charming children's adventure book, brilliantly illustrated by Grace Fielding, was written by Kirra (a descendant of the Martu People of the Western Desert), when she was only nine years old! The book earned her a 2004 WA Children's Book Council of Australia prize and fuelled her passion for writing, especially about animals in the Australian bush. The story of four monitor lizards tells of their efforts to cross a raging river flood. Each lizard has a different skill that helps them all to reach safety. The moral of the story? Good-natured teamwork.



Australian Seeds

Edited by: Luke Sweedman and David Merritt
Publisher: CSIRO Publishing
272 pages, soft cover, full colour
ISBN: 0 643 09298 6
RRP: $59.95

At a time when the world's plant biodiversity and ecosystems are being destroyed at an alarming rate, this book's appearance is timely. With more than 1400 colour images, this guide to the collection, identification and biology of Australian seeds is a comprehensive pictorial guide to the collection, processing, storage and use in conservation and restoration of wild seed.

While this seedbanking will not conserve ecosystems, it will at least conserve biodiversity and genetic diversity.

Wild Familiars

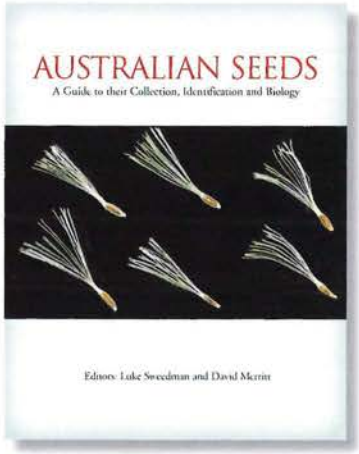
Author: Liana Joy Christensen
Self-published
43 pages, soft cover
ISBN: 0 9775403 0 8
RRP: $15.00

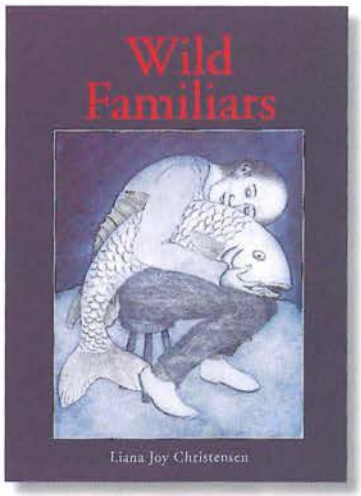
Wild Familiars celebrates our various connections with Australian native animals, and is drawn from an enduring interest in environmental issues, fostered during the author's time as one of the first editors of *LANDSCOPE*, more than 20 years ago.

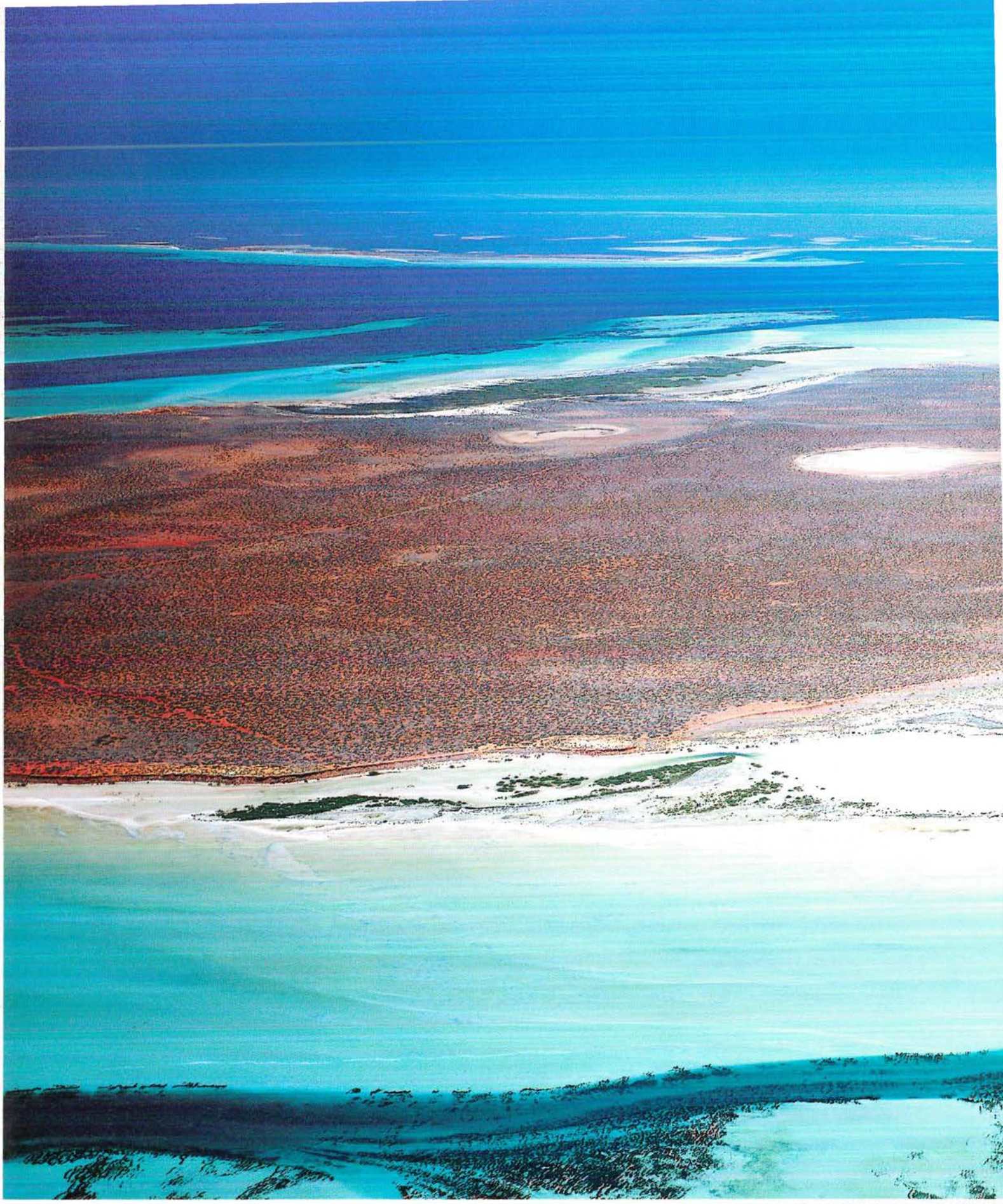
Written in poetic form, the book gained an Honourable Mention in the 2006 Writer's Digest International Self-published Book Awards.

Included is 'Arachnead', which admires the combination of beauty and deadly purpose in the construction of a spider's web. Other pieces such as 'The Once' and 'Future Frogs' are celebratory, joyously welcoming long overdue rain.

Wild Familiars is available through ToneRiverPress@slow-stories.net.



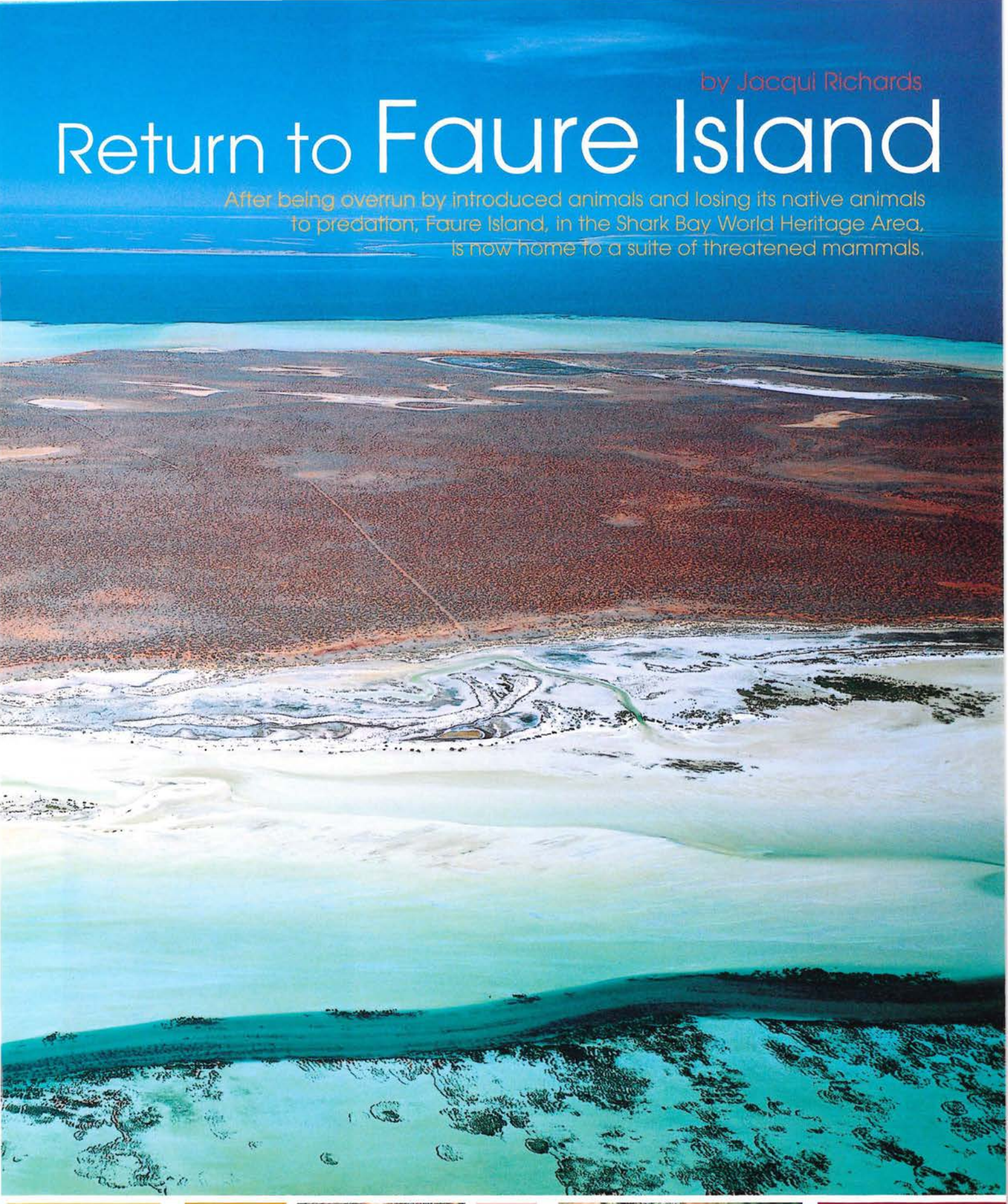




by Jacqui Richards

Return to Faure Island

After being overrun by introduced animals and losing its native animals to predation, Faure Island, in the Shark Bay World Heritage Area, is now home to a suite of threatened mammals.



Faure Island was named by French explorer Nicolas Baudin in 1801 after Pierre Faure, the geographer aboard the *Naturaliste*, who first saw and drew the island plan. The 6000-hectare island lies in Disappointment Reach, east of Peron Peninsula in Shark Bay, and is visible from the beach at Monkey Mia (see map on page 19).

Previous page
Main Faure Island.
Photo – David Bettini
Insets from left Western barred bandicoot.
Photo – Babs and Bert Wells/DEC
Banded hare-wallaby.
Photo – Linda Reinhold/DEC
Greater stick-nest rat.
Photo – Jiri Lochman
Boodie.
Photo – Andrew Burbidge/DEC
Djoongari or Shark Bay mouse.
Photo – Babs and Bert Wells/DEC

Below Faure Island.
Photo – Marie Lochman

Pastoral history

A pastoral lease for the island was granted to Charles Broadhurst in 1873 for pearling interests, then in 1883 to WD Moore and Company, which released angora goats from South Africa on to the island. The Hoult family of Denham took over the lease in 1905, stocking the island with additional angora goats and, later, merino sheep. Stocking rates on the unusually productive island reached highs of more than 2700 sheep in 1974, well beyond its estimated capacity of 1700. More than 3400 sheep were removed in 1999 when the Hoult family sold the lease.

The Hoults spent part of each year in a tin 'homestead' at the southern end of the island that looked over the shallow turquoise waters of Hamelin Pool towards the mainland. In the early years Dick Hoult, then a lad in his twenties, remembered moving up to 1500 sheep at a time on an ex-pearling lugger to Nanga Station on the mainland, followed by six weeks of droving south along the coast to Northampton. In latter years, stock were taken to Monkey Mia by barge then trucked southwards.

Smaller lots of 40 to 50 goats were transported to Northam or the Claremont sale yards in Perth, where they fetched as much as $1000 a head. Dick also recounted the post-war years, when wool prices were high at a "pound for a pound", and leaner years through the 1960s, 1970s and 1980s, when fishing was the family's mainstay. However, despite the challenges of moving stock from the island and times of low commodity prices, the venture was profitable.

Australian Wildlife Conservancy

The Australian Wildlife Conservancy (AWC)—a non-profit organisation dedicated to conserving Australia's biodiversity—purchased Faure Island in 1999 to establish viable populations of threatened mammals on the island and initiate ecological

Top left Bones of pale field rats found on Faure Island.
Photo – Jiri Lochman

Top Faure Island.
Photo – Jacqui Richards/DEC

Above Mangroves on Faure Island.
Photo – Jiri Lochman

research to increase the effectiveness of threatened species management in arid Australia.

The roots of AWC are firmly embedded in Western Australia, home of its Chairman and founder Martin Copley. Martin's vision, supported by Chief Executive Atticus Fleming and some 40 staff, has led to a national organisation that now manages 15 sanctuaries across Australia encompassing 1,100,000 hectares. Five are in WA: Karakamia and Paruna on the outskirts of Perth, Mount Gibson in the northern Wheatbelt, Mornington in the Kimberley and Faure Island Wildlife Sanctuary. With the aid of private and government donations, AWC has recently acquired Wongalara, a 200,000-hectare property on the southern edge of Arnhem Land in the Northern Territory. AWC's activities are helping to ensure the future of a host of threatened species and their habitats.

The habitat

Faure Island was separated from the mainland about 6000 years ago at the end of a period of deglaciation after the last ice age. It has a similar landscape to Peron Peninsula, typified by undulating red and white sandy plains and dunes with birridas or claypans in the lower lying areas. At its highest point, Faure Island is only 26 metres above sea level. Hills are almost absent. The only raised areas are the limestone and red sand cliff edges that, like nearby Peron Peninsula, make the coast so spectacular.

Most of the island is dominated by low wanu (*Acacia ramulosa*) shrubland, but four other major plant communities were identified by Department of Environment and Conservation (DEC) botanists Greg Keighery and Bill Muir during a survey in 2000: mallee shrublands, spinifex grasslands, samphire and *Atriplex* shrublands, and mangrove communities. There is a rich flora of at least 140 native species, many of which have increased in cover and shown other signs of regeneration since introduced stock were removed. Unfortunately, due to its grazing history, 21 weeds have invaded the island, the most significant of which are buffel grass (*Cenchrus ciliaris*) and African boxthorn (*Lycium ferocissimum*).

The only mammals known to inhabit Faure Island at the time of the AWC purchase were introduced house mice, goats, sheep, horses and feral cats. Neither rabbits nor foxes had ever been recorded on the island. House mice were in low numbers and goats, sheep and horses were confined to the island's southern half, near water points and the homestead.

Alex Baynes, a WA Museum research associate, uncovered an array of skeletal remains in dune blowouts on Faure Island, providing clues to its past mammal fauna. Western barred bandicoots (*Perameles bougainville*), woylies (*Bettongia penicillata*), djoongari or Shark Bay mice (*Pseudomys fieldi*) and pale field rats (*Rattus tunneyi*) had once called the island home. The Hoult family reported one 'porcupine'—the echidna (*Tachyglossus aculeatus*)—on the island in the 1930s and 1940s and had introduced another in the 1990s. Intensive surveys in 1989 and 2000 found the only native mammal still

present on Faure Island was likely to be the Hoult's lone echidna. Though it wasn't seen, fresh tracks and a 'smelly' scat were found along the eastern coastal cliffs.

Twenty two reptile species and more than 90 bird species have been recorded from Faure Island. A mangrove-lined lagoon on the northern side of the island is home to an extensive pied cormorant rookery. Excrement from the noisy gaggle of birds is so extensive that the lagoon is filled with thick green coils of algae during the breeding season, and swathes of mature mangroves are left lifeless when the fledglings leave their roost. Fortunately, the nutrient-rich environment provides for a healthy crop of young mangroves each subsequent winter.

Island preparation

During a biological survey in May 2000, staff from DEC, the WA and South Australian museums and AWC worked together to assess the island's potential conservation value and collect baseline data.

The task of preparing Faure Island for the change from production of sheep and goats to the production of threatened mammals was welcomed by all, including members of the Hoult family. All but two of the nine horses were removed in 2000, goats were eradicated in 2004 (after removing more than 2000 in three years) and, by 2006, about 80 sheep were held in a single paddock on the southern half of the island.

While removing livestock from the island was relatively straightforward, it was thought that eradicating the 40 or so feral cats would represent a greater challenge. The mostly black cats were believed to have been introduced in

Top left Pied cormorant.
Photo – Sallyanne Cousans

Centre left A feral cat on Faure Island in June 2000.
Photo – Greg Keighery/DEC

Left Western barred bandicoot.
Photo – Blair Parsons/CSIRO

Right Greater stick-nest rat.

Below Right Banded hare wallaby.
Photos – Jiri Lochman

the late 1800s by pearlers who camped at the island's northern end.

Feral cats are difficult to control due to their desire to hunt live prey. Ten thousand meat baits impregnated with 1080 poison were dropped throughout the island from the air by a team from what was then CALM, led by Senior Research Scientist David Algar in February 2001 at a time when it was hoped that cats were hungry, and therefore more likely to scavenge baits due to a lack of prey. Ninety per cent of the cats were eradicated within days of the bait drop. Despite some cat activity, particularly from kittens, around water points and the homestead immediately following the baiting, by March there were no signs of fresh tracks. After a follow-up survey in June, the island was declared free of feral cats.

This success makes Faure the third largest island in the world from which feral cats have been eradicated. The rapid removal of these introduced predators paved the way for a fauna reconstruction project of national significance.

Translocations

At a workshop in March 2001, staff from DEC, AWC, CSIRO, WA Museum and Kanyana Native Fauna Rehabilitation Centre banded together to compile a 'top five' list of native mammal species considered to be suitable for the habitat on Faure Island. The choices were also based on conservation status and the need for additional conservation efforts for a range of species.

The first native mammal to call Faure Island home—after an absence of more than 90 years—was the djoongari (or Shark Bay mouse). Like many of Australia's small-to-medium sized native mammals, it became extinct from mainland Australia following European colonisation. The only natural wild population occurs on Bernier Island in Shark Bay. Eighty six djoongari made the pilgrimage from a breeding colony at Perth Zoo, and were released in June 2002, followed by another 28 in the same year.

The boodie (*Bettongia lesueur*), not recorded from Faure Island but sharing a similar fate of extinction from the mainland, was introduced at the same time. The species is still found on Bernier and Dorre islands in Shark Bay and Barrow Island to the north. Seventeen animals made a shorter but still adventurous crossing by car, plane and boat from a population established at nearby Heirisson Prong by CSIRO and the Useless Loop community in 1992.

These new Faure Island populations were monitored for two years to ensure their prospects for survival on the island were secure. Banded hare-wallabies (*Lagostrophus fasciatus*) were the next candidates, with 26 translocated from DEC's Peron captive breeding colony in May 2004, 2005 and 2006. As the only wild populations of banded hare-wallabies occur on Bernier and Dorre islands, establishing a third population was a high priority.

The western barred bandicoot was reintroduced, also from an established population on Heirisson Prong, in October 2005. Twenty animals were flown from Useless Loop to Faure Island. The Heirisson Prong and Faure Island populations are free of a wart-like disease found in the wild Bernier Island population and a number of captive breeding populations.

The fifth species to call Faure Island home was the greater stick-nest rat. Sixteen came by boat and plane from St Peters Island in South Australia in September 2006. Another six rats arrived after a shorter boat ride and flight from Salutation Island in Shark Bay, where a population had been established by DEC in 1990.

During each translocation, several animals were radio collared to enable AWC to monitor their survival, habitat preferences and movements. As a result, we gained an intimate knowledge of the activities of the banded hare-wallabies—which had come from DEC's Peron captive breeding colony complete with breeding history and

names such as Shaggy, Stroppy, Himby and Kettle—following their release on Faure Island. Radio collars with a year's battery life, combined with their lack of movement away from the release site and ease of capture in cage traps, provided outstanding post-translocation monitoring results. The animals clearly preferred the chosen habitat at the release site, dominated by thick pockets of wanu and kurara (*Acacia tetragonophylla*) along the dune ridges.

