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Whales — their migration, songs and stranding, Killer Whales or Orcas — ruthless predators with enormous appetites, Kookaburras — everyone's favourite birds.

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Cardinal fish among the delicate coral of Elizabeth Reef Lagoon. Photo Ken Grange.

Laughing Kookaburras favour the forested zones along the east coast of the continent, where a large variety of food can be found. Apart from their normal diet of snakes, lizards, rodents and the odd small bird, during insect plagues kookaburras will feed entirely on the pest. Photo W. R. Taylor (NPIAW).

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Cover

Killer Whales 'spy-hopping' in Johnstone Strait at the northern end of Vancouver Island, Canada. Photo Graeme Ellis, West Coast Whale Research, Vancouver, Canada.

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From the inside

A pair of fast-moving Killer Whales. Killer Whales or Orcas are very efficient predators of seals, walruses, other whales and birds. In the 1880s, a pack of Killer Whales, led by an individual known as 'Old Tom', herded baleen whales into Twofold Bay in southern New South Wales where the baleens were killed by whalers in long boats. Photo Graeme Ellis, West Coast Whale Research, Vancouver, Canada.

Since the International Whaling Commission voted to ban all commercial whaling by 1985 there has been mounting evidence that the world's dwindling whale populations may yet be saved.

Many whale species are already on the brink of extinction. Bowhead Whales are estimated to number fewer than 2000 while Blue, Humpback and Right Whales each have world populations of less than 5000 individuals.

Australia banned whaling in 1978 and in four short years one whale species in particular, the Southern Right Whale, is showing signs of making a comeback. For the first time in over 80 years Southern Right Whales, hunted to the point of extinction in the first half of the nineteenth century, have appeared off the Australian coast. Last July, a group of female whales with their calves in tow used Nursery Bay at Warrnambool, Victoria to rear their young before heading south for summer.

The Right Whales unexpected appearance highlighted the paucity of knowledge concerning these large but vulnerable animals and emphasised the pressing need for more Australian whale research. Realising this need Arthur Boyd, one of Australia's well-known artists, donated the proceeds from the sale of one of his paintings, Wimmera Landscape *to help fund some much-needed Australian whale study.*

Managed by the Australian Museum this grant is specifically designed to support the study of whale strandings together with library-based research of historical population levels so that the effects of harvesting over the last few decades can be accurately measured.

Roland Hughes
Editor

WHALES

Whale stranding —accident or design?

by Robert Warneke

Whales, dolphins and porpoises or Cetacea, as they are collectively known, are probably the most awe-inspiring and fascinating of all the earth's animals. Their sheer size alone, sometimes in excess of one hundred tonnes and over thirty metres in length, can take one's breath away. Unfortunately, most of us only come in contact with whales after they strand, often *en masse,* in what seems to be senseless self-destruction.

Last year, because of the outcry and concern by state wildlife authorities and conservation groups, the Federal Government published a national contingency plan for cetacean strandings setting out basic objectives and guidelines for the rescue of stranded whales. The plan is only the first step in the formulation of official rescue operations to save stranded whales. It involves the coordination of marine biologists, State Governments, conservation groups, veterinary practitioners, the RSPCA and even the RAAF and Army.

In this article Robert Warneke, a Senior Research Officer with the Victorian Fisheries and Wildlife Division, investigates whale stranding. A mammal specialist, his particular interests are the behaviour and life history of Australian Fur Seals, the effects of sealing on all the species that occur around our coasts as well as whales and whale stranding.

Impractical attempts to rescue one of a group of Sperm Whales stranded at Ocean Beach, Macquarie Harbour, Tasmania on the 17th January, 1981.

Opposite, one of a herd of 87 False Killer Whales that stranded over six kilometres of beach in the Croajingolong National Park, eastern Victoria, on 18th January, 1983. Photos Robert Warneke.

During the past 200 years or so a huge mass of scientific and narrative literature on cetaceans has accumulated in our libraries yet they are still creatures of great mystery. This is partly due to their inaccessibility. At sea we are lucky to catch more than a fleeting glimpse, and should we happen to encounter a whale or dolphin on shore it is likely to be dead or dying. Some species have been successfully accustomed to captivity where they can be observed at leisure but we cannot expect to learn much of their true lives from the confined performers in marine aquaria.

The result of their evolutionary development in the sea has distanced them from other mammals in many ways. Their bodies have been refined and streamlined into naked, fish-like shapes that now reveal little of their quadruped ancestors. Their hind limbs have been utterly lost and their tails have expanded into lateral flukes.

Internally more subtle changes have been wrought in senses and function. For instance, only within the last thirty years or so has it been appreciated that many cetaceans have an extraordinary ability to communicate with

each other and to probe their surroundings by a form of sonar. Their system of beaming sounds and interpreting echoes is incredibly sensitive and exceeds our own sophisticated technology in this area.

Their cerebral capacity also appears to be quite remarkable but the nature and extent of their mental powers remains obscure. Captive dolphins have shown themselves to be adept and innovative in performing display routines, and in the wild many species exhibit social and individual behaviour in which some observers see evidence of mental abilities equal to that of man. Unfortunately there is little common ground for comparison as cetaceans do not have the kinds of manipulative abilities that have been the stimulus of man's intellectual development. Cetacean 'intelligence' is therefore a fertile field for scientific and non-scientific speculation and controversy. However clever they may be there is one feature of cetacean behaviour that seems to demonstrate very little intelligence indeed. This is the phenomenon of live stranding and, in particular, of stranding *en masse*.

It is a paradox that has puzzled and intrigued man throughout history. Such unaccountable behaviour undoubtedly contributed to the wonder and awe in which whales and dolphins were held by many sophisticated as well as primitive cultures. Fables, poems and eulogies to dolphins have survived from the times of Aesop. In the second century AD the poet Oppian of Corycus

A young 17.5 metre Blue Whale, stranded alive at Levy's Point near Warrnambool, Victoria, on the 17th April 1976 and its dissection after death for research at the National Museum of Victoria. Photos Wayne Smith.

wrote "... then coastward from the great deeps they go and running themselves ashore on the beach's yielding sand, there breathe their last; preferring to meet their doom on land, in hope some man may find them and (still remembering their loving gentleness of heart) may stay to fling a mound of shingle o'er them..."

Three centuries before Christ that remarkable philosopher and natural historian Aristotle wrote "It is not known for what reason they (dolphins) run themselves on dry land...", and over thirteen centuries later our understanding of this phenomenon has not progressed very far. It is therefore not surprising that many explanations and theories have been advanced to explain it.

The most popular, at least with the mass media, is suicide. This melodramatic explanation is well suited to the perplexing events that often occur at a mass stranding of one of the smaller species where, despite the best efforts of onlookers to return animals to the sea, they persist in rejoining their fellows to die on the beach. It appears to be a conscious rather than instinctive act. Those species that strand *en masse* move about in close family groups of five or more animals or much larger social aggregations which may comprise hundreds. Social cohesion is so strong that the whole group may seek to render aid to one of their fellows if injured or in distress. One animal may therefore precipitate the stranding of an entire herd.

One highly speculative theory maintains that strandings are an expression of a race-subconsciousness in moments of extreme stress, a primeval urge to return to the ancestral security of the land. It is argued that this response overrides their otherwise complete adaptation to an aquatic existence as well as that high intelligence that some believe to be so alert and reasoning.

Another explanation has it that migratory species become unwitting victims when attempting to follow ancient sea-ways through narrow straits

that have since been closed by changes in sea level or have sanded up.

At our present state of knowledge it is impossible to prove or disprove either of these theories, but it seems clear enough that they cannot explain all strandings. Scientists are now looking much more closely at the circumstances of individual strandings and are attempting to assess the physical condition of the animals involved, to see if cause and effect relationships become apparent as reliable data accumulates.

Causal or contributory factors within the environment may include unusual tides, the state of the sea, configuration of the coast, nature of the adjacent seafloor, and meteorological events such as electrical storms. Rarely is the cause so simple and obvious as, for example, ever-eager pursuit of fish into shallows.

Important clues may be gained by carefully observing behaviour before and during a beaching and, finally, from the age and health status of the strandlings. We know from past events that lone animals, as distinct from social groups, can be highly stressed or dying **before** they beach. Some were dependent young that must have been separated from or abandoned by their mothers, others were injured or crippled by disease. Recently, internal parasites have been diagnosed as the cause of some single strandings but we still have much to learn about their effects on their hosts. Although large numbers of nematode and trematode worms have been found in the ear sinuses of stranded whales it is not certain that they interfere significantly with hearing and therefore impair an animal's sonic ability to avoid obstacles. It may be a very different matter however if parasites cause inflammation and pain or damage tissues in the ear region or the brain, as has been noted in some dolphins.

Clearly, any cetacean with impaired hearing and unable to navigate properly or severely stressed for whatever reason, would be unlikely to cope with unfamiliar surroundings, rough seas, strong currents, harassment by sharks and the like. Stranding of some of these unfortunates is inevitable. Their deaths are not tragedies — they are merely part of the natural process of weeding out the aged and unfit to the benefit of the populations of which they were a part. However, there is one exception, the ailing member of a group or herd that, by stranding, draws in its fellows to share its fate. Even so, these mini-disasters are part of the natural mortality to which these social species have adjusted over a vast period of evolution.

In Australia most strandings have occurred on the southern coasts, but this is to be expected as there is a greater variety and abundance of cetaceans in temperate waters. A fair series of records has accumulated over the past 120 years or so and is now being collated and analysed for clues to contributory causes.

WHALE AND DOLPHIN STRANDINGS IN VICTORIA AND TASMANIA

Mysticetes (baleen whales)	**Total**
Right Whale, *Balaena glacialis*	1
Pygmy Right Whale, *Caperea marginata*	31
Blue Whale, *Balaenoptera musculus*	6
Fin Whale, *Balaenoptera physalus*	2
Minke Whale, *Balaenoptera acutorostrata*	9
Sei Whale, *Balaenoptera borealis*	1
Bryde's Whale, *Balaenoptera edeni*	1
Humpback Whale, *Megaptera novaeangliae*	2
Odontocetes (toothed whales and dolphins)	
Sperm Whale, *Physeter macrocephalus*	41
Pygmy Sperm Whale, *Kogia breviceps*	10
Southern Bottle-nosed Whale, *Hyperoodon planifrons*	2
Cuvier's Beaked Whale, *Ziphius cavirostris*	11
Blainville's Beaked Whale, *Mesoplodon densirostris*	1
Strap-toothed Whale, *Mesoplodon layardii*	8
Gray's Beaked Whale, *Mesoplodon grayi*	6
Andrew's Beaked Whale, *Mesoplodon bowdoini*	3
True's Beaked Whale, *Mesoplodon mirus*	1
Arnoux' Beaked Whale, *Berardius arnuxi*	1
Killer Whale, *Orcinus orca*	6
False Killer Whale, *Pseudorca crassidens*	16
Pilot Whale, *Globicephala melaena*	33
Short-finned Pilot Whale, *Globicephala macrorhyncha*	1
Risso's Dolphin, *Grampus griseus*	1
Bottle-nosed Dolphin, *Tursiops truncatus*	32
Common Dolphin, *Delphinus delphis*	27
Southern Right Whale Dolphin, *Lissodelphis peroni*	1
Frazer's Dolphin, *Lagenodelphis hosei*	1

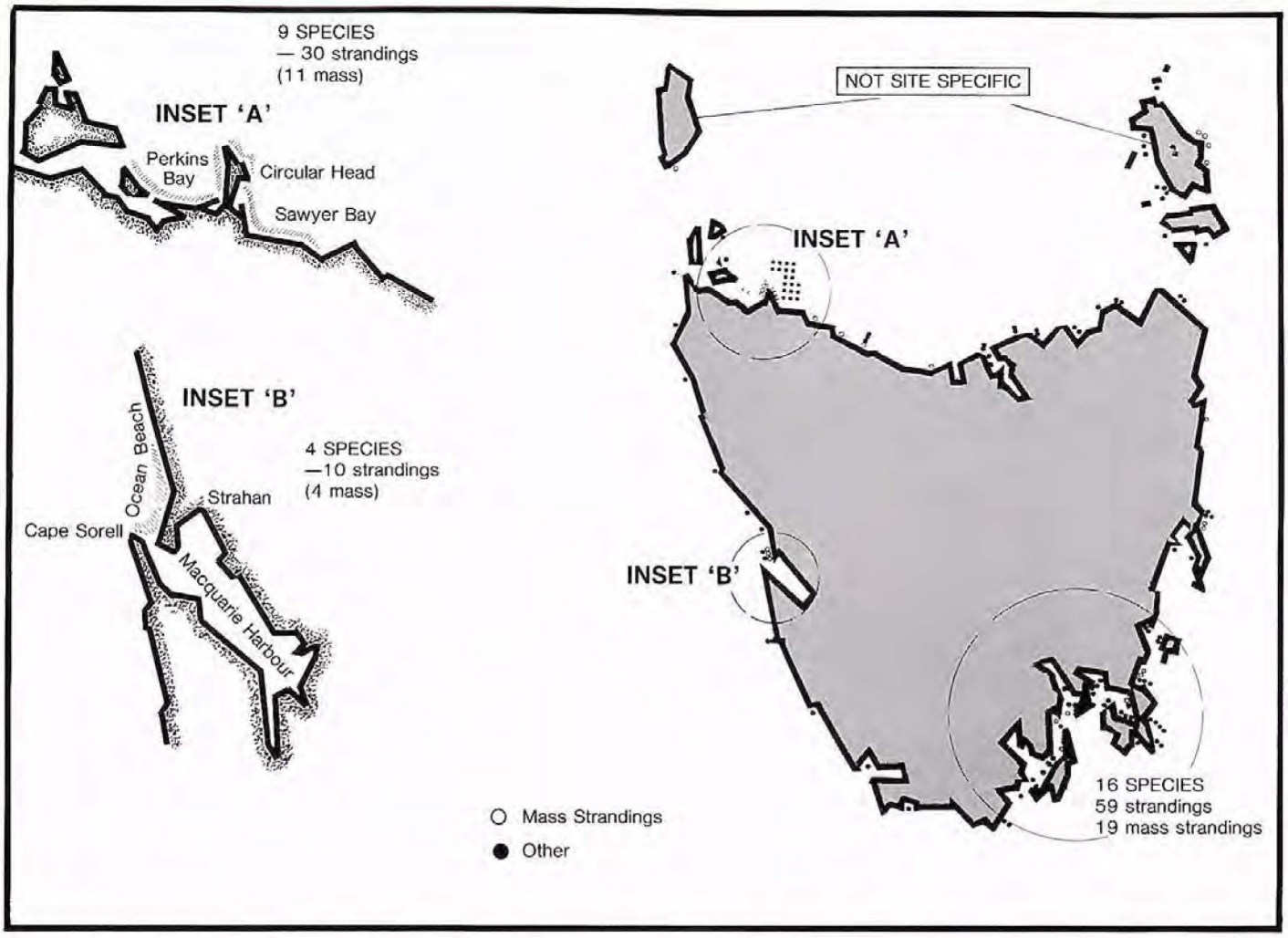
Two groups of strandings of particular interest are those which have occurred in Victoria and Tasmania, since their coastlines lie adjacent to seas of contrasting character — the broad and shallow basin of central Bass Strait, the narrow continental shelf of east and west Tasmania and the deep oceanic waters of the Tasman Sea and the Great Australian Bight. The hydrology of Bass Strait is exceedingly complex, with variable intrusions of at least four major water masses of differing temperatures and chemical composition. These components are moved and mixed by currents, tides and winds according to season and the vagaries of a climate dominated by a progression of pressure systems that sweep across the Southern Ocean from Antarctica.

As a result, in this region, the natural habitat of oceanic whales occurs close to most of the Tasmanian coast as well as parts of Victoria and is connected east-west by a shallow continental sea some 180 kilometres in width. Although Bass Strait is an alien environment for large whales, they appear to use it as a convenient corridor for movement at certain seasons between the central Tasman Sea and the Southern Ocean to the West.

Overall, eight species of baleen whales (mysticetes) and 20 species of toothed whales (odontocetes) have stranded in the region. Of these only two are coastal species which are more or less local inhabitants — the Bottle-nosed and Common Dolphins. Two others are represented by vagrants far from their normal tropical range — the Short-finned Pilot Whale and Frazer's Dolphin. All the rest are widely distributed oceanic species. Most of them do not often strand because they either do not normally approach the land or they regularly visit coastal waters and are at home in shallows. The latter include the Right and Humpback Whale.

The earliest records of strandings in Victoria and Tasmania date from the 1830's and the tally now stands at 256. Many more must have passed unremarked in earlier times when there was less interest in whales, but in recent years as many as ten strandings per year have been reported. Unfortunately, in the majority of cases the actual stranding was not observed and the bodies were not closely examined so that the individual records do not yield a lot of relevant information. We can however analyse the whole series of events in a number of ways including the variety of species involved, time of year, number of individuals involved, lunar cycle and locality.

To begin with, almost the entire range of species known from the temperate latitudes of the Southern



Hemisphere is represented in our series, excepting only the Dwarf Sperm Whale and Shepherd's Beaked Whale, two stranding rarities which are known from South Australia. Seasonal cycles in the occurrence of some species are apparent and these relate, generally speaking, to normal migratory movements or reproductive cycles. All the known mass-stranders are represented — Sperm Whale, Killer Whale, False Killer Whale, Pilot Whale and the two local species of dolphins. So far this century there has been a minimum of 40 mass strandings.

The high total strandings of the Bottle-nosed and Common Dolphins are to be expected as they are both abundant in our coastal waters, but the Pilot, Sperm and False Killer Whales, all oceanic species, appear to be at risk whenever they venture onto the continental shelf. They might be at hazard because they are inexperienced or unable to correctly interpret the acoustic information they receive when swimming in coastal waters. There is evidence that a shoaling sandy bottom poses a problem for those cetaceans which rely on sonar for navigation because sounds beamed shorewards are deflected away and do not return as echoes. It follows then that family groups or large herds trapped in this way or swimming to the aid of a group member in difficulty are mainly healthy active animals. Their death through stranding is accidental and unnecessary and many can be saved if human aid is given promptly. Successful rescues have been achieved in South Australia, New South Wales, Victoria and Tasmania during the last fifteen years.

STRANDINGS	MASS	TOTAL
Pilot Whale	17	33
Sperm Whale	8	41
False Killer Whale	7	16
Common Dolphin	4	27
Bottle-nosed Dolphin	3	32
Killer Whale	1	6

It has been claimed that many strandings occur at or within a few days of a full moon. There is some suggestion of this in our series and in the case of the Pygmy Right Whale the correlation is quite strong, however the causal factor has not been demonstrated although it possibly has something to do with the unusually high tides that can occur at that stage of the lunar cycle.

