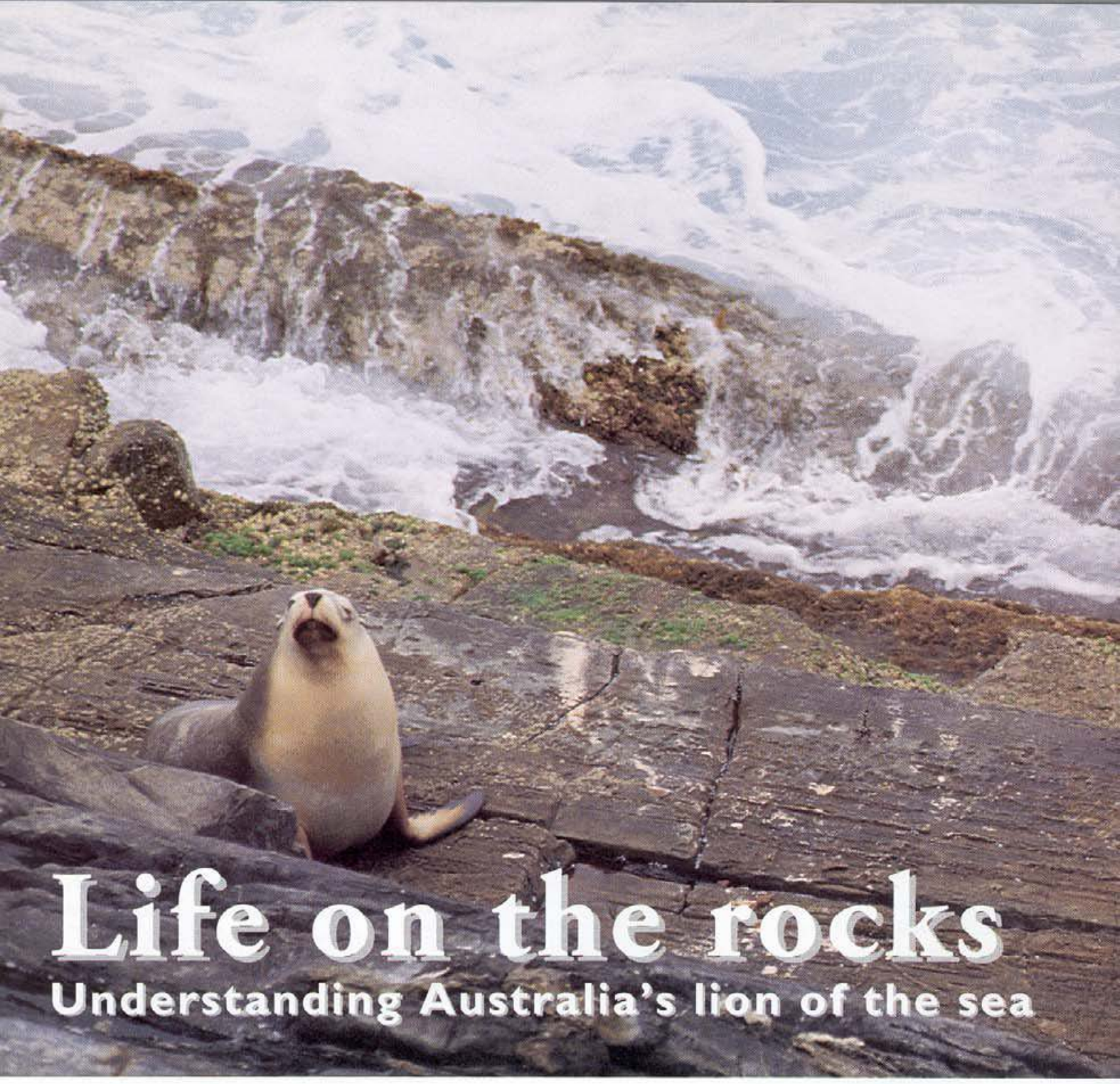


# Life on the rocks

## Understanding Australia's lion of the sea

On the rugged edge of Cape Gantheaume, where Southern Ocean waters lap Kangaroo Island's protective shore, a colony of New Zealand fur seals (*Arctocephalus forsteri*) is busy breeding. The headland is a mass of lumbering bodies: watchful mothers suckling furry, round-eyed pups, and bellicose males, fighting, mating and snoozing on the smooth rocks licked with sun and spray.

For this productive horde, the Christmas accommodation at Kangaroo Island is first rate: NZ fur seal numbers are expanding exponentially, both here and at Cape du Couedic to the west. More than 90% of the pregnant mothers at Cape Gantheaume will give birth in the five weeks from December 4. By the end of January, the cries of some 1400 hungry pups will ring out across the colony: a sure sign that the NZ fur seal is thriving.

Twenty kilometres north-west of the cape, a similar scene animates the sands of Seal Bay, where a relative of the fur seal, the Australian sea lion (*Neophoca cinerea*), has begun to breed. But here, the cast numbers hundreds, not thousands. This is the world's third largest colony of Australian sea lions, yet it will yield fewer than 200 pups in the breeding season.

The disparity in colony size is echoed in the species' overall abundance. Australian sea lions and NZ fur seals inhabit a similar range in South Australia and Western Australia, but the Australian population of NZ fur seals nudged 37 000 in 1990, more than treble that of *N. cinerea*. In fact, the Australian sea lion is one of the world's rarest pinnipeds (seals, sea lions and walruses) and is classified rare in SA.