By contrast, the radio collared but nameless djoongari moved away from their release site in the first four weeks and tracks were noted throughout the island. Radio collars typically lasted only five weeks due to weight constraints, and a number of djoongari were killed by a pair of southern boobook owls in June and by Gould's monitors (*Varanus gouldii*) in October. Nevertheless, radio tracking clearly showed djoongari preferred coastal areas dominated by beach spinifex (*Spinifex longifolius*) and completely avoided the acacia shrublands that cover most of the island.

Monitoring and population growth

AWC's last annual survey of native and translocated animals on Faure Island in July 2006 produced a boodie bonanza. The 17 founders had given rise to an estimated population of more than 400 animals in four years—a good demonstration of the capacity of our native wildlife to recolonise habitat in the absence of introduced predators! Given the chance, boodies can produce up to three young each year.

Left Faure Island Project Officer Jo Williams releasing a boodie during the animal survey.

Below AWC Director Ross Ledger and south-west manager Alison Dugand setting cat traps for western barred bandicoots after their translocation from Heirisson Prong.
Photos – Jacqui Richards

The strong growth of the boodie population, however, created a significant monitoring problem. As 41 per cent of cage traps were filled by boodies, fewer traps were available to more trap-shy species. Fifteen western barred bandicoots—five of them born on Faure Island—and only three banded hare-wallabies were captured. Fortunately, track counts, spotlighting and additional targeted trapping showed that populations of both species were likely to be in excess of 50 animals each.

The boodies also provided an opportunity to learn more about the ecology of this species in a more accessible location than the wild Bernier and Dorre island populations. Felicity Donaldson, a PhD student of the The University of Western Australia has spent the past couple of years studying the taxonomy and genetics of remnant boodie populations on Bernier, Dorre and Barrow islands and the genetic consequences of translocations to sites such as Faure Island.

Banded hare-wallabies have had more than a year's head start on the western barred bandicoots, but usually produce a single young each year, while the bandicoots can produce up to three young per litter and up to four litters per year in rapid succession.

More than 100 djoongari were trapped in July 2006, a significant increase from the 40 caught in the previous annual survey. Their tracks cover the island. It is rare to see signs of the introduced house mouse, and encouraging that the native rodents are faring much better. Its ability to produce up to five young per litter means the djoongari is likely to continue to increase and outcompete the introduced house mouse.

It is early days for the greater stick-nest rats of Faure Island, but it is hoped that their population size will follow the trend of rapid growth seen by the other four species of threatened mammals.

Weighty gains

Many Australians struggle against weight gain, but the reverse is usually true for our native animals, which compete for food in an often harsh and unforgiving environment. Boodies and

bandicoots on Faure Island appear to have bucked the trend.

The average weight of adult boodies captured on Bernier Island is 1260 grams, compared with 1310 grams on Dorre Island, 1360 grams on Heirisson Prong and 1490 grams on Faure Island. The largest boodie trapped on Bernier and Dorre islands was an 1860-gram male, while the record on Faure Island is an amazing 2390-gram female. Radio collars have had to be modified to encompass their chubbier stature and the two kilogram scales are often relegated to the bottom of the trapping kit in favour of a three kilogram model. Similarly, the average weight of western barred bandicoots is 219 grams on Bernier and Dorre islands, 230 grams on Heirisson Prong and 261 grams on Faure Island. While the latter sample is from only 13 animals born on the island, they are already visibly larger than their counterparts.

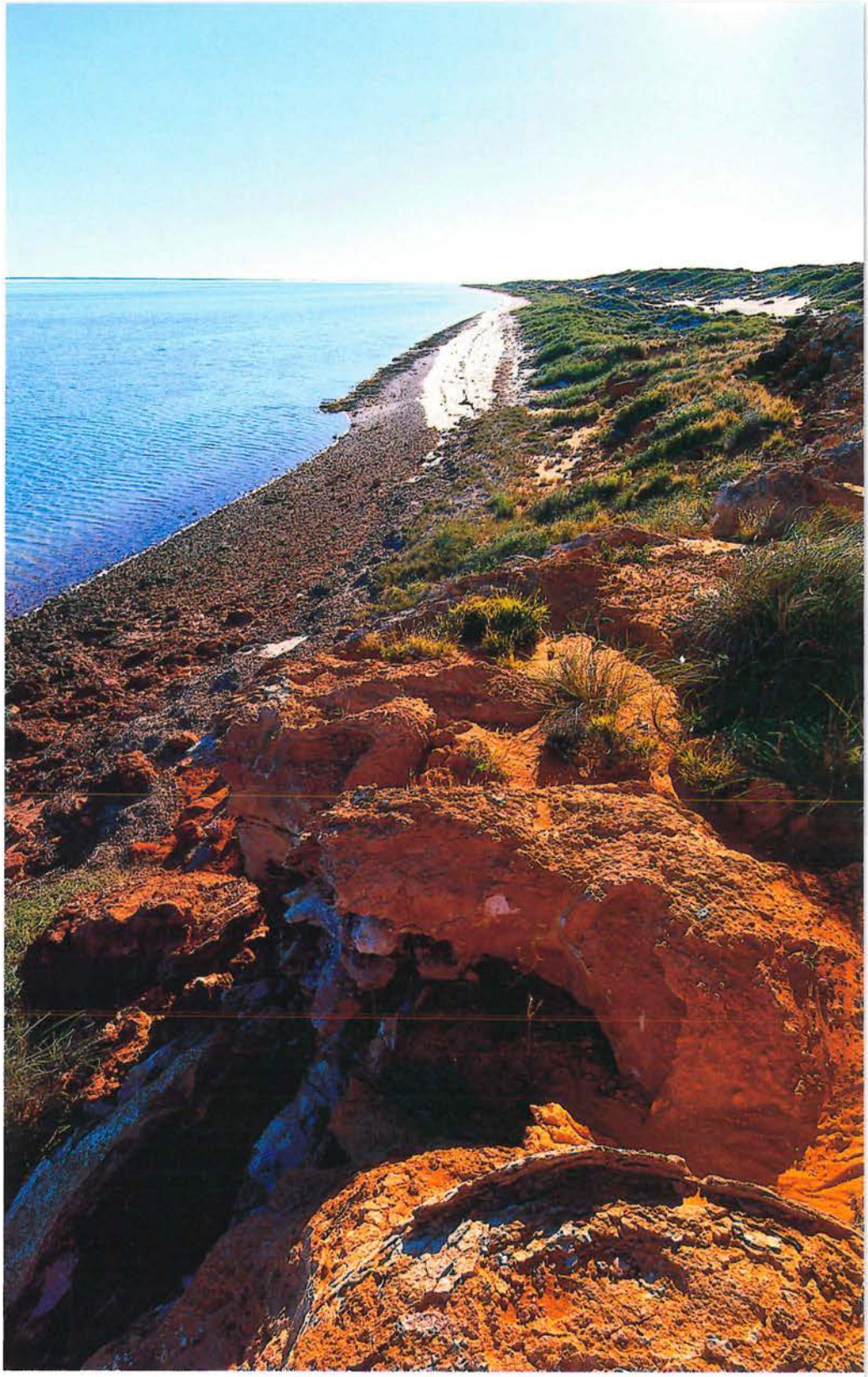
It seems that good quality habitat, abundant food and low levels of competition on Faure Island have enabled the threatened mammal populations to rapidly increase, in both body size and number.

Beyond Faure Island

Faure Island is now criss-crossed by an array of native mammal tracks. The hoof prints of the previous century have all but gone and prickly kurara shrubs have begun to cover the weedy remnants of the island's pastoral history.

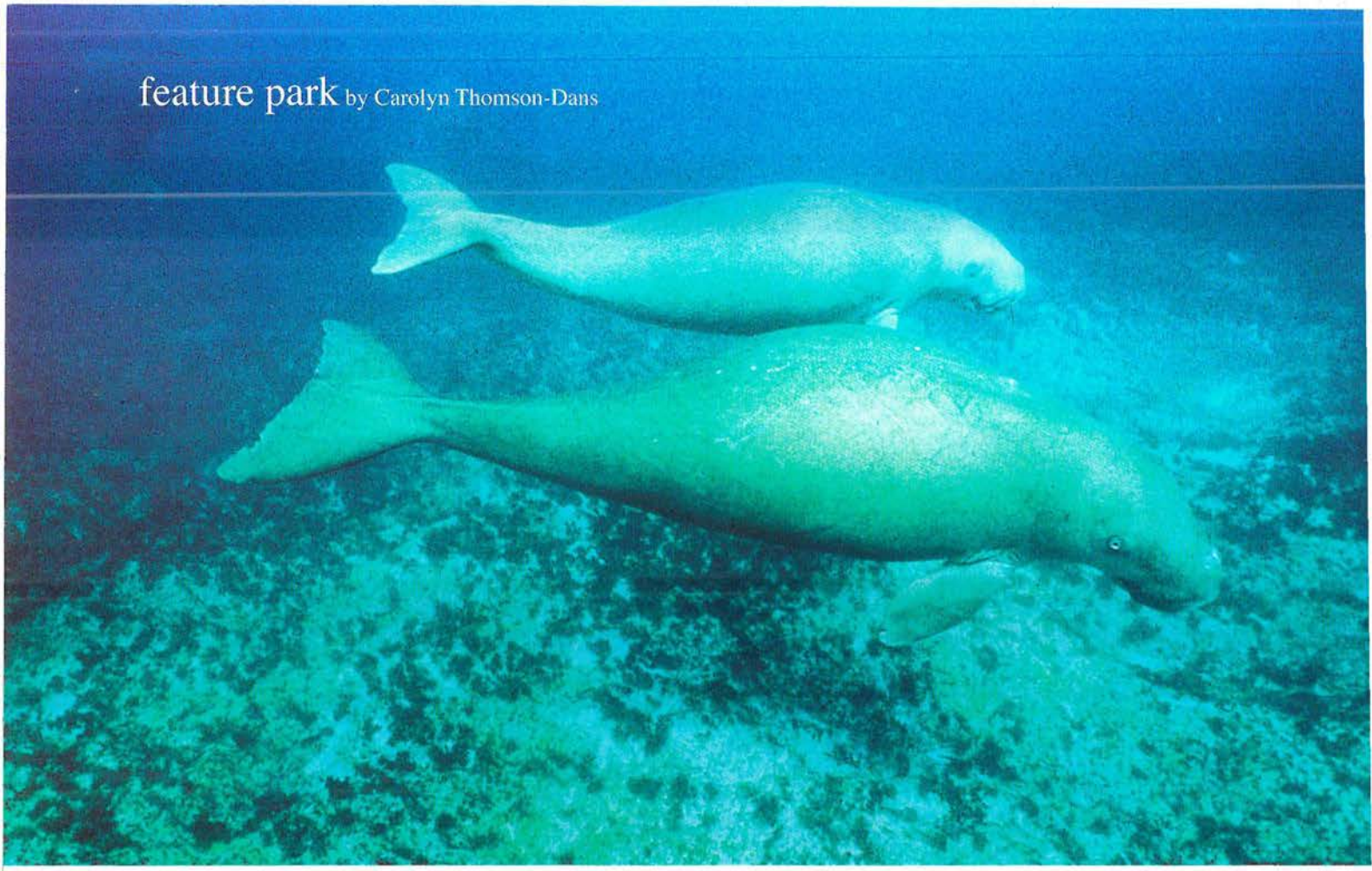
The almost overnight success of Faure Island is testament to the true spirit of collaboration. DEC, a raft of conservation-minded organisations and many donors and volunteers have all contributed to AWC's mission to conserve Australia's biodiversity. As the threatened mammal populations increase on Faure Island, the opportunity to translocate animals to other Australian sites is fast becoming reality. AWC, DEC and the Invasive Animals Cooperative Research Centre are already working to control introduced feral cats, foxes and wild dogs at AWC's Mount Gibson Wildlife Sanctuary in the northern Wheatbelt, as a precursor to reintroducing threatened mammals there.

As DEC's challenge of transforming the nearby and much larger Dirk Hartog Island pastoral lease to a conservation estate unfolds over the next few years, the threatened mammals of Faure Island may prove a key component in continuing the transformation of much of the Shark Bay region from pastoral to conservation pursuits.



Above Faure Island's coastline.
Photo – Jiri Lochman

Jacqui Richards, a Regional Ecologist for the Australian Wildlife Conservancy based in Perth, has been involved in conserving threatened mammals in Shark Bay for the past decade. She can be contacted on (08) 9226 0340 or by email (jacqui@australianwildlife.org). Visit the Australian Wildlife Conservancy's website (www.australianwildlife.org) for more information about the organisation.



Shark Bay Marine Park

Shark Bay Marine Park—an integral part of the Shark Bay World Heritage Area—boasts the world's largest meadows of seagrass, a population of more than 10,000 dugongs, large marine creatures such as marine turtles and humpback whales, and of course the famous bottlenose dolphins of Monkey Mia.

Above Dugongs.
Photo – Doug Perrine/Innerspace Visions
Far right Seagrass and sand banks.
Photo – Kevin Crane

Shark Bay was named in 1699 by William Dampier who noted that 'The sea fish we saw here are chiefly sharks. There are an abundance of them in this particular Sound and I therefore give it the name of Shark's Bay'.

While Shark Bay is not a well-known destination for divers and snorkellers, it is a wonderful place to explore the underwater world and provides a diving experience unlike any other. Dugongs, whale sharks, sea turtles, humpback whales, massive Queensland groper, sharks, curious sea snakes, coral bombies, seagrass and shipwrecks—this spectacular marine park has it all.

Non-divers can have just as much fun, with an array of marine or boat-based adventures on offer. These adventures include tours of a working pearl farm, boat cruises, fishing safaris, sea kayaking, whale watching and much more.

Aquatic life

The many bays, inlets and islands in the Shark Bay region support a profusion of aquatic life. Turtles, dolphins, prawns, scallops, sea snakes, fish and sharks are common. In some areas communities of corals, sponges and other invertebrates support a unique mix of tropical and temperate fish species. The wide intertidal flats on the shore of Shark Bay support a unique community of burrowing molluscs, hermit crabs and other invertebrates. But the very foundation of Shark Bay's ecosystem is the seagrass—meadows and meadows of it!

Shark Bay has the largest area of seagrass and the largest number of species ever recorded in one place in the world. Elsewhere, one or two species cover large geographic areas. But in Shark Bay there are 12 species and, in some places in the bay, nine can easily be identified in a square metre. The most abundant is wireweed (*Amphibolis antarctica*), covering nearly 3700 square kilometres of the bay's sandy bottom. Ribbon weed *(Posidonia australis)* is the other large seagrass which grows in large meadows, which

cover about 200 square kilometres of Shark Bay. The ribbon-like leaves provide a handy attachment point for many plants and animals.

One of the features of Shark Bay Marine Park is the abundance of large aquatic animals that are easily seen from boats and vantage points on land such as at Eagle Bluff and Skipjack Point. The shallow marine environment of Shark Bay has one of the largest and most secure populations of dugongs in the world, with an estimated 11,000 animals. Although they are very shy, dugongs can often be seen from boats. Green and loggerhead turtles are also common in Shark Bay all year round and congregations of turtles can be seen from the end of July. From July to October numerous humpback whales visit the area. If you cut the engines of your boat and they are in a playful mood they may be encouraged to approach of their own accord. Between January and April, whale sharks can be seen around Cape Inscription and the top of Dirk Hartog Island.

Diving the bay

Shark Bay offers a quite different experience to diving on the coral reefs of the tropics, or on the temperate limestone reefs further south, but is equally enjoyable. Corals are present, sometimes in large patches, at places like Broadhurst. Monkey Rock, out from Steep Point in about six to 18 metres, is one of the area's most renowned dive sites.

Dive charters are available (by request) and are recommended as the best way to dive in Shark Bay if you don't have good local knowledge, as currents can be quite tricky (and dangerous) due to strong tidal movement. Always dive or snorkel on a slack tide.

If you do plan to dive in Shark Bay make sure you check out the books *Dive and Snorkel Sites in Western Australia* and *More Dive and Snorkel Sites in Western Australia*, which contain mud maps and descriptions of a number of good dive sites in the park. Divers and snorkellers should be wary of dangerous marine animals such as stonefish.

The wreck of the *Gudrun*

The *Gudrun*, the biggest wooden shipwreck found off Western Australia, sank at Shark Bay in 1901, carrying a load of jarrah from Bunbury to England. It was deliberately scuttled with more than a metre of water in its hold, after being sabotaged by the ship's carpenter. He admitted drilling a hole through its bottom. The wreck was rediscovered in 1989, when Paul Anderson, a Canadian studying dugongs in Shark Bay, found it on the sand flats north of Cape Peron. Today, the wreck lies in about six metres of water. A special sanctuary zone extends for 500 metres around the wreck to protect the site. Artefacts can't be removed and line fishing and spearfishing are not permitted.

The wreck is 65 by 20 metres, with another 20 by eight-metre section nearby, making it one of WA's largest untouched wrecks in shallow waters. The hull is buried largely intact up to a metre in the soft sands, but anchors, fastenings, deck knees and so on are visible. The remains, however, do not project much more than a metre from the seabed. Because of its relatively untouched wreckage, stunning marine life and remote location and history, Maritime Museum archaeologists rate it as one of the State's best wreck dives. It is now home to a rich variety of fish and marine animals, including turtles, giant groper and stingrays.

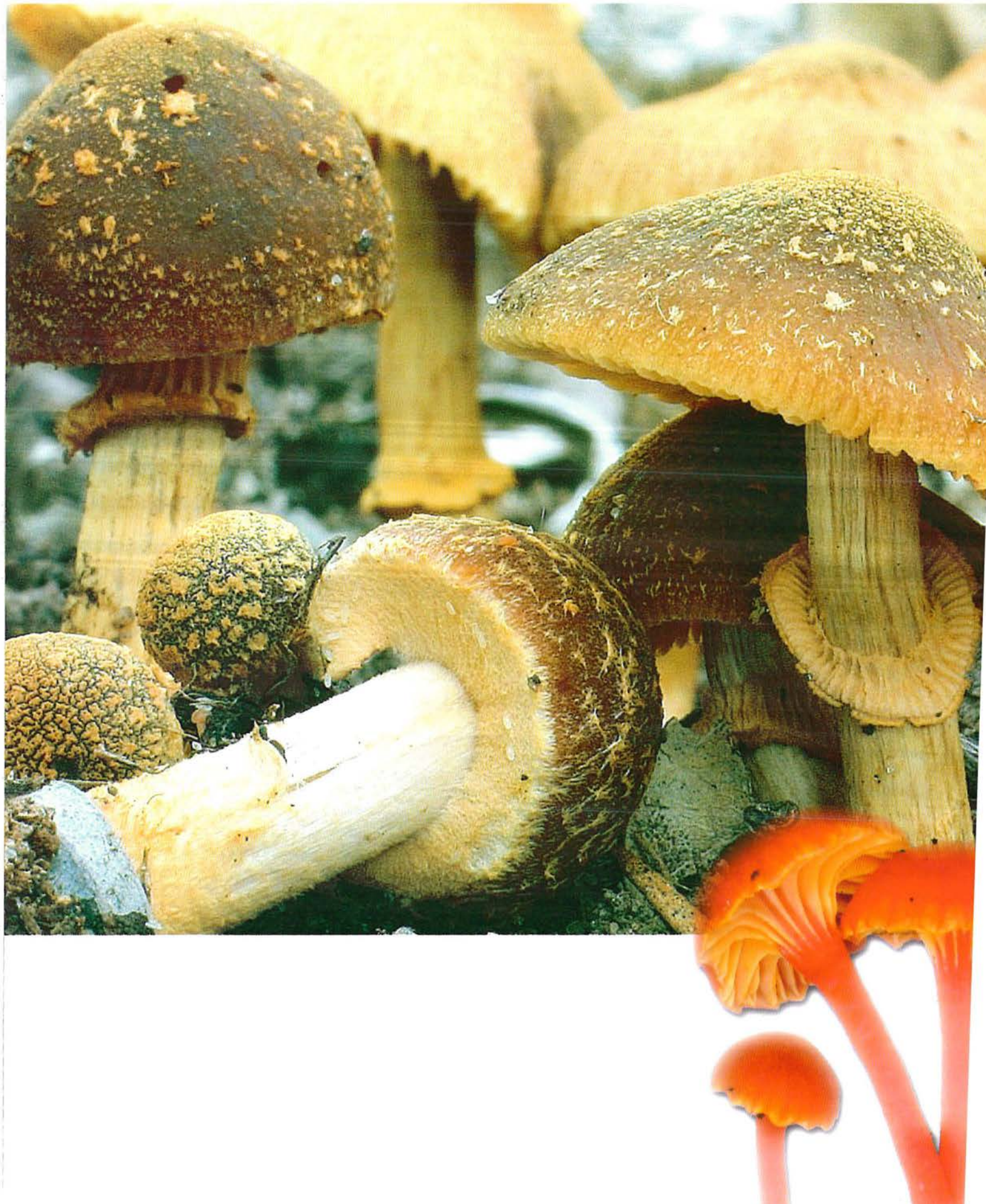
park facts

Where is it? Denham is 330 km from Carnarvon and 400 km from Geraldton, and Monkey Mia is 23 km from Denham.