A map showing the sites of all strandings is most illuminating. At a glance it is apparent that they are non-randomly distributed, even allowing for limited reporting from areas remote from centres of human activity. High numbers of strandings in certain areas suggest that they are particularly hazardous for cetaceans.

Cetacean strandings around Tasmania (above) and on the Victorian coast (bottom opposite).

There are two such areas in Tasmania where the continental shelf is relatively narrow. One is in the south-east where the coastline is a fantastic complex of sprawling peninsulas and islands with a multitude of bays, channels and shallows. Fifty-nine strandings of 16 species have occurred in and around this maze. By contrast the other area is very clearly defined. It is on the west coast at the entrance to Macquarie Harbour. Here the danger lies in the juxtaposition of a long, featureless ocean beach and a jutting rocky headland, Cape Sorell, which forms a pronounced hook. Whales heading south close in and parallel with the beach find their progress barred ahead and, deceptively, to the right as they near the harbour entrance. If they become confused and take the seemingly less obstructed passage to the left, they end up on the beach or enter the long, narrow landlocked harbour beyond. This has happened at least six times within this hook to whole herds of Pilot Whales and Sperm Whales, and four of these strandings have occurred since 1977!

A similar trap awaits whales attempting to escape south and westwards from the central Bass Strait basin. They are forced to negotiate a northward trending coast which guides

them inexorably into the gently shoaling waters of Sawyer Bay at Stanley. The western shoreline of this bay turns sharply seaward for several kilometres and then recurves beyond the township at the high bluff, Circular Head. Any whales that manage to pass this barrier are then confronted by a confusion of shoals and channels among the islands and islets of the Hunter Group. Between them, Sawyer Bay and Perkins Bay immediately to the west have accounted for 30 strandings of nine species since 1911.

Lesser whale traps on the same principle exist on the Victorian coast at Portland, Port Fairy and Wilsons Promontory, but the major feature of this northern boundary to the Strait is the central indentation between the Promontory and Cape Otway. This bight appears to funnel unwary cetaceans into the dead-ends of Port Phillip and Westernport Bays, where some 28 strandings of 10 species have occurred since the 1860's.

This brief resume of strandings in one part of Australia has revealed patterns which point to some of the contributory causes and in that sense they have predictive value. This is particularly important in relation to mass strandings, where many animals may be rescued if appropriate preparations are made and suitable equipment is strategically placed. However the majority of strandings involve lone animals, some mother-calf pairs and occasionally a male-female pair. Evidence is accumulating that in these cases terminal disability is commonly the primary cause, which means that returning them to the sea will not prolong life in any effective sense. Each animal must therefore be carefully assessed by competent specialists before a rescue or salvage operation is mounted.

Although the Federal Government has no jurisdiction over whales stranded in State waters it has taken the first step to develop a national, coordinated approach to the problem. In 1982 it published a national contingency plan for cetacean strandings, which sets out some basic objectives and guidelines for practical means of achieving them. This is an interim document intended to assist State or Territory wildlife agencies in developing regional strategies. With their high incidence of strandings it is not surprising that Tasmania and Victoria are actively developing and coordinating research, veterinary, volunteer and public relations capabilities to deal with large and small cetaceans, singly or *en masse*.

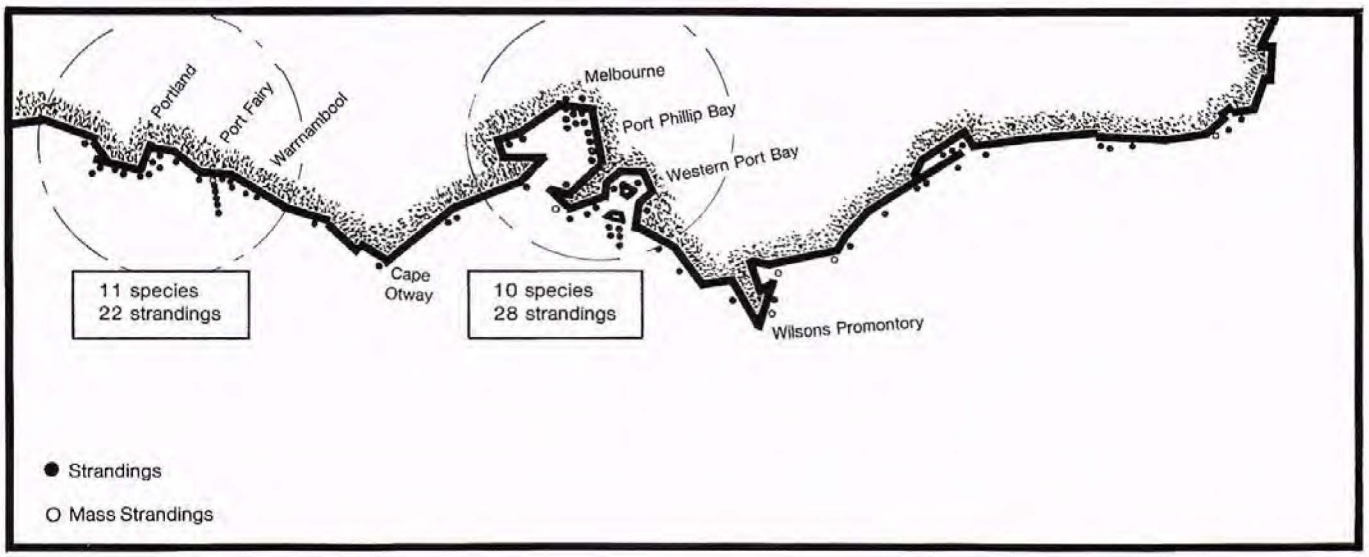
A six metre female Cuvier's Beaked Whale landed injured and bleeding on Bridport Beach, Tasmania on the 22nd February, 1977 and had to be moved by tractor after it died. Our entire knowledge of some species of beaked whales is from strandings. Photo courtesy of the Queen Victoria Museum, Launceston.

When whales lie stranded on a beach the general public can assist in two critically important ways, firstly by **immediately** reporting their location, number and size to the local wildlife authorities or to the police so that the appropriate contingency groups can be alerted.

Secondly, the public can render **vital** first-aid to live whales until responsible officers and specialists arrive on the scene. Since a beached whale will rapidly overheat it is essential to keep the animal as cool as possible by shading and wetting it down, by bucketing water over it or draping its body with wet towels, but care should be taken to keep the blowhole uncovered and clear of sand. Its flippers and tail-flukes are the most important areas of the body for dissipating heat and should be kept constantly wet.

Those first on the scene can also aid in the study of stranding phenomena by **noting down** the state of the sea and tide, strength and direction of the wind and any unusual circumstance that might have precipitated the stranding. If there is more than one animal it is important to note, if possible, the sequence in which they came ashore and to identify the lead animal. Photographs of the surroundings and close-ups of the animals are invaluable.

A dead whale, even if it is decomposing, is valuable for research. In most States stranded cetaceans cannot legally be removed from the beach or interfered with in any way. In Victoria, for instance, the Protection of Whales Act provides for very heavy fines for mutilation, including the removal of teeth.



Giant travellers of the ocean depths

by William Dawbin

Seventy million years ago the oceans teemed with large, ferocious reptiles and there were no marine mammals. However within five million years these oceanic reptiles had died out and several groups of mammals radiated into the seas to take their place. One of these first groups of ocean-going mammals were cetaceans. Cetacean's ancestors were originally land-dwelling and today survive in two distinct groups, toothed and baleen whales.

Toothed whales are generally the smaller size of the two groups being more diverse than baleen whales. They range from the only large toothed whale, the 18 metre Sperm Whale, down to dolphins and porpoises of two metres or less. Toothed whales do not undergo regular long distance migration and feed on fish, squid and other large prey, catching them with their sharp teeth and swallowing them whole.

The Baleen whales are all large and have been subject to massive slaughter by man over the years. It is this group of whales which are examined in this article on whale migration in Australasian waters.

All ten species of baleen whales feed on elements of the plankton group of animals. They strain these plankton from the water by means of horny or 'whalebone' plates called baleen which fringe the upper rim of the mouth. As the greatest concentrations of suitable plankton occur in the polar waters, the whales congregate in these regions during the warmer summer months to feed. In order for the calves to survive at birth, these whales require warmer water. So each winter the whales travel northwards from the Antarctic to one of the many tropical breeding areas.

These animal movements, some over 16,000 kilometres, are followed by mating, birth and suckling and then a long journey back to the feeding grounds from which they initially came. All this is undertaken using energy from the fat reserves built up in the Antarctic. The whales seem to eat very little, if anything at all, during their time spent in the tropical breeding areas.

William Dawbin is a Research Associate of the Museum and has been studying whales ever since he first sighted them during naval service in World War II. During forty years of whale work he has marked over 1000 Humpback Whales around the Pacific Islands and New Zealand in a study of Australasian migration paths, served on the International Whaling Commission and was Reader in Biology at the University of Sydney.

Worldwide there are ten species of baleen whales and two of these, the Arctic Bowhead and the California Gray Whale are localised and do not occur in Australian seas. Another animal, the Pygmy Right Whale, occurs in a narrow belt around the southern hemisphere in a zone that includes southern Australia, New Zealand and southern South America but it is little known and its migrations, if any, are small scale. The remainder, are a streamlined group all having throat grooves and dorsal fin, (rorquals) and include the Humpback, Blue, Fin, Sei, Brydes and Minke Whales. They, together with the Right Whales, which have no dorsal fin or throat grooves, occur in some parts or other of all oceans.

Humpback Whales grow to about 15 metres and 50 tonnes. They are dark above, with white areas of variable extent on the underside of the body, flippers and tail and their unique feature is the relatively huge size of the flippers, exceeding four metres in adults. The flippers are especially distinctive in views from the air, during the not infrequent occasions that humpbacks wave them above water or when the animal breaches. Humpbacks have a tendency to travel relatively close to the shoreline so local sightings and catching have made them the best known baleen whale in Australian waters.

Humpback distribution in the southern hemisphere first became known from catches made in the early nineteenth century. During winter coastal whaling around Australia and New Zealand, Right Whales were the prime target because of the great value of their fine textured baleen plates and their high oil yield. However, humpbacks were sometimes taken to supplement oil. In tropical oceanic waters, Sperm Whales were the main target for both the valuable wax or spermaceti as well as sperm oil.

Some captains, in the early 1820's and 30's, spent winter periods 'humpbacking' between the main hunt for Sperm Whales. Information on the grounds slowly increased and revealed major winter concentrations from Shark Bay to beyond North West Cape off Western Australia, the Coral Sea east of the Great Barrier Reef and around Tonga. Elsewhere in the southern hemisphere major concentrations were located near the coasts of South America along Ecuador and near the west coast of Africa from Angola to the Congo and along the east coast of Mozambique and Madagascar. The only continental southern coastlines with no major humpback concentrations identified were eastern South America, and arguably eastern Australia unless we accept the Coral Sea as close to continental shore.

With the change from sailing ships and hand harpoons to engine powered catchers with large explosive harpoons, most winter concentrations except stocks in Tonga and the Coral Sea were again exploited early this century. However, the advent of new whaling technology enabled whalers to exploit summer concentrations of humpbacks in cold waters. In particular, the feeding areas around South Georgia and South Shetlands yielded more than 30,000 humpbacks in the years 1907—1915, a catch from which the local stocks never recovered.

Later, development of huge floating factory ships allowed catching to be exttended to Antarctic waters north of the thick ice. They found humpback catches were not evenly distributed around Antarctica and instead were concentrated in the cold water feeding grounds as southerly extensions from the known tropical winter assembly points. Finally, total collapse of stocks throughout the area brought humpback whaling to a close and ironically they were given world wide protection a year later.

Probable migration paths between each breeding area and the nearest part of the southern ocean were at first interpreted as streams of animals travelling separately and in isolation. The degree of accuracy of this concept became clarified by programmes of marking and recapture.

Several methods of marking whales have been tried for later recognition of live animals at sea or the carcases at a

whaling platform, but only one has produced long term results. This method, first developed by Discovery Investigations of the United Kingdom is to use a modified shoulder gun to shoot in a numbered metal tube sufficiently deep to completely embed in the blubber and muscles of the mid-back where there is little chance of causing injury to the whale. Marks that protrude tend to work out fairly quickly. No type of externally visible mark has had long term success.

Early marking was carried out mainly by UK investigators in Antarctic waters and followed later by USSR and Japanese biologists. The CSIRO carried out a marking programme off both the east and west coasts of Australia while my own programme concentrated on island groups further east mainly in non whaling localities. These included Foveaux Strait, Cook Strait and Hauraki Gulf in New Zealand, Vanuatu, Norfolk Island, Fiji, and Tonga. At that time, the Australasian whaling localities were Albany, Carnarvon, and Point Cloates in the west, Moreton Island, Byron Bay, Norfolk Island and New Zealand in the east together with very small scale open boat whaling from Tonga. The area in a wide belt around and to the south of Australasia finally contained more marked humpbacks than any other region. Approximately 3000 humpbacks with about 1000 from each of the three programmes namely southern ocean, mainland Australia and islands to the east, were available to be tapped from the whaling stations and the Antarctic pelagic fleets.

The main results, proved that humpbacks disperse widely in the southern feeding grounds so that each tropical breeding group is drawn from a wide range of longitudes. One example is that humpbacks caught near coastal west Australian breeding areas from Shark Bay to North West Cape were drawn from localities between longitudes 75° and 140°E, while those caught off Byron Bay and Moreton Island were drawn from the region between longitudes 110°E and 165°W. An overlap of 30 degrees in the feeding areas for animals that later separated to breeding areas on opposite coasts of Australia was the surprising finding of these programmes. The other finding was the overlap between New Zealand, Fiji, and Norfolk Island animals with east Australian humpbacks.
Breeding concentrations in tropical

In the tropics Sperm Whales were the main target of whalers for both the valuable wax or spermaceti they provided as well as sperm oil. These whales feed on fish, squid and cuttlefish, some of which are obtained as far as one kilometre below the water surface. Dives to this depth may last 75 minutes and are only possible because of whales' complex physiological adaptations. Photo on Page 53 by courtesy of Green Peace. All other photos in the article by William Dawbin.

Above and opposite a gunner from a New Zealand whaling boat darts a bomb lance into a Humpback Whale after it has been harpooned in the Cook Strait, New Zealand.

waters are widely separated from each other, either physically by intervening land masses or long stretches of deep oceanic water. As a result humpback movements can be traced within the southern zones, where quite a lot of intermingling occurs. There are no sharp boundaries that demarcate the previously separate breeding stocks, once they disperse in southern waters.

Despite the southern intermingling there remains the problem of geographic segregation in tropical waters. From both west and east coasts of Australia by far the majority of animals marked locally and recaptured in warm waters during later seasons, had in fact returned near to the original breeding area. However, separation was not quite complete since two humpbacks marked off western Australia were caught in later seasons off eastern Australia. Likewise there has been some limited interchange between humpbacks off Fiji, Norfolk Island, New Zealand and east Australia, but the overall tendency of animals to mainly return to the same breeding areas in separate seasons is now confirmed. From humpbacks marked near Moreton Island, 37 were caught there in later seasons compared with three such animals off New Zealand.

The greatest separation between the longitudes of marking and catch was the surprise occurrence of an animal marked in Tonga at Longitude 175 °W and caught near the Bellinghausen Sea at Longitude 95 °W, almost south of South America and in a direct line distance of some 5000km. So humpbacks migrate to separate and concentrated tropical breeding areas in coastal waters at about 25 °C whether off continental or island shores. This is followed by a fanning out as they disperse more widely in the Antarctic feeding areas. While most return to their original breeding location the small proportion that migrate back to different breeding areas ensure some intermixing of genes between stocks. There are no distinctive geographical races among southern hemisphere humpbacks.

Along the west coast of Australia, northbound humpbacks start to enter coastal waters a little east of Albany (Lat 35 °S) and steadily increase in numbers because of other arrivals as they travel north to the North West Cape region. The coastal section of the return migration southward follows a similar course with a decrease in numbers by the time Albany is reached. Negligible numbers occur along the coasts of the Great Australian Bight, South Australia, western Tasmania and western to mid-Victoria as the waters are too cold for humpback breeding requirements and the coasts are a big deflectionary barrier to further progress north.

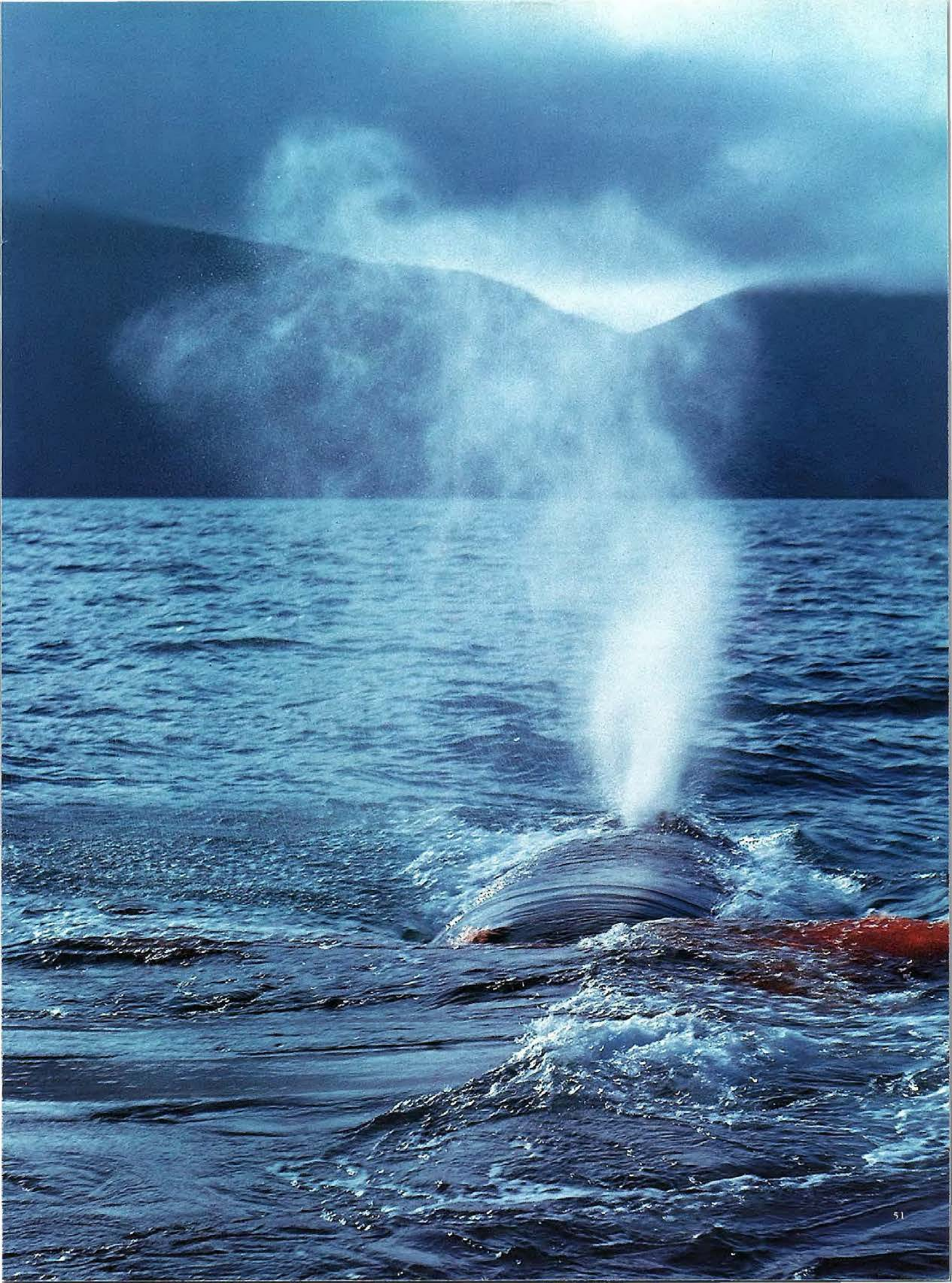
From the east coast of Tasmania up to Moreton Island, humpback numbers are at first very low along Tasmania and eastern Victoria but steadily increase along New South Wales. From a whaling station near Eden (at Twofold Bay) humpbacks were caught in small numbers until 1930. However, sightings near the later and much larger whaling stations at Byron Bay (29 °S), and Moreton Island (27 °S), demonstrated the cumulative effect of animals encountering the coast from June through to August as they are deflected to the most easterly part of the coast. In this region humpbacks are still travelling north and observers sometimes observe animals continuing more or less steadily from the limits of visibility south until they are lost going north. They are clearly not milling about and staying put as in breeding localities.