Unravelling the reasons for the Australian sea lion's sparse distribution, and the implications for its conservation, has been the focus of intermittent study since the 1960s. A breakthrough in the research came in 1994 with the results of a six-year investigation into the sea lion's abundance and breeding cycle, a joint effort between Dr Nick Gales, then based at Murdoch University's School of Veterinary Studies, Dr Peter Shaughnessy from CSIRO's Division of Wildlife and Ecology,

**With their sparse distribution and extended breeding cycle, Australian sea lions seem well adapted to life on the bare continental shelf. But nobody knows for sure. Bryony Bennett reports.**

**Above: Australian sea lions at South Pages Island. Below: A mother and pup on the sands of Kangaroo Island's Seal Bay.**

and Terry Dennis, former South Australian National Parks and Wildlife Service district ranger for Kangaroo Island east.

The project was born in 1987 when Dennis and Shaughnessy met at a marine mammal conference in Sydney. Dennis, a self-confessed lobbyist for the Australian sea lion, was aware of Shaughnessy's work with fur seals, and was keen to harness his expertise. At the same time, Gales returned from 18 months in Antarctica at Heard Island and Davis Station, where he had been studying elephant seals. He decided to investigate aspects of the population ecology and reproductive biology of Australian sea lions for his doctorate.

Back then, little was known about the population and status of the Australian sea lion. Research during the 1970s by former South Australian Museum director Dr John Ling had shed light on the species' breeding cycle, and Dr Leslie Higgins from the University of California was studying the ecology of females at Kangaroo Island. But no survey had covered the species' entire range. Population estimates, based on ad hoc counts at breeding and non-breeding islands, ranged from 2300 to 5000.

'We had been monitoring the Australian sea lion colony at Seal Bay since the late 1970s,' Dennis says. 'My concern was that it was not showing the same rate of

Liz Poan/CSIRO Wildlife and Ecology

Liz Peon/Wildlife and Ecology

**Top: The territorial posturings of adult male sea lions are a good indication of breeding activity at the colonies.**

**Above: Pilot Peter Kies delivers Peter Shaughnessy and Peter Canty to an Australian sea lion colony at Dorothie Island.**

**Below: Counting Australian sea lions is never easy. Their rocky habitats can be treacherous, and are well guarded during the breeding season.**

increase as the nearby colonies of NZ fur seals. We needed reliable information about the sea lion's distribution, abundance and behaviour as a basis for developing management and conservation strategies. It was important to establish a baseline against which future surveys could be compared.'

In view of this need, the team set out to:

- document breeding sites over the Australian sea lion's entire range;
- determine the breeding season at the various sites;
- estimate the total number of pups born at each site;
- estimate the total population size based on pup production; and
- describe the habitat of breeding sites.

Achieving these goals required a study of epic proportions. Aerial photography was of little use, (except for determining timing of the breeding season), mainly because rocks and sea lions are difficult to distinguish. Every island between Houtman Abrolhos near Geraldton in WA and The Pages, just east of Kangaroo Island in SA, had to be visited. Staff from the WA Department of Conservation and Land Management, the SA National Parks and Wildlife Service and the SA Department of Fisheries helped to cover this vast territory.

## The best laid plans

The field work involved a good deal more than selecting a day, dropping off a form and calling back a week later. Australian sea lions are difficult to census. Their terrestrial habitats, apart from being inaccessible, usually are difficult to view or traverse. They often take alarm and rush to the sea when approached, and can become aggressive when breeding. A further difficulty is that an unknown portion of the colony is likely to be at sea.

The most meaningful surveys are done when all members of one age-class are ashore. A suitable class is newborn pups whose numbers from successive breeding seasons provide a useful index for the status of a population. Pup numbers can also be used to estimate total population size. But here lay the greatest hurdle: when to visit each island to coincide with the breeding season?

Most pinnipeds breed annually during spring or summer. Shaughnessy's research into the breeding ecology of NZ fur seals is based on field trips made each year to Kangaroo Island, always mid to late January (just after the Christmas breeding frenzy). But the Australian sea lion cannot be categorised so neatly.

This was discovered the hard way by Dr Basil Marlow from the Australian Museum at Sydney. In July 1968, Marlow set up camp at Dangerous Reef, home of one of Australia's largest sea lion colonies, and waited for the breeding to begin. He knew his timing was right, because pupping had occurred there a year earlier. He waited until October, but few pups appeared.