Total area 8240 square kilometres.

What to do Dolphin interaction, watching wildlife such as dugongs and marine turtles, snorkelling, diving, fishing and boating.

Nearest DEC office DEC's Shark Bay District Office is in Knight Terrace, Denham 6537, phone (08) 9948 1208.



Perth's **fungi** forever

Story and photos by Neale Bougher

With eyes attuned to small bumps in the ground and an irresistible urge to scratch among the leaf litter, volunteers with the Perth Urban Bushland Fungi Project are revealing Perth's fungal treasures. With each new discovery, awareness is growing of why we need to understand and nurture the links between flora, fauna and fungi to help keep Perth's bushlands healthy forever.

Perth is blessed with numerous urban bushlands that harbour colourful displays of local flora, fauna and fungi. For many people, a stroll through one of Perth's bushlands may bring renewed appreciation of simple vistas—perhaps of trees, flowers and birds—and an unwavering expectation that the vistas will be unchanged on their next visit. Few people are aware that this expectation may partly hinge upon the capacity of bushland managers to understand and nurture a legion of concealed organisms linked to the more highly visible plants and animals. Most of the living things within Perth's bushlands are not easily seen, but have essential roles in sustaining bushland health. Fungi are foundation members of this support crew. Indeed, fungi are among the most ancient members of any bushland—fungi assisted the earliest plants to colonise the land. Without fungi, much of our bushland vegetation would struggle to thrive.

Many people may be familiar with at least a few fungi, aside from the ones in the supermarket, such as the luminescent ghost fungus that appears on trees around Perth every winter. In recent years, much more of the incredible diversity of fungi in Perth's bushlands has been coming to light—including those with strange names such as red fingers (*Colus pusillus*) and white punk (*Lactiporus portentosus*). But there is much more significance to fungi than their strange names, fascinating forms and mysterious nature.

Fabulous fungi

Western Australia has much more biodiversity than just flora and fauna—at least flora, fauna and fungi (and some that fit into other kingdoms). Fungi are not plants or animals, but are placed in a separate kingdom. After centuries of including fungi in botany at universities, fungi are now known to be more closely related to animals than to plants. There are probably at least 10 times more species of fungi than plants in the world. For WA that equates to about 140,000 fungi and 14,000 plant species. No-one really knows how many fungi we have, but it is estimated that only about 5 to 10 per cent of fungi species have been discovered and named so far.

Networks of cobweb-like threads called hyphae comprise the feeding and growing body of fungi. Fungal networks are ubiquitous in bushlands and are in a commanding position to influence bushland well-being. Fungi recycle precious nutrients in bushlands through the decomposition of organic material, including litter, dung and wood, and redistributing the nutrients throughout their extensive hyphal highways. Fungi also help to sustain healthy bushlands by interlinking directly with flora and fauna. Beneficial mycorrhizal fungi extract nutrients from the soil and supply them to plants such as eucalypts, wattles and orchids. Fungi also provide food and habitat for

Previous page
Main The spotted descolea (*Descolea maculata*) is a mycorrhizal fungus with a delicately grooved skirt-like ring on its stem. **Inset** Wax caps (*Hygrocybe*) are often very brightly coloured.

Top Birds nest fungi such as this *Cyathus olla* are shaped so that rain drops splash out their 'eggs' (spore packages) sending them whirling up into the air.

Above Many of Perth's fungi barely emerge from the soil, such as the rare pink-gilled amanita (*Amanita carneiphylla*).

Left The brightly coloured fruit bodies of the cup fungus (*Inermisia fusispora*) are tiny but occur in crowded groups.

Top left Fruit bodies of crust and skin fungi are flat, often on wood. Some have short spines or fingers such as the golden splash fungus (*Mycoacia subceracea*) pictured here in a battle for space with a smooth purple fungus (*Peniophora*).

Top The eyelash cup fungus (*Scutellinia scutellata*) is often the focus of camera-wielding people.

Above left The beefsteak fungus (*Fistulina hepatica*) is seen mostly on jarrah trees around the Perth region.
Photo – Joe Froudist

Above The shotgun fungus (*Pilobolus*) blasts its spores off the top of tiny semi-translucent stalks at high speed up to several metres away.

many animals, ranging from beetles and native flies to bandicoots and woylies.

Perth's larger fungi

Most fungi are entirely microscopic, but an estimated 5000 species or more in Australia produce fruit bodies that are visible to the naked eye. These are the larger fungi (macrofungi) such as mushrooms, toadstools, puffballs, coral fungi, brackets, earthstars and truffles.

About 500 species of larger fungi have been recorded in WA according to the only published State census. Most of them are known from few locations. Fungi of the Perth region exhibit a diverse array of forms, ranging from beautiful and colourful to bizarre and grotesque. Around May to July is the best time to see them. However, until recently, there have been no coordinated programs to document the diversity, abundance and distribution of fungi in the Perth region. Kings Park and Bold Park had attracted the most fungal attention. Mycology courses held at The University of Western Australia Botany Department by ERL Johnson and then Roger Hilton (until 1987) sent many undergraduates, including this author, scurrying about in Kings Park to complete their second-year fungi assignment. Many hundreds of fungi species probably occur in Kings Park, but most remain unrecorded. Surveys in Bold Park began in 1999 and have recorded about 280 species of fungi so far, with many previously unrecorded fungi discovered each year.

Mushrooming interest

The Perth Urban Bushland Fungi Project was initiated in 2004 to increase community skills in identifying fungi and surveying local bushlands, and thereby helping fill in some of the gaps in baseline knowledge about our fungi. The project also set out to encourage the consideration of fungi in managing Perth's bushlands, by raising awareness about the roles fungi have in helping to sustain healthy bushlands.

The distinctive forms and colours of Perth's fungi attracted enthusiastic support and participation from many volunteers in both the field and laboratory. From 2004 to 2006, about 2400 people took part in 86 Perth Urban Bushland Fungi Project workshops, forays, educational courses, survey contracts and seminars. A number of volunteers embraced roles as fungi leaders to teach others during surveys.

The project has so far surveyed 38 urban bushlands in the Perth

region—the first time fungi had been surveyed in most of these bushlands! Approximately 3000 fungi recorded as a result represented about 300 species. About 40 of the species were new records for WA, and several were new to science. More than 100 of the fungi discovered so far in Perth's bushlands are featured online in the ever-expanding *Perth Urban Bushland Fungi Field Book*. The book, and more about the project, can be seen at www.fungiperth.org.au.

Fungus forays

There is something addictive about hunting for fungi. The trick is to know how to find them in the first place. The Perth Urban Bushland Fungi Project's fungi leaders delight in showing people how to hunt for fungi in local bushlands, such as how to recognise small bumps in the ground and carefully lift off the soil to reveal the fungus below.

For many people, the array of fungi in their local bushland comes as quite a surprise, as they may not have seen many fungi there before. But once they have 'their eye in' many people find themselves on hands and knees, struck by an irresistible urge to scratch among leaf litter in search of fungal treasures or to contort themselves under logs to capture that perfect fungal photograph. With increasing incidence of such behaviour, Perth's fungi are beginning to reveal their hidden secrets, often raising yet more perplexing puzzles or challenges for management of our bushlands. Here are just a few examples.

Gondwanan relic

The volvate cortinar (*Cortinarius phalarus*) was discovered for the first

Top left Perth Urban Bushland Fungi Project volunteer John Weaver and Community Education Officer Roz Hart with a large bracket fungus on a tuart log at Bold Park.

Centre left A Gondwanan fungus recently discovered for the first time in the Perth region—the volvate cortinar (*Cortinarius phalarus*).

Left The pinwheel fungus (*Agaricus rotalis*) occurs in Perth, Hawaii and Estonia.

Right Pink clusters of *Mycena clarkeana* form on paperbark trees in swampy areas around Perth in winter.
Photo – Patricia Gurry

time in the Perth region during recent Perth Urban Bushland Fungi Project workshops at Forrestdale Lakes, Modong Nature Reserve and Whiteman Park. This fungus is known from only a few other scattered locations in southern parts of Australia.

The volvate cortinar is considered to be an ancient Gondwanan fungus, as it belongs to an unusual small group of *Cortinarius* species also found in South America. Members of this group are not typical of the genus *Cortinarius* as they have a cup (volva) at the base of their stem, whereas most other species do not. *Cortinarius* species are mycorrhizal fungi. So far, in Perth bushlands, our volvate cortinar has always been found near *Astartea* shrubs and *Melaleuca* paperbarks. The extent to which these plants and the fungus depend on each other is not known, but the discovery of this Gondwanan fungus emphasises the high conservation value of the bushlands where it was found.

Strange geography

A rather striking fungus called the pinwheel fungus (*Agaricus rotalis*) is another example of how little we know about our fungi. In 2005 it was discovered for the first time anywhere in Australia in various habitats and locations in the Perth region. It is a large fungus with black marshmallow-shaped buttons and a black and white radial pattern on its mature caps.

It is surprising that such a distinctive fungus could have been unrecorded anywhere in Australia before, and its known geographical distribution provides a further puzzle. Strangely, this fungus was initially discovered and named from the Hawaiian Islands in 2000, where it occurs in woodchips and also in litter under sheoaks. Until the Perth discovery, it had been unknown outside the Hawaiian Islands. Then it was reported from a zoo in Estonia. The known distribution now includes tropical Hawaii, temperate Perth and cool-temperate Estonia. Such a strange distribution may be due to recent introductions, but from where? Will it turn up in other parts of the world?

Fungi weeds

The invasion of weed plants into gardens and bushlands is a familiar sight in the Perth region. Less well recognised is that some fungi can also act like weeds. Just like plant weeds, these fungi arrive from somewhere else, quickly colonise disturbed areas, and may compete with or prevent native species from establishing.

One such species is a large member of the ink cap fungi, which self-digest into a black liquid as they mature. It is a variant of *Coprinus stanglianus*—a rare fungus previously known only from a few places in Europe. The first report of this fungus in Australia was from a public fungus foray in Kings Park about 10 years ago. Since then, abundant crops of its statuesque fruit bodies have been spotted in many Perth urban bushlands, mainly during June and July. It seems to be restricted to highly disturbed patches, such as alongside tracks among weeds, particularly in tuart/banksia woodlands. It seems unlikely that this distinctive large fungus had been overlooked before 10 years ago, and it may be spreading rapidly following its introduction into the Perth region. Many questions remain unanswered. Is this fungus native to Australia? If not, where did it come from, and how and when was it introduced? Does it affect bushland ecology or other fungi?

Above left A truffle (*Scleroderma*) exposed from under the ground cut to show the spores embedded in the front body. Truffles are mycorrhizal partners of plants and food for many animals, and need to be considered when restoring plants and translocating animals.

Above Ink cap fungi (*Coprinus truncorum*) occurs in large troops often around stumps.

Bottom left Red fingers (*Colus pusillus*) are coated with a slime that contains its spores. The foul-smelling slime is nauseating and attracts blowflies.

Perth's truffle orphans

Native truffles are mega-diverse in Australia. There are perhaps up to 2000 species, with only about 10 to 25 per cent named to date. Several dozen species of truffles have so far been found in Perth's bushlands.

Truffle fungi produce their tuber-like fruit bodies below ground and rely on animals to disperse their spores. Truffle odours attract animals such as bandicoots and woylies, which dig them up and eat them. The spores are unharmed when deposited in the animal's dung. Unfortunately, many of Perth's truffles may be sending out their special odours in vain. Fungus-eating mammals are now rare or absent in Perth's bushlands. How are these truffles dispersed in the absence of their mammal vectors that formerly coexisted with them in the bushlands? Are Perth's truffles doomed to a shrinking existence within the bounds of their bushland patch?

Fungi future

Flora, fauna and fungi—and the interdependencies between them—need to be understood and managed as a key part of nurturing Perth's bushlands. Growing awareness that fungi are a significant component of Perth's biodiversity has triggered increased demand for better information about our fungi. A scientific program dedicated to creating and distributing accurate and comprehensive information about fungi species of the Perth region now would be timely. This could provide the type of information we have at our fingertips about many of our plants, such as how to easily identify each species, where they occur, what conditions they prefer to live in, and how to grow and restore them. Improved information would help lift fungi out of the perceived 'too hard basket', and encourage the inclusion of fungi alongside flora and fauna in bushland management.

Through programs such as the Perth Urban Bushland Fungi Project, and with continuing community support, we are gradually becoming better placed than ever to nurture the biodiversity of our three 'F's'—flora, fauna and fungi. Along the way, many more surprises will be revealed about Perth's fungi and there will be many opportunities for community members and bushland managers to take part in unearthing exciting new discoveries.

Neale Bougher is a fungi specialist (mycologist) at the Department of Environment and Conservation's (DEC's) WA Herbarium. He has conducted many fungi expeditions and research projects throughout Australia and the world, and written several books and more than 200 scientific papers and educational articles on fungi ecology and taxonomy. He can be contacted by email (neale.bougher@dec.wa.gov.au).

The Perth Urban Bushland Fungi Project is a collaboration between the Urban Bushland Council, WA Naturalists' Club and DEC's WA Herbarium, with support from Lotterywest. Along with Neale Bougher, the core project team includes Roz Hart, Sarah de Bueger and the many volunteers who have contributed greatly to the project's success. A number of volunteers trained to become fungi leaders to teach on public forays. A georeferencing-based kit for fungi surveys was developed for the project by volunteer John Weaver, who has also been webmaster for the associated website and electronic designer of the *Perth Urban Bushland Fungi Field Book*.

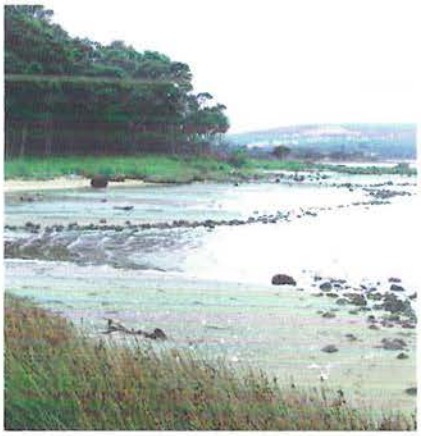
The book, *Perth Urban Bushland Fungi Field Book*, and more information about the project, can be seen at www.fungiperth.org.au.

Oceans of opportunity for our southern coast

The marine environment of Western Australia's south coast is one of the State's natural treasures. Home to a stunning array of plants and animals, the Southern Ocean also provides valuable resources and has been an important recreational destination for generations of Western Australians and visitors alike. A new planning initiative aims to ensure the many benefits of this unique resource are available for all time.

by Ian Herford

Western Australia's south coast fronts the ceaseless swells of the Southern Ocean with its fearsome reputation as one of the world's wildest bodies of water. The marine plants and animals off this coast are well adapted to ferocious seas and thrive in such conditions. The people of the State's south have also 'adapted' to the Southern Ocean and have found ingenious ways to harvest its resources and enjoy its restless beauty.



Something for everyone

Aboriginal people have spent time on this coast for thousands of years, fishing and collecting shellfish, crustaceans and other marine resources. Today, commercial and recreational fishers, divers, surfers and sailors all enjoy the benefits of the south coast marine environment. The ports of Albany and Esperance are connected to the world by sea lanes traversing this stretch of coastline. Exploration for petroleum is about to begin offshore. Whales frequent these waters on a seasonal basis, as they have done for millennia, and these days whale watchers have joined them. Islands off the coast are home to colonies of seals, sea lions, penguins and other seabirds, all of which depend on the sea to survive.

A unique assemblage of plants and animals has evolved in the waters of the south coast. The south coast marine environment includes spectacular granite reefs, sponge gardens, limestone reefs, seagrass meadows, kelp gardens and communities of filter feeders in deeper waters. In the Recherche Archipelago off Esperance, the only area that has been intensively surveyed, scientists have also discovered large areas containing rhodolith beds of calcareous algae.

An extremely high proportion of species in Australia's southern waters are found nowhere else in the world, such as the remarkable and uncommonly seen leafy seadragon. When marine biologists surveyed the Recherche they collected 300 to 400 species of sponges and around 40 to 50 per cent were new to science! Even in a better-known group like the fish, six completely new species were discovered.

The south coast marine environment—and all it offers—is worthy of our protection, not just for the users of today, but for the future. At present, the complex array of uses of the marine environment is not managed in an integrated way. Each group of users, such as government bodies, businesses, natural resource management groups and volunteers is active in planning and managing various aspects of the marine environment and its resources. What is lacking is integration of these sectoral contributions—and the assurance that, when they are added up, the various uses make a sustainable whole. Will future generations be able to enjoy the same range of benefits we currently derive from the marine environment, or are we depleting it in some way and reducing their options?

A new approach to marine planning

This is where the concept of 'regional marine planning' comes in. The WA Government has recently announced an initiative designed to provide the integration currently lacking in planning for and managing the marine environment. Put simply, regional marine planning is designed to produce a strategic plan for each marine region, to better integrate the activities of the various marine sectors. The aim is to achieve protection, maintenance and sustainable use of the marine environment. The strategic plans must be based on the best available science but, at the same time, take into account the views of

Previous page
Main Fishing Beach Boat Harbour, Bremer Bay.
Photo – Dennis Sarson/Lochman Transparencies
Insets from left Seaweeds, sea squirts, buffalo bream and Australian sea lion.
Photos – Eva Boogard

Above Aboriginal fish traps, Oyster Harbour.
Photo – Ian Herford

Left Albany Port and commercial charter boat, Princess Royal Harbour, Albany.
Photo – Bill Belson/Lochman Transparencies

Above Watching a pod of five humpback whales in Flinders Bay near Augusta. *Photo – Tourism Western Australia*

marine users. Governments, agencies, maritime industries, non-government organisations and the general public will all play a role in regional marine planning.

It is important to realise that regional marine planning is not the end of the story. Marine strategic plans will be high-level documents dealing with processes and approaches to managing the marine environment. Regional marine planning will not include specific management actions. It will provide a framework within which each of the different marine user groups can conduct detailed planning and management in an integrated way to ensure the overall result is sustainable.

At the State level, a framework for regional marine planning is to be prepared with input from a policy stakeholder group and a new scientific panel (see box). At the same time, the first regional marine planning process is to be initiated for WA's south coast from Cape Leeuwin to the South Australian border. This exercise will be one of the first of its kind in Australia and will put WA among the frontrunners in regional marine planning worldwide.

Putting the State framework in place

A broad-based State marine policy stakeholder group has been established to provide advice to the Western Australian Government on a new regional marine planning framework and on the south coast regional marine planning project. The group is chaired by former Environmental Protection Authority head Barry Carbon. A reference panel of leading scientific experts will also be appointed to provide advice on planning and policy development.

The 'New Horizons in Marine Management' policy, adopted by the State Government in 1994, is to be reviewed and updated with input from the policy stakeholder group to create a new policy on marine conservation reserves for WA.

As regional marine planning gathers pace, a community education program will help to explain the new initiatives and encourage everyone to become involved in the future of WA's unique marine environment.

Frontrunners

Regional marine planning is very much in its infancy worldwide. Around the globe, only a handful of similar processes have been undertaken. These include an Arctic Marine Strategic Plan (2004) produced by the nations with Arctic territories; an Irish Sea Pilot Regional Plan (2005) from the UK; and the Eastern Scotian Shelf Integrated Ocean Management Plan (2006) from Canada.

Australia is also among the leaders. In 2004, the Australian Government released the South East Regional Marine Plan covering Commonwealth waters off Tasmania, Victoria and parts of New South Wales and South Australia. The first regional marine plan for State waters in Australia is the Draft Spencer Gulf Marine Plan released by the South Australian Government in 2006. Western Australia is now taking its place among the frontrunners in regional marine planning.

Marine stakeholders on the south coast and elsewhere will be encouraged to have their say on the key issues affecting the south coast marine environment. Regional marine planning for the rest of the WA coast will be considered in the light of experience with the south coast planning process.

To ensure that the south coast regional marine planning process is scientifically robust, existing information about the region's marine

environment will be collected together for the first time, and included in a geographic information system. This work is being carried out through a project funded by the South Coast natural resource management group, SCRIPT. Ocean habitat types, fisheries data, marine plant and animal distribution, Aboriginal interests and recreation, tourism and port usage information will all be included, enabling the production of maps to aid the planning process. Relevant information on social and economic aspects of the south coast marine environment will also be collated.