This raises the problem of their ultimate destination. In the days before whaling decimated the stocks, humpbacks were a special feature of the Whitsunday Passage region but even there and elsewhere inside the Great Barrier Reef the numbers did not seem to account for all those known to pass Cape Byron and Moreton Island. It is tempting to suggest that a concentration in the Coral Sea demonstrated by the nineteenth century pelagic whalers must be the main site but a regular major concentration of humpbacks in this region has not been demonstrated in recent years.

Southward migrating humpbacks pass Moreton and Stradbroke Islands in substantial numbers during September through November but apparently decrease in density further south off Coffs Harbour, Port Macquarie, Sydney and Jervis Bay. This suggests that they are leaving the coast progressively while moving towards their Antarctic feeding grounds.

Further east of Australia humpbacks regularly pass New Zealand following a different northerly route to that during their return migration. New Zealand has an overall southwest to north east trend in its coastlines and numbers build up along the eastern coastlines of the South Island with one stream of animals passing through Cook Strait as others continue along the east coast of the North Island before passing north. Marked animals show that they can reach Fiji and probably Tonga where some cease steady northward movement and then remain for weeks at a time during the breeding season (mainly August through October). Some may travel still further north or to other island coastal areas yet to be defined. Some humpbacks, probably in relatively small numbers only, pass New Caledonia, Loyalty Islands and the New Hebrides region. There has been very little evidence of them through the Solomon Islands and further to the north. Perhaps the New Hebrides and also Norfolk Island animals contribute to stocks in the Coral Sea.

Return routes towards the Antarctic are best known past New Zealand



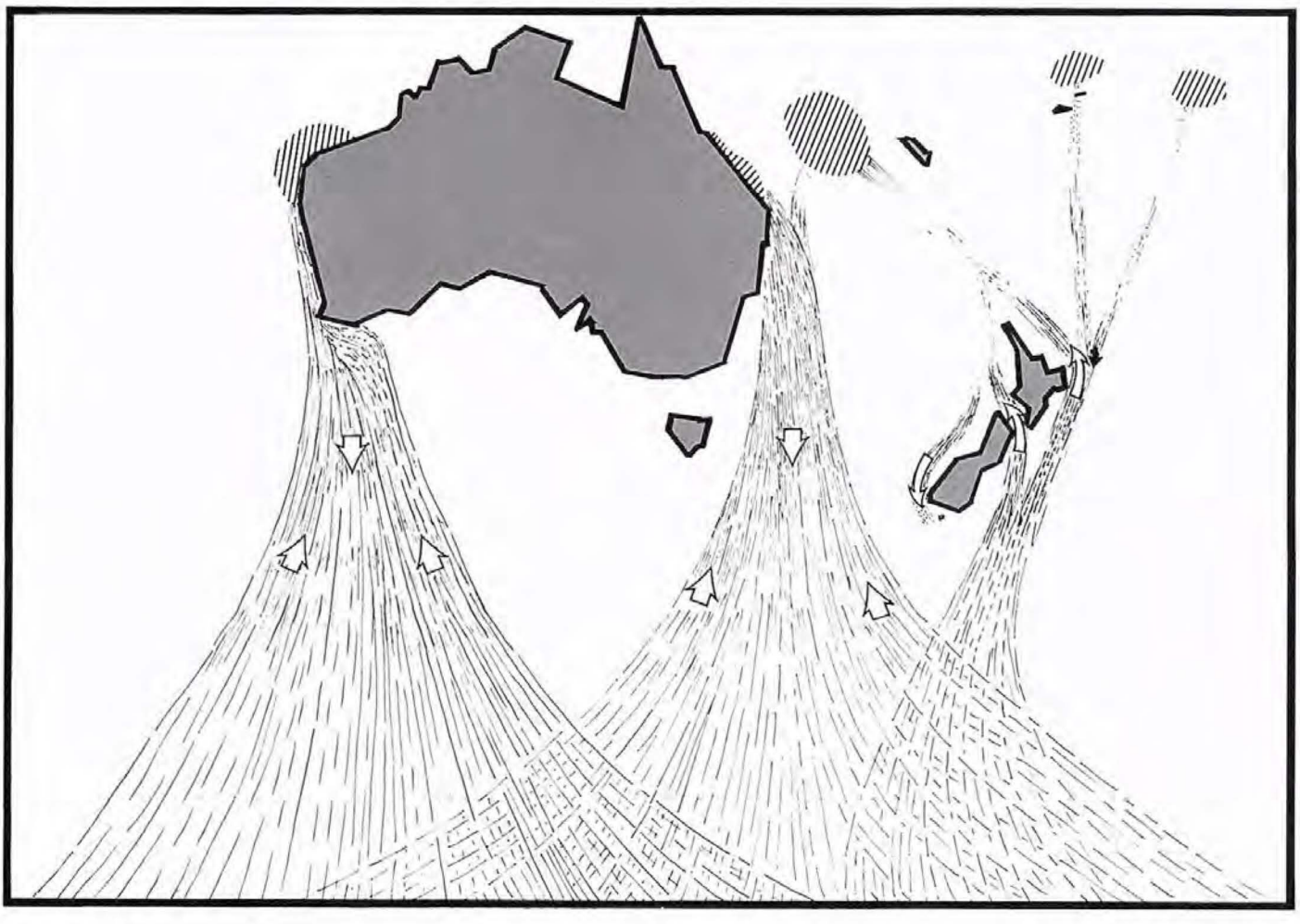
where animals from October through December mainly approach the west coast reaching their greatest density at its most southerly part (western Foveaux Strait, between the South Island and Stewart Island). Here more than one hundred per day could be seen in the early 1950's. Unlike the northerly stream through Cook Strait, very few humpbacks have ever been seen travelling back through Cook Strait. Nearly all west coast animals are therefore deflected to Foveaux Strait and here many have been seen feeding on the local plankton (which is not krill) after the several months of fasting during the northward migration and breeding sojourn.

Humpbacks take two to three months to pass any given point on the coast but the time required to travel from Antarctica to the tropics is less certain. Individual animals off Cape Byron, Point Lookout, and Cook Strait New Zealand have been kept under observation for three or more hours while maintaining a fairly steady four to five knots and there is good evidence that this occurs at night as well as day. Such speed maintained steadily in a direct line from feeding to breeding areas (say 65 °S to 15 °S) would cover the distance in about three weeks. However, the times of peak density at various latitudes suggests a much longer interval. The interval between peaks at Foveaux (46 °S) and Tonga (22 °S) indicate a northerly progression of about 15 ° per month or 30 nautical miles per day. Intervals between Albany and Point Cloates or Madagascar and Congo where different stocks are involved) are at least consistent with a fairly slow overall rate of progression.

One question that could not be answered from humpback sightings is whether the migrating stock contains a randomly mixed sample of the population at any one time. Examination of length, gonads and foetuses' on 2,000 humpbacks from New Zealand, 10,000 from West Australia and 8,000 from East Australia (including Norfolk Island) show all regions have the same overlapping migration sequences on arrival at breeding sites. Always following the same highly significant pattern, mothers with recently weaned 'yearlings' travel north first, followed successively by immature males and females, mature males and resting females and then finally females in late pregnancy. The time interval between the peak arrival of the early mothers with weaned yearlings and females in late pregnancy is one month. The latter produce their calves on the tropical breeding grounds and travel back to the feeding grounds in the latter part of the return migration. The newborn calves are therefore among the last animals to re-enter the cold southern waters.

However, 'yearlings' accompanying the mother are the first to begin the next migration northward. This means that the timing of the mother's departure from cold waters changes after pregnancy to an earlier date followed during lactation. Since great seasonal changes in day length are the most substantial environmental change in polar waters a changed response to length of day during pregnancy would seem a likely trigger.

It is easier to comment on environmental factors that appear to be disregarded by migrating humpbacks than to identify possible navigational cues. We now know that humpbacks migrate north along both coasts of the southern hemisphere land-masses at roughly the same time. Those travelling north along the west coasts of Australia, South Australia and Africa are all moving in the same direction as northward flowing cold currents while humpbacks on the equivalent east coasts travel against southward flowing warm currents. The only obvious difference is that those in the cold currents travel further north to breed, the extra distance being necessary to reach warmer water (about 25 °C). It might be argued that these groups are largely separate breeding stocks that each have become adapted to their local current flow. However, we have seen that between seasons some intermixing does occur



Humpback migration paths around Australia.

Southern Right Whales are characterised by individual patterns of knobs along the top of the head and jaws. This whale was preferred by Australian whalers because of accessibility, valuable baleen and high oil yield.

between widely separated stocks and that animals within the same migrating stock may traverse quite different currents. For example, those that pass New Zealand encounter quite different current directions and water temperatures along the east coast to those of the west coast, yet both currents are entered simultaneously by parts of the same migrating stock.

Underwater topography provides no clues on submerged ridges etc that could serve to indicate a humpback's position in each region. While stocks do accumulate and increase in density following deflection along extended shore lines, others must necessarily travel the whole distance from polar to tropical seas without encountering any long coastlines (as in the case of those around Tonga and Fiji in the southern hemisphere and those at Hawaii and Bermuda and the Virgin Islands in the northern hemisphere). Coastal waters are clearly not essential as guidelines during migration but, for reasons that are not yet understood, they do appear to be essential at the time of courting, mating and calving. This results in all known breeding concentrations being situated off continental (or reef areas such as the Coral Sea) or island group shore lines. In these tropical localities humpbacks are very rarely seen over the deep water of mid ocean, although some of these regions must be traversed later when they migrate back to feeding areas.

The method of direction finding by whales is largely unknown. Since the sense of smell is absent it seems clear that orientation to sunlight and or starlight must be used. Sonar reflections from bottom or shores are unlikely to be the major guide over long distance, but might well provide useful supplementary information in localised parts of the migration.

Blue, Fin and Sei Whales were all abundant at one time in the southern ocean during summer until each in turn was decimated by whaling. However, they have never been observed in significant numbers near any of the coast lines in Australasia. It seems clear that they actively avoid coastal waters while migrating to warm waters to breed. Possibly they are thinly dispersed at this time or there may be some tropical oceanic concentrations which are not yet discovered.

Brydes whale, a species reaching 15 metres in length and in appearance very similar to Sei Whales appears to be a temperate water species with rather limited north south movements. It has coarse baleen enabling it to feed on small fish and a variety of temperate water plankton. A localised pocket is known off northeast New Zealand and they are sighted irregularly off Australia. The small (eight metre) Minke Whale is sometimes sighted in small groups near Lizard Island during winter but whether this is part of a semi-localised warm water race or its possible migratory relationship (if any) to the substantial summer populations in Antarctic waters, is unknown.

Right Whales were seasonally once the most abundant of all whales along the southern coasts of Australia and New Zealand. In winter they assembled in sheltered bays along eastern Tasmania, southern New South Wales, Victoria and South Australia to the southern portion of Western Australia in a zone approximately south of 35 °S. Here the females calved and were exceedingly vulnerable to coastal whaling, whether from shore or stationary ships. As a consequence they were quickly decimated with some 20,000 taken from the area as a whole — between 1820 and 1850. They have never recovered to former abundance and are still rare off eastern Australia.

Pregnant females seem to have been the main category of whale to come inshore. There they calved and remain in sheltered waters for some weeks at least before returning to the open sea. Records show that their arrival started along south east Tasmania, especially the Derwent estuary and then spread to other bays and inlets along the Tasmanian coast and part of New South Whales past Twofold Bay to the environs of Sydney as the northern limit.

Another stream passed west of Tasmania which has few sheltered bays along the west coast and was not often used as a calving region. The females assembled in bays west of Geelong, especially from Warnambool to Port Fairy in Victoria, and at Encounter Bay and the Port Lincoln region of South Australia.

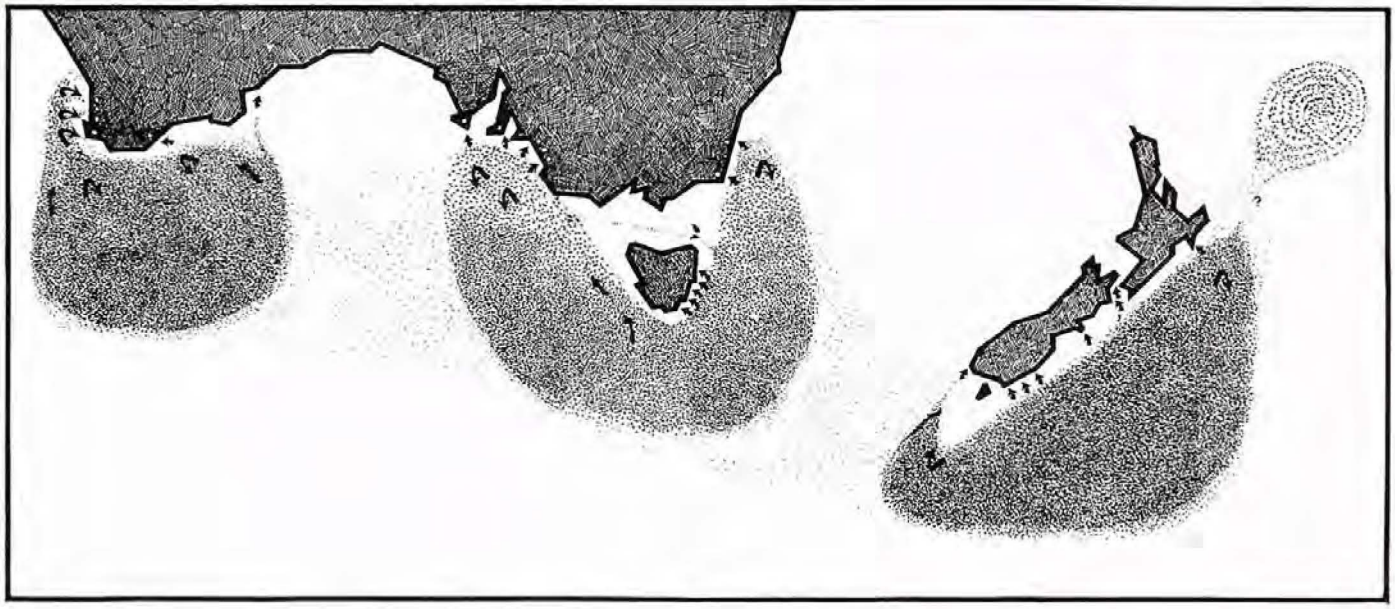
On departure the whales appear to leave the coastlines and presumably head south rather than return along the routes followed before calving. A similar movement occurred around the south west corner of West Australia and it is not known whether this group represented a separate stock or was loosely linked to those of south east Australia.

Other groups of Right Whales assembled in bays and inlets of New Zealand mainly along the South Island and Cook Strait, but with some along parts of the east coast of the North Island. Unlike humpbacks, the coastal schools did not contain a full representation of the stocks (immature animals, males and non pregnant females). Nevertheless the category represented (cows and calves) were so vulnerable that stock devastation was inevitable.

Because there is a three year interval between calving, pregnant females arrive in different groups each year for three years before the original group returns. As a result it only takes a few sequential years of whaling operations before stocks are rapidly depleted with dire effects on recruitment to the population. Local pockets identified as males have been described recently in coastal waters near the Valdez Peninsula, Argentina but cows and calves in schools were more common.

The southern limits during feeding are uncertain but a number of major sighting surveys show that they do not travel as far south as the krill feeding rorquals. With much finer texture of baleen, Right Wales can sieve much smaller plankton animals and appear to obtain all their food requirements in subantarctic waters north of about 55 °S. They also have lower northern limits than Humpback Whales (about 35 °S) due to their thicker blubber which allows the fatter calves to withstand considerably lower sea temperatures at birth than humpbacks. As a result total latitudinal range during migration is considerably less than humpbacks and other rorquals.

A great deal of our present informa-



Right Whale migration in Australasia.

tion on whale migration has been derived directly or indirectly from observations and material collected during whaling. Since whaling around Australasia has fortunately ended, direct observations from catches are no longer available. However, there are many questions relating to the migrations that still remain unanswered and it is a most interesting challenge to attempt to fill some of these by using new techniques and approaches that do not depend on whaling.

Sighting data, formerly came mainly from the whaler's own records of sightings made from ships, shore vantage points, or aerial spotting. To replace the whaler's data and even add to it, other observers must spend long hours watching during enough weeks to adequately sample a particular migration. It is good to know that this is being carried on from land and air by investigators at several points on both east and west coasts of Australia. However, more of these sites, separated as widely as possible in latitude, could clarify uncertainties on the rate migrating whale stocks increase in numbers as they travel up the coast.