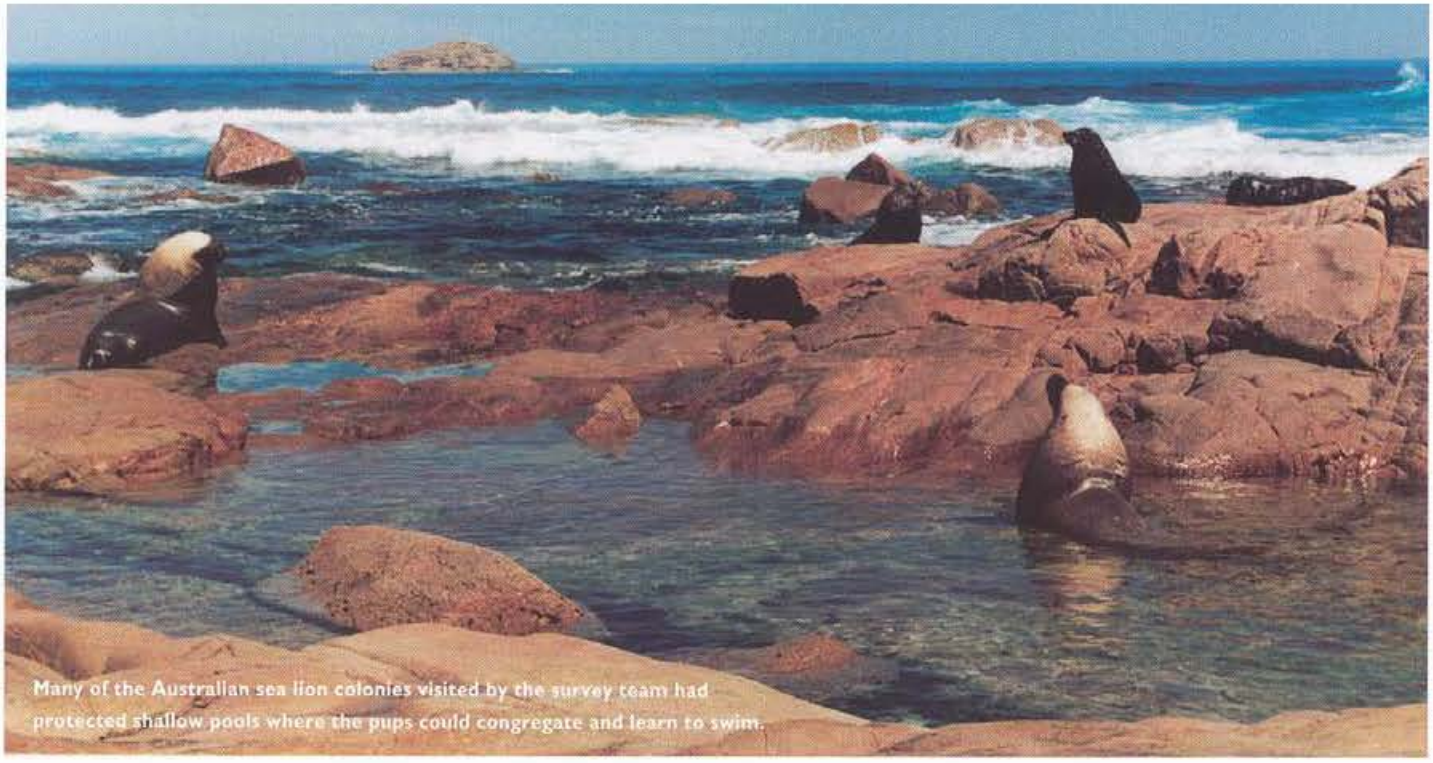
A decade later, the mystery was solved by John Ling. The Australian sea lion didn't breed every 12 months as everyone had assumed. Unlike any other pinniped, the sea lion had a 17-18 month breeding cycle which didn't align with seasonal conditions, and didn't follow any temporal pattern across the species' range.

Take Kangaroo Island as an example. During the 1970s, breeding occurred at Seal Bay in autumn or spring, but in the 1980s, it occurred in the summer or winter. The 1990s has seen a shift towards autumn and spring breeding. At The Pages, two tiny islands a few kilometres east of Kangaroo Island, the breeding begins two months before Seal Bay. But further north, on islands off the tip of the Eyre Peninsula, the season ranges from six months ahead, to five months behind Kangaroo Island.

When Ling's finding was publicised, marine biologists found it difficult to believe. Shaughnessy and Dennis still call it 'weird', and in the 1980s, without an overall picture of the species' breeding range, any attempts at an explanation were speculative. All this added weight to the need for a comprehensive survey. As to the question of when to visit each island, the team could only gather all existing data on known breeding sites, estimate when each colony was due to breed, and prepare for the inevitable return visits.

In most instances the islands were reached by boat, circumnavigated and inspected with binoculars for evidence of pupping (or suitable pupping habitat). Breeding colonies are recognised by the presence of newborn pups which have a chocolate-brown natal coat. After three to four months the pups moult, developing the colour of cows. Mature

Liz Peon/Wildlife and Ecology



Many of the Australian sea lion colonies visited by the survey team had protected shallow pools where the pups could congregate and learn to swim.

males have a white cap when of breeding age. They are also bigger than females and have a broader skull and darker ventral coat (dark brown). Their posturings are also indicative of a breeding colony.

A landing would then be made in a small dinghy or by swimming ashore, depending on sea conditions. This exercise is fraught with danger, posed not only by the fickle surf and jagged rocks, but by the real chance of meeting the Australian sea lion's fearsome predator: the great white shark.

The 1990 population survey was led by Nick Gales who instigated the risky practice of swimming onto islands garbed in wetsuits, flippers and gloves. 'We'd surf up to the rocks, hang on as the wave retreated and cling on,' Peter Shaughnessy says. 'It's effective, but makes a mess of your wetsuit which is rather dangerous as sharks are attracted to them. I was pretty scared the day I saw an adult male seal with its hindquarters chopped off and still bleeding, and I still had to swim back to the boat!' (This happened at the aptly-named Termination Island, south of Esperance.) Another means of island-access is to land on top in a helicopter, then scramble down to the sea.

Once on the island, the intrepid 'counters' clambered over rocks just above water level, keeping a tally of males, females, juveniles and pups. 'We'd search carefully under vegetation and rock holes, and keep a look out for sleeping cows with pups which are easy to step on,' Shaughnessy says.

'Sea lion cows are aggressive when with pups, and will pursue their counters if approached too closely. They might smell or hear us coming and either bite or bolt for the water. When females with pups are around, the males are watching for cows in oestrus. There are territorial skirmishes and we are seen as intruders.'