Conserving a mixed bag

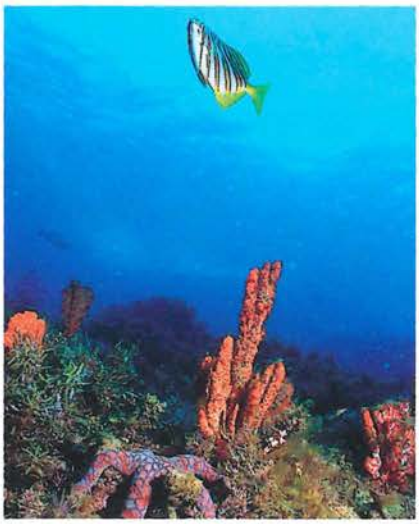
The temperate seas of WA's south coast are subject to the vagaries of the Leeuwin Current. This band of warm, relatively-low-salinity, nutrient-depleted water starts near the North West Shelf, and travels down the west coast, wrapping around Cape Leeuwin and continuing eastwards as far as the Great Australian Bight, though it varies in strength from year to year. In so doing, it transports tropical species of plants and animals to the temperate south coast of WA. Thus the south coast is home to a mixture of species of both temperate and tropical origin.

It is this marine diversity which attracts recreational divers and snorkellers to the south coast and which supports active commercial and recreational fisheries. Commercial fishers target species ranging from crustaceans and abalone, to finfish, sharks and in some years, even scallops. Recreational fishing is a favourite south coast pastime with black bream, cobbler, King George whiting, herring and Australian salmon being caught from the shore and trevally, queen snapper,

Top left Lucky Bay and the Recherche Archipelago.

Centre left Aerial photo of Esperance showing Bandy Creek Boat Harbour bottom centre and Esperance Port upper left.
Photos – David Bettini

Left Information collected during studies on the south coast will guide in the protection of unique assemblages of marine plants and animals.
Photo – Justin McDonald



Above A commercial pilchard catch being unloaded in Albany.
Photo – Department of Fisheries

Above left Sea star and footballer sweep on the coast offshore from Fitzgerald River National Park.
Photo – Eva Boogard

red snapper and sharks among the species favoured by offshore anglers.

Although there have been no comprehensive surveys of marine flora and fauna along the WA south coast, a number of site-specific studies have been conducted. As an example of the biodiversity of the south coast, consider that about 60 seagrass species are known worldwide, with some 20 of these restricted to southern Australia. In the Recherche Archipelago off Esperance, 263 species of fish and an amazing 234 species of marine algae have been identified (see 'Researching the Recherche', *LANDSCOPE*, Winter 2003). Nearly 400 species of marine molluscs have been recorded in the Albany area.

In order to conserve this extraordinary biodiversity, planning will have to consider the need for a network of marine protected areas on the south coast. The 1994 report of the Marine Parks and Reserves Selection Working Group identified areas of conservation interest and these will be reviewed as part of the regional marine planning process. After the Marine Strategic Plan is completed, the Department of Environment and Conservation and other agencies will work with the community and users to consider marine reserve creation in more detail. This process will be carried out under the umbrella of the Marine Strategic Plan to ensure that marine protected areas are integrated with other marine uses.

Though the many marine species are unaware of it, at the three nautical mile limit of State waters, they leave WA and enter Commonwealth waters. Beyond the three nautical mile State boundary, Australia's marine environment is managed by the Australian Government, which is preparing a 'marine bioregional plan' for Commonwealth waters in the 'south-west marine region'. This stretches all the way from Kangaroo Island in South Australia to offshore Shark Bay in WA. As this is happening at the same time as the south coast regional marine planning process, close contact is being maintained between the State and Australian governments to ensure maximum integration of the two planning approaches. Further information about the Australian Government's marine bioregional planning is available from the Department of the Environment and Water Resources website at www.environment.gov.au/coasts/mbp/index.html.

Getting involved

The hub of stakeholder engagement for the south coast regional marine planning process will be a local planning and advisory group. Members of this group will represent the range of marine interests and the geographic spread of the planning region. Commercial and recreational fishers, Aboriginal people, tourist operators, natural resource management organisations, aquaculturalists, conservation groups, local authorities, educators and other interested people were all invited to express an interest in joining the planning advisory group.

More broadly, there is a role for everyone who has a stake in the south coast marine environment. The public will be encouraged to become involved in regional marine planning through calls for comment, regional meetings and the chance to provide submissions to a draft strategic plan. The target date for release of the final marine strategic plan is mid-2008.

Regional marine planning is an exciting new direction to ensure the protection, maintenance and sustainable use of our priceless marine environment. Western Australians are known for their love of the ocean—now we can all help plan for its future.

Ian Herford is the Department of Environment and Conservation's Principal Marine Policy Officer. He is based in Albany, having moved there in 1989 to take up the position of Regional Planning Officer for the south coast region with the former Department of CALM. He can be contacted on (08) 9842 4500 or by email (ian.herford@dec.wa.gov.au).

Special thanks to Carolyn Thomson-Dans, Eve Bunbury, Paula Tomkins and Peter Dans for their input to this article.

One hundred years of the CANNING

It is 100 years since the Canning Stock Route was first surveyed by Alfred Wernam Canning. This 2000-kilometre track that crosses four deserts is a journey through remote, breathtaking country: the breakaways, springs, giant saltpans, mysterious rocky outcrops and endless dunes that have made the 'Australian outback' legendary to the rest of the world.

1897
A long-distance stock route to service Kimberley pastoralists was deemed unviable

1906
An expedition led by Alfred Canning set out to survey an inland stock route to the Kalgoorlie Goldfields

1907
Canning's team leaves the Kimberley to retrace its route to Wiluna and locates more wells

1908
Canning recruits team to construct a series of 52 permanent wells

1910
First commercial drove on Canning Stock Route

1911
Drovers murdered at No. 37 Well

1920s
Wells deteriorate from fire, termites and vandalism

1929
Government contracts William Snell to refurbish wells

1931
Canning completes refurbishment

1940s
Following bombing of Wyndham Harbour, Government commissio further renovation of the wells

Stock Route

by Ken Leighton

1959
The last cattle drive leaves Billiluna at the northern end of the stock route

1963
A survey party took five weeks to travel the length of the route by four-wheel drive

1977
First commercial operator takes tourists along the Canning Stock Route

2002
Access rights for Canning Stock Route travellers preserved by a native title ruling

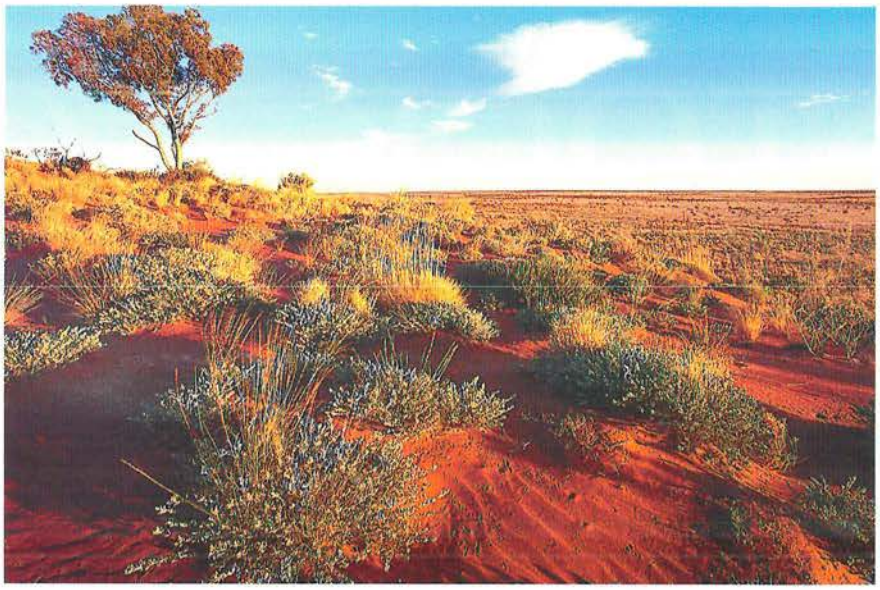
2007–10
Centenary of Canning Stock Route celebrations

In 1906, the State Government, under pressure from Kimberley pastoralists, agreed to investigate the viability of establishing a stock route to bring live cattle to southern markets. David Carnegie had explored the area further east in 1897 but suggested the scheme was "absolutely impracticable". However, a decade later, Alfred Wernam Canning proved him wrong. He found a viable route that has since become known as one of the world's premier four-wheel drive adventures.

A problem and its solution

The Kimberley cattle industry had its beginnings in the 1880s, following marathon overland droving trips from the New South Wales and Queensland cattle areas. The expanding gold mining industry in Kalgoorlie and Coolgardie lay more than 2000 kilometres to the south. The hungry miners provided a ready meat market but the Kimberley cattle were being increasingly affected by ticks and were quarantined from being transported south. The cattlemen reasoned that a 2000-kilometre, well-watered stock route through the centre of the State—and the change of climate along the way—would see the ticks drop off and the cattle arrive in good condition.

Hence, in 1906, an expedition led by Canning set out to survey an inland stock route to the Kalgoorlie Goldfields. Canning, an accomplished surveyor with the Department of Lands and Surveys, had just finished the epic construction of the 1850-kilometre No. 1 Rabbit Proof Fence. With his able deputy Hubert Trotman, Canning spent months preparing for the trip. They amassed an enormous quantity of gear and stores for two years. All had to be transported by camels. They hired well builders, cameleers and general hands and, by May 1906, were ready to leave Day Dawn near Cue with eight men, 23 camels, two horses and the cook's new dog. Ahead of them was the unknown: about 2000 kilometres of sometimes thick bush, spiny spinifex, some 900 soft sand dunes often up to 15 metres high, blazing hot days, freezing nights, scurvy from an inadequate diet and a cantankerous and vindictive cook.



Previous page
Main Durba Hills shine red in the sun along a stretch of the Canning Stock Route.
Photo – David Bettini
Insets clockwise from left
Ranji bush (*Acacia pyrifolia*).
Photo – Ken Leighton
Early expeditions along the Canning Stock Route.
Photos – Courtesy of Landgate

Above Red sand dunes adorn the arid inland of the Canning Stock Route.
Photo – Jiri Lochman

Left Camel tracks in Lake Disappointment in the Little Sandy Desert.
Photo – Marie Lochman

Canning knew that locating a suitable stock route would depend on the ready availability of water. The water had to be potable, at a reasonable depth and at intervals not exceeding a fair day's droving distance (about 25 kilometres). To this end he enlisted local Aboriginal people to act as guides. Often, his wells were sunk alongside or on an Aboriginal waterhole. Canning reasoned that if the Aboriginal well was replaced there was less likelihood of vandalism or pollution by the locals. In 1906, there was little or no Aboriginal cultural awareness. Canning would have been unaware that he himself was committing cultural vandalism and that the consequences would be exacted on some unfortunate future travellers along the route.

Parts of the central Western Australian desert had previously been crossed by a series of dedicated explorers. In his quest for a stock route, Canning crossed the routes of Warburton (1873), John Forrest (1874), Ernest Giles (1876), Laurence Wells of the Calvert Expedition (1896) and David Carnegie (1897). Collectively, they identified key topographic features such as Joanna Springs, Weld Springs, Calvert Ranges, Breaden Hills and Sturt Creek. Canning used this scant knowledge to guide him through the deserts but none had travelled extensively along his prospective route. Canning's own intuition and skills as a surveyor and bushman got the route through, together with a lot of help from local Aboriginal people.

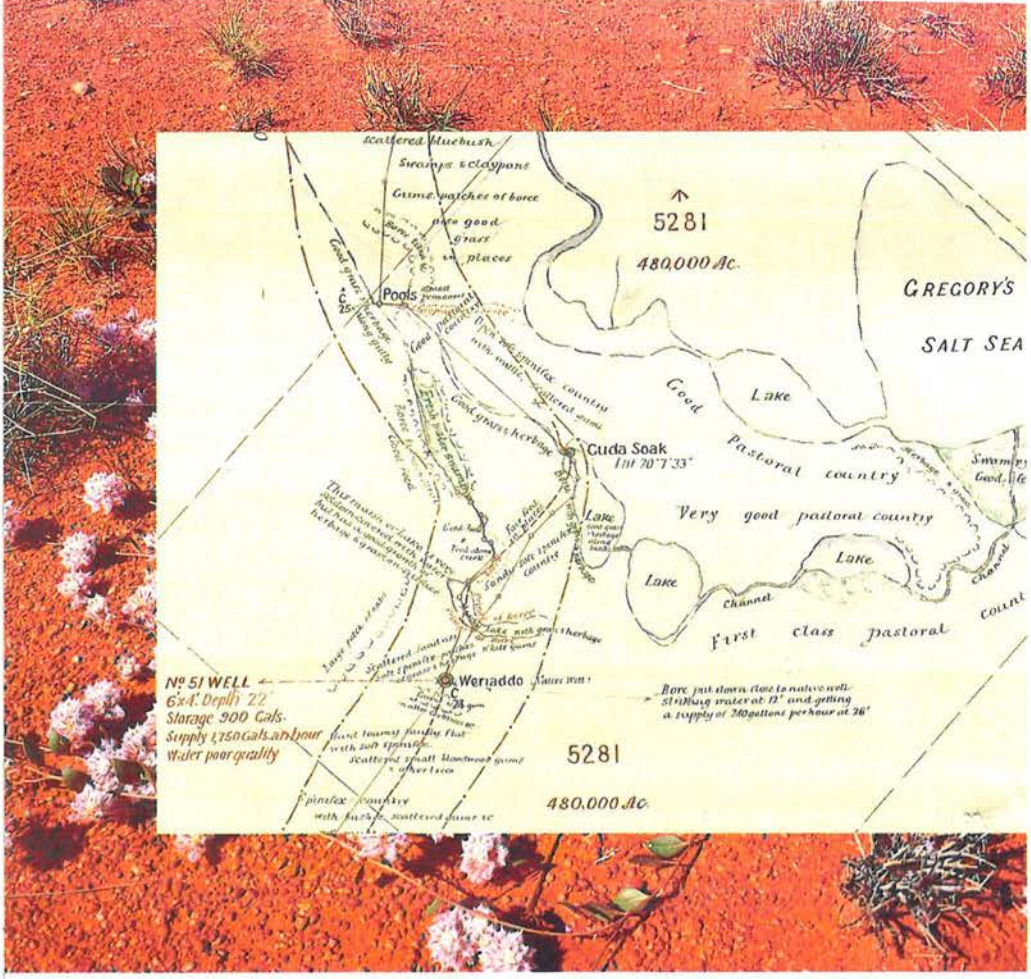
It took five months, about 100 years ago, for Canning and his team to traverse the harsh wilderness of central WA to the Kimberley. After spending Christmas in a rough bush camp in the far north of WA and having sat out the northern summer and replenished their supplies, the team left the Kimberley to retrace its route to Wiluna in February 1907. On this trip they located more wells and test bored potential sites. Two months on, at No. 40 Well, a skirmish between a local Aboriginal man and Michael Tobin, who was employed with his brother as a well sinker, saw both men die in what an investigation deemed was more likely a misunderstanding than a malicious act. These were the first recorded deaths on the Canning Stock Route, but would not be the last.

Boring wells

Canning's enthusiastic report to the State Government was widely acclaimed, especially by the Kimberley cattlemen. So by March 1908 Canning had again recruited a team of hardy souls to embark on the construction of a series of 52 permanent wells. This was to be a two-year project, again of epic proportions. Canning used 70 camels and four wagons to transport 100 tonnes of food and equipment, and 267 goats were herded for meat and milk. The construction team consisted of 30 men, who operated in three groups. The first preceded the others and bored for water, which was then 'on tap' for the second and third teams, which leap-frogged each other and sunk the well around the bore casing.

Above Remains of No. 10 Well.
Photo – Jiri Lochman

It was a very efficient operation and the teams averaged one well every 15 days on the northward journey.



Above left Part of Canning's six-metre-long detailed survey map, prepared in 1907. *Photo – Courtesy of Landgate*

Above Lake Disappointment from the air. *Photo – Jiri Lochman*

Each well was equipped with 13 metres of galvanised trough, a whip pole, pulley, a hand-operated windlass on supporting legs and two 45-litre buckets. All this had to be carried by camel for the entire route—there would be no resupply mission. The wells were timbered from trees found locally, the most common and durable being the stately desert oak (*Allocasuarina decaisneana*). By April 1910 Canning and his team were back in Wiluna, having completed this extraordinary task.

Droving days

The first commercial drover on the Canning Stock Route appears to be George McIntyre in October 1910. He took 42 horses from Pine Creek in the Northern Territory to Coorow in WA. Only nine survived. Next, in December 1910, William Mayberry drove 77 head of horses south, and 13 died along the way. In January 1911, Shoesmith, Thomson, Chinaman and maybe three other Aboriginal stockmen left Halls Creek with a mob of 150 bullocks. From Thomson's diary entries it appears that on or about 26 April they were murdered at No. 37 Well. Cole and Pennefather discovered the bodies on 29 June 1911 while droving a substantial mob of 350 bullocks south.

Despite these difficulties, the concept behind the route worked. The ticks indeed dropped off and died along the way, the cattle flourished, calves were born and all generally arrived in better shape than when they left the Kimberley.

The immediate decline in use of the route has been attributed to fear of attack from Aboriginal people. By the mid-1920s, the wells had become so badly deteriorated—as a result of fire, termites and vandalism—that it was imprudent to drive cattle along the route. In 1929, the State Government contracted a reconstruction team, led by William Snell of Leonora, to refurbish the wells. Snell sank three new wells (3a, 4a, 4b) and erected six windmills and tanks, becoming the first person to make limited use of a motor vehicle along the stock route. However, he failed to complete the refurbishment. In 1930 the State Government asked Canning (now aged 70) to complete the job. For 16 months Canning and his crew systematically resurrected the wells, including most of those previously attended to by Snell. Canning rarely agreed with Snell over the siting of wells and resolutely resited those that Snell had shifted. Between 1911 and 1931 only eight mobs of cattle had used the stock route.

With the advent of World War II and the bombing of Wyndham Harbour—the port by which most cattle were now being shipped south—the then Public Works Department commissioned further renovation of the wells. By 1944, however, Wyndham Harbour had reopened and the more efficient southern shipping trade resumed. Again the Canning Stock Route languished. In the period 1932 to 1959 only 20 mobs completed the journey. The last cattle drive left Billiluna at the northern end of the stock route in 1959.

Route reborn

By this time the Canning Stock Route lay neglected, destined to become a fading dotted red line on maps and at risk of becoming lost forever. The route had served only 30 cattle drives. All that energy and the lost lives hardly seemed worth the effort! Then, in 1963, a survey party took five weeks to travel the length of the route by four-wheel drive. The Canning Stock Route was reborn. By 1977, the first commercial operator was taking wide-eyed tourists along a track on which only cattle and horses and few men had trodden before. More vehicles than cattle have now travelled the length of the Canning Stock Route. It has become an international icon of adventure, but not all have come in four-wheel drives. Beach buggies, a Citroen 2CV, the ill-fated Murray Rankin trolley, motorcycles, camels, walkers, joggers and a helicopter have all conquered the challenge—where the journey itself is the main attraction rather than any destination.

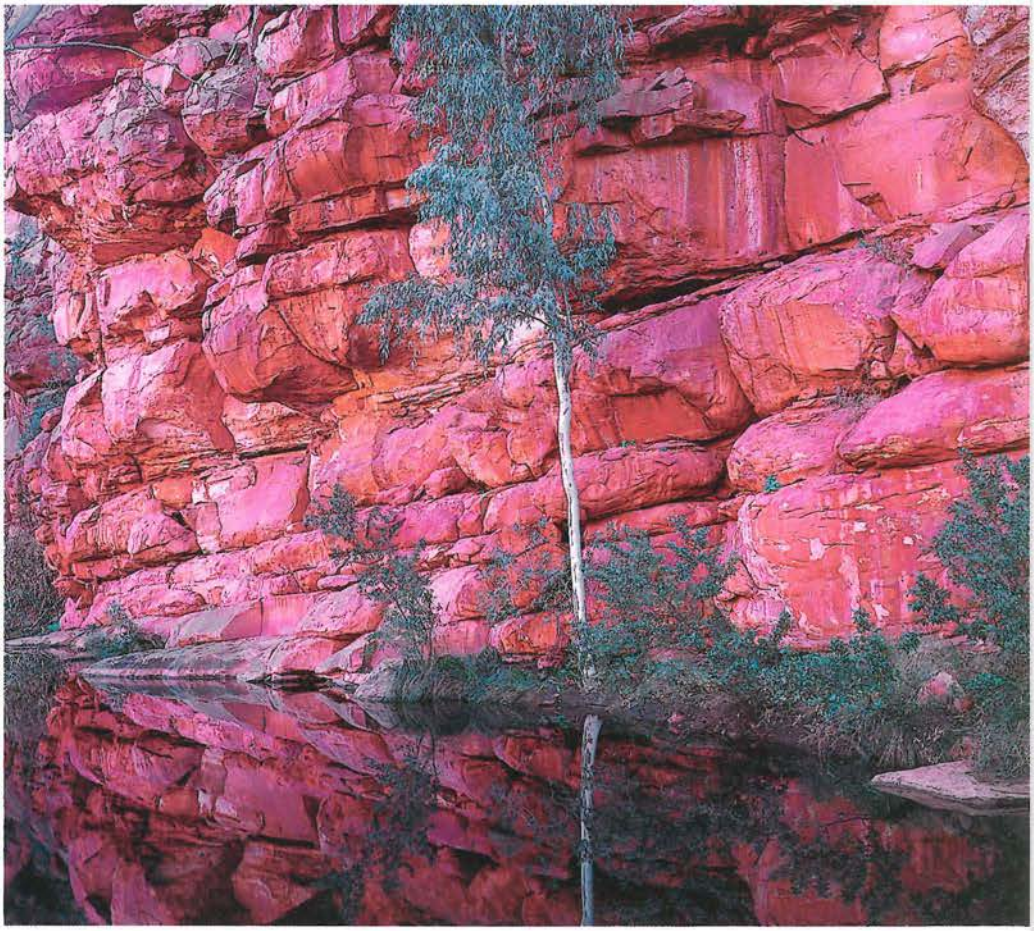
One hundred years ago Canning faced challenges presented by the terrain and carrying enough supplies to sustain him and his party. Today, even in the comfort of a four-wheel drive, the corrugations along the track pose a serious test for any vehicle but the sand dunes are not so formidable for the new breed of four-wheel drive. Information to help prepare for the journey is readily available through the internet and good publications. Thorough preparedness is the key to safely enjoying the serenity and history of the desert environment.