Marking whales by embedding numbered darts had given interesting information in the past but since whaling is now banned no further data of this type can be expected. Repeat observations on known individuals are now needed and methods other than tagging are being developed. Already there has been good success in identifying Right Whales individually by making photographic records of the wart-like callosities over the head, since it has been shown that these differ in detail between animals. However, one of the main problems in successfully identifying whales is that they surface infrequently ove ten to thirty minute periods and only show a fraction of their bodies. Aerial photos taken from vertically above the whale are best but it may well be possible to build up patterns of 'identikit' type from photos and sketches made of head regions observed from ship, shore or even underwater now that many keen scuba divers are available.

Off Hawaii and western North America, humpbacks have been identified by the differences in detail of the colour pattern on the underside of the tail. This has resulted in a considerable number of animals being recorded individually. Such observations are made most readily in regions where the whales mill about, circle and remain in the same general area giving observers a reasonable chance to reach the appropriate distance and angle to photograph during the brief and sometimes widely spaced time intervals that the underside of the tail is visible. At the present observation points off eastern Australia, whales head more or less steadily north or south and it requires a great deal of effort and luck to obtain many good diagnostic pictures.

Acoustic signals from whales may be another way of identifying whale stocks and perhaps ultimately individuals. Radio transmitters and satellites offer the best long term prospects for tracking over useful distances as well as for individual recognition. The technical difficulties and costs are considerable but transmitters have already been successfully embedded in whales and in one case a Fin Whale was continuously tracked for some weeks.

The potential for accurate tracking of whale migration is now realisable and if the increase in numbers of Humpback and Right Whales off western and eastern Australia continues as is presently indicated, the task will become progressively easier.

To the point of extinction

The figures below indicate the number of adult Humpback Whales caught in Australasian waters between 1949 and 1962. These were all taken as the whales travelled to and from their breeding areas and in the feeding grounds in Antarctic waters. Estimates of the initial humpback numbers before whaling in 1949 were approximately 15,000 individuals passing West Australia and 10,000 for those passing East Australia and New Zealand.

After whaling ceased in 1962 the total number of adult humpbacks in the west was 800 and in the east 300. This drastic decimation of Humpback Whales caused the cessation of whaling in Australia. Ironically, they were given world wide protection a year later.

	NUMBERS CAUGHT		
	To from breeding areas	Feeding grounds	Total caught
West Australia	12,276	Area IV 5,860	18,136
East Australia	7,425	Area V 5,115	12,540
Norfolk Is & NZ	2,856	—	2,856
	22,557	10,975	33,532

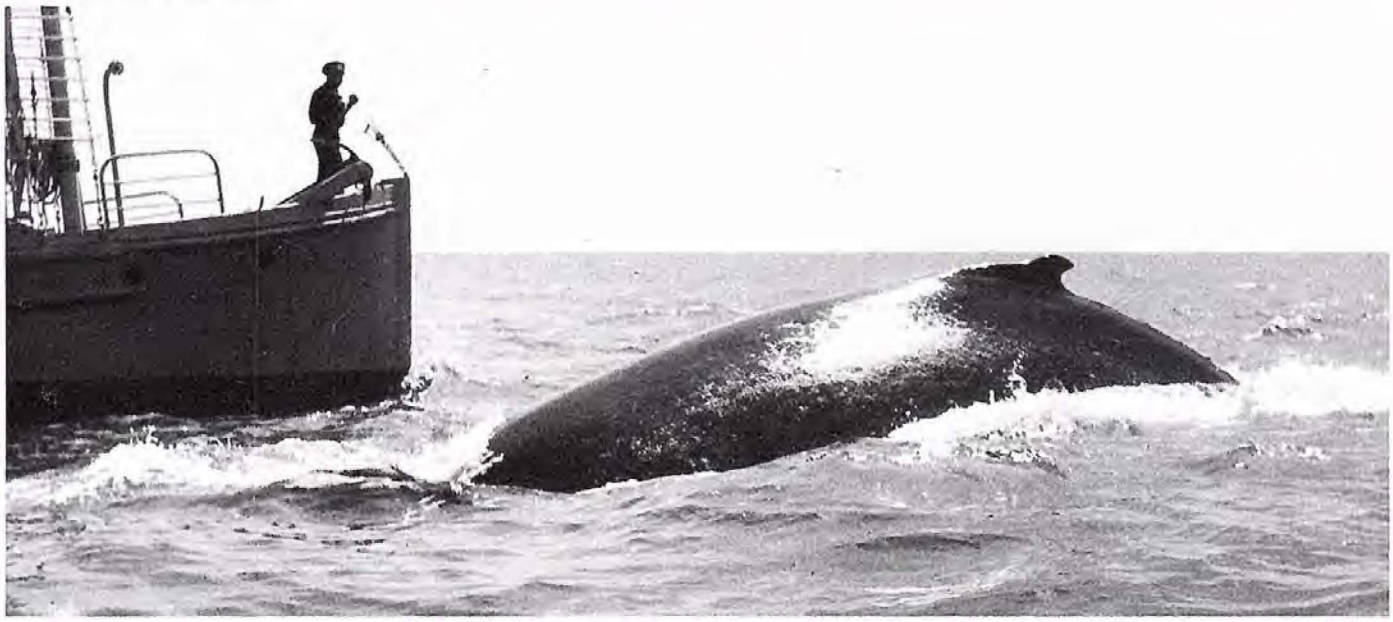
Area IV extends from Longitude 70 °E to 130 °E and relates to West Australia.
Area V extends from 130 °E to 170 °W and relates to East Australia and New Zealand.

As the table clearly shows 33,532 humpbacks were harvested over a period of 13 years from an original population of only 25,000 whales. Such was the extent of the slaughter that to this day Humpback Whale stocks have never recovered to their former size.

Soaked in sound

ethereal songs of moans, clicks and whistles

by William Dawbin



A 15 metre Humpback Whale breaking the water surface. These whales got their name from the habit of exposing large areas of their backs as they dive. Photo William Dawbin.

Probably the most sophisticated call of any animal species would be the eerie, yet enchanting cry of the Humpback Whale. No one knows the real reason why humpbacks and other whales sing but biologists believe that it is to identify individuals and hold small groups together during long transoceanic migrations.

There are two broad types of sounds used by whales, pulsed sounds and pure tones. Various calls involve pulsed sounds or clicks and are used for echo-location as well as communication. The pure tones are beautiful, complex, whistle-like calls and in the case of humpback songs, can last for intervals of seven to more than thirty minutes. Each group of whales sing their own particular variation of the song and change their calls slightly from year to year.

While some other whales also sing using components which are similar to those used by humpbacks, no other song approaches the complexity of this one species.

William Dawbin, a world authority on whales and whaling, only began to seriously examine whale songs during the last few years. In collaboration with Douglas Cato of the Royal Australian Navy Research Laboratory and with the help of Ken Mainsbridge, owner of the Manaroa Bay and Dr Robert Loch and staff from the Warrnambool Institute of Technical Education in Victoria, William Dawbin has been able to record and study a number of Australian whale songs. This initial work, the subject of this article, will go a long way towards providing the basis for Australian research on whale songs.

Until the early 1950s whales and dolphins were generally thought to be mute since anatomists had shown they did not possess vocal cords. Old time whalers had sometimes talked of sounds they heard through their row boat hulls before the days of motors particularly from the Arctic White Whale or Beluga. However, this information was generally not taken very seriously. Often underwater sounds of unknown origin were recorded during listening through hydrophones for submarines during World War II but it was not until considerably later that scientists realised that many of these sounds originated from whales and dolphins.

The first identifiable recordings were made from Bottlenose Dolphins in captivity in Florida. These animals were the first members of the whale-dolphin group to be kept in captivity and they proved to be a remarkably good first choice for experimentation. Dolphins respond very quickly to human contact constantly emitting and responding to sound signals. Their sounds prove to be of two main types, a range of whistles which are used for communication and very rapid trains of pulsed clicks used for echo location. The rate of firing and variations in frequency are adjusted to the distance of the target object and return echoes provide the data for the animal to judge distance and direction of food, obstacles, other animals etc.

As a result a great deal of research has been carried out on both these and other aspects of sound production, particularly by teams of American, Dutch and French investigators in both controlled aquarium conditions and in the oceans.

Sounds from the 'great' (plankton feeding baleen or whalebone) whales presented many problems, not the least of which, was the fact that whales are far too large to keep in captivity under anything remotely resembling natural conditions. In fact, no adults of any of these species have ever been studied in captivity.

Despite these difficulties underwater sounds have been recorded from identifiable baleen whales in many of the world's oceans. Their most striking features are the very low notes which, in the case of the Blue Whale, are below the limits of human hearing and at a wavelength in water that is con-

Songs from the sea

siderably longer than the total length of the animal (which can exceed 30 metres from snout to tail).

How these sounds are produced is the subject of much speculation but the problem has not been fully solved. These low sounds are ideal for transmission over great distances (tens or hundreds of kilometres) and it has even been suggested that under special conditions these sounds may be recognisable between whales thousands of kilometres apart.

The Humpback Whale which reaches a length of 15 metres, has the most extensive sound repertoire of all the whales. Humpback Whale signals were first recorded during underwatering listening at Bermuda. Early recordings were not at first recognised as whales and it was some time before the relationship between the whales and the complex sounds with their huge range in pitch and phrases, were recognised.

Detailed study showed that whole complex sequences could continue for up to half an hour or more, before the full sequence or song was repeated. Already two major record lps on whale songs have been released and some of the sounds used in radio and television sequences on animal behaviour. They have even been used on the satellite en route to leave the solar system.

Recent work on Australian whales has mainly been limited to the Humpback, Right and Minke Whales. My own tentative foray into listening began with an attempt to find the interaction between the noises of certain dolphins and those from rocks struck together underwater. This method is used by the inhabitants of the Solomon Islands to drive dolphins into bays where they can be caught by hand. After this work a few attempts were made to obtain sound sequences from some rare and localised animals — Hector's Dolphin, off New Zealand and the Irrawaddy Dolphin, from the Cairns region. This work confirmed that a lot of time needs to be given to this research, if only because animals that were often visible for long periods of time or relatively close to boats did not always make recognisable signals. The one dolphin that can always be relied upon to signal is the ubiquitous and well-known Bottle-nose Dolphin, a common inhabitant of our coastal waters.

In the 1960s and most of the seventies the large whalebone whales, through previous over exploitation, were still so rare that it was a problem to locate any in east Australian coastal waters let alone justify boat charters and the time needed for attempts at recording.

This situation changed when Dr Robert Paterson spent several successive seasons counting Humpback Whales passing Point Lookout on Stradbroke Island and found more humpbacks swam by than were previously expected. This initial work prompted the Australian National Parks and Wildlife Service to undertake a whale survey along the east Australian coast from Tasmania to Queensland. These aerial surveys were conducted over 1979 and 1980 and showed that humpback occurrences were still fairly infrequent along more southerly parts of the Australian coast. It soon became clear that the animals were accumulating from different arrival points along the coast and only reached their greatest concentration in the most easterly regions (from Cape Byron to beyond Stradbroke Island). Further intensive shore and aerial observations by researchers from the University of Queensland were conducted over these easterly areas and regular whale concentrations were recorded.

The first attempts to record Humpback Whale songs in Australia occurred off Stradbroke Island in October 1981. On several days humpbacks passing at a tantalisingly close distance to the shore could not be reached because of bad weather and high seas. After a week of daylight to dusk monitoring following this experience some very distant signals which seemed to be of humpback type were recorded although no whales were seen.

In 1982 this time at Cape Byron more attempts were made to record humpback songs. In July a team led by the Australian Museum, split into land and sea parties and linked by radio contact successfully located and recorded songs from Humpback Whales. In one instance five northbound humpbacks, some fifteen kilometres distant from the boat, were continuously monitored

Above, the head and body of a Right Whale calf, while (opposite) an adult breaks the surface during its long journey to sub-Antarctic feeding areas. Photos Paul Haskew and William Dawbin.

while one emitted a clear sustained sound sequence for about half an hour before abruptly stopping. This recording of the one humpback's song was of sufficient quality that it can be used as the basis for future comparisons of the songs of all northbound humpbacks. It also showed that these large animals still sing some 200 kilometres further south from Point Lookout where previous songs were heard.

Some American studies indicate that humpbacks sing mainly in or near their tropical breeding areas and may be largely silent at other stages of their migration. Because much of the local stock pass within reasonable reach of our shores for considerable distances, further checks were made to the south. In 1982, Coffs Harbour, 500kms south of Point Lookout was selected since it has a suitable headland for shore based watching and because Ken Mainsbridge could take researchers out to the whales on his boat. After repeated wide searches of the area the distinctive humpback song was recorded for about 40 minutes until it again suddenly stopped. No whales were sighted during or even after the calls despite intense searching so this whale was presumably 15 kilometres or more distant.

During October, the whales were tested at a different stage in their migration path to those sampled earlier from Cape Byron. They were now southbound, returning towards Antartic waters after a sojourn in the warm waters of their breeding area. Simultaneous observations from Point Lookout and Coffs Harbour allowed a comparison between songs from different locations in humpbacks' southbound migration paths. Recordings from these different areas revealed virtually identical songs, all of which were very different from all known songs recorded in the northern hemisphere. This is not surprising since northern and southern humpback stocks enter their tropical breeding areas during the polar winters and are therefore out of phase, preventing stock mixing. Northern research has shown gradual changes in humpback songs from year to year despite uniformity within a season.

Further work is needed to check this in Australian waters and above all biologists need recordings from Western Australia and other parts of the Pacific Ocean in order to identify regional differences. The possibility that these could help indicate whether stocks intermix is shown by the American discovery of identifiable differences between Hawaiian and Mexico-Californian sounds and the recording of one of the latter among the otherwise uniform songs at Hawaii. This discovery poses the question, how far afield does the Australian dialect extend?

Sounds from Right Whales, have been recorded in both the north and south Atlantic by American workers showing a range of deep notes and variations that are not as intricately structured into songs as is the case for Humpback Whales. Right Whales have been rare off south eastern Australia for over a century following massive earlier exploitation from whalers and it wasn't until 1982 that the first significant sighting of a coastal school occurred near Warrnambool, Victoria, when a group of at least seven females all calved near shore and remained there for approximately two months.

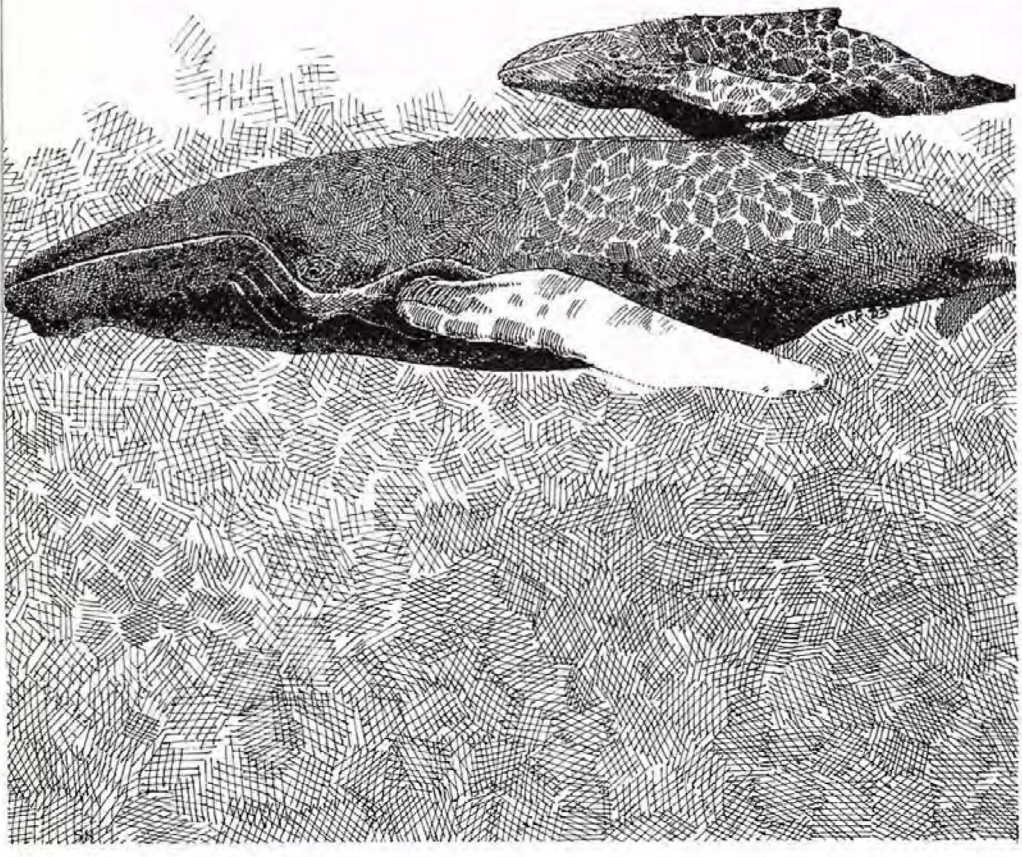
This rare occurrence provided five days of concentrated, uninterrupted monitoring for whale songs. During the first couple of days the calves would dive under the mother and come up on the side away from the boat. However after a while they did not bother to change position and the opportunity for recording became easier. Despite the whales relaxation in human presence very little sound was emitted. In fact a few isolated or occasionally two or three consecutive long deep moans sometimes spaced hours apart were the only sounds heard. Whether significant or not, it seems that their moans coincided with the few times a calf came close to the back of the main line of breakers rolling onto the beach.

While local observers described a case of possible mating early in the season there was no evidence of more than cow calf pairs and a one lone adult which looked as though it was in the advanced stages of pregnancy. If this group is the forerunner of more in future seasons, any sounds produced during courtship and behaviour before and after the birth of calves must be monitored and checked with those recorded from other areas such as Cape Valdez, in the Argentine where Right Whales occur.

A byproduct of the sound monitoring were the opportunities for closely observing the group for a series of days. Daily counts from shore ranged from 12 to 15 suggesting a possible group of over hundred animals, taking into account that there were only females in advanced stages of pregnancy and that the other members of the group (non pregnant females, early pregnant and immature females and males) were missing.

Songs from the sea

The song of the Right Whale (pictured) is made up of a range of deep notes but variations are not as complex as those of the Humpback. Photo Paul Haskew.