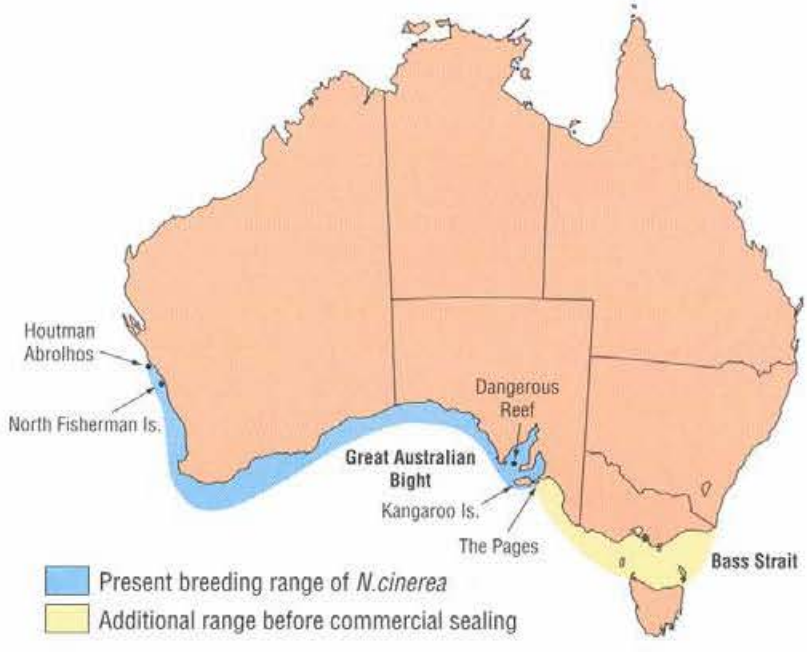
Australian sea lions give birth in a wide range of habitats, generally using the island's most sheltered aspect. On the west coast of WA they breed on low-lying limestone islands rarely exceeding 10 m above sea level. These are well protected from rough seas by perimeter limestone reefs. Islands on the south coast of WA and SA are generally higher than those on the west coast and are formed from igneous or metamorphic rock (usually granite), with occasional islands comprised of igneous platforms below limestone caps. Sand beaches are uncommon. The low, coastal vegetation rarely exceeds 0.5m.

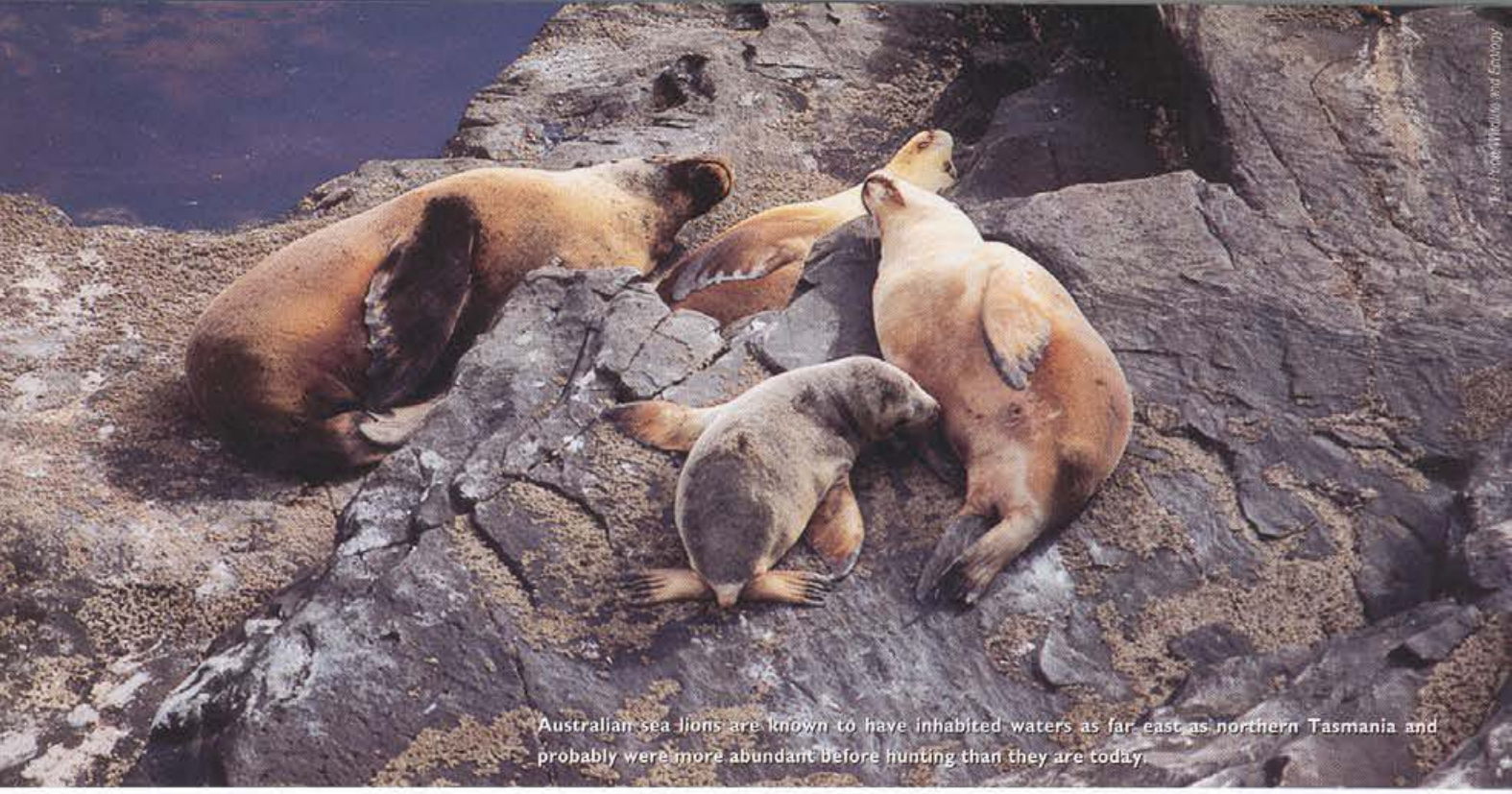
Although there is no clear pattern of site selection for pupping on the south coast, an important criterion is the existence of protected shallow pools in which pups congregate and presumably learn to swim. Unlike NZ fur seals, the sea lions do not like to breed on exposed, rocky headlands such as Cape Gantheaume.