The track offers extremes in scenic diversity. The pastoral country in the south and the ancient salt-lake systems blend into the rugged Durba Hills and the hidden treasures and unlikely permanent waters of Durba and Killagurra springs. Just north, the sand dunes start and the vegetation changes dramatically. After summer rains the spinifex plains produce an abundance of wildflowers and majestic desert oaks provide picturesque campsites. At dawn and dusk, nature seems to be at its most intense. The colours are more dramatic and the wildlife more inquisitive. At any time you would be unlucky not to have a close encounter with the camels, dingoes, kangaroos, emus, bustards, parrots and a great diversity of reptiles that inhabit the route. Contrary to its name, Lake Disappointment will not disappoint. This enormous, usually dry, lake has unique shimmering salt crystal formations and is so hostile in terms of surface roughness and its ability to draw moisture from tissue because it can get so hot, that insects and small animals often die trying to cross it. Often their skeletal remains are preserved by the salt. Its sheer size and purity commands respect. It should not be driven on as it is significant to the traditional Aboriginal owners and its unique ecosystem can be damaged easily.

It is probably unavoidable that access to the Canning Stock Route will need to be more rigorously controlled in order to protect its natural and cultural values. Few tourist icons left in the world have no active management to promote a sustainable future. Just as Canning would not have envisaged the transition from cattle to cars, it is difficult to predict what might be in store for the route in years to come. The cost of fuel will make some reconsider the journey, and the corrugations are a test of man and metal. However, few who have completed the journey would not consider themselves privileged.

Left Euros are a common sight on the Canning Stock Route.
Photo – Jiri Lochman

Below Durba Spring provides a scenic setting along the route.
Photo – David Bettini



Above Salt flats on Lake Disappointment.
Photo – David Bettini

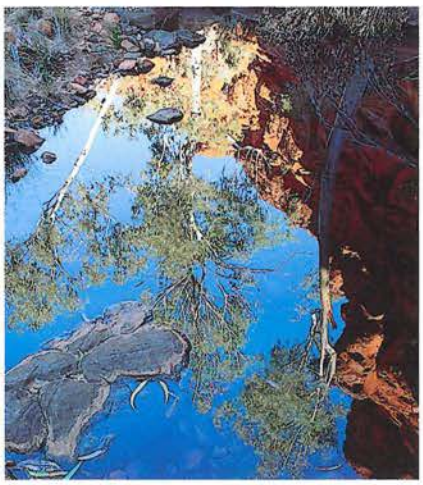
Right The Canning Stock Route now serves as an exciting tourist attraction.
Photo – Ken Leighton

Centenary celebrations

It has been 100 years since Canning and his team set out into the unknown. Can the culture and heritage of the Canning Stock Route be preserved for the next 100 years? To celebrate its centenary a program of events has been compiled by Landgate (formerly the Department of Lands and Surveys and Canning's employer). A number of State and local government agencies, TrackCare, private industry, Aboriginal interest groups and research and tourism groups have been invited to take part in the program of events through to 2010. The public will be invited to become involved through a number of Department of Environment and Conservation *LANDSCOPE* Expeditions over the ensuing years. For more information on the *LANDSCOPE* Expeditions visit www.naturebase.net.

The program of celebration will be divided into four streams: *science*, incorporating the *LANDSCOPE* Expeditions and geographic studies; *history and heritage*, to audit, register and help preserve heritage assets, record oral histories and produce various publications; *art and culture*, to facilitate access and participation in community events; and *tourism*, to develop tourism strategies through education programs involving local Indigenous communities. The centenary initiative is still in its early stages and events have yet to be properly scheduled. However, it has become apparent that sustainable management of the Canning Stock Route into the future will involve local Aboriginal communities with strong ties to the area (see box).

There has never been a time in the Canning Stock Route's history that didn't present a challenge to those who sought to travel along it. The centenary project is not a publicity campaign to get more people on the track. The route doesn't need more people. It needs more informed people, better management and a mindset change for the outback tourist. This is already beginning, with more responsible attitudes to removing rubbish and leaving campsites in better condition than they were found. Encouraging travellers to show temperance in lighting up the traditional romantic campfire is a challenge that has a way to go, but the biggest cultural change will be acceptance of and respect for native title and all that it entails.



Above Trees reflect from the waters of Durba Springs.

Below right Camels are common along the route.
Photos – Jiri Lochman

Access rights for those wishing to travel along the Canning Stock Route were preserved in the native title determination by Justice French in 2002. However, the native title claimants have what amounts to common law title over areas along the route. For some time, traditional owners have been concerned about uncontrolled access to their significant sites and about them being photographed, published, and, in extreme instances, vandalised. Although the Aboriginal heritage along the route is of interest to tourists and an integral part of the cultural narrative, until such time as access permissions can be negotiated, the traditional owners have requested that people respect their heritage and refrain from visiting significant sites. Further information on access restrictions to significant areas can be obtained from the Ngaanyatjarra Council in Perth (phone 1800 189 936).

The Canning Stock Route's rich history—starting with Canning's epic journeys of discovery and well construction, and embracing the tough Kimberley cattlemen and drovers, the Aboriginal stories and, much later, its morphing into a tourist attraction—has ensured the dotted red line on the map will last well into the future. The centenary projects over the next four years will help to preserve the many unique qualities of the route for the next generation of adventurers.

The Old Bullock Road – Warntarri Purlumanupurru

The Canning Stock Route, or Warntarri Purlumanupurru, crosses the traditional lands of the Walmajarri and Wangkajunga people to the north of the Percival Lakes and the Martuwanga people to the south to Wiluna. These were the nomadic Aboriginal people who Canning used to guide him through the deserts. Collectively they form part of a wider Western Desert community who long ago left the desert lifestyle behind, ironically travelling along the stock route to settle in established communities like Fitzroy Crossing, Billiluna, Mulan or Jigalong, Punmu and Kunawarritji (No. 33 Well) and Parnngurr (Cotton Creek) to the south.

These Aboriginal people had never seen a white man or clothes before nor a horse or camel. These were alien things in their lands that disrupted their solitude. And they wanted the most precious of their resources, their water. It is little wonder that the Aboriginal people in these areas were often aggressive to approaches by the explorers.

After a rapport had been struck, however, Aboriginal people would accompany the exploration team and show them where to find water. Some were probably coerced into the role but others stayed on voluntarily with their wives after they finished acting as guides and continued to draw on the rations they received. Canning was adamant that without the help of the local Aboriginal people he couldn't have completed his task and issued them with team medals when they left. However, despite a Royal Commission investigating the claim of a disgruntled cook exonerating Canning of ill treatment, many Aboriginal people were not well treated 100 years ago.

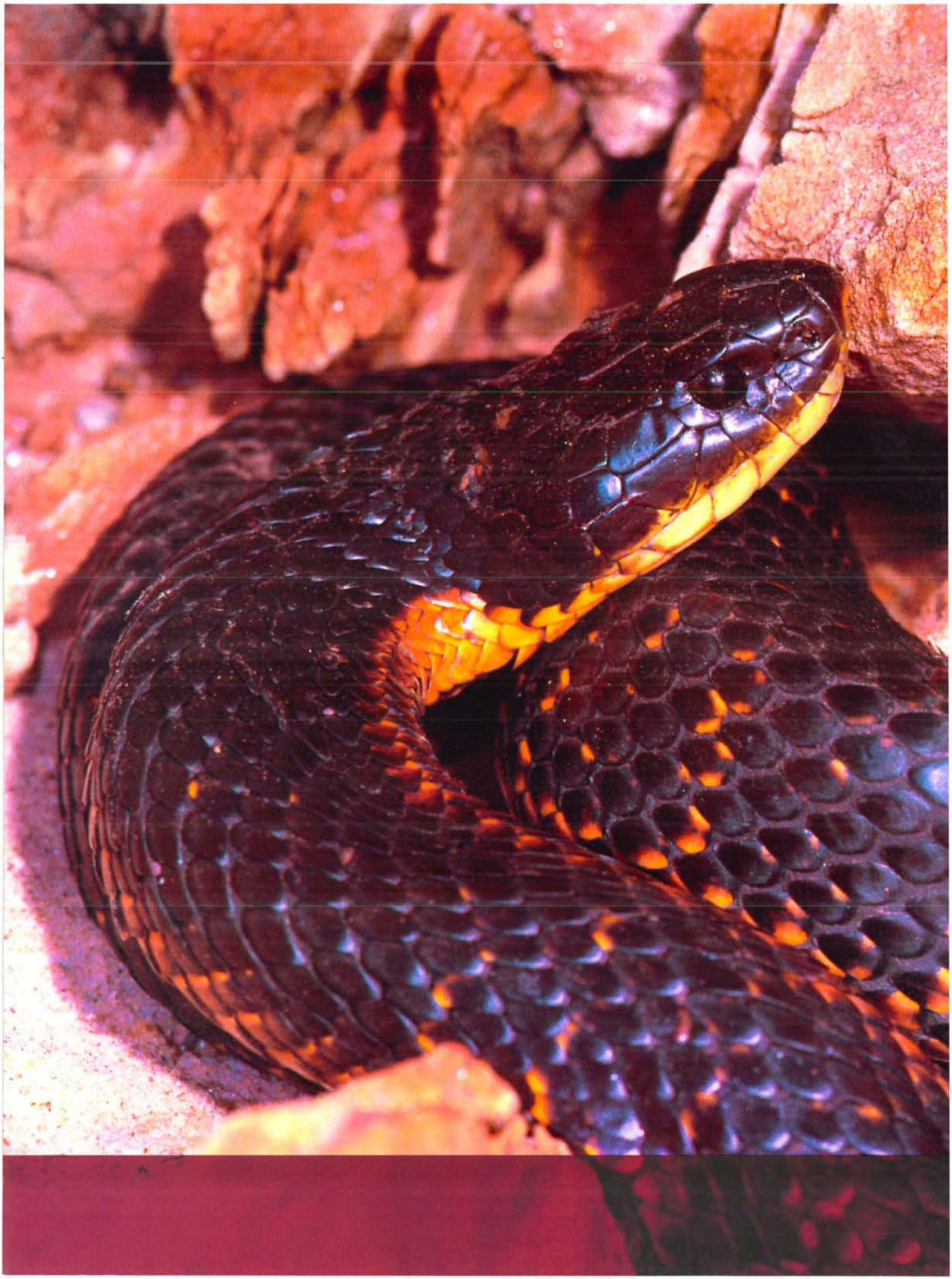
After the completion of the Canning Stock Route and the 52 wells, the guaranteed supply of water about every 25 kilometres meant Aboriginal people could more readily move about the deserts. The water also attracted wildlife, making it easier to gather food.

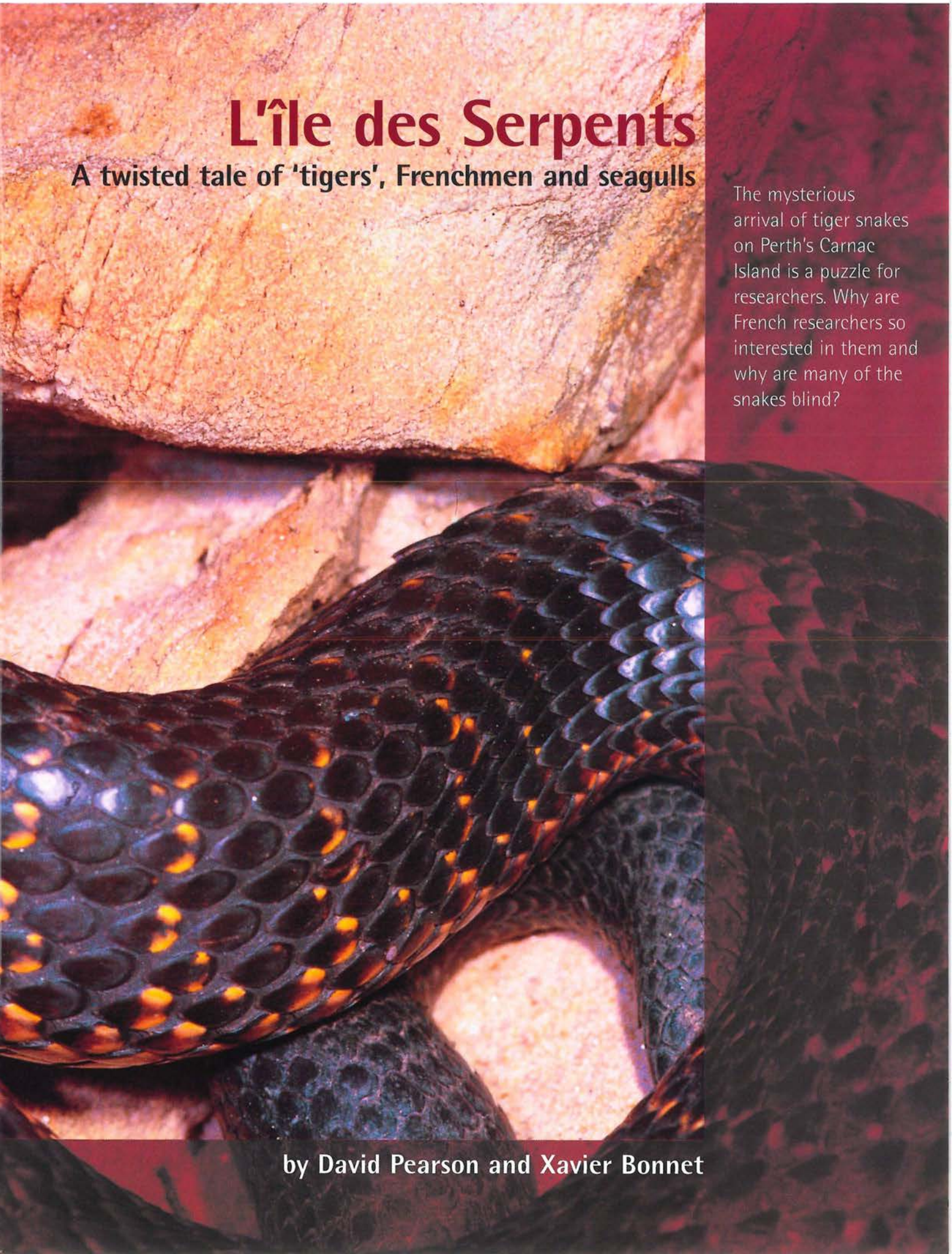
Today the senior men and women who were born (to parents who would have known Canning's survey and construction teams) and raised in this area never knew their land without the drovers and other transient non-Aboriginal people, or without the introduced camels and the feral cats and foxes that displaced so many of the native species. They had to adapt to European culture and accommodate neighbouring linguistic groups who were displaced from their hunting grounds by Europeans.

Their traditional ties with country were recognised by Justice French in his determination of the Martu Native Title claim over the mid-section of the Canning Stock Route. Significant sites along the route remain important to Aboriginal culture. As part of the centenary celebration programs proposed over the next four years, organisations such as the Australian Institute of Torres Strait Islander Studies intend to rigorously document the traditional culture and art. The Alice Springs-based Desert Knowledge Cooperative Research Centre has also instigated a program to seek opportunities for desert communities to take advantage of the burgeoning tourist market, such as active participation in desert guide programs and co-management arrangements for the Canning Stock Route.

It is hoped that such programs will benefit Aboriginal communities and all who wish to experience the unique qualities of the Australian outback.

For more information on the celebration of the centenary of the Canning Stock Route contact Ken Leighton, Project Manager, Geographic Services Branch, Landgate, PO Box 2222 Midland 6936, phone (08) 9273 7130 or email ken.leighton@landgate.wa.gov.au.



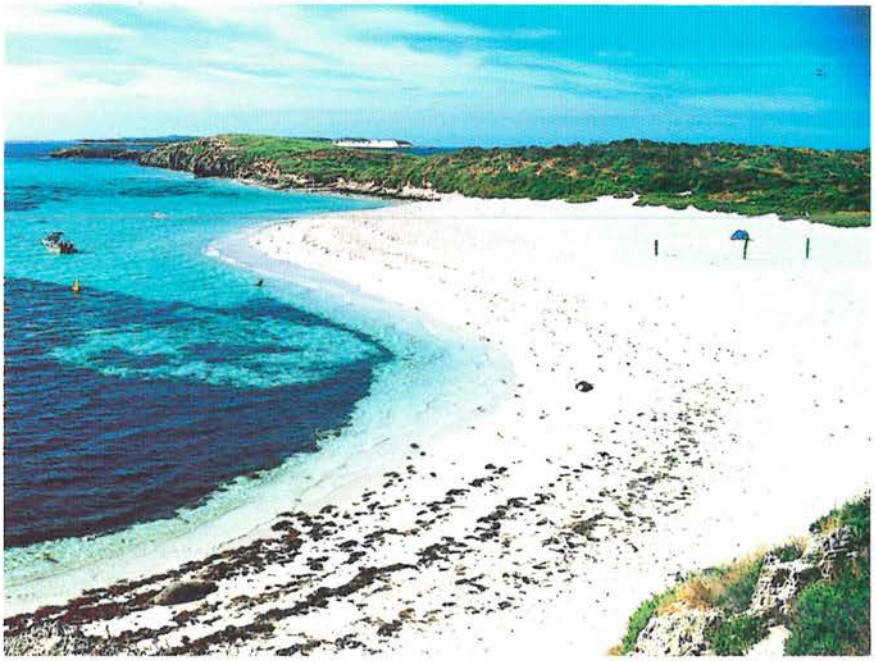


L'île des Serpents

A twisted tale of 'tigers', Frenchmen and seagulls

The mysterious arrival of tiger snakes on Perth's Carnac Island is a puzzle for researchers. Why are French researchers so interested in them and why are many of the snakes blind?

by David Pearson and Xavier Bonnet



Previous page
Main Tiger snake.
Photo – Jiri Lochman

Above Carnac Island's main beach.
Photo – David Pearson/DEC

Below Carnac Island.
Photo – Dennis Sarson/Lochman Transparencies

Carnac Island lies about 10 kilometres south-west of Fremantle, rising from the sea between its better-known and larger neighbours, Garden and Rottnest islands. Several thousand years ago, all three were joined to the mainland when sea levels were significantly lower. Nyoongar people knew this little island as Ngooloormayup, which means 'place of little brother' (Rottnest Island was the big brother).

French explorer Louis de Freycinet, captain of the *Casuarina*, was the first European to give the island a name, Île Pelée (meaning 'Bald Island'), in 1803. Captain James Stirling changed its name to Carnac Island in 1827 in honour of his First Lieutenant John Carnac. Two years later, Stirling returned as Lieutenant Governor with settlers to establish the Swan River Colony. One of his ships, the *Parmelia*, ran aground between Woodman Point and Carnac Island and 29 people were forced to spend five days on the island until their vessel could be refloated. Since that time, Carnac Island has been used briefly as a jail for Aboriginal prisoners, a whaling station and a quarantine station for the Port of Fremantle. During World War I, Carnac was acquired by the Commonwealth Government for defence purposes. It was returned to the State Government in 1961 and was declared a nature reserve in 1963.