The very unusual circumstance of an adult female Minke Whale that became trapped in a lagoon about 60 kilometres east of Shute Harbour, Queensland provided an interesting challenge to set it free and monitor it for sound. It seemed that if this species was ever going to make click-type or other echo locating sounds, then it should do so when confined by barriers of a reef with only a 100 metre radius. This involved drifting in an inflatable rubber zodiac within the lagoon and listening continuously in shifts through daylight and night hours. With no land visible in any direction and the reefs fully submerged at high tide, a rubber boat with two people seems to decrease in size especially in the tropical blackness between sunset and in this case, a late moon rise. A consecutive 24 hour monitoring, and other periods of daylight testing totalling 35 hours of listening produced no Minke sounds. The Minke had lost a great deal of condition during its entrapment and the poor state of the animal may well have been a big factor in its silence. Although some echo location tape clocks have been described for Minke and also Blue Whales there is as yet no universally accepted evidence that Baleen Whales use pulsed sound for distance and direction finding.

The varied results from sound recording whales off eastern Australia highlight the fact that proximity to whales or dolphins does not ensure sound recordings. At least some species are often silent. On the other hand whale sounds may be heard with no animal visible in the area. Now that numbers of humpbacks are increasing and we know the main regions that they regularly pass, it is well worthwhile going to sea and listening as the opportunity arises rather than wait for sightings to use as target locations.

There is a great deal about the calls of baleen whales that are not understood beginning with the means of sound production, particularly of the very long wave length and enormously powerful low notes. Since the sound carries great distances and is difficult to localise, it is very rare that a particular sound can be attributed to an individual whale let alone related to specific behaviour. The reason for humpbacks' long intricate songs is still very conjectural. Their complexity seems to suggest that they carry many different messages. However, the fact that their songs are repeated over and over again, as in the constant repetition of a Beethoven's symphony on a stereo at the same volume each time, poses a real problem to this belief. For humpback songs to contain many different types of information they would need to produce many different variations in signal. Also the great uniformity of songs from humpbacks in any one area and time is very puzzling, all the more so, because they slightly change from season to season. However the regional differences can probably be used as some index in intermixing between stocks once these have been identified fully by sound, and may be useful to supplement data for population estimates — a topic of great interest now that we seem to be entering an era of increasing numbers after decades of drastic decimation.

CENTREFOLD 2

Orca, the Killer Whale

Orcinus orca

by Alan Baker

Orca or the Killer Whale, *Orcinus orca,* is the most powerful, robust member of the dolphin family. It has an awesome mouth containing 22—26 large conical teeth and a reputation which has resulted in common use of the name 'Killer'. The sinister reputation of Orcas is in fact not supported by scientific evidence. Although they may be unique among the whale and dolphin family (Cetacea) for their habit of feeding on warm-blooded vertebrates, such as other whales, dolphins, and seals, there are no reliable records of deliberate, fatal attacks by Orcas on humans.

Granted, they may be unpopular with fishermen because they are competitors for fish, and they most certainly give the impression of 'looking over' people on small boats, but recent research workers studying the behaviour of Orcas from kayak canoes or from inside a wetsuit, have found them to be harmless. Indeed one canoeing scientist, lost in fog off the Canadian coast, was guided to land by a herd or 'pod' of Orcas.

Orcas are cosmopolitan in distribution, being found in both cool and warm waters of all oceans. There are few records of these whales having stranded on the Australian coast, unlike their relatives the False Killer Whale and Pilot Whale, but there have been enough sightings at sea over the years to show that Orcas are fairly common, especially in the southern areas of NSW, Victoria, Tasmania, South Australia, and Western Australia.

Orcas are often resident in certain limited areas, where they travel to and fro in socially organised pods of up to 40 animals. These family groups may be segregated into smaller groups by age and sex. Solitary whales are usually adult males, which can be recognised by their very tall, sharply triangular dorsal fin. Although Orcas are whales of the open ocean, they also approach close to the shore and enter bays and harbours. Around southern Australia their abundance may vary seasonally and may be correlated with the summer appearance of fur seals and sea lions on the coast.

The behaviour of Orcas at sea can be very spectacular. They hunt in packs, and can swim at high speeds on the surface. When curious, they will approach an object or boat very closely, sometimes 'spyhopping', or raising themselves vertically out of the water to beyond their flippers, and rotating, to scan the surrounding ocean. They often breach the water to land on their sides or back and may slap their tail or flipper hard on the water surface. When alarmed, Orcas, like many other dolphins, bunch together and increase speed to porpoise across the ocean.

Orcas navigate and find their food by echo-locating emitting high frequency sounds and receiving echoes which enable the whale to determine the direction, range, and characteristics of the echoing object, be it a food item, the ocean floor, or other whales. Such an ability (shared with many other cetaceans) allows for food searching in the murky depths of the ocean. One Orca was found tangled in a telephone cable at a depth of just over 1000 metres.

Species which strand in mass are those which normally travel in social groups under leaders, and a 'herd instinct' as well as a 'caring instinct' could play a major part in these strandings. It is generally believed that once a group of whales have stranded, they will refuse to swim off when returned to the water. This could happen when only a few individuals are set free, for the instinct to remain with the leader or the rest of the herd may be overpowering. When most of the herd is returned to the water however, refloating may be successful — as in New Zealand cases of 36 out of 40 Pilot Whales which stranded in Hawke Bay in 1967, and 49 out of 50 Bottlenose Dolphins near Whangarei in August, 1981. In most instances, the problem of moving a large number of heavy animals prevents attention being given to more than one or two individuals.

A group of three Killer Whales showing variations of dorsal fin and saddle patch shapes. These differences are used to photo-identify each animal, allowing its growth and movements to be monitored. Photo Graeme Ellis, West Coast Whale Research, Vancouver, Canada.

Centrefold (overleaf), Orca, has the black reputation of being a ruthless and indiscriminate butcher of the seas. Almost anything in the ocean seems to be at risk and, sometimes, even terrestrial animals. The Killer eats squid, sharks, seals, sea birds and other whales — their appetites can be enormous. Photo Eliot Porter.

KILLER WHALE (*continued*)

In Australasia most mass-strandings have occurred on gently-shelving beaches or muddy areas, particularly Treachery Head, Macquarie Harbour, Flinders Island, Stradbroke Island, in Australia and Paraparaumu, Farewell Spit, Opoutama, Marsden Point, in New Zealand. One stranding theory suggests that the reception of navigation echoes becomes difficult for whales in such areas. Among 48 stranding records for Orcas in Australasia are two mass-strandings. One involved 17 whales at Paraparaumu, New Zealand, in May 1955, and in the other more recent incident, 11 Orcas died on the Chatham Islands in April 1981.

The most celebrated stories of Australian Killer Whales are those connected with the shore whaling at Twofold Bay, New South Wales. From about 1843, Orcas were known to assist local whalers by alerting them to the passage of Right and Humpback Whales past Twofold Bay by tail-slapping or breaching behaviour, and to harrass the whales before and during capture. The Killers were rewarded with the dead whale's tongue.

Many of the Killers were individually identified by various whalers over the years, and the most famous was a large male nick-named 'Old Tom', who could be recognised by his tall, slightly deformed dorsal fin. Published stories, and local folklore, gave 'Old Tom' an age of between 50 and 90 years, but a recent study of the skeleton, reputed to be of 'Old Tom' and now in the Eden Museum, has shown that the particular whale, 'Old Tom' or not, was only about 35 years old at death in 1932.

Orcas grow to about nine metres in length. Their head is fat but pointed, and there is a very slight, rounded beak which overhangs the mouth and lower jaw. The flippers are big, and rounded, and in adult males, which grow larger than females, the dorsal fin is very tall (up to 1.8 metres). In females the fin is shorter (up to 0.9 metres) and slightly hooked.

The colour pattern is very striking, with distinct black and white areas. The animal is black from the tip of the snout to the trailing edge of the tail, except for an oval patch above the eyes and a light grey saddle just behind the dorsal fin. On the underside, the white extends from the tip of the lower jaw through to the tail flukes, and rises up the flanks in a rounded, tailwards-pointing patch each side, just ahead of the genital region. The ventral posterior margin of the tail is black. This colour pattern and the tall dorsal fin should enable easy recognition at sea.

The only other whales of similar size are the False Killer, and the Pilot Whales (two species). The former has no white on the body whatsoever, and has a small, decidedly hooked dorsal fin. The Pilot Whales have a blunt, bulbous head and a low, long dorsal fin. Although they are mostly dark brown or black, there is often a pale patch on the back behind the dorsal fin, similar to that on Orca's back, and a pale anchor-shaped patch on the throat and belly.

Extracts from Alan Baker's forthcoming book, *Whales and Dolphins of New Zealand and Australia,* **Victoria University Press, Wellington. This book deals with the identities and lives of the 45 species of cetaceans which live in Australasian seas. Each species is fully described and illustrated, and there are sections on the natural history of whales and whaling. Alan Baker works at the National Museum of New Zealand, and is currently studying the endemic New Zealand dolphin,** *Cephalorhynchus hectori.*

False Killer Whale

Although similar by name, the False Killer Whale, *Pseudorca crassidens* is a very different animal to Orca. The Killer Whale is the largest of the dolphins but the False Killer is a member of the family of toothed whales — its external resemblance to Orca is only superficial.

The False Killer Whale is long and slender with a head more rounded than that of the Killer. Its mouth opening is large. Compared to the broad paddles of Orca, the False Killer's flippers are narrow and pointed. The dorsal fin is thin and strongly curved almost to a 'cucumber shape'. The body of the False Killer is completely deep grey or black, except for a thin light grey blaze on its underside. A social animal, the False Killer Whale is often attracted to the bows of moving ships. It is the largest of the whales ever likely to be seen in a bow wave and will ride in front of smaller vessels for minutes on end.

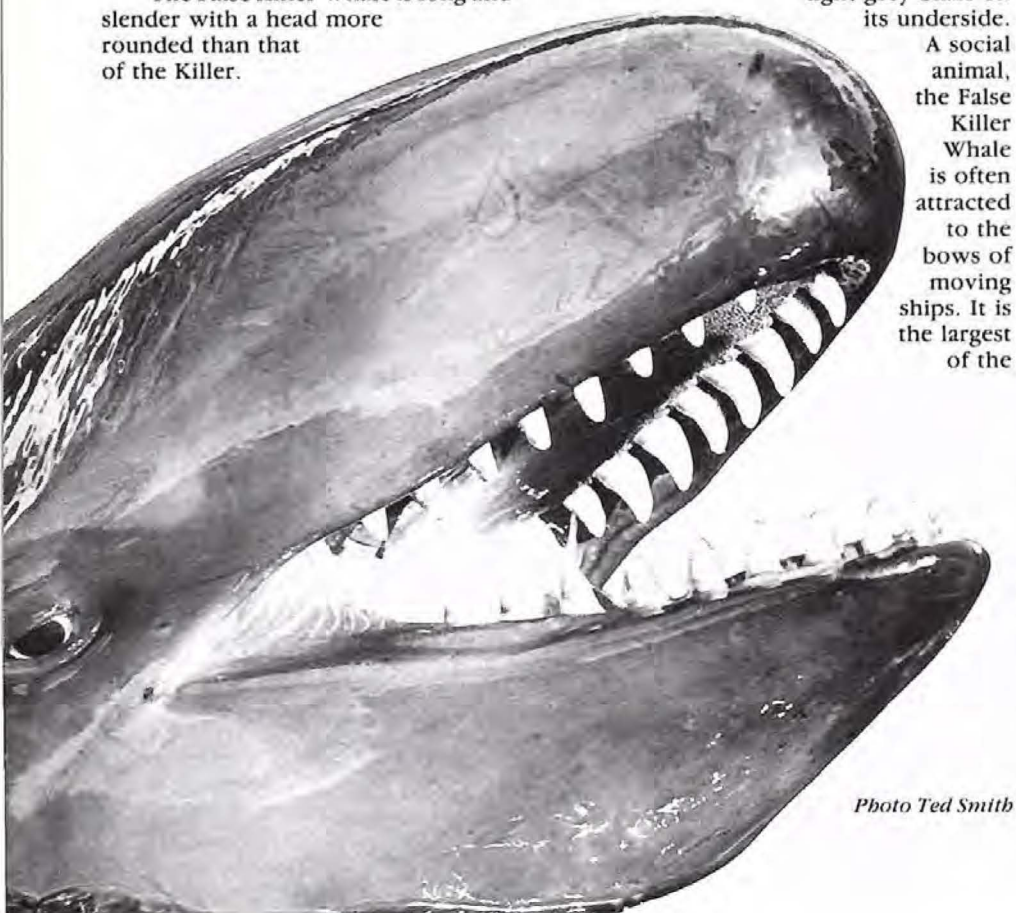


Photo Ted Smith

The piercing whistles of the False Killer can be clearly heard at distances of over 200 metres, even above the noise of outboard engines. Their sounds are diverse and more varied in pitch and intensity than the tones of human speech.

One of the best documented strandings of False Killers ever to take place occurred in July 1976 when 30 whales swam into shallow water off the shore of Florida. At their centre was the lead male, seriously wounded and bleeding from one ear. For three days, half the whales continuously supported their leader by forming 'living wedges' on either side, holding him up with his head pointed toward the beach. Severely sunburned and uncomfortable in the heat of the day, the False Killers stayed by their leader's side until he died. Not even with human intervention could the group be persuaded to leave. This was despite the fact that tidal change is very low in this region and all the whales could have swum away at any time. When some of the whales were pushed ashore they became highly agitated, returning straight away to the pod on the beach. After the lead male's death the formation broke up and swam safely away. Perhaps on some other coast with a normal tidal range, this would have become another inexplicable mass stranding.

— Virginia Richmond.

More brains than brawn?

by Roland Hughes

Any consideration of whale intelligence is fraught with danger for the unsuspecting writer not only because of the emotion the subject raises in some quarters but more importantly because so few established facts are known.

Radical conservationists often launch into the subject claiming whales have ideas, philosophies and ways of life never even conceived by man. Not only are they more intelligent than human beings but that they communicate with each other in a complex language, is a standard catchcry.

As attractive as these ideas may be, scientists say there is no evidence at present which even suggests cetaceans are more intelligent or have a more intricate social behaviour than other animals. In fact, when it comes to intelligence, social behaviour and adaptation to the environment, whales, dolphins and porpoises can be classified with apes, bears and elephants.

Probably the main evidence given to support sensational claims of cetacean intelligence is the animals' large brain size and exceptional ability to imitate.

Brain size alone is no measure of intelligence, especially when one considers elephants have a brain weighing approximately 6,000 grams, four times our own, and an intelligence well below that of humans.

A better evaluation of intelligence is the ratio of brain weight to body weight. With Blue Whales having a ratio of 1:20,000, Sperm Whales 1:4,000 and the Bottlenose Dolphin 1:76, only the dolphins and smaller toothed whales come near to humans' brain-body weight ratio (1:50).

Some biologists, after witnessing what seemed to be clear evidence of cetacean's higher intelligence, took these previous anatomical studies further and examined brain and spinal cord weight ratios. Their results, while still placing human beings in the number one spot, showed that the gap between cetaceans and man had considerably narrowed.

However, this research did nothing to dispel the doubts in some scientists' minds as brain, body and spinal cord weight ratios were being applied to animals which lived in the sea and were essentially 'weightless'.

Investigation and debate on cetacean intelligence accelerated with individual biologists and marine researchers concentrating on anatomy, physiology and behaviour in an attempt to find an answer to the whale intelligence puzzle.

The latest and perhaps the most exciting theory focuses on the cerebral cortex. This is the region which differs most significantly when comparing humans and other animals and governs all behaviour.

In terms of the size and complexity of the cerebral cortex, researchers found that dolphins are the most highly evolved animals on earth, and in every anatomical way, are comparable to ourselves. Any difference between the cerebral anatomy of humans and dolphins merely relates to different lifestyles. Man uses his hands, so the motor regions of his brain are well-developed while dolphins show a marked development of those brain parts dealing with social perception.

They claim that dolphins are keenly responsive to environmental orientation, social skill, emotional self-control and perhaps even humour. Lyall Watson clearly clarifies this concept in his book *Sea Guide to Whales of the World.*

"Unlike us, they seem to have responded to social and sexual pressures rather than to the purely physical. Our dependence on tools, which now extends to books and computers, means that a large part of the mental capacity of human culture exists outside the individual, whereas in non-manipulative dolphins it is still embodied in brain and behaviour".

These biologists believe that our ability to act as social beings may be inferior to many cetaceans.

Others are not as enthusiastic in their support for this view of whales and man's intelligence.

Experiments and research conducted on a number of dolphins show that their intelligence lies somewhere between that of dogs and chimpanzees. Researchers studying dolphins for signs of a language identified some twenty different whistles used to keep schools together, broadcast warning cries and identify individuals. Despite the intricacy of these sounds no researcher was able to show dolphins put these whistles together to form a sentence. As a result dolphins are well below rhesus monkeys, chimpanzees and other nonhuman primates in language ability.

Despite scientists conflicting views all agree that cetaceans are extremely complex animals. Behavioural biologists working on dolphins are convinced these animals probably make conscious decisions which greatly affect their behaviour.

Do these intelligent responses lie solely with dolphins truly remarkable imitative powers? Does their ability to imitate explain dolphins' large brain size?

While dolphins are not as easily trained as seals and chimpanzees to perform tricks, they show a strong tendency to imitate the actions of other animals.

Often captive dolphins will imitate the actions of divers making sounds similar to those made by the air-demand valve and emit streams of bubbles similar to the exhaust air bubbles of a diver's air tank. Others mimic human laughter, cheering and shouts as well as performing circus tricks after only seeing them demonstrated once. Some dolphins have even learned to use tools to capture prey.

One explanation may be vocal mimicry, a common function used by birds and mammals so that individuals within a group can convey information and identify other members. An ability for auditory communication is especially evident in cetaceans through their development of echo-location for orientation and detection of prey and could account for their large brain size.

Claims that co-operation between cetaceans are evidence of high intellectual skills are quite unfounded. This explanation has mainly been used in the case when dolphin schools cluster around an injured member of the group, holding it at the surface of the water, so it can breathe.

These same acts of 'companionship' or rescue are performed by a number of mammals including wild dogs, African elephants and baboons. This behavioural response is not as complicated as the well-known tail-waggle dance of honeybees or the nest building of some birds.

Whatever view one favours there is no doubt that the actual level of cetacean intelligence is an intriguing mystery. Whether cetaceans make conscious decisions and that these in turn affect behaviour, can only be guessed and more research will be needed before any concrete answers can be given.

The fact that these remarkable creatures are bright, is undisputed, and any assessment which fails to take this into account, completely ignores some of their astonishing behaviour both in captivity and in the wild.

Prehistoric animals of Australia

These days parents can often be put to shame by their children's knowledge on any number of topics but few subjects capture a child's imagination as much as dinosaurs. Many ten year olds can rattle off the names of all the well-known dinosaurs even spelling them correctly. But although dinosaurs tend to grab the limelight, many other extinct animals are equally interesting.