On west coast islands a good friend of the sea lion is *Nitraria schoberi*, a bushy shrub which grows to about 1.5 m. The shrubs are used as 'pup holes': areas where cows give birth and provide shelter. On islands where the vegetation is too low to provide protection, rock holes are used instead. Pups born into the densest colonies, such as The Pages and Dangerous Reef, are offered less protection. These islands have a rocky substratum and the small amount of vegetation is quickly trampled. Thus most pups in these colonies are born on open ground.

## Doing the numbers

When counts from all the islands were tallied, a fresh picture emerged of the Australian sea lion's abundance, distribution and reproductive behaviour. The sea lion was found to breed on at least 50 islands, 27 in WA and 23





Australian sea lions are known to have inhabited waters as far east as northern Tasmania and probably were more abundant before hunting than they are today.

in SA. Of the 50 breeding sites, 31 had not been reported previously. Another 19 islands were considered potential colonies. A total of 1941 pups was counted and pup production estimated at 2432. Total pup production for each colony was assessed by determining the stage of the breeding season at which the count was conducted and extrapolating to an estimated pup production figure.

With data gathered during the study, Gales developed the first predictive model for estimating Australian sea lion population size from pup production figures. The model indicated that pup numbers could be multiplied by between 3.8 and 4.8 to estimate the total population. This led to a total of 9300 to 11 700, considerably greater than earlier estimates. (During 1994 and '95 Dennis and Shaughnessy surveyed the sea lion's haul out and breeding sites along the coast of the Great Australian Bight. They discovered a further 10 breeding colonies, leading to a new total population estimate of 9900 to 12 400.)

Like most simulations of the natural world, the model will need adjusting as the information on which it is based is updated. Its accuracy at present relies on eight assumptions, some of which are based on few or no data. Variables such as differences in mortality between the sexes and pup survival rates are examples. Most of the more reliable assumptions – such as the sex ratio of male and female pups and the age at which females first give birth – were based on data recorded at Kangaroo Island by Leslie Higgins, and on previous studies by Gales at breeding colonies on the west coast of WA.

The population estimate, while significantly higher than before, does not suggest a short-term expansion in numbers. Rather, it reflects the first thorough census of *N. cinerea*. Previous estimates relied on actual counts of animals, (minus foraging animals and some 'haul out' sites) rather than on predictive modelling of pup production.

Nor has the population grown on a historical scale. Just as tens of thousands of NZ fur seals were killed for their luxurious pelts during the 18th and 19th centuries, Australian sea lions, despite their lesser value, also were heavily exploited. While no data exists on their pristine status, the sea lions are known to have inhabited waters as far east as northern Tasmania and probably were more abundant before hunting than they are today. During surveys of Bass Strait islands in the early 1800s, Matthew Flinders noted many 'hair seals' and the remains of *N. cinerea* were seen in Tasmanian Aboriginal middens early this century. The only recent sightings east of the current breeding range are of single adult males on the coasts of Tasmania and New South Wales.

## Pleasures of the east

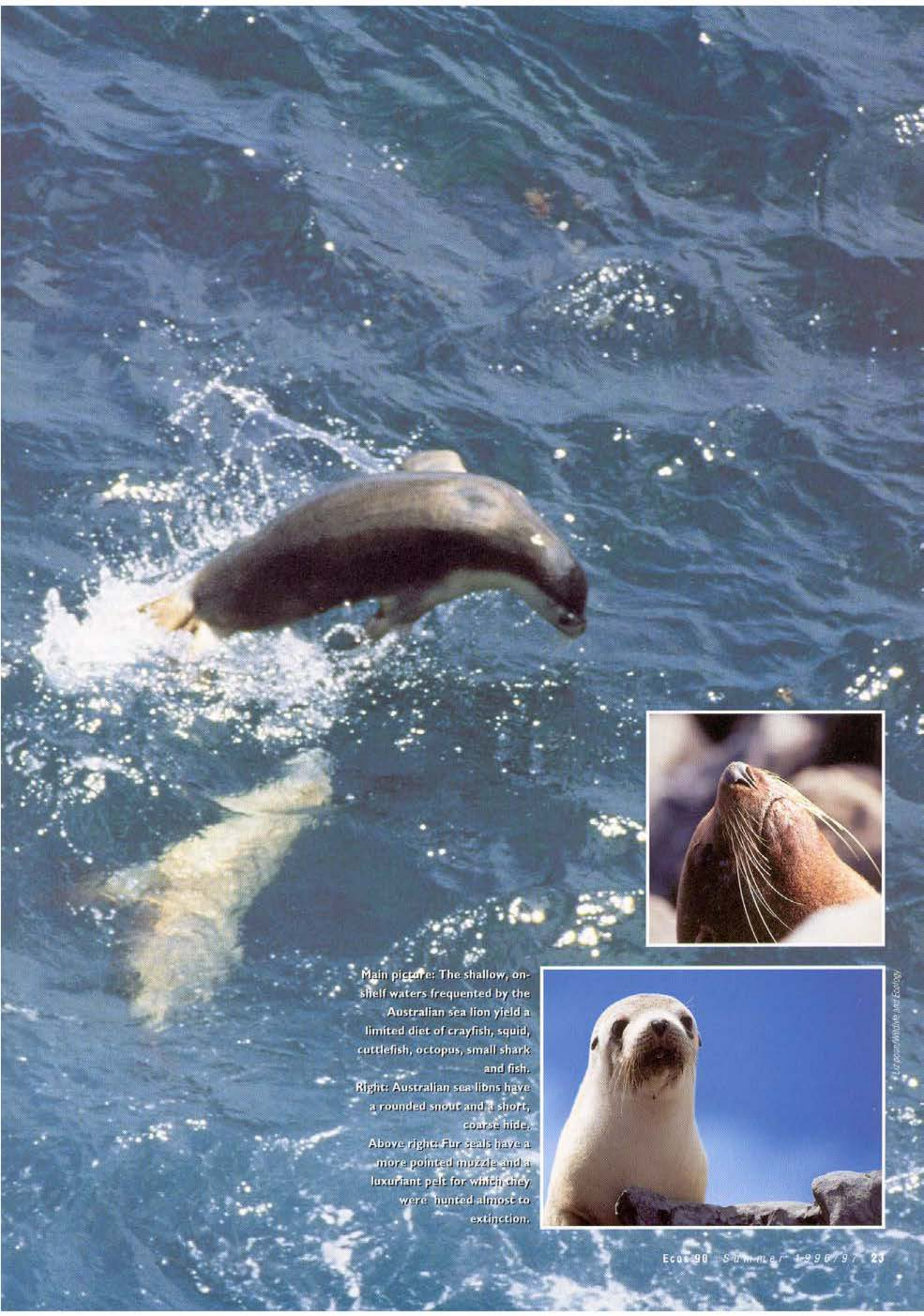
As well as documenting the sea lion's overall numbers, the survey revealed an interesting pattern of distribution. The sea lion population is crammed to the east of its range, with about three-quarters of pups born in SA. Only five sea lion colonies produced more