After a 200-year absence, the French have returned to Carnac Island on a new quest of discovery. The attraction now is a remarkable population of tiger snakes (or just 'tigers' to their devotees) that exist on this tiny island of just 19 hectares. A chance meeting at a conference in Chizé, a little village 200 kilometres north of Bordeaux in west central France, led Professor Don Bradshaw of The University of Western Australia to invite herpetologist Xavier Bonnet of the Centre National de la Recherche Scientifique (the French equivalent of the CSIRO) to visit Perth to conduct ecological research on tiger snakes (*Notechis scutatus*). In 1997, Xavier travelled from his base in Chizé (which, as Xavier is keen to explain, was the site of a French victory over the British in 1373) to Perth to begin research. Since that trip, the work has blossomed to include researchers from the Department of Environment and Conservation (DEC) and the University of Sydney. The island has also been a major field site for two students who completed their doctoral studies on the evolutionary ecology of tiger snakes.

Mysterious origins

Tiger snakes occur across temperate southern Australia, including Tasmania. Their presence on a number of islands in Bass Strait and around the South Australian coast is well known. On some of these islands they feed primarily on muttonbird chicks and grow to impressive sizes, with some

Right Juvenile tiger snake.
Photo – Jiri Lochman

Right below Snake showman 'Rocky' Vane displaying tiger snakes at Perth Zoo in 1928.
Photo – Courtesy of John Cann

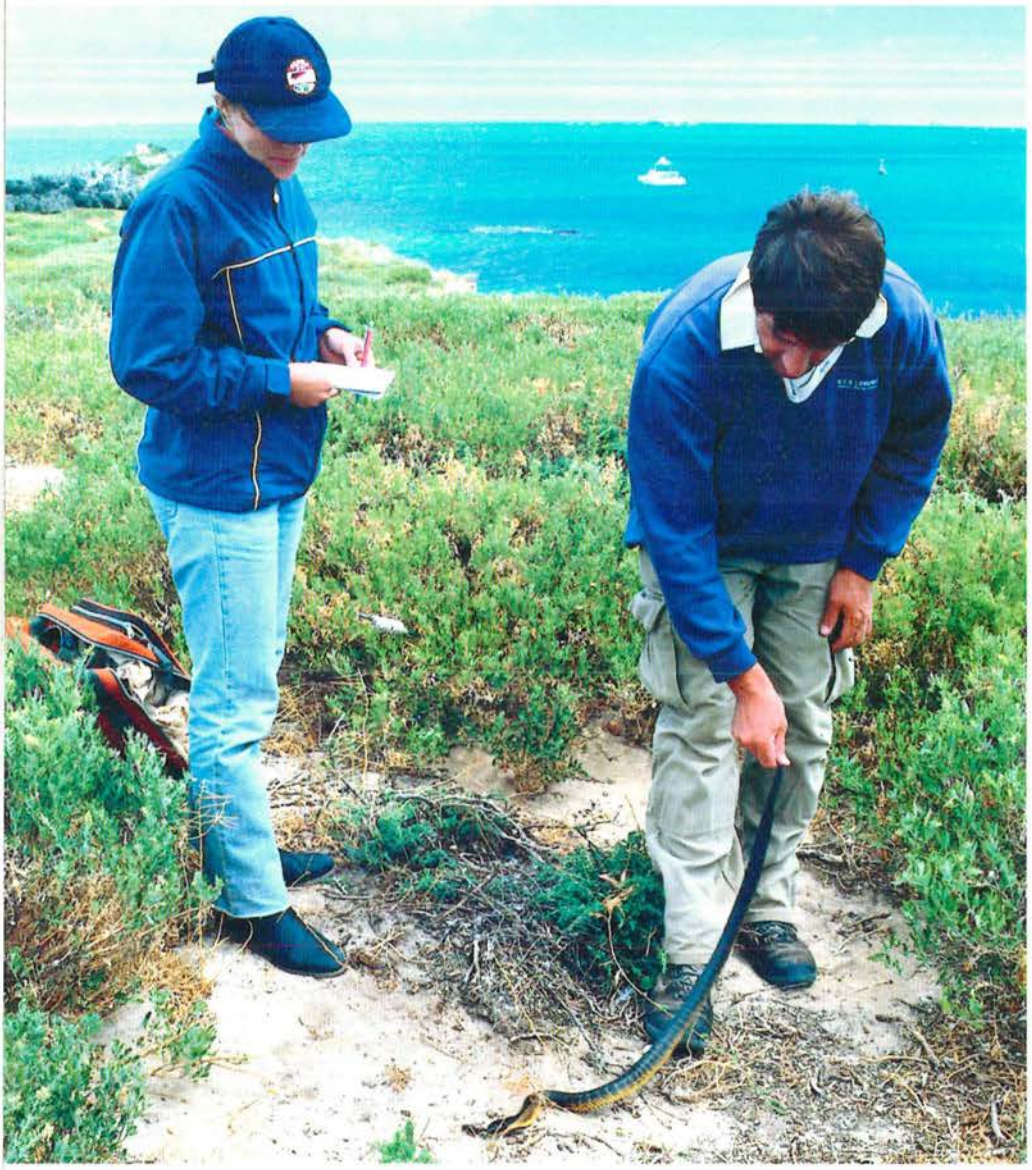
individuals reaching two metres in length. As tiger snakes eat their prey whole, and the chicks grow very rapidly, they are only able to swallow them early in the breeding season, so are often forced to fast for much of the year. Other neighbouring islands shelter dwarf tigers that feed heavily on lizards. Study of these populations by researcher Terry Schwaner provided an early example of the ability of snakes to evolve rapidly to cope with differing environmental conditions.

On the mainland, tiger snakes are typically day-time hunters and feed on lizards, birds, small mammals and frogs. Because of their love of frogs and sometimes tadpoles, tiger snakes are often found around the margins of freshwater swamps. They are accomplished swimmers and, around Perth, are frequently seen at places such as Herdsman Lake Regional Park. Tiger snakes only occur on two WA islands: Carnac and Garden islands.

The origins of the Carnac Island tiger snakes are a mystery. Were the ancestors of these snakes marooned on Carnac Island by rising sea levels 6000 to 7000 years ago? It seems unusual for such a small island to have had a large predator survive over such a long time period. Perhaps, being capable swimmers, tiger snakes were able to colonise Carnac Island from the larger Garden Island. As tiger snakes have been observed in the ocean off Carnac Island, it does seem possible that they could swim between the islands.

Another bizarre but plausible explanation is that a snake showman, 'Rocky' Vane (derived from Vagne, the surname of his French grandfather), released tiger snakes on Carnac Island. Vane travelled around Australia in the 1920s, displaying snakes and selling his own snakebite antidote. Sometimes he would allow tiger snakes to bite him to demonstrate the qualities of his home-made antidote. In fact, recurrent bites probably maintained his immunity against the venom, and offered a better protection than his 'antidote'. Vane and his wife Dot worked their way to Perth, where he was anticipating huge crowds as female snake-handlers had not been seen in the west.

However, in January 1928, his wife was bitten and died. He took on a new partner, Harry Melrose, who was also bitten by a tiger snake and died in 1929. As a consequence, the coroner recommended that snake exhibitions be banned in WA. This much of the story can be verified from newspaper reports and investigations by herpetologist and author John Cann, but the remainder is as yet unconfirmed. According to a gentleman who contacted DEC 20 years ago, he had accompanied Vane when he rowed out to Carnac Island with his disgraced tiger snakes



and released about 40 on the island. Genetic testing of the Carnac tigers has been inconclusive in determining their precise origin; an unsurprising result. This is due to remarkably low genetic divergence between all populations, including WA and eastern Australian tiger snakes. The tiger snakes exhibited by Vane were probably caught around Perth, but current genetic markers cannot distinguish sub-populations within WA. An additional complication is that the two hypotheses for their origin are not exclusive—the Carnac tigers may be a mix of original Carnac snakes and those introduced by Vane, as it is likely that any tiger snake mating combination would be fertile.

Studying large venomous snakes

Conducting research on venomous species requires particular precautions to minimise the risk of being bitten, along with a contingency plan should this occur. Carnac Island tiger snakes appear to be much more 'relaxed' than their mainland compatriots and are easier to catch. Nonetheless, handling the snakes is kept to a minimum. Tiger snakes are not particularly tolerant of heat and tend to bask early in the day, then retreat to shelter. Consequently, most of the fieldwork was conducted in September, October and early November, when nights are cool and days are mild. At this time of year, tiger snakes are mating and feeding, and the females are developing follicles (they bear live young in later summer). Large numbers of tiger snakes could be captured early in the morning by searching the island when they were likely to be basking.

Once located, the tiger snakes were pinned with a padded stick, then placed in calico bags and carried back to the beach. Here, under a shade shelter,

Above Left Tiger snakes usually have distinctive yellow bands.

Left Tiger snakes are handled with extreme caution by the scientists who research them.
Photos – David Pearson/DEC

Above Xavier Bonnet measuring a tiger snake.
Photo – David Pearson/DEC

each snake was measured and weighed. The stomach was gently squeezed to feel for prey items and, if possible, droppings were examined to see if they contained fur, feathers or scales. Adult female snakes were carefully palpated to determine if they contained follicles. Each snake was then individually marked by removing a few scales and returned to the site of its capture.

Over the past decade, more than 570 individual snakes have been captured, with many caught repeatedly over that period (1077 recaptures). Being able to collect such long term mark–recapture data for a snake species is unusual. Typically snakes do not occur in high densities, they have cryptic habits and are hard to capture and recapture. The beauty of the Carnac population is the density of the population and its novel ecology.

Heaven for serpents?

Carnac Island offers abundant food for tiger snakes in the form of small lizards, introduced house mice and birds. Diverse shelter from the sun and the cold of winter is available in limestone crevices and beneath large bushes. Once the snakes reach adult size, they appear to have no predators. Is it something close to heaven for a snake?

Juveniles are rarely observed and we do not know what may eat them. There is no evidence of cannibalism by larger snakes based on our examination of their diet. The reputation of Carnac Island for its tiger snakes—and the existence of a sanctuary zone limiting public access over much of the island—means there are few human-snake interactions which, on the mainland, usually lead to snake deaths.

Population estimates based on the mark–recapture study show that Carnac Island has between 250 and 400 adult snakes. This translates to a very high density of snakes—about 20 per hectare—an exceptional number for a vertebrate predator. How is the island able to sustain such a large number of snakes? The answer lies with the combination of large populations of house mice and silver gulls (*Larus novaehollandiae*). The vast breeding effort of the thousands of gulls results in many chicks and thus plenty of food for tiger snakes. If Carnac Island was not as close to the Perth metropolitan area, there would be many fewer gulls. The resources around the island alone could not support their numbers, but most of the Carnac gulls are commuters. They make frequent trips to the mainland to scavenge at rubbish tips and along the coastal strip (such as around food outlets), and so are able to obtain sufficient resources to breed in their thousands on Carnac Island. The large mouse population provides abundant food for new hatchlings, juveniles and small adult tigers. It is likely that the mice also benefit from the resources returned to the island by the gulls in the form of droppings that provide nutrients for plants.

Carnac Island also has many other conservation values. It is an important breeding site for a variety of seabirds including little penguins, wedge-tailed shearwaters, pied cormorants and Caspian, bridled and crested terns. The Australian sea lion (*Neophoca cinerea*)—one of the world's rarest species of seal—hauls out on its beaches to bask and digest its food. Carnac Island is frequently used as a resting site for male sea lions taking a break from breeding activities on islands further north.

Surprising discovery

Examination of the tiger snakes that were caught led to a novel observation. Many of the adult tiger snakes had large wounds on their bodies and especially their heads. There was no apparent predator of adult tiger snakes on Carnac Island, so what was inflicting the wounds? It didn't take long to

Left Researcher Olivier Lourdais wearing the latest fashion in amphibous French field gear for snake catching.

Middle left Many Carnac Island tiger snakes have wounds to their heads.
Photos – David Pearson/DEC

Bottom left Seagull chicks are important food items.
Photo – Jiri Lochman

establish the identity of the culprits. Adult tiger snakes feed mainly on silver gull chicks. An estimated 3000 to 4000 pairs of silver gulls nest on Carnac Island each year, so nests are spread across most of the island and situated close together. In spring, tiger snakes never need to go far to locate a gull nest with a chick. The adult gulls aggressively defend their nest from tiger snake raids, inflicting pecks to the body and head. Though the snakes are rarely perturbed by the seagulls, over time, some of the tiger snakes are badly damaged.

Around 5 per cent of the adult tiger snakes on Carnac Island are totally blind as a result of the pecking. Basic evolutionary theory (for instance, 'survival of the fittest') suggests that the loss of a major sense such as sight should lead to the starvation and death of these tiger snakes. Much to our surprise, blind tiger snakes were recaptured from year to year (some of them surviving the entire survey period from 1997 to 2006). They continued to catch food, gain weight and were found mating with other snakes. Despite their loss of sight, they were able to successfully function, implying either that vision was of little importance in locating prey and mates or that, once blinded, they were able to change their hunting technique.

Simple laboratory experiments showed that blindfolded tiger snakes had great difficulty catching mobile prey, so what was the explanation? The field data on the diet of Carnac tiger snakes indicated that blinded tiger snakes fed entirely on seagull chicks. There is only one record of consumed mice among hundreds of samples. Normally-sighted snakes ate gull chicks, but also took more mobile prey such as mice and lizards.

Above David Attenborough visited Carnac Island with a BBC film crew.
Photo – John Hunter/DEC

Therefore, blind tiger snakes were able to survive on Carnac Island because of the abundance of an immobile prey in the form of gull chicks that could be readily located by smell. This also explains why blind snakes are always large individuals—only huge tigers can swallow the chicks and so are subject to gull attacks.

This unusual feature of Carnac Island tiger snakes led to their recent inclusion in a forthcoming television series on reptiles called *Life in Cold Blood*, to be narrated by David Attenborough. In November 2006, Attenborough visited the island with a BBC film crew and local herpetologist and educator Brian Bush to document the remarkable ecology of the Carnac Island tiger snakes on film.

Questions for the future

Long term mark–recapture studies of snakes are rare, perhaps due to the difficulties of securing ongoing funding to study a species without an obvious charismatic 'cuddle factor'. People query why you would bother to research a large venomous snake on a tiny island and question its relevance to the conservation of biodiversity on mainland Australia. The Carnac Island study of tiger snakes has generated a valuable dataset with limited fieldwork (six to seven days per year for the capture of around 150 snakes per annum) that is useful for ecological comparisons with snakes elsewhere. It illustrates the remarkable ability within a species to cope with differing environmental conditions and change. Tiger snakes are important predators on Carnac Island, consuming several thousand seagull chicks each year in addition to vast numbers of mice and lizards, in contrast to their predominantly frog-eating mainland relations. Without the kind of information collected by such studies, there are few opportunities to establish educational programs (including natural history documentaries) that explain the interesting ecology of species rather than focusing on the sensational, such as the killing power of venom and the 'danger' of tiger snakes.

Despite the volume of data collected on the Carnac tigers, there are still unresolved questions that have wider implications for conservation. Why, for instance, do we catch many more males than females? Is it due to different sex ratios of births, or do females have higher mortality rates? Or perhaps males are just more easily captured due to more overt behaviour. High density populations of species on islands are very valuable to undertake cost-effective research that would be difficult and expensive to do elsewhere. So, despite the passage of 200 years since the visit of Freycinet, the unique wildlife of the south-west coast continues to attract scientific interest from both local and French researchers.

David Pearson is a Principal Research Scientist with DEC. He has particular research interests in threatened reptiles and mammals, impacts of the cane toad and biological survey.

Xavier Bonnet is a scientist with the Centre d'Etudes Biologiques de Chizé, Centre National de la Recherche Scientifique and works on evolutionary and ecological questions concerning a range of reptiles including adders, sea kraits and tortoises.

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endangered by Mia Morley

Scott River Ironstone Association

Remarkable plant communities associated with restricted areas of massive ironstone occur in a number of areas in Western Australia's south-west, including the Scott River, Gingin and Busselton areas. These communities are among the State's most threatened and each is characterised by different plant species.

The Scott River Ironstone Association, an endangered ecological community, is confined to shallow soils over massive ironstone in the Scott Coastal Plain near Augusta. Many of the species in this heath and shrubland community have highly restricted distributions, can only reproduce from seed and are susceptible to *Phytophthora*-caused dieback. Five declared rare flora and 18 priority flora occur in the community, of which five are endemic to the area.

The community is variously dominated by melaleucas, hakeas or kunzeas, and there are many occurrences of beautiful and diverse annual flora. The community composition varies as a result of different soil depths and types over the massive ironstone but it is usually found in areas with soil depths of up to half a metre and often where there are ironstone outcrops. This impermeable layer of ironstone results in the pooling of rainwater and, in combination with high groundwater levels that may reach the surface, causes waterlogging during winter. A suite of aquifers within sand or sandstone occur beneath the Scott River Ironstone Association. Shales, siltstones and clays occur between these aquifers and restrict the vertical and horizontal flow of water to varying degrees. The major aquifer of the Scott Coastal Plain is the south-west Yarragadee Formation.

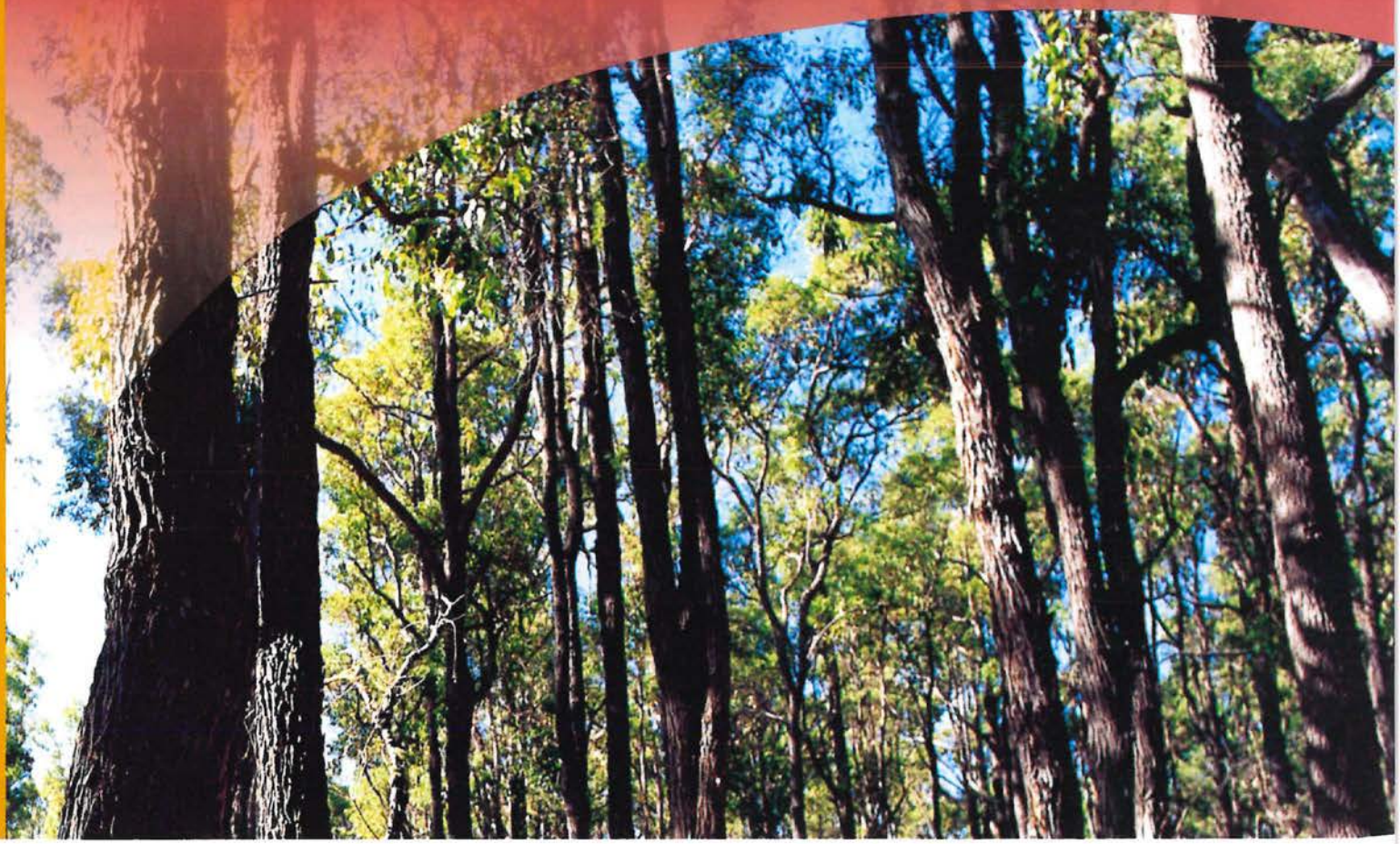
The original extent of the community was about 1780 hectares of which only 325 hectares remain uncleared—an 82 per cent loss of the community's area, that was already highly restricted in distribution. The remaining areas are threatened primarily by dieback, grazing and changes in groundwater levels.