Australia, in particular, is now one of the last frontiers in the world-wide search for both dinosaurs and other extinct vertebrates. Fossil animal discoveries on this continent were previously very patchy but the last ten years has witnessed the discovery not only of many new types of Australian dinosaurs but also dozens of other extinct forms — fish, amphibians, reptiles, birds and mammals.

With these Australian fossil finds the connection between vertebrates of our continent and those of the rest of the world is clearly established. This link will be especially visible to Australians during the months of August through to October, at the Australian Museum. For then, the amazing exhibition *Dinosaurs from China* will be on show. It coincides with the release by the Museum of *Prehistoric Animals of Australia,* the first book ever to be published on the prehistoric fauna of this continent.

On show between the 18th August and the 30th October, the exhibition, sponsored by ESSO, will feature some of the largest dinosaurs ever to roam the earth. Included will be the awe-inspiring 150 million year old, 22 metre long skeleton of *Mamenchisaurus hochuanensis,* a 50 tonne monster that ate only plants. There is also a 70 million year old duck-billed dinosaur, *Tsintaosaurus spinorhinus,* over seven metres long and five and a half metres high, as well as displays of another 15 or more assorted skeletons and remains.

To complement the exhibition, *Prehistoric Animals of Australia* will feature the fine detail and excellent work of artist, Peter Schouten on thirty of Australia's most fascinating prehistoric animals together with descriptions by scientists from all over Australia and New Zealand.

The two dinosaurs and ancient mammal covered briefly on the next few pages have been taken from *Prehistoric Animals of Australia* to give *Australian Natural History* readers a preview of a book that will be very much in demand.

— Roland Hughes.

Muttaburrasaurus — beaked dinosaur

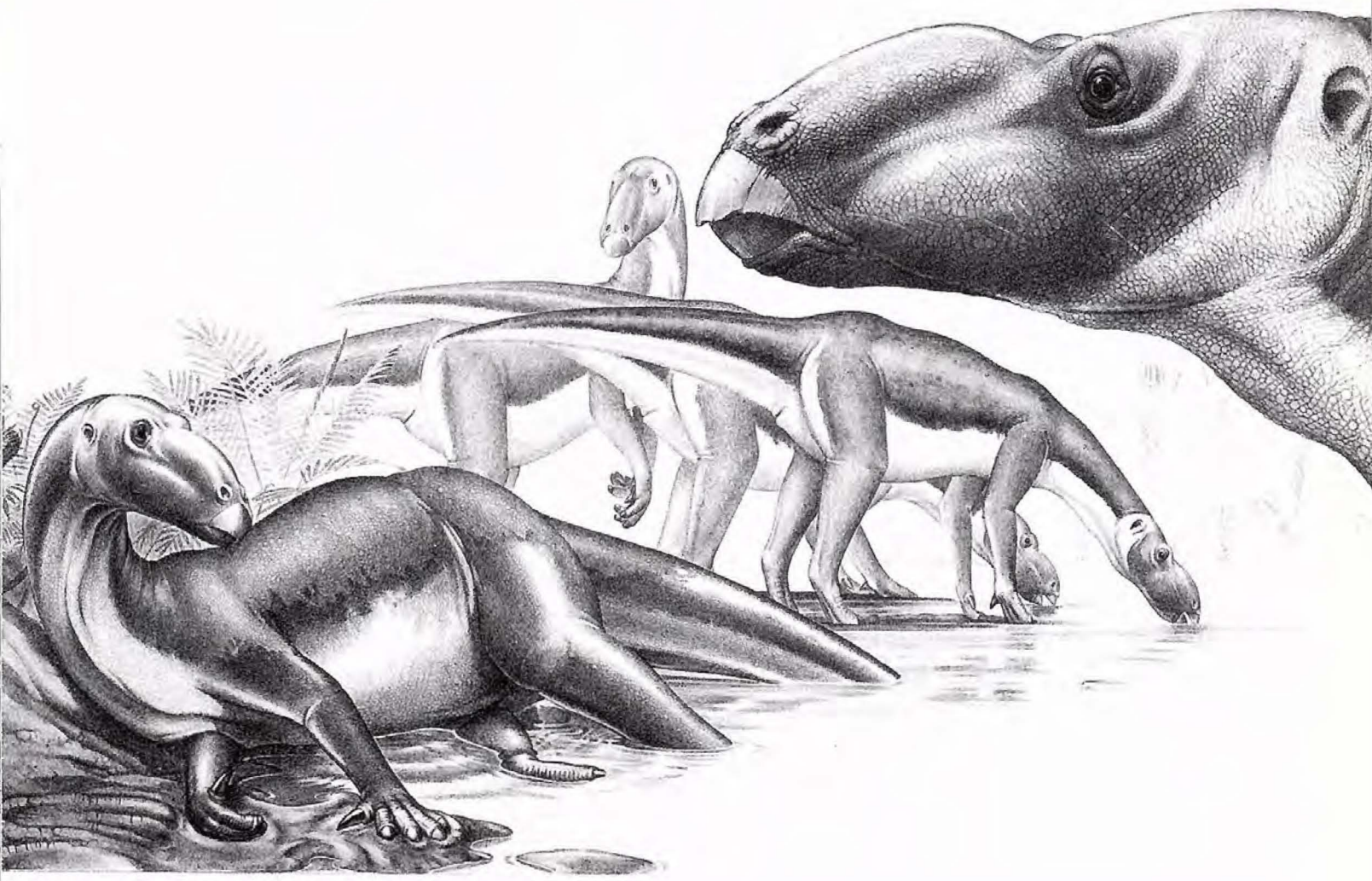
Dinosaur discoveries in Australia are few and far between and most of them are disappointingly incomplete. As more finds come to light and the search intensifies exciting finds will undoubtedly be discovered.

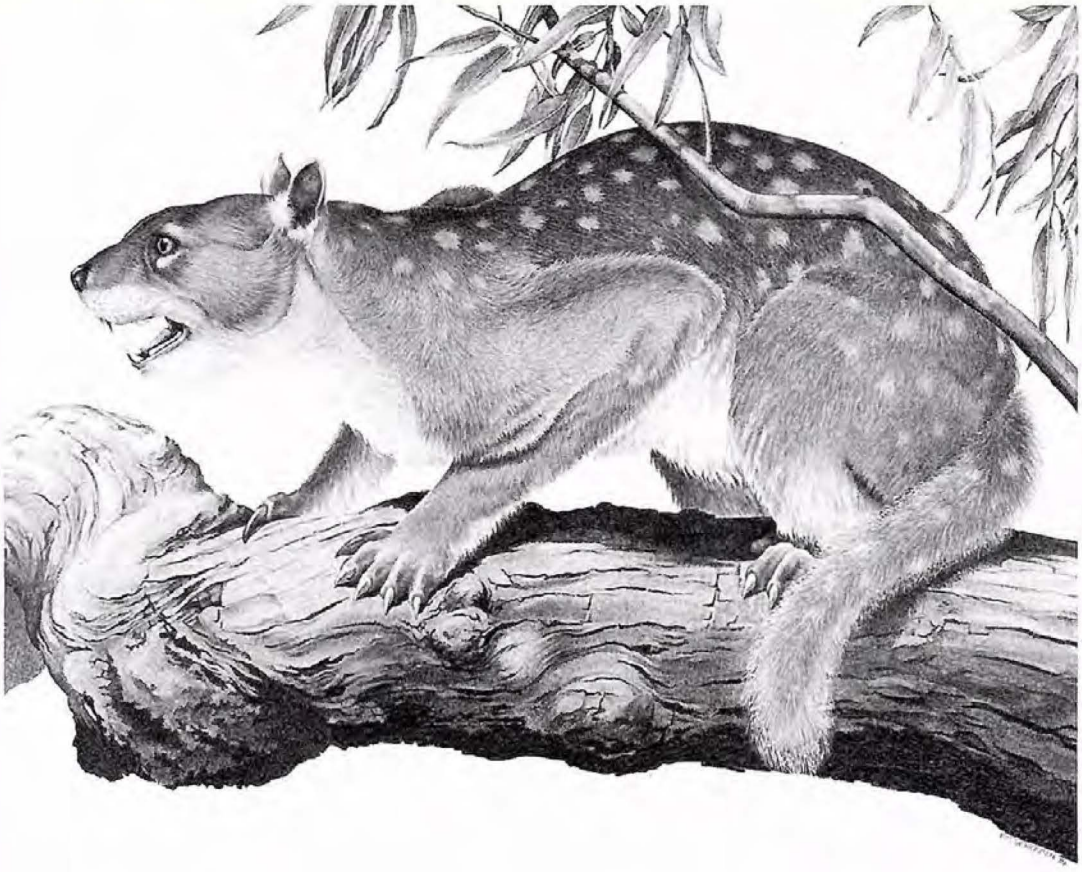
The most complete dinosaur skeleton yet discovered in Australia is that of *Muttaburrasaurus langdoni* which comes from Early Cretaceous marine deposits of central Queensland. It consists of a skull and most of the skeleton but lacks much of the tail. The fossil bones of *Muttaburrasaurus langdoni* came to light in a cattle mustering area on the banks of the Thomson River, near Muttaburra, 100 kilometres north, north-east of Longreach, Queensland. Before their significance was recognised many of the bones were broken and scattered by the hooves of cattle and others 'souvenired' by local residents. In 1963 after being reported to the Queensland Museum by a local grazier, a Museum team visited the site and recovered what was left. A public appeal later led to the return of most of the parts removed by locals. After years of painstaking work it became obvious that they came from a completely new type of dinosaur belonging to a group, the iguanodontids, which were well-known from finds in the northern hemisphere.

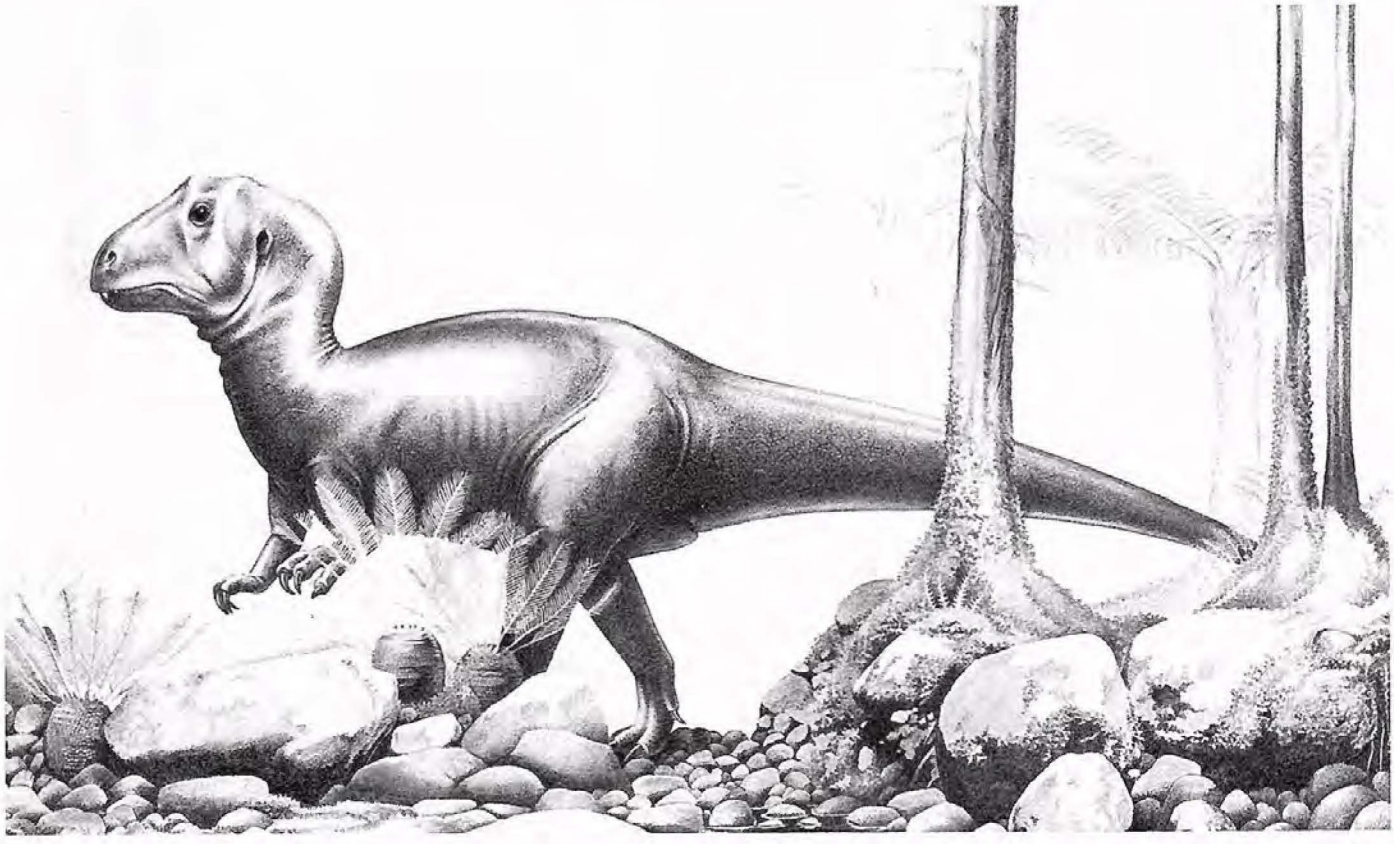
Muttaburrasaurus langdoni was about seven metres long, able to walk on its hind legs but probably spent much of its time on all fours browsing. It is an ornithischian ('bird-hipped') dinosaur and is most closely related to the iguanodontids (such as species of *Iguanodon* and *Camptosaurus)* remains of which have been found on every continent except South America and Antarctica.

One of the most distinctive features of *Muttaburrasaurus langdoni* is an inflated, hollow bony roof over the snout in front of the eyes, the function of which is not known. The front of the mouth lacked teeth and was probably developed as a horny beak, like most ornithopods. The rows of lateral teeth were rather unusual and suggest while *Muttaburrasaurus langdoni* was mainly a plant eater it may also have been partly carnivorous.

— Alexander Ritchie.







Marsupial lion

During the Pleistocene, the large *Thylacoleo carnifex* roamed most of Australia except the arid centre, in the company of large marsupials such as the *Diprotodon,* giant wombat, *Phascolonus gigas,* and giant kangaroos.

Thylacoleo, was a most unusual animal first recognised from a long ridge-like tooth found in the 1830's in the Wellington Caves, New South Wales. The discovery at first utterly confounded England's famous palaeontologist of the day, Richard Owen. Later, discovery of skull fragments suggested affinities with the possums, but the unique features of this animal were decidedly un-possum-like.

What could have been the feeding habit of this huge 'possum'? The most recent reconstruction of jaw musculature, along with work on jaw mechanics and studies of the microscopic wear patterns on the carnassial teeth, has revealed that the powerful jaws of *Thylacoleo carnifex* were well-adapted to kill. Its incisors were probably used like knives to kill and its carnassials to rend the dead prey of its flesh or to dismember the carcass into bite-size pieces.

In the 1950's, the first postcranial skeletal material was unearthed in South Australia. Since then, more has been found in New South Wales. The vertebral column was strong, yet flexible, while the limbs were long and powerful. All digits were clawed but the 'thumb' supported a huge compressed claw three to four centimetres in length. The forelimb was obviously an efficient striking weapon and holding mechanism while the hindlimb was possum-like with an opposable first toe. This sort of foot serves to provide grip and balance so important to arboreal possums such as the Common Brushtail Possum.

Certainly their limbs were well-adapted for medium-paced running and prey-catching, but to what extent this leopard-sized carnivore used its possum-like hind foot to climb is uncertain. The answer must await further study of the anatomy of each of the bones of the whole skeleton.

— **Eileen Finch.**

Allosaurus — killer extraordinaire

The various kinds of *Allosaurus* were the largest and most impressive carnivores of their day. Up to 10 metres long and nearly four metres high, the allosaurs could probably prey on dinosaurs as large as species of *Apatosaurus* (formerly known as *Brontosaurus).* Despite the vast bulk of these allosaurs, they were not very bright because they possessed a brain about the size of a kitten's. The name *Allosaurus* means 'different lizard'. They received this uninspiring name simply because their obviously impressive remains were different from those of any of the other dinosaurs known at the time.

During the Jurassic and Cretaceous Periods, when the allosaurs existed, most of the world's landmasses were connected and the climate was a lot more uniform than today. These factors allowed many kinds of plants and animals, such as the allosaurs, to have a world-wide distribution.

The Australian allosaur is known from the discovery of a single ankle bone found preserved along with the remains of smaller herbivorous dinosaurs in sandstone exposures in coastal cliffs and rock platforms near Inverloch, Victoria. The ankle bone of the Victorian allosaur is more sturdily built than those of other allosaurs suggesting that this species was more robust.

The Victorian species is important because it is the latest surviving allosaur known. Elsewhere, allosaurs became extinct by the end of the Jurassic period 135 million years ago. The Victorian species is about 125 million years old or early Cretaceous in age.

Interestingly, when the Victorian allosaur stalked the Earth, southern Victoria was well within the Antarctic Circle. But there were no polar ice caps and plants and animals flourished even at these high latitudes. Apart from the allosaur, other relict species are known from the early Cretaceous rocks of Victoria and it is possible that the south polar region acted as a refuge for species that became extinct earlier elsewhere. — **Tim Flannery**

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Two Ways of Interpreting Nature

by Charles Birch
Challis Professor of Biology
University of Sydney

There are two ways of trying to understand nature. One is to reduce living organisms to next to nothing, such as atoms or their parts and then try to build up a world from these so-called building blocks. This is reductionism. The movement is from atom to man. But that presupposes that atoms in living cells are the same as atoms not in living cells and that atoms in human brains are the same as those atoms not in human brains. If atoms are the same everywhere, independent of the environment in which they find themselves, then when you try to 'construct' a world or a frog or human from them, you get a machine. This I shall argue is profoundly wrong. Yet it is the dominant mode of science and is particularly applicable to biology as it is taught today. It leads to a materialistic or mechanical view of life which fails to do justice to what each one of us knows about being alive, namely, being creatures who feel and respond and have hopes, fears and purposes. A view or model of livingness that leaves out feelings and consciousness is an emasculated view of life. I believe it has grave consequences.

But suppose we start our journey of understanding nature at the other end. Not with the classical atoms of the physicist, nor even with trees and frogs, but instead begin with that collection of atoms of which we are constituted, and more particularly the most complex of all forms of atoms that exist, the human brain. Now if we work backwards, what then? We shall reach quite another conclusion.