## Family feats

SEALS, sea lions and walruses are known collectively as pinnipeds, a latin term meaning 'fin-footed'. Pinnipeds are classified into three families: Otariidae (eared seals) Phocidae (true, or earless seals), and Odobenidae (walruses) Otariids are divided into two sub families: Arctocephaline (fur seals) and Otariinae (sea lions). These are thought to have diverged some two million years ago. Sea lions have a rounded snout and a short, coarse hide. Fur seals have a more pointed muzzle, longer foreflippers, and a luxuriant pelt for which they were hunted to near extinction.

Otariid seals use their long foreflippers for balance and propulsion when swimming, moving through the water with their long necks extended, almost as a bird flies through the air. Fur seals can swim at speeds of about 16 knots, while sea lions can reach bursts of speed of 25-30 knots. Their hindflippers, which act as stabilisers, are not used much in swimming, but can be turned under the body for 'walking'.

Phocid seals in general are less agile. On ice, however, the Antarctic crabeater seal is the fastest sprinter, reaching reported speeds of up to 25 km per hour when chased. At this speed, the seal could easily overtake a man running at top speed. Phocid seals seem to be especially well adapted to deep diving. The maximum recorded dive for a Weddel seal is 741 m and female southern elephant seals have been recorded diving to 1430 m. Both seals can stay submerged for more than an hour.







Main picture: The shallow, on-shelf waters frequented by the Australian sea lion yield a limited diet of crayfish, squid, cuttlefish, octopus, small shark and fish.
Right: Australian sea lions have a rounded snout and a short, coarse hide.
Above right: Fur seals have a more pointed muzzle and a luxuriant pelt for which they were hunted almost to extinction.

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than 100 pups each during the survey period, and they accounted for almost half of the pup production. Most of these colonies were near Kangaroo Island.

The eastern bias in population density reflects a corresponding pattern of food availability. In the western and central part of their range, Australian sea lions live and breed in shallow, (less than 200 m) on-shelf waters which are separated by the Leeuwin Current from the richer, sub-Antarctic waters to the south. The warm, low-nutrient current, which flows southwards along the west coast and then eastward along the south coast of Australia, also limits the range and density of microalgae, seagrass, coastal fish and seabird populations.

But as the Leeuwin Current nears its eastern limits, its meagre bounty is augmented by richer waters from the east (see satellite image). During winter, when the prevailing winds are westerly, the current mixes with higher-nutrient outflows from the Great Australian Bight. And in summer the current is blocked, and sometimes reversed, by south-easterly winds, causing upwellings of relatively nutrient-rich, cold water. The upwellings occur in areas where the continental shelf is narrow, such as the south-west corner of Kangaroo Island and the southern tip of the Eyre Peninsula. Thus when Australian sea lions in these regions set out to forage, they rely on the productivity of near-shore waters which are influenced by the Leeuwin Current.

## All for one and one for all

In Australian waters, NZ fur seals also are most abundant to the east of their range, in numbers much greater than the sea lion. This is probably due to differences in feeding behaviour between the two species. The shallow, on-shelf waters frequented by the sea lion yield a limited diet of crayfish, squid, cuttlefish, octopus, small shark and fish. The NZ fur seal, which ventures further from the coast, into deeper waters off the continental shelf, has access to a more plentiful food supply. This may help to explain why the NZ fur seal can sustain an annual breeding cycle while the sea lion cannot.

But is the Australian sea lion disadvantaged? At this stage of the research, nobody knows whether its relatively small population and slow reproduction rate signifies danger. The sea lion may simply be exercising adaptations evolved over thousands of years to survive in one of the most nutrient-poor marine environments in the world: each aimed at minimising the food requirements of the population as a whole. For example, a wide distribution of small colonies minimises competition for a limited supply of food.

**Australian sea lion pups begin to forage independently at about five months of age. This enables them to maintain normal growth rates, despite the relatively poor quality of their mothers' milk.**