An interim recovery plan for the community outlines recovery actions such as mapping, prevention and treatment of dieback, fencing remnants, and monitoring water levels and quality. These actions are implemented by the South West Region Threatened Flora and Communities Recovery Team, the Bunbury Naturalists' Club and local authorities. It is hoped that what is left of this unique ecological community and the many rare flora it supports will be protected and conserved with the continued assistance of these organisations, local landholders, and other key stakeholders.

Photos by Mia Morley (main) and Janine Liddelow (inserts)

Will curiosity kill the cat?

Research examining fox and cat interactions in the northern jarrah forest is adopting some new technologies to try to untangle the complicated interactions between introduced and native predators.



by Paul de Tores and Oliver Berry

In Western Australia, research aimed at improving control of introduced predators, specifically the fox and feral cat, is taking on new dimensions. The Department of Environment and Conservation (DEC, formerly CALM) has been at the forefront of introduced predator control. DEC has demonstrated many native species increase in abundance when fox numbers are reduced and has shown the importance of controlling foxes before initiating native wildlife translocation programs.

A spectacular example is the response to fox control by the black-footed rock-wallaby (*Petrogale lateralis*) at Nangeen Hill and Mount Caroline in the Wheatbelt. Baiting for fox control at these reserves—both small granite outcrops with remnant vegetation in a sea of agricultural land—began in the 1980s and resulted in dramatic and sustained increases in rock-wallaby numbers. A similar response has been shown by tammar wallabies (*Macropus eugenii*), at Tutanning Nature Reserve, east of Pingelly, where the number of tammar wallabies increased to nuisance levels—an unusual problem for a conservation management agency.

These examples are convincing and show the benefits of fox control. However, disturbing patterns have recently emerged. At some sites where foxes have been controlled for several years, the initial pattern of native species recovery has not been sustained. For example, by the late 1990s at Leschenault Peninsula Conservation Park north of Bunbury, translocation of western ringtail possums (*Pseudocheirus occidentalis*) seemed to have been successful. However, follow-up research in 2002 and from 2004 to 2006 revealed the population had significantly declined, despite reduced numbers of foxes. Intensive monitoring of radio collared ringtails since 2004 showed the fox was no longer a problem at Leschenault. However, the feral cat (*Felis catus*) and the native south-west carpet python (*Morelia spilota imbricata*) seemed to have taken over the role of the fox. These predators accounted for more than 95 per cent of predation of radio collared western ringtail possums since 2004.

A similar pattern emerged from *Operation Foxglove*, the large-scale fox control program in the northern jarrah forest from 1994 to 2000. The data strongly suggested predation by feral cats increased when fox density was reduced. Cat predation on translocated populations of woylies (*Bettongia penicillata*) increased in two of the three areas where fox control had been carried out. This pattern has also occurred at other sites where woylies have been translocated.

Mesopredator release—what is it?

The pattern of an increase in one or more subordinate predators (such as feral cats) after the removal or reduction in numbers of a dominant predator (such as the fox) is known as 'mesopredator release'. It can be caused by changes to simple or complex interactions between these predators. Removing or reducing numbers of the dominant predator clearly advantages subordinate predators. They are no longer preyed upon directly by the dominant predator, and no longer have to compete with it for resources. When the dominant predator is removed, or reduced in number, the absence of its territorial defence mechanisms (such as physical aggression or strategic

Previous page
Main Jarrah forest.
Photo – Chris Garnett/DEC
Inset Feral cat from Leschenault Peninsula Conservation Park.
Photo – Paul de Tores/DEC and Suzanne Rosier

Above left Tammar wallaby.

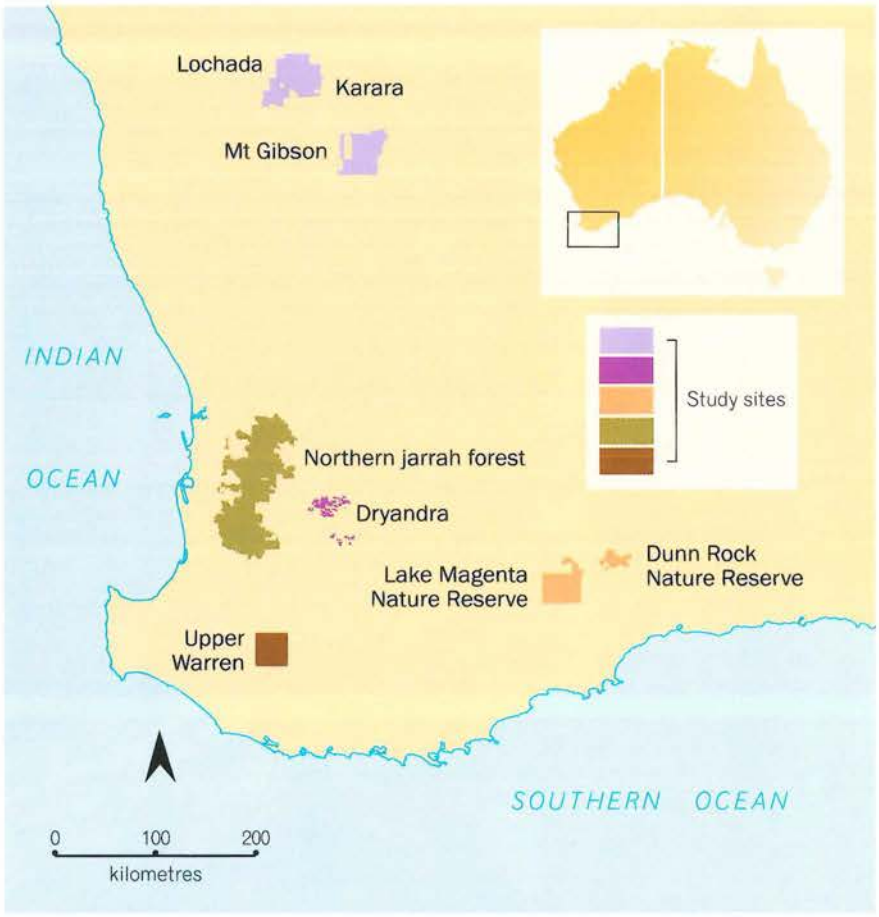
Left Black-footed rock-wallaby at Mount Caroline.
Photos – Jiri Lochman

Right Western ringtail possums.
Photo – Geoff Taylor/Lochman Transparencies

placement of faeces and scent markers) also frees up the environment for the previously subordinate predators.

These interactions are difficult to predict, so there is considerable debate in the scientific community about the benefits of reducing numbers of, removing, or adding predator species. Some believe the phenomenon of mesopredator release is an argument for reintroducing the dingo (*Canis lupus dingo*) to parts of mainland Australia where it is no longer present. Some anecdotal evidence suggests fox numbers remain low in the presence of dingos. However, the dingo is thought to have arrived in Australia as recently as 3500 to 4000 years ago and it has no affiliation with Australia's Gondwanan heritage. Reintroducing it may not be appropriate if the intent is to restore Australia's native fauna. Proposals to reintroduce the dingo certainly receive a mixture of responses, often heated, from conservationists, ecologists, pastoralists, graziers and politicians.

Mesopredator release may also be an argument for reintroducing the Tasmanian devil (*Sarcophilus harrisii*) to mainland Australia, where it was present until relatively recent times (ironically, the dingo has been implicated in its demise). Reintroducing Tasmanian devils to areas from which dingos are absent, along with effective fox control, may be one strategy to restore the diversity of natural predator species. However, the complex interactions between these native predators and introduced foxes and cats are poorly understood.



Understanding predator interactions

DEC recently embarked on an ambitious collaborative program with the Invasive Animals Cooperative Research Centre (IA CRC), the Australian Wildlife Conservancy (AWC), Alcoa of Australia and Worsley Alumina Pty Ltd. The program is examining interactions between native and introduced predators at five sites in WA (see map above). Each site has a slightly different focus, but all are examining fox and cat interactions.

The northern jarrah forest research is perhaps the most ambitious of these projects. The research will examine and test several hypotheses. Firstly, we need to determine whether, in the presence of fox control, cats increase in abundance. That is, do cats show a 'mesopredator release' response when fox density is reduced?

It is notoriously difficult to monitor foxes and cats and derive reliable and meaningful estimates of density. No two scientists are likely to agree on the best method. The four scientists in the northern jarrah forest research team report to an independent review panel of three additional scientists. Debate runs high, but we have agreed on the fundamental principles and research

has begun. The study area within the northern jarrah forest has been zoned into two large areas of 172,000 and 121,000 hectares, which are both aerially baited with baits containing 1080, a naturally occurring poison, six times a year. A control zone of about 63,000 hectares will be left unbaited.

We also need to determine whether subordinate native predators also show a 'mesopredator release' response. Hence, the chuditch (*Dasyurus geoffroii*), south-west carpet python and two large goanna species (*Varanus gouldii* and *V. rosenbergi*) are being closely examined. Mesopredator release may manifest itself through behavioural changes and changes in the density of these species.

Complicating this, the flow-on effect from mesopredator release can also manifest itself through changes exhibited by prey species. We are monitoring the brushtail possum (*Trichosurus vulpecula*) and hopefully also the quenda (*Isoodon obesulus*) to determine if there is a flow-on effect (or 'trophic cascade', as it is referred to in scientific literature). Monitoring will enable us to determine if levels of predation on these two indicator species increase or decrease. We will also be able to determine if the rate of juveniles reaching adulthood is being limited by fox predation, by cat predation, or both. Ultimately, this recruitment determines whether the population is increasing.

The research will also examine whether these prey species behave differently once predation pressure is lifted. For example, brushtail possums may spend more time foraging on the ground and less time avoiding predators by switching dens. However, such behaviour may not occur if we are simply replacing predation pressure from foxes with predation pressure

Top left A red fox.
Photo – Dennis Sarson/Lochman Transparencies

Centre left Dingo.

Left Tasmanian devil.
Photos – Jiri Lochman

Right Gould's monitor.
Photo – Jiri Lochman

from cats. We may not see these changes until we can effectively reduce both fox and cat density.

Estimating fox and cat density

Estimating fox and cat density is central to the research program in the northern jarrah forest. The technique most widely used to estimate the density of foxes and cats involves using 'passive' or 'active' sandplots. In either case, a passing fox or cat will leave its tracks in these smoothed sandy patches. Passive plots have no lure to attract the fox or cat to the sandplot and no reward. The number of tracks left in the sand is then used to estimate the density of foxes or cats in the area. Active sandplots incorporate a lure or attractant and may have a reward.

Both techniques confound activity with density and it is impossible to know if we are seeing the activity of one fox or cat, or many. Consequently, the techniques may, but equally well may not, accurately reflect the density of each species. Both passive and active techniques are imperfect and need to be validated in the environment in which they are being used to give any confidence in the derived estimate of density. Active sandplots were previously used in the northern jarrah forest as part of *Operation Foxglove*. This technique was validated and we believed we had a reliable estimate of density, at least for foxes. However, it provided very little data on cats. Importantly, relying on sandplot data alone does not enable us to identify individuals.

DNA-based monitoring

It seems the time has come to use more sophisticated techniques that will provide more accurate estimates of fox and cat density.

Each fox or cat has a unique DNA fingerprint or 'genotype', and will leave its identity card in the environment when it defecates or sheds hair. By collecting scats (faeces) or hair samples and identifying the individuals to which they belong, we can estimate the number of foxes or cats present in the landscape and map their movements. This exciting research brings together our ecological expertise in mark–recapture analyses (conventionally applied to capture, mark, release and recapture of trapped animals) with newly developed DNA-based techniques.

The challenge for the northern jarrah forest research team is to find ways to collect this DNA. Scats are particularly useful for monitoring foxes because they are often deposited in prominent locations such as track junctions. Foxes also tend to deposit scats on novel features, such as sandplots. Scat collection and analysis is not glamorous nor for the faint-hearted, but the information provided makes the smelly job worthwhile.

Unfortunately, cats don't defecate in prominent locations, so we also target hair samples. Hair is more pleasant to work with, but to collect it we have had to develop special snares which capture hairs plus the all-important DNA-containing follicles. Captive trials at DEC's Dwellingup Research Centre have shown fox hair yielding usable DNA can be collected on strategically positioned sticky wafers and barbed wire.

Luring cats to hair collection points has proven more difficult. Captive animal trials and field trials involving a range of attractants and snares are underway. Among the attractants being trialled is an audible lure known as a 'Felid Attracting Phonic' developed

by Dave Algar, from DEC's Science Division. Alone or combined with a visual or olfactory attractant, it appeals to the curiosity of the cat. The desired outcome of our testing will be a lure which works equally well for foxes and cats and enables us to collect hair from both species at a single point.

Wildlife forensics

With trace DNA samples there is usually only a very small amount of DNA present and it may be highly degraded. This makes analysis difficult, requiring intensive work on each sample. As there is a high chance of sample contamination from extraneous DNA, we use strict sample handling protocols like those typically used in human forensics. All laboratory work is conducted in a dedicated wildlife forensics laboratory at The University of Western Australia (UWA).

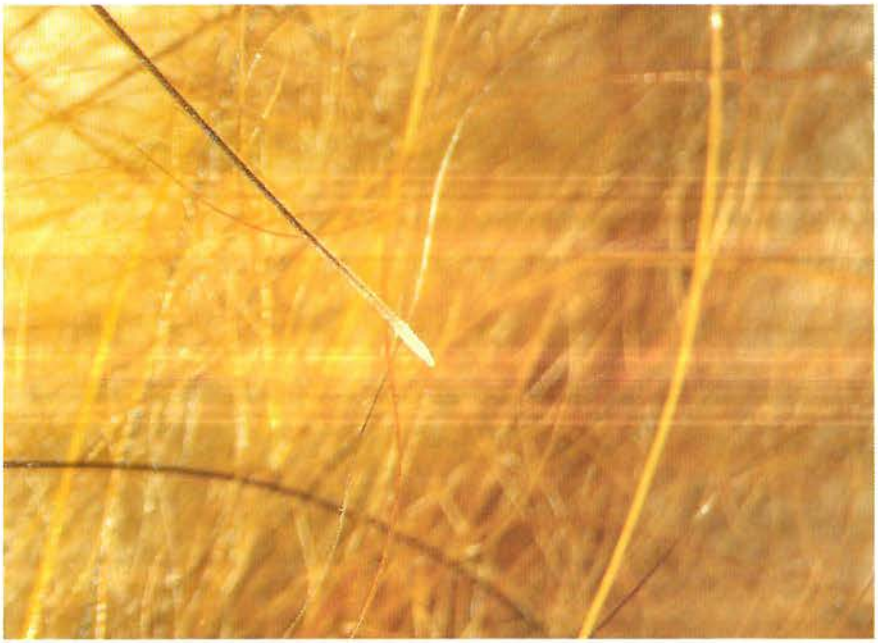
Identifying individual foxes and cats enables us to answer some major questions with immediate implications for conservation management. For example, DEC's current baiting programs rely on repeated baitings and we accept some foxes will survive each baiting event. However, we are unsure if it is the same individuals surviving each baiting session. By identifying the individuals present within an area after each baiting event we will be able to determine whether the same individuals continue to survive repeated baiting sessions. If this is the case, we may be facilitating the 'natural selection' of foxes which avoid baits or develop a tolerance to the 1080 toxin. If so, alternative control strategies would need to be employed in conjunction with the standard 1080 baiting programs.

Use of the landscape by predators

The research needs to determine if, and how, use of the northern jarrah forest by feral cats changes when fox density is reduced. To test the hypothesis that cats will become more conspicuous and less restricted in their movements with reduced fox density, we are fitting satellite radio collars to cats and foxes to monitor their use of the landscape in baited and unbaited areas. The satellite radio collars have also been fitted with proximity circuitry and data loggers so we can tell whether foxes and cats are regularly coming into contact, or if they are avoiding each other.

This will also enable us to shed light on an issue which has long vexed biologists involved in radio-telemetry studies—determining the predator responsible for individual predation events. This requires fitting radio collars with proximity circuitry and data loggers to the prey species: brushtail possums and quendas. The data loggers will record when a radio collared fox or cat comes in contact or close proximity with a radio collared brushtail possum or quenda. The brushtail possum research is being undertaken by a PhD student, Jennyffer Cruz, supported by an IA CRC scholarship.

The collaboration with, and financial support from, IA CRC has also enabled DEC to employ two post-



Above left A collection of fox hair strands.

Left DNA sampling of fox scats.
Photos – Oliver Berry/UWA

Above Dryandra woodland.
Photo – Alex Bond

Right Chuditch.
Photo – Jiri Lochman

doctoral research scientists, Al Glen and Duncan Sutherland, who are working on chuditch and goannas respectively. This work will assess whether these species show a mesopredator release response and whether the diversity of predators changes as a result of fox control.

The python research is examining the role of this ambush predator from a mesopredator release context and the role of python predation in translocation outcomes. Predicted changes in python behaviour as a result of mesopredator release include longer periods of time in foraging, and ambush positions, longer periods of time in exposed basking positions and a less limited choice of clutch brooding sites by females. This research is being undertaken by Gillian Bryant, a PhD student supported by DEC and Murdoch University.

Monitoring the range of prey species

An equally important component of the research is aimed at determining whether the dominant and subordinate predators are selecting prey items on the basis of their availability. To determine this, we will assess the prey species present and their respective abundance and then examine the proportion of prey being eaten by each predator species. This is achieved by conventional trapping programs followed by more scat analysis.

The ultimate objectives of the research are to reduce fox density and ensure we are not simply replacing foxes with cats. If this is the case, control strategies to reduce cat density will also need to be implemented. Once foxes and cats are reduced in number, we anticipate native predators will become more abundant and change their behaviour. We need to be able to demonstrate the flow-on effects from these changes improve biodiversity conservation, including sustained native predator diversity and increases in the abundance of native prey species.

How you can be involved

The research team based at Dwellingup needs volunteers to assist with seasonal trapping sessions and monitoring of brushtail possums, ringtail possums and pythons. Please contact Paul de Tores if you would like to be involved in the northern jarrah forest research through DEC's volunteer program.

Paul de Tores is a Research Scientist with DEC's Science Division at the Dwellingup Research Centre. Paul can be contacted on (08) 9538 0025 or by email (paul.detores@dec.wa.gov.au).

Oliver Berry is a post-doctoral Research Scientist with IA CRC and UWA. Oliver is based at UWA and can be contacted on (08) 6488 4509 or by email (ofb@cyllene.uwa.edu.au).

Surprises in the sand

When we think of marine biodiversity, coral reefs or perhaps seagrass areas spring to mind. But what about bare sand habitats? The sand patches in shallow areas between the offshore reefs and the shoreline—such as at Jurien Bay Marine Park on the Turquoise Coast—appear devoid of life. Or are they?

by Sue Morrison

Jurien Bay Marine Park has some extensive patches of bare sand or soft bottom habitats covering about 130 square kilometres, or 10 per cent of the region. Some of this habitat has a sparse cover of short-lived seagrasses such as paddleweed (*Halophila*) and eelgrass (*Heterozostera tasmanica*) species, plus a small quantity of algae during the warmer months.

Cryptic creatures

While bare sand may appear to be largely devoid of life, some fascinating marine plants and animals have adapted to this relatively inhospitable environment. Although the species tend to be less diverse than in habitats with greater physical complexity, such as seagrass meadows and rocky reefs, numbers of individuals can be large. Many organisms are cryptic or only active at night, and many are microscopic.

In the Jurien Bay Marine Park, sand consists mainly of calcium carbonate from the shells of marine animals and smaller quantities of quartz particles from eroded rock. Sands range from less than 0.5 to two millimetres in diameter. Smaller grains are classified as mud and silt, and any larger are considered to be gravel. The size of sediment particles has a major influence on fauna in sand habitats. The smallest organisms live under the surface, on and between the sand grains. Some of the smallest, such as protozoans, bacteria and microalgae, are associated with the surfaces of particles. Others, such as nematodes, flatworms and crustaceans, live in the spaces between sand grains. Animals big enough to burrow through the sediment include worms, crustaceans, bivalves and echinoderms. Those living on the sediment surface tend to be much larger and include fish, echinoderms, molluscs and crustaceans.

It is difficult for seagrasses and algae to establish in sandy habitats, particularly where turbulence is strong and sediment transport is high. A few may grow in more sheltered areas, but usually wash away in winter storms. Because of the lack of marine plants, plant matter needed for the food web must largely come from outside the sandy habitat. In protected areas, however, a small amount of

single-celled algae survive near the sediment surface and provide some plant material from within the habitat. A few herbivores are found in sandy regions, often adjacent to seagrass or algal beds. One is the bubble shell (*Bulla quoyii*), which retreats under the sediment during the day and emerges at night to graze on algae.

Most plant matter that enters the food web in sandy habitats, however, is dead material (detritus) that has washed in from seagrass meadows and rocky algal reefs. A surprising number of detritivores live in soft-bottom habitats. Plant and animal plankton are another important source of food in such habitats and are consumed by filter or suspension feeders.