The first way is to interpret the higher in terms of the lower. The second way is to interpret the lower levels of organisation in terms of the higher. I do not know the great Amazon River by standing at its sources in rivulets in the Andes. I have to see what the Amazon becomes at its mouth. Likewise, I cannot know what atoms or electrons are by looking at them after dissecting the universe down to bits and pieces. I have to know what they become. They become human brains with human thoughts and feelings. Now a universe that produces human beings is a different universe from one that could not do so. It is a humanising universe. Norman Mailer said that if the universe is a lock then the key to that lock is not a measure but a metaphor. The metaphor I suggest is personality. Personality — not classical atoms — is the key to the universe and all that is in it including ourselves.

The basic principle I am proposing is that we understand what is not ourselves (atoms) by analogy with what we know ourselves to be. The human is the most fundamental model of life.

In the dominant mechanistic paradigm the view of entities, be they atoms or humans, is that they are independent of other entities. That is the definition of a machine. It is subject only to the law of mechanics. It has only external relations such as the energy that is fed into it. This is the notion of substance. A substance has only external relations. We are prejudiced to think of all entities as self-contained in this way, even cells and humans. This is the substantialist prejudice.

So we attempt to analyse entities, be they rocks or stars or humans into other entities which we think are even more substantial and enduring than they are. This is the classical notion of Democritus' atoms that are indivisible and unchanging. There are no substances. What are there? There are relations between events. The basic event in human existence is experience. I am what I am by virtue of my relationships, not the ones that push and pull me hither and thither but the internal relations that make me feel elated, depressed, sad, joyous and so on. These relations have nothing to do with the laws of mechanics. The idea of an internal relation is one that is constitutive of the character or even the very existence of the entity. Instead of the world as made of substances, let us think of it as made of events.

The hydrogen atom is an event depicted by a positive charge surrounded by a negative charge. Stop the electronic event and there is no hydrogen atom. Entities such as atoms, cells and humans take account of their environment internally. They are subjects. That is to say they have subjective experience. Now of course that aspect is greatly attenuated in the inanimate world so that most people tend to rule out the possibility that it is a part of nature at all. But we do usually acknowledge that human beings and our pets at least are subjects. Subjects are not primarily means but are ends in themselves. We respect them for what they are in themselves for themselves. Science, whatever its virtues, is at best a language of objects and not subjects. Sociology and psychology should remember that.

The view I am putting is that not only humans and our pets are subjects that are characterised by internal relations but that there are entities all down the line from humans back to atoms and electrons taking account of their environment internally. They are what they are by virtue of the internal relations established in different environments. A sodium atom in the molecule sodium chloride is not the same as a sodium atom not in sodium chloride. When it is alone the sodium atom has peculiar metallic properties. And when alone the chlorine atom has gaseous properties. But in the appropriate combination in the sodium chloride molecule new qualities emerge which we did not appreciate before, such as the quality of saltiness. We know more about the atoms chlorine and sodium in the particular relations in which they exist together in sodium chloride. Likewise with all atoms in all their different possible combinations, as is the case in human brains. So too, cells in brains are different from cells not in brains. Humans in this particular relationship are different from humans in that particular relationship.

As contrasted with the substance or mechanical model of nature I call this the ecological model of nature because it emphasises relationships to environment, particularly internal relationships. What have modern physics and biology to say to the ecological model?

In physics the notion of substance received a profound blow when physics began to move toward an ecological model. The modern physicist still talks about fundamental

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particles. Not one of them believes in particles any more. Neither electrons nor protons or any other such entity is a particle. We may have an image of a particle but that is our construction. The hunt for the elusive quark will not end up in the discovery of a lump of stuff of some sort. The physicist's particles (for want of a better word) are not things but events.

Professor David Bohm, a quantum physicist at London University, thinks that physics has reached a hopeless mess with substance thinking, with its images of waves and particles, both of which are substance notions. In his book *Wholeness and the implicate order* he says: "Give us altogether the notion that the world is constituted of basic objects or building blocks". To advance, he says, we must think of the implicate order and that is the order due to internal relations. We have to think inside out. By analogy the explicate order is the picture on the television screen. The implicate order in this example is the unseen message that goes through space to make the picture. Another analogy Bohm uses is the hologram. A regular camera gives us a point picture of the object. Cut the negative in half and you get half the picture. In the hologram when you do the corresponding manipulation you do not get half a picture but the whole in attenuated form. It is a holistic way of perceiving an object.

In biology Pribram uses the same hologram model for the occipital lobe of the brain. This is the part of the brain that registers stimuli from the retina of the eye. Pribram tells us that each cell in the lobe registers the whole image from the eye rather than each cell registering one part of a mosaic. Each cell registers all the relations. Many cells together presumably give the clearest picture. It is not parts, but relationships of the whole that each cell registers.

In genetics we used to speak of Mendelian genetics as particulate genetics. This was because Mendelian genetics was to be contrasted with what went before namely 'blending inheritance'. Characters were thought to blend in inheritance. Mendel showed that they did not blend. They retained their integrity. It looked as though particles were inherited. But the gene is no longer thought of as a particle. We say it is a DNA molecule. How one bit of the molecule expresses itself depends very much on the environment, that is to say on the rest of the molecule and the other genes that are part of its environment. The modern concept of the gene is an ecological one. The gene is more like an organism than a substance. And so I could add to the story with the views of other biologists who have come to an ecological model of the organism such as C. H. Waddington Sewall Wright, J. Z. Young and Alister Hardy. It concerns me that most teachers of biology still teach a 19th century mechanism when already to hand we have a much richer vision of what life is.

A. N. Whitehead, the philosopher of science anticipated the necessity of such a movement of thought within biology long ago when he wrote: "A thoroughgoing evolutionary philosophy is inconsistent with materialism. The aboriginal stuff, or material, from which a materialistic philosophy starts is incapable of evolution. This material is in itself the ultimate substance. Evolution, on the materialistic theory, is reduced to the role of being another word for the description of the changes of the external relations between portions of matter. There is nothing to evolve, because one set of external relations is as good as any other set of external relations. There can merely be change, purposeless and unprogressive ... The doctrine thus cries aloud for a concept of organsim as fundamental for nature."

What Whitehead called the concept of organism is what I have called the ecological model. In this context the word ecological has a more radical meaning than in its normal use. It includes the usual meaning but adds the notion of internal relations with the environment as constituting the organism. "We murder to dissect" said Wordsworth, because we murder the internal relations of life.

Our society operates out of a profound error that is destroying much that is worthwhile in ourselves and in the world when it opts for the substantialist prejudice. Consider what it does in our universities. The substantialist prejudice leads to a substantialist view of the disciplines. We separate knowledge into disciplines, each being a substance in its own right. When you get a discipline you get a department. The function of a department is to produce experts in that discipline. There is a difference between an expert and a thinker. The thinker crosses boundaries. The expert sees knowledge as a jig-saw puzzle. You work on your bit and I work on mine. Then we put the pieces together to get the picture of the truth. The general idea has been that if society has well-trained experts in all the disciplines the experts would guide us in the truth and to right action. It hasn't worked out that way. What went wrong?

Knowledge cannot be divided into separate compartments like substances. Knowledge is not like the blocks in a jigsaw puzzle. The title of Arthur Koestler's last book is *Bricks to Babel*. In it he wrote: "We seem to be compelled to shape facts and data as we know them into hard bricks and stick them together with the slime of our theories and beliefs." The result — a tower of Babel.

The crisis of knowledge has helped plunge the world into its present global crisis of management. We are confronted with a lot of problems simultaneously but none of them can be solved one at a time. All are interconnected yet the way of the world is to go to experts. We get partial answers that don't fit together.

In the name of scientific objectivity we have been given an emasculated vision of the world and all that is in it. The wave of anti-science and the profusion of cults and sects in our day is an extreme reaction to this malaise of materialism, mechanism, substance thinking or what you will.

I believe biologists and naturalists have a special responsibility to put another image before the world that does justice to the unity of life and all its manifestations of experience — aesthetic, religious and moral as well as intellectual and rational. In Australia at present that lead is not coming from academic biologists so much as from conservationists and especially those involved in the so-called 'deep ecology' movement. But that's another story.

Kookaburras - everyone's favourite birds

by Joseph Forshaw

Kookaburras, with their dawn to dusk choruses of raucous laughter and stocky appearance, have come to characterise the Australian bush, not only to the inhabitants of this country but people throughout the world. In this article, Joseph Forshaw, an officer of the Australian National Parks and Wildlife Service and Research Associate of the Australian Museum, examines these famous birds. Joseph Forshaw is the author of a number of widely acclaimed books on parrots and birds of paradise and has just had another multi-volume book, *Kingfishers and Related Birds,* published in May.

With the possible exception of the Emu, *Dromaius novaehollandiae,* the Laughing Kookaburra, *Dacelo novaeguineae,* is surely the most familiar of Australia's native birds. Even where it does not occur, it is well known from countless media references which have made the species an unofficial national emblem. In past years, a pair of kookaburras giving their famous laughing call introduced national cinema newsreels, and there are numerous examples of the species being depicted to signify Australia — on postage stamps, as a trademark on export products, travel brochures, and souvenir items. An erroneous belief that the Kookaburra's origin was New Guinea resulted in the inappropriate scientific name, and that is unfortunate because the Laughing Kookaburra is indeed uniquely Australian!

What may not be so widely known

Left, in addition to snakes and lizards, kookaburras take a wide variety of prey, including insects, earthworms, snails, crayfish, frogs and occasionally small birds, rodents and fish. Photo J. Carnemolla, National Photographic Index of Australian Wildlife (NPIAW).

Opposite, two species of kookaburras occur in Australia. The familiar Laughing Kookaburra is widespread throughout the south-east of the country but the more brightly-plumaged Blue-winged Kookaburra is not so well known and is confined to the tropical north. Painting by William T. Cooper from Kingfishers and Related Birds, *published by Lansdowne Editions, Melbourne and reproduced courtesy of the artist and publisher.*


W.T. Cooper. 77.

Kookaburras

is that the Laughing Kookaburra is a kingfisher and, with its body weight of approximately 400 grams, is the largest of all kingfishers. At the other end of the scale is an African species, the diminutive Black-fronted Pygmy Kingfisher, *Corythornis lecontei,* which is only 10 centimetres in total length and weighs little more than 10 grams.

Kingfishers are characterised by a compact body with a large head and proportionately large, usually long bill, and by short legs with the front toes joined together for part of their length. They belong to the family Alcedinidae and together with their relatives the bee-eaters, motmots, todies, rollers, hoopoes and hornbills, make up the order Coraciiformes. A number of kingfishers, including the kookaburras, have adapted to a life away from water and are known as 'woodland kingfishers', a term distinguishing them from their aquatic, fish-eating relatives. These woodland kingfishers are grouped in the subfamily Daceloninae.

There are four species of kookaburras, all belonging to the genus *Dacelo.* The two smaller, brilliantly coloured species are confined to New Guinea, including the Aru Islands. The two larger species occur in Australia, though the more brightly plumaged Blue-winged Kookaburra, *Dacelo leachii,* of northern Australia does extend into southernmost New Guinea.

The natural range of the Laughing Kookaburra is eastern and southeastern Australia from Cape York Peninsula in north Queensland, south to Victoria and across to southeastern South Australia, including Eyre Peninsula. Birds from Cape York Peninsula are smaller and are grouped as *Dacelo novaeguineae minor.*

During 1906, kookaburras were liberated in the Epping district, northern Tasmania and they spread throughout the north and much of the east of the apple isle, becoming generally common in sclerophyll forest and savannah woodland. By 1960 they reached the Hobart district where they are now reasonably common, and still expanding. A few birds were introduced to the central regions of Flinders Island, in Bass Strait, in about 1940 and although well established now the species has not yet reached the extreme north or south of the island. Likewise, the introduction to southwestern Australia, from 1897 onward was spectacularly successful and the Laughing Kookaburra is now firmly established in forested country from Albany north to Jurien Bay, with a subsequent successful introduction being made farther north in the Irwin and Mingenew Rivers region. Not so successful were the introductions to New Zealand, where several small shipments from Australia were liberated between 1866 and 1880. Only along the western shore of Hauraki Gulf, north of Auckland, does a small but apparently fairly stable population survive.

The Laughing Kookaburra is very common and often abundant in open forest, dry woodland, the margins of closed forest, as well as occasionally following streams or gullies well into dense forests, and inhabiting trees dotting cleared farmlands. It is a most successful coloniser of man-made habitats and is a familiar bird in city parks, urban gardens or sportsgrounds and around country homesteads.

In much of the humid coastal lowlands of eastern Queensland, the Laughing Kookaburra occurs together with the Blue-winged Kookaburra but the two species tend to replace each other locally as one or the other predominates in each district. On Cape York Peninsula, the Laughing Kookaburra tends to be generally more plentiful in the drier central range country, with the Blue-winged Kookaburra being the common species throughout both the eastern and western lowlands. However, there is significant overlap. In any particular locality one usually well out-numbers the other and as a rule the Laughing Kookaburra prefers rivers and freshwater swamps, especially where bordered by large eucalypts, whereas the Blue-winged Kookaburra favours woodland savannah and open forest, well away from water.

Breeding pairs of Laughing Kookaburras are sedentary and extremely territorial, so movements associated with colonisation of new areas, particularly in Tasmania and southwestern Australia, are probably by young birds or non-breeding adults. An adult banded on 13 March 1971, at Pambula, on the south coast of New South Wales, was found dead near the banding place on 27 May 1981, and another adult banded on 7 December 1965, at Nambucca Heads, on the north coast of New South Wales,, was recaptured there on 11 April 1977, more than 11 years after the original banding.

Unusual circumstances surrounded the first records of Laughing Kookaburras from Ivanhoe, western New South Wales. On 15 February 1973, the first kookaburra was seen in the town and it remained for about a week. Some weeks later a second bird was found huddled in a rail truck, so presumably it had entered the truck and been transported from some place to the east. Possibly both birds reached Ivanhoe in this manner.

In the vicinities of farmhouses or in suburban gardens, kookaburras become quite tame, consequently acquiring reputations as 'friendly birds'. If offered food regularly, they soon adopt a fearless disposition, even coming at the same time each day to the back-door or verandah to be fed. There are many reports of birds that will knock their bills against a window or come into the house if feeding is delayed.

Kookaburras reside in clearly delineated territories which may contain a mated adult pair or a family group comprising the adult pair together with one or more auxillaries. These auxillaries are the young from previous years and as non-breeding adults remain with their parents to aid in territory defence, incubation of eggs, and care of chicks. Some individuals are known to remain auxillaries for up to four years before replacing breeding adults, usually on the death of members of dominant breeding pairs in the same or neighbouring territories.

The average size of territories is 1.2 hectares per bird, so family groups occupy far larger territories than do single pairs. Throughout the year, kookaburras spend much time defending their territories.

Within each territory certain large trees are favoured for roosting, and as darkness gathers a family group comes together on a high branch amid dense foliage where, after some preening and wiping of bills, they cluster together side by side to appear as one mass of feathers with multiple bills and tails.

Dawn and dusk choruses from groups of Laughing Kookaburras is a sound which so effectively epitomises the Australian countryside. The famous laughing song is given only by this species, usually by two or more birds and most frequently in the twilight or early morning and evening. When calling, a bird characteristically throws back its head so that the opened bill is pointing skyward, and its tail is cocked up. The laughing song is given at all times of the year to advertise territorial ownership but, as would be expected, it is especially frequent during the few months before nesting. There are also six shorter calls common to kookaburras, each with a different primary function.

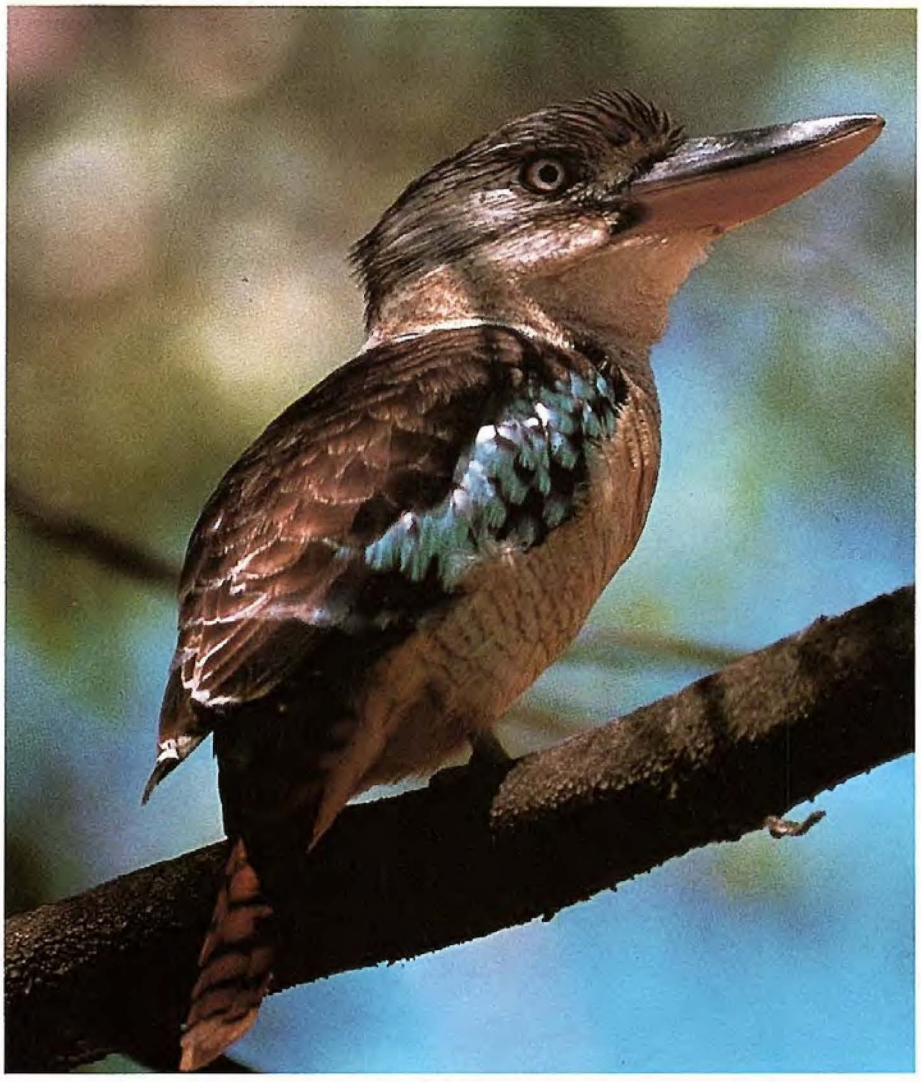
Kookaburras killing snakes is a feature of Australian folklore, and there are ballads describing situations where a bird swoops down to kill a snake which was about to attack a playing child. There is no doubt that these birds are efficient predators of small to medium-sized snakes, but stories are so exaggerated that now they rival the tales of dragons being slain by knights of old! It is known that young snakes hatched in the spring make ideal food for nestling kookaburras, and on one occasion the 20 centimetre posterior end of a snake was found protruding from the bill of a 20 days old chick. There is also evidence suggesting that even when no chicks are present, kookaburras will kill

Opposite, when giving its famous call, the Laughing Kookaburra characteristically throws back its head so that the opened bill is pointing skyward and its tail is cocked up. Drawing by William T. Cooper from Kingfishers and Related Birds, *published by Lansdowne Editions, Melbourne and reproduced here courtesy of the artist and publisher.*

Kookaburras

but not eat large snakes or rodents, possibly because these are regarded by the birds as a potential threat.