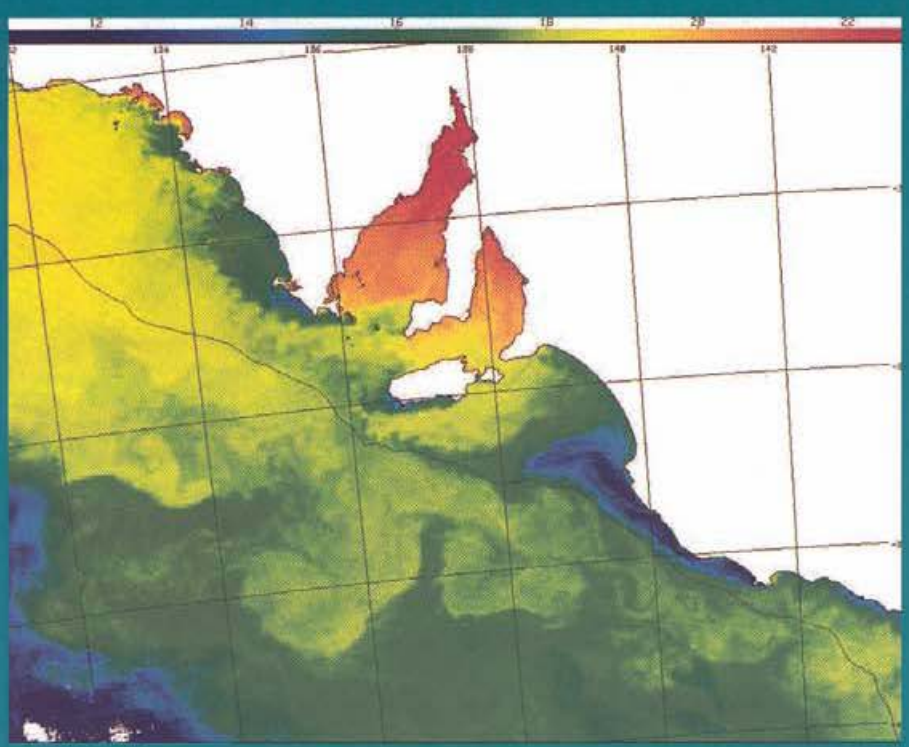
Other adaptations that may serve this survival strategy include:

- an 18-month breeding cycle;
- extended lactation and lower energy milk compared with other otariids;
- a five to seven-month breeding season; and
- an asynchronous breeding cycle (neither seasonally, nor geographically dependent.)

The average female Australian sea lion suckles her pup for about 17 months and weans it a few weeks before the next is born. This may provide two advantages. First, the mother can spend longer with the pup before weaning, allowing plenty of time for the pup to become a proficient forager. Secondly, in extending the duration of maternal care, there is the potential to decrease the rate of energy transfer from mother to young.

Like all marine mammals, pinnipeds produce milk that is rich in fat and protein, which is important for rapid tissue growth. The mother's key task is to transfer large quantities of extremely fat-rich milk to her offspring. The time taken to achieve this, (length of lactation), and even the quality of milk produced by each species, depend largely on its foraging and breeding habitat.

The Antarctic fur seal, facing time constraints imposed by a highly seasonal yet nutrient-rich environment, produces milk containing 40% fat and 17% protein. On this diet of virtual cheese, the pups gain 76-90 grams a day during a four-month lactation. Among seals that breed on Arctic and North Atlantic pack ice there is even stronger selection pressure for a short, efficient nursing period. Arctic harp seals and bearded seals lactate for 10-12 and 12-18 days respectively, and North Atlantic hooded seals nurse their young for only four to five days.



**This image, taken in February 1995 by the NOAA14 satellite, shows upwellings of cold water as the Leeuwin Current is blocked and reversed by south-easterly winds. These winds move surface waters offshore to be replaced by deep, cold water that can be rich in nutrients. A large cold plume (coloured blue) is visible west of Portland in Victoria, and smaller plumes can be seen south-west of Kangaroo Island and west of the Eyre Peninsula. The latter regions support a high proportion of Australia's New Zealand fur seal and Australian sea lion populations. The thin black line marks the edge of the continental shelf which is thought to be the boundary of the sea lion's foraging range. (Source: CSIRO Marine Laboratories Remote Sensing Facility, Hobart.)**

In contrast, Australian sea lions are characterised by slow pup development in a low-nutrient environment. Research by Gales has shown that the energy content of milk from *N. cinerea* is low compared with other otariids (fur seals and sea lions) and yet the overall growth rate of the pups is within the normal range. This growth rate can be achieved only if the pup forages independently before weaning. Observations indicate that *N. cinerea* pups may begin to forage at about five months of age.

While the survey confirmed the sea lion's 17-18 month, asynchronous breeding cycle, it offered no method for predicting the timing of the breeding at any particular site. An asynchronous breeding season may simply have evolved because it staggers the demands of lactation across the population. Not only are the energy needs of individual lactating females reduced through protracted lactation, but competition for food between females is decreased by avoiding seasonal peaks.

Gales has also investigated the theory that the sea lion's extended gestation might result from an unusually long delay between fertilisation and the first stage of embryo development (implantation of the blastocyst). By analysing blood hormone levels at various stages of the reproductive cycle, he found that the blastocyst reactivates and implants at about four to five months of pregnancy, a similar duration of inactivity to other seals. Thus the Australian sea lion actually has a prolonged placental gestation of 14 months, much longer than in any other pinniped.

Factors influencing the timing of reproduction in Australian sea lions, however, are yet to be defined. In most pinnipeds, this is thought to relate to day length (photoperiod). A different theory applies to grey seals in the North Sea, which are thought to somehow add up daily sea temperatures, with the first stage of embryo development being cued when the sum reaches 800 'degree days'.

But neither of these models can be applied to explain external cues for the reproductive cycle of *N. cinerea*. This raises some tantalising questions:

- Does the Australian sea lion have a special internal mechanism which controls its reproductive cycle?
- If so, might similar mechanisms operate in pinnipeds with annual cycles?
- Is the hypothesis that environmental cues control reproductive events based on observations of seasonally coincident occurrences that have no cause and effect relationship? If so, *N. cinerea* may be an ideal model for investigating the physiological factors controlling pinniped reproductive cycles.