Some animals, such as worms and echinoderms, alternate between deposit feeding and suspension feeding. Many of the worms are small and hide beneath the sand. One more visible species is the purple feather duster worm (*Sabellastarte* species). Its delicate feathery plumes act as gills and also trap small food particles. Smaller particles are eaten and larger ones are used to build up the tube it inhabits.

Sea cucumbers, heart urchins and sand dollars consume large quantities of detritus. Ludwig's sea cucumber (*Stichopus ludwigi*) and the ubiquitous soft sea cucumber (*Stichopus mollis*) occur in sandy areas, often close to seagrass beds. They slowly amble over the sand at night, ingesting great quantities of sediment, picked up with leaf-shaped tentacles around the mouth. Their convoluted gut absorbs the small amount of organic matter in the sediment. They must consume huge quantities to obtain sufficient nutrients. A sea cucumber that feeds during the day, *Neothyonidium* species, buries itself in the sand with only its fine, branched tentacles protruding. It traps plankton and can pick up particles from the sand with its tentacles. It is possible to see it insert its tentacles into the mouth one at a time, and suck off the attached food.

Heart urchins, such as *Brissus agassizii* and the smaller *Echinocardium cordatum*, hide under the sand during the day. They have short, fine spines and a few longer, flattened spines for burrowing. Equally well hidden are Lesueur's sand dollar (*Peronella lesueuri*) and the sand dollar *Ammotrophus arachnoides*, which only extends from Cockburn Sound to Jurien Bay. These flattened, disc-shaped urchins have very short, fine spines and lie just beneath the surface. You can sometimes see their outline in the sand. Heart urchins and sand dollars sieve small organic particles from the sand. The sea star *Stellaster inspinosus* also ingests large quantities of sediment, from which it extracts organic matter.

Several species of tiny crustaceans, known as gammarid amphipods, live in soft sediments and feed on detritus. Ghost and mud shrimps sometimes occur in huge numbers in soft sediment areas. They are rarely seen, however, because they build extensive burrows under the sediment. They fan water along their burrows and trap organic particles that float through.

Bivalve burrowers

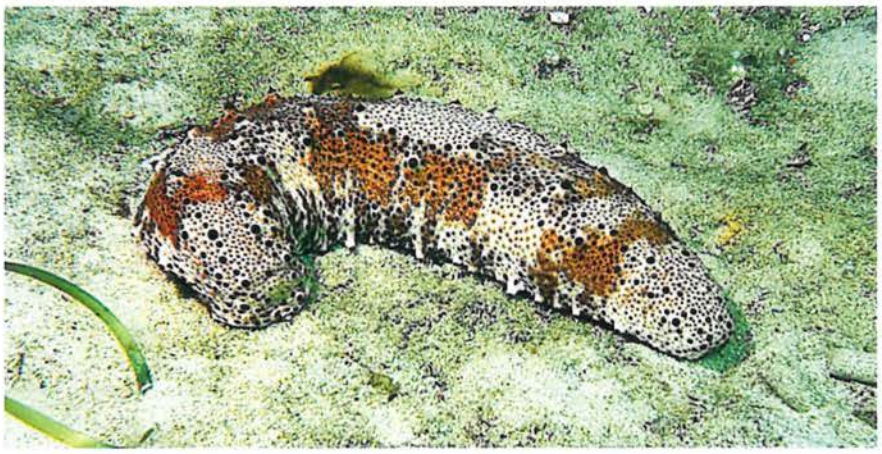
Soft sediments, including those of Jurien Bay Marine Park, are a haven for filter-feeding bivalve molluscs. Normally, they are only noticed once they have died and their empty shells wash onto the beach. For most of their lives they remain hidden under the sediment, using various adaptations to filter organic particles from the water.

Bivalves inhabit different depths in the sediment, depending on their body

Previous page
Main Lesueur's sand dollar mostly remains hidden but you can sometimes see its outline in the sand.
Inset The little scorpionfish is a carnivore that feeds on smaller fish.

Above The sea star *Stellaster inspinosus* ingests large quantities of sediment, from which it extracts organic matter.

Left Purple feather duster worm (*Sabellastarte* species).
Photos – Sue Morrison



Above Wavy grubfish hiding under a sand anemone.

Left Ludwig's sea cucumber consumes large quantities of detritus from the sea floor.
Photos – Sue Morrison

structure. Those that bury deep—to about 20 centimetres—include the trough shell (*Lutraria rhynchaena*) and *Psammotellina biradiata*. These molluscs have long siphons that reach up to the sediment surface, enabling them to breathe and filter feed, or deposit feed while hidden from predators. The lucinid (*Divalucina* species) lives at similar depths but, as it lacks long siphons, builds a mucous-lined burrow, which it irrigates instead. At mid-level, just a few centimetres down, are species such as tellins (*Tellina perna*) and sunset shells (*Soletellina biradiata*). Just below the surface, particularly at the shallow, low tide level, are pipis (*Donax* species). In slightly deeper water (three to 15 metres) there are numerous species of Venus shells (such as *Paphia crassisulca* and *Dosinia incisa*), dog cockles (*Glycymeris striatularis*) and carditas (such as *Cardita incrassata*). Those with short siphons burrow just below the surface, while species without siphons are at the surface with their back end exposed. Since most of these bivalves are largely sedentary, they need to live in areas with good water movement that will supply sufficient oxygen and food particles suspended in the water.

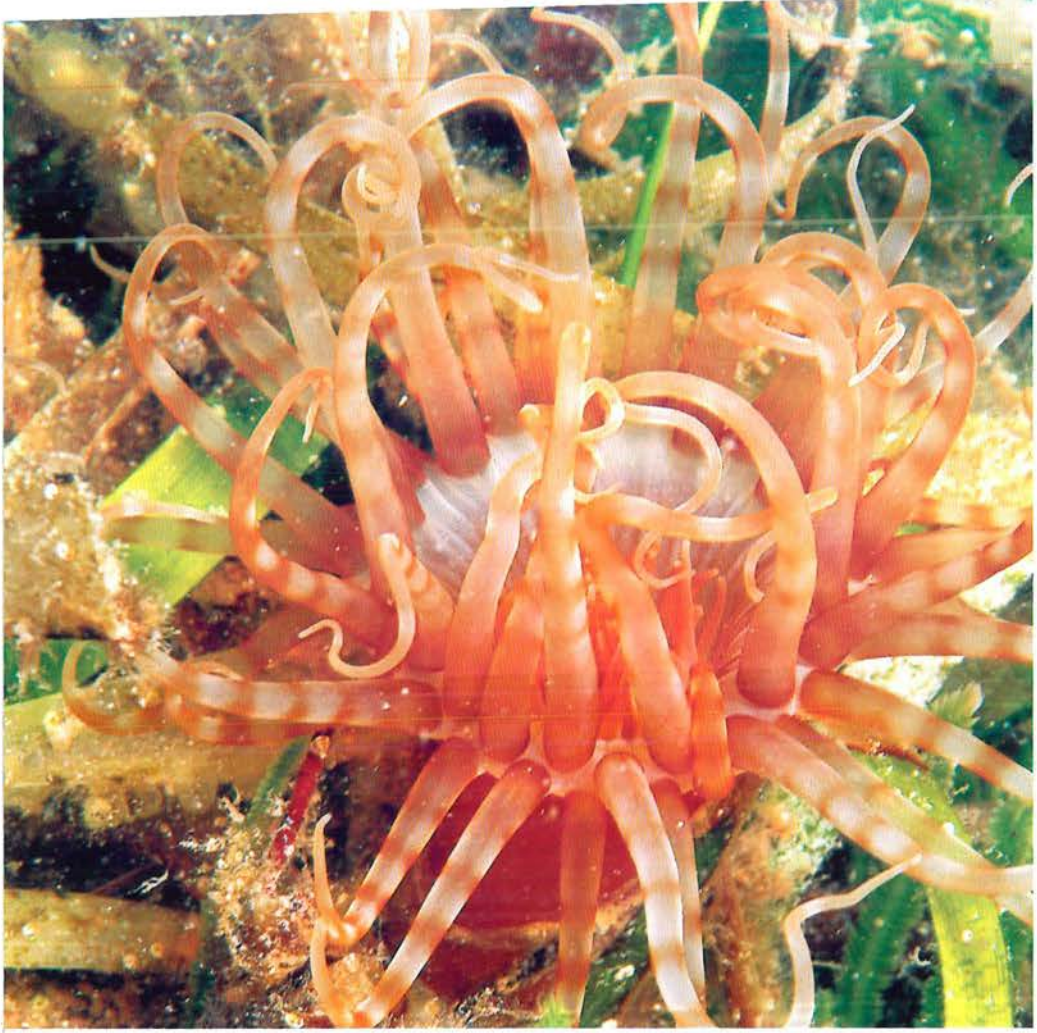
Scallops, such as the commercially caught saucer scallop (*Amusium balloti*) and the king scallop (*Pecten fumatus*), live at the surface of the sediment, sometimes disguised by a thin layer of sand. They are more visible than their buried relatives, but can escape predatory sea stars and fish by rapidly flapping their valves together and swimming off.

Omnipresent omnivores

Omnivores and scavenging species are less numerous than the detritivores and filter feeders in soft-bottom habitats. The popular edible king prawn (*Metapenaeus latisulcatus*) and western school prawn (*Metapenaeus dalli*) walk over the sand in search of food on dark, moonless nights. They are scavengers, and also take in some detritus. During daylight hours they remain under the soft sediment, hidden from the watchful eyes of predators such as fish.

The oddly shaped rounded pebble crabs are well adapted to living in soft sediments. Their triangular mouth cavity narrows at the front, allowing them to breathe when buried under the sand. They are thought to be general scavengers that also ingest some detritus.

A few species of omnivorous fish live in the sandy areas of the Jurien Bay Marine Park. The snakeskin wrasse and wavy grubfish prefer sandy areas adjacent to rocky reef and weed habitats. The inquisitive wavy grubfish often perches on its pectoral fins, surveying the



Left Tube anemones (*Pachycerianthus* species) use microscopic stinging cells on their tentacles to trap tiny organisms.
Photo – Ann Storrie

Below The bivalve *Cardita incrassata* usually sits just under the surface of the sand.
Photo – Sue Morrison

surroundings with its bright, mobile eyes. The snakeskin wrasse has the curious habits of sometimes swimming vertically and also of lying on its side on the sand.

Some gobies, such as the barred goby, are omnivorous and can be quite numerous, though often overlooked because of their small size. Stinkfish, including the painted stinkfish and fingered dragonet, have stunning colour patterns. These fish appear to 'walk' over the seabed at night using their pectoral fins, in search of small prey and organic matter. Goodlad's stinkfish often lies half-buried in the sediment, waiting for passing prey. The banded toadfish is familiar to anyone who has fished from a jetty. This widespread species feeds on anything it can scavenge or capture with its strong beak-like teeth. At night it can be found half buried in sand.

Carnivores of the bare sand

Carnivorous cnidarians, particularly anemones and sea pens, are abundant in soft sediments. They catch plankton and tiny invertebrates with stinging cells on their tentacles. Tube anemones, such as *Pachycerianthus* species, have long, fine tentacles that sway in the current. They live in a sand-encrusted mucous tube, into which they retract if threatened. Sea pens usually retract under the sediment during the day. At night, they pump their bodies full of water to reveal their beautiful forms. They have fine polyps either attached directly to the central stem, as in *Cavernularia* species, or on feather-like branches, as in *Sarcoptilus* species.

Carnivorous worms can be numerous, but are rarely seen because many species of nematodes and flatworms are microscopic. Occasionally, the large predatory nereid worms, such as *Perinereis* species, can be seen running across the sediment at night in search of tiny invertebrate prey.

Mantis shrimps, including *Squilla laevis*, are well-equipped predators. Huge spined claws on the second thoracic appendage are used to grasp and hold small fish and crustaceans. They live in burrows. Often, all that is visible is their large, reflective eyes that can move independently, peering from the hole.

Even carnivorous nudibranchs are found on soft sediments, including *Armina cygnae*, which feeds only on sea pens. Attractive olive shells (*Oliva* species) are also predatory. They often plough through the sand with just the tip of their siphon showing. They capture and hold invertebrate prey with their large foot.

Sea stars are slow moving but persistent predators. Some species that burrow in soft sediments have modified tube feet that are pointed at the tip and lack suckers. They include *Luidia australiae*, which is large enough to engulf whole heart urchins and bivalves, and an *Astropecten* species that feeds on small bivalves.

Some carnivorous fish leave a distinct trail where they have been feeding. Rays furiously flap their 'wings' to waft the sediment away from shelled

Above Snakeskin wrasse.

Right Western king prawn.
Photos – Ann Storrie

Far right Sea pens are carnivores that trap fine particles and plankton in their tentacles.
Photo – Sue Morrison

molluscs and other small invertebrates hidden under the sediment. This leaves round depressions in the seabed. Rays, such as southern fiddler rays and western shovelnose rays, feed mainly at night and grind up their prey with modified flat plates of teeth.

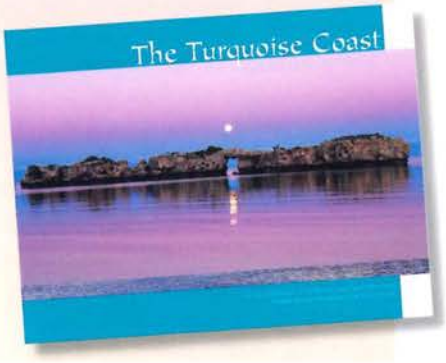
Fish such as spiny gurnard, trumpeter whiting and yellow-finned whiting feed on the abundant small worms, crustaceans and molluscs just beneath the sediment surface. The bar-tailed goatfish locates crustaceans and worms by probing the sediment with the two long barbels under its chin. The tiny slender seamoth has a very small mouth and feeds only on tiny crustaceans and worms. The silverbiddy or roach uses its small protrusible mouth to catch small crustaceans. The little scorpionfish lies in wait for small fish to prey on, and the southern blue-spotted flathead ambushes fish, crabs, shrimp and squid.

Flatfish are also active predators, beautifully adapted to living on flat, soft sediments. The many species of flatfish along the Turquoise Coast include the small-toothed flounder, elongate flounder and southern tongue sole. These peculiar fish have extremely compressed bodies and swim on their sides, maintaining a low profile. During their early development, one eye migrates to the top side of the body, so both eyes are eventually located on the upper surface. They are well camouflaged and can lighten or darken their skin to blend in perfectly with the underwater surface on which they are resting.

While the larger marine animals, such as whales, sea lions and fish, easily capture our attention when it comes to marine conservation, the smaller and even microscopic creatures are equally deserving of protection.

Sue Morrison works at the WA Museum as Collection Manager in the Fish Section of Aquatic Zoology. Museum field work has taken her all around the State, studying marine fish and, occasionally, marine invertebrates.

This article is based on a chapter from *The Turquoise Coast*, a full-colour, exquisitely photographed book on the area between Lancelin and Leeman, which is available from DEC and most bookshops for $29.95. Sue and co-author Ann Storrie took most of the photographs in the book.



urban antics by John Hunter

Well... I'll be bugged

Autumn is a time when your backyard and even your bed is probably crawling with life... who mentioned bed bugs?

Did I see you wince a little? Let me confuse you a little more.

The word bug is generally a colloquial term used by most urbanites to describe those insects and some other small crawling creatures that occasionally share the same locality and personal space as us. It is only natural, therefore, that most people think of centipedes, slugs, maggots and spiders—the classic 'creepy-crawlies'—as bugs... but they are not.

True bugs, of the group Hemiptera (meaning, half-wings) are in fact insects, but then, not all insects are bugs. The Hemiptera has members of many different forms including aphids, hoppers, scale insects, cicadas and, confusingly, the true bugs of which there are many types and species. The one thing they all have in common is their sucking beak-like mouthparts. While most use this to suck juices from plants, some are voracious predators of other animals.

The animals mentioned, and many more, are all invertebrates having no internal backbone but rather a hard outer covering or exoskeleton. Animals without backbones account for as much as 98 per cent of the Earth's animal diversity, and are of fundamental importance in almost every ecosystem on the planet.

It's enough to make you, a single human species, feel uncomfortable, more confused and totally unimportant. It's enough to bug you... oh no!

A common aquatic bug (true bug) often found in our swimming pools is the backswimmer *Anisops* sp. They are often seen swimming upside down on their back with their legs up just below the surface. They are recognised by a repetitive jerky motion and their two large hairy back legs as they search the surface for prey. Adults are also conspicuous by the very big eyes that occupy most of their head, their curved back and a broad keel on the abdomen.

Backswimmers are found naturally in ponds, slow-flowing creeks, canals and rivers. They spend most of their time in water but fly from pond to pond should the area no longer suit them. Adults and larval animals are voracious predators and eat smaller animals such as blood worms and aquatic larvae. They attack prey as large as tadpoles and can inflict a painful bite from their proboscis needle on a human finger. When hunting, they snatch invertebrates from the water's surface, drag them under, impale them and suck the body juices.

Adult backswimmers breathe by storing oxygen in a bubble on the body hair of their abdomen. When required, they do a quick turn at the surface to replenish the air bubble. It is this bubble reflecting from the sky that, gives backswimmers a silvery look. To find a mate, the males make sounds to attract a female and after the eggs are fertilised inside her body, she lays them in holes she drills into plant stems.

So, to feel at ease, keep your pool free of vegetation and smelling like battery acid and you'll have no little backswimmers or white pointers to worry about.

DID YOU KNOW?

- Australia has some 5650 known species of bugs from about 60,000 worldwide and more are being discovered all the time.
- Fish, turtles, waterbirds and lots of insects that live in the natural waterways eat backswimmers.
- Backswimmers have the ability to withstand extremely contaminated water.

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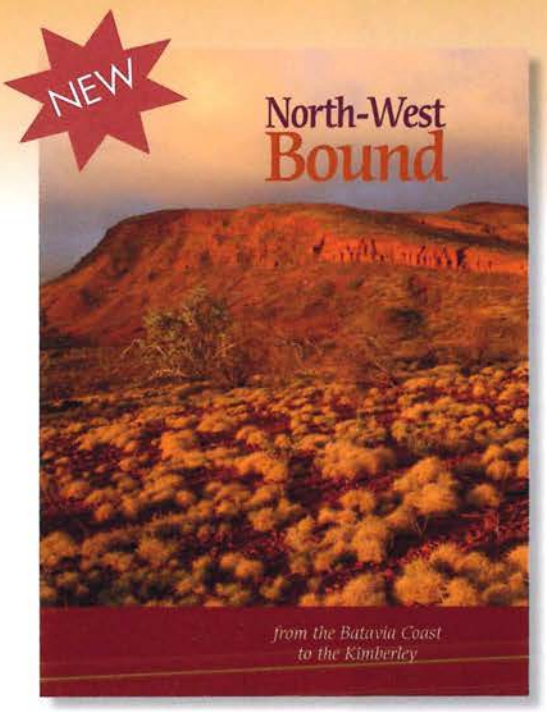

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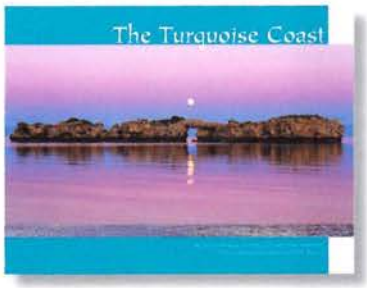

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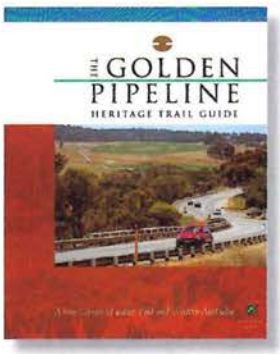

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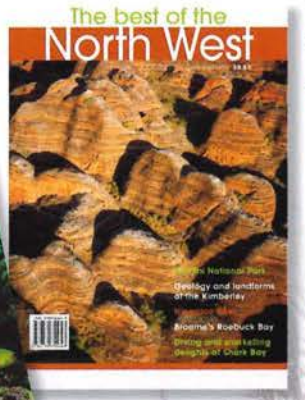

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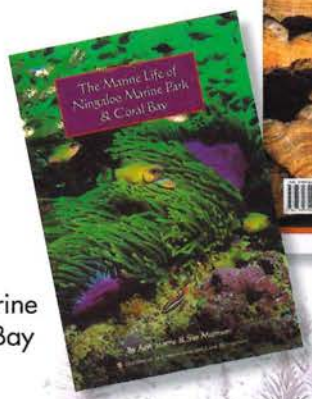

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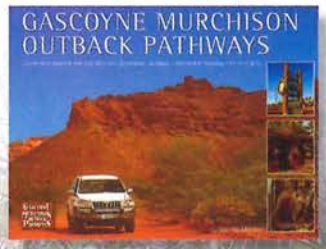

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