With so many mysteries still surrounding the Australian sea lion, the scope for further study is broad. In ongoing research, colonies are being monitored to provide a basis for

**In 1994 and '95, Peter Shaughnessy and Terry Dennis surveyed Australian sea lion haul-out sites on the coast of the Great Australian Bight in South Australia, from Twin Rocks to Wilson Bluff. The initial search involved a 14-day traverse by Dennis along 210 kilometres of cliff edge, using binoculars and a telescope to scan the cliff base. The locations of likely haul-out sites were logged using a Global Positioning System (GPS) instrument. A low-level aerial survey was then conducted from a Bell Jet ranger helicopter, with potential sites logged using the helicopter's GPS system.**

**Getting a closer look at the sea lions presented an even greater challenge. Platforms at the cliff base were viewed with the aid of ropes and safety harnesses, and cave colonies visited in an inflatable dinghy, with help from the southern right whale research team headed by Steve Burnell from the University of Sydney. On one occasion the SA State Emergency Service cliff rescue team was called in to supervise a cliff descent.**

# No free lunches in the Bight

AUSTRALIA's sealing era is well and truly past, but humans still have an impact on seal and sea lion populations through their fishing and recreational activities. Because some seals and sea lions rob lobster pots and fishing nets, they often are regarded by the fishing industry as competitors and pests. But the animals pay a price for their thievery. Dead sea lions are recorded entangled in shark monofilament netting, and pups are known to drown in lobster pots.

In 1994 and 1995, CSIRO's Peter Shaughnessy and Stevie Davenport took video footage of Australian fur seals swimming around trawl nets towed behind the CSIRO ship FRV Southern Surveyor. Some of the seals were found dead when the nets were raised. 'The seals discovered a predictable, yet risky source of food and I suspect they entered the net to feed,' Shaughnessy says. 'Although the seals can swim faster than the nets are towed, they become confused in the low light and turbulence at the cod end of the trawl net and lose coordination. They may be unable to find their way out and either suffocate or drown before the net reaches the surface.'

On the other hand, some fisheries may benefit from Australian sea lions. The inshore fishery for small, schooling sharks off southern Australia may be removing a potential competitor for the limited food resources and the deliberate removal of large sharks such as the white pointer potentially decreases predation. Conversely, an increasing trend off southern Australia has been the attraction of white pointers with fish oil and animal blood to specific sites for filming, fishing or tourist operations. These sites are usually close to sea lion colonies (Dangerous Reef in particular) and the practice may lead to increased predation.

Former South Australian National Parks and Wildlife Service district ranger for Kangaroo Island East, Terry Dennis, says that as well as robbing baits from set pots, seals and sea lions take undersized lobsters near the surface as they are discarded by rock lobster fishers. He says the animals are attracted by old baits, bycatch or other waste dumped from fishing vessels. Potential solutions to the problem include the use of baskets which release undersized fish on the sea floor (a system used in Tasmania); removable spikes in the centre of lobster pots which prevent seal pups from entering (being tested by fishers off the Eyre Peninsula); and changes to fishing practice, so that seals and sea lions do not learn to associate boats with a foraging opportunity.

Although most of the Australian's sea lions terrestrial haunts are on off-shore islands which have some conservation status, human disturbance is still a threat, particularly during the breeding season. For the on-shore breeding colonies of sea lions in the Great Australian Bight, Shaughnessy and Dennis (in a 1994 formal submission to the Great Australian Bight Marine Park Management Plan Advisory Committee) recommended the establishment of a one-nautical-mile-wide 'Sanctuary Zone' around each breeding colony.

In September 1996, six of the known breeding colonies were specifically proclaimed as 'prohibited areas', under the National Parks and Wildlife Act, as part of the declaration of the larger Great Australian Bight Marine National Park. Together with the Great Australian Bight Marine Park Whale Sanctuary (at the Head of the Bight), which was proclaimed in June 1995 under the Fisheries Act, these protected areas comprise the Great Australian Bight Marine Park, SA's first marine park.

The multiple-use park was established principally to protect the critical calving and breeding habitats of the Southern Right Whale and Australian sea lion and comprises all coastal waters from the WA border to 132 00' East, extending seaward to a distance of three nautical miles. Fishing is prohibited within the Whale Sanctuary and 'prohibited areas'. The remaining area of the multiple-use park is the subject of a draft management plan.

Other conservation measures recommended by Shaughnessy and Dennis included public education about the Australian sea lion's unique life history; the control of human access to coastal colonies; investigations of interactions between Australian sea lions and the fishing industry, and a comprehensive survey of sea lion populations in the Bight region. The survey work subsequently has taken place.

population-viability analysis. This year (1996) Shaughnessy and SA National Parks and Wildlife Service Eyre District Manager, Paul Seager, have conducted a series of aerial surveys to determine pupping seasons at some of the smaller island colonies off the SA coast.

'We need to look at the colonies and predict their long-term sustainability under a range of hypothetical conditions,' Dennis says. 'For example, we need to know what level of mortality rates would cause a measurable decline in the population.

'We know there are substantial fluctuations in births and pup mortality. At The Pages' last breeding season (summer '95-'96), 56% of sea lion pups died. Similarly, at Dangerous Reef in October 1996, 30% of pups were found dead. These are absolutely staggering figures and we don't yet know whether these mortality levels are sustainable, or even what caused them.'

Another factor affecting the future management of Australian sea lions is the level of genetic relatedness between populations. The limited amount of DNA sampling carried out so far indicates little interaction between colonies. Further sampling of this kind will reveal where the population boundaries are within the species' range, and how much genetic exchange there is overall. This information will help determine whether the sea lions need to be managed at a colony level.

In addition to this work, studies of the diving ecology and foraging behaviour of both the sea lion and NZ fur seal – using time-depth recorders and radio transmitters – are needed to help explain why the fur seals can sustain a larger and expanding population in the same general area. Surely it would be simpler if pinnipeds could talk! But that's another story . . .

### More about the Australian sea lion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