One of the few documented instances of a Laughing Kookaburra killing and eating a large snake comes from southeastern Victoria where, on 2 January 1973, a bird flew to a branch carrying in its bill a vigorously wriggling metre-long snake, thought to be a venomous Copperhead, *Austrelaps superbus*. The snake was struck many times against the branch and, when apparently dead was manoeuvred so that it could be swallowed head first. Considerable difficulty was exprienced by the bird in swallowing the snake and after each portion was swallowed there was a partial regurgitation. This was followed by a pause and then another swallow and the entire action gave the impression that the snake was being lubricated with saliva so that it would pass down the gullet. After swallowing the snake, the kookaburra sat on the



Right, the Blue-winged Kookaburra.

Below and opposite, because the rate of reproduction of the Laughing Kookaburra is so low, they are not able to quickly recover from catastrophes. As a result the destruction of habitat or misuse of pesticides can cause a sudden crash in their numbers. Photos G. Chapman, W. R. Taylor and G. Webber (NPIAW) respectively.

branch in a crouched posture with its feathers fluffed out. Some 40 minutes after first being sighted with the snake, the kookaburra flew off.

In addition to reptiles, kookaburras take a wide variety of prey, including insects, earthworms, snails, crayfish, frogs, and occasionally small birds, rodents and fishes. They are patient hunters, and a familiar sight is a kookaburra sitting motionless for long periods on some vantage perch, such as an overhead telegraph wire or on a fencepost, peering intently at the ground below before it pounces on its prey. Larger prey is grasped firmly in the bill and usually held just behind the head. After flying to a branch the kookaburra strikes its prey repeatedly against the perch until apparently lifeless and then is swallowed head first.

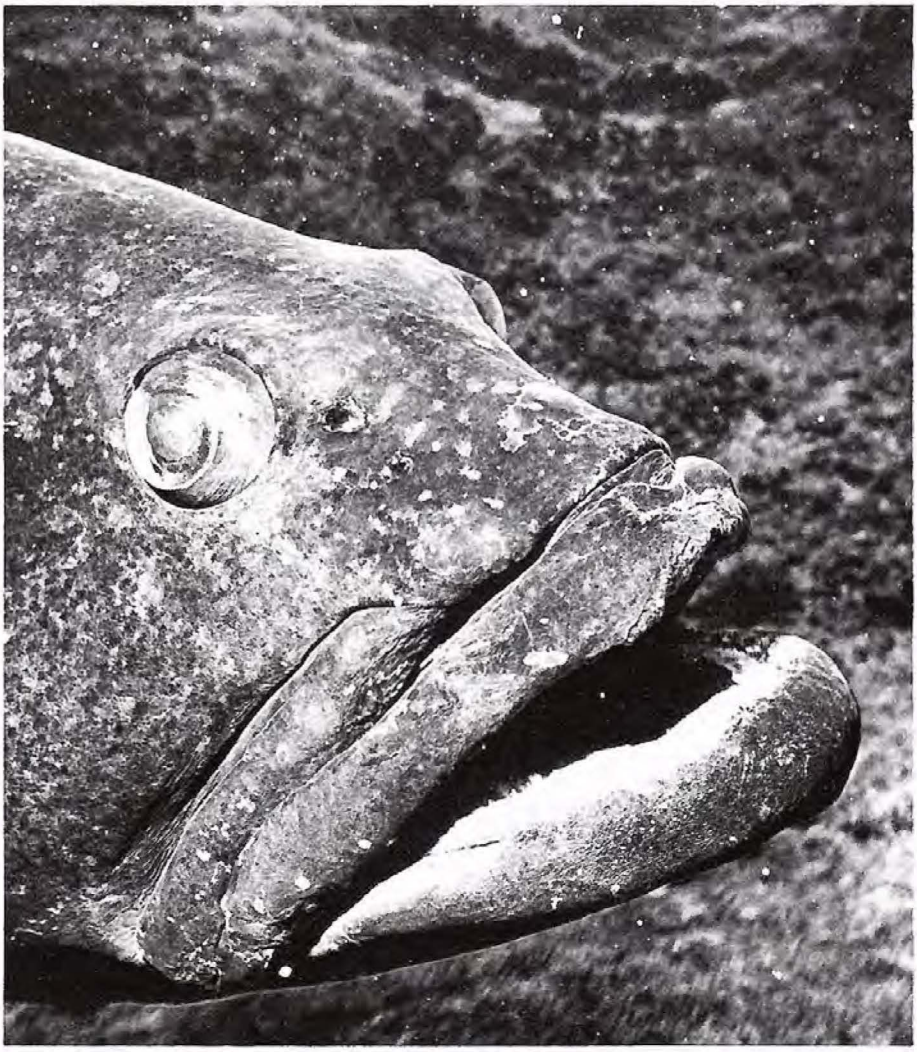
Nesting takes place between August and January, with egg-laying being mainly in September to December. The pair bond is for life, so courtship displays are not elaborate. The nest is usually in a hollow limb or hole in a large tree but another commonly used site is a hole excavated by the birds in termite mounds on trees.

Nests are found in unusual locations and include holes in haystacks or in the walls of buildings. The nest entrance is at least 15 centimetres in diameter and opens into an egg chamber measuring approximately 30 centimetres in width or depth and about 25 centimetres in height. It is important that there is no obstruction between the chamber and the entrance because the chicks excrete their waste out through the entrance hole . This keeps the nest clean. The same nest is reused year after year.

The number of eggs depends on whether one or more females lay, but a clutch of one to five with an average of two or three eggs is laid on wood dust lining the bottom of the hollow. All members of the family group develop brood patches and share incubation although one of the mated pair spends most time on the nest with auxiliaries contributing from 5 to 32 percent of total incubation time.

Incubation lasts 24 to 26 days and the chicks remain in the nest for 33 to 39 days. Feeding of the nestlings is undertaken by all members of the family group, with auxiliaries bringing between 10 and 61 percent of food items. Development of the chicks is slow, and plumage is acquired over a period of 27 to 33 days.

After having fledged, young birds do not return to the nest although for the next eight weeks they remain totally dependent on the adults for food. For the first two to three weeks after leaving the nest, young birds remain within the same clump of densely foliaged trees where they spend a lot of time preening or undertaking short practice flights. After this period they move around with the family group.



Right, the Inquisite Groper, Epinephalus daemelii, *is a purple-black fish bearing irregular blotches and speckling which normally feeds on crabs, shellfish and fishes.*

Bottom, giant clams are abundant inside the lagoons of both reefs.

Opposite, large feather stars, probably the most elegant of all echinoderms, use their many feather-like arms to filter planktonic food from the water.

Australia's lonely atolls

by Ken Grange and Dick Singleton

Elizabeth and Middleton Reefs, today unspoilt and largely unknown, lie in the north Tasman Sea some 600 kilometres east of the New South Wales coast and 150 kilometres north of Lord Howe Island. Middleton Reef is approximately 50 kilometres north of Elizabeth Reef and both are controlled and administered by the New South Wales Government. Both reefs lack permanently exposed land and terrestrial vegetation and can only be seen from the sea as a ring of white breakers.

Ken Grange and Dick Singleton, two New Zealand marine biologists working for the New Zealand Oceanographic Institute, have visited these atolls several times while investigating the origins and distributions of that country's marine fauna.

Elizabeth and Middleton Reefs are both kidney-shaped coral atolls each about five kilometres long and three kilometres wide. The reef crest surrounds shallow lagoons which average only one metre in depth at low tide and are surrounded by white sand and isolated coral heads of varying sizes. There are isolated patches of deeper water inside Elizabeth Reef but none is deeper than 10 metres. The outer reef slopes are steep on all sides and drop away to over 35 metres in depth within 1.5 kilometres of the reef crest.

Middleton reef was discovered on July 20, 1788 by Lieutenant John Shortland in the *Alexander,* and named after Sir Charles Theodore Middleton who became admiral of the First Fleet in 1795. The discovery of Elizabeth Reef is not so clear. It is generally thought of as being discovered in 1820 by two ships, the *Claudine* and the *Marquis of Hastings,* although a 300 ton whaler, the *Britannia* may have been wrecked there in August 1806. Whatever the discovery date, Elizabeth Reef was named after a brig of the same name which ended its life on the reef in 1831.

Throughout the nineteenth and twentieth centuries, ships tried to steer well clear of Elizabeth and Middleton Reefs. Despite this they still became known as the graveyards of the Pacific. Twenty wrecks were known to have occurred on the reef up to 1926. Before 1937 the most prominent wreck on Middleton Reef was the 1436 ton steel barque *Annasona,* which crashed ashore on the morning of January 18, 1907. The wreck remained largely intact until it became a bombing target for the Australian Air Force. All that now remains are parts of the masts, bow, the huge steel-plated wooden rudder and the anchors. Even in recent years, ships have continued to run aground on the reefs and at least three are still standing almost intact.

However, the most spectacular wreck occurred on February 19, 1961, when the 13,587 ton Shaw Savill liner *Runic* crashed her bow against Middleton Reef after passing through the tail-end of a cyclone between Brisbane and Auckland. Salvage attempts lasted for almost a month but another storm in mid-March drove the ship a further 100 metres onto the reef, gashing the port side and exposing the set of three single-reduction-geared steam turbines on that side. The *Runic* was declared a constructive total loss on March 22, 1961. She is still upright on the north-west side of the reef, largely intact apart from the stern section which has broken away. Most recent among the many shipwrecks on Middleton Reef was the *Josephine II,* a 10 metre keeler being sailed by Bill Belcher in the 1976 Auckland to Sydney single-handed yacht race. It became blown off-course

Australia's lonely atolls

Right, a large moray eel lurking among the rocks can be fiercely aggressive and cause serious wounds in humans. Their bite, however, is not poisonous. They feed on smaller animals and are very effective scavengers.

Bottom, one of the two species of lionfish found on the reefs. Lionfish are some of the most spectacular of all coral fish with their dazzling display of feathery fins and coloured stripes. Looking more like a water-borne bundle of weeds, the lionfish will rest motionless on the sea bottom until a small fish swims by, then will use its fins as a net to drive the prey into a suitable position to attack.

Above opposite, another large feather star.

Bottom opposite, the SS Runic *ran aground on Middleton Reef in 1961. A wrecked Japanese fishing boat is visible on the far side of the reef.*

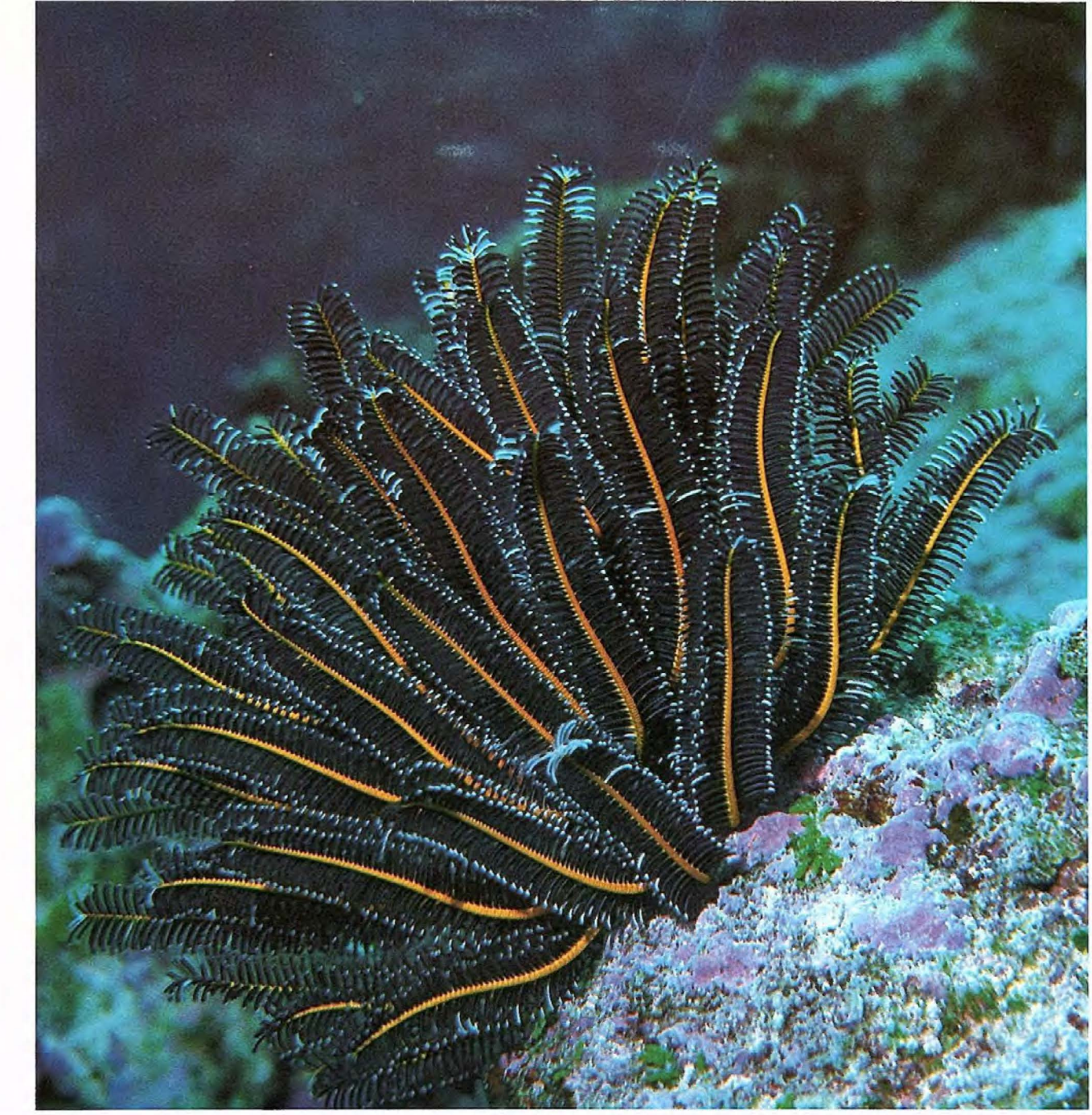
and was washed over the reef crest ending up in the centre of the lagoon.

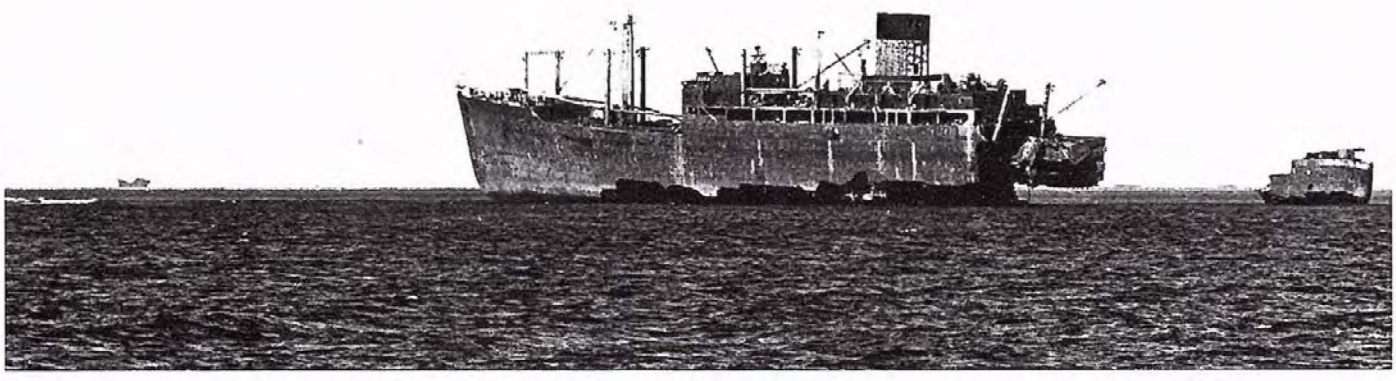
The natural history of these isolated atolls is not well known and little advance has been made since 1936 when G. P. Whitley of the Australian Museum was invited to join an expedition aboard the yacht *Wanderer*. During the past few years the research vessel *Tangaroa* from the New Zealand Oceanographic Institute has made several visits to the reefs examining fish and invertebrates. The area from New Zealand northwards represents a gradual decline from wholly temperate in New Zealand to near-tropical at Elizabeth and Middleton Reefs, and mixtures of both temperate and tropical species are found throughout.

The fauna of Elizabeth and Middleton Reefs is clearly related to that of Lord Howe Island rather than the Great Barrier Reef or islands further to the north, such as New Caledonia. Because the reefs are at the confluence of tropical and temperate waters wide-ranging species such as the Green Turtle, *Chelonia mydas,* and the Sharp-spined Sea Urchin, *Diadema setosum,* are common. Corals are plentiful but not as diverse as more tropical areas to the north. The Staghorn Coral, *Acopora hyacinthus,* is abundant in the shallower areas but below 20 metres on the outer slopes the dominant coral is *Turbinaria frondens.*

Diving in the clear waters around the reefs and inside the lagoons is impressive. The absence of human interference and fishing pressure has allowed large populations of many fish species to become established including demersal kingfish, trevally, demoiselles and grey sharks as well as reef fish and large groper, *Epinephalus damaelii.* On one cruise a 163 kilogram Queensland Groper, *Promicrops lanceolatus,* was caught, extending the southern range of this species.

Although the many shipwrecks point to a harsh and often inhospitable climate, this is not reflected in the diversity of marine life which has adapted to the environments of Elizabeth and Middleton Reefs. At present there is an abundance of fish and clams, but each reef is finite in size and remote from other populations of these animals. Over exploitation would occur easily should the reefs be opened to commercial fishing and any regulations implemented would be difficult to enforce because of their remoteness. Perhaps it is fortunate that the long list of known shipwrecks deters fishing vessels and allows the reef to remain virtually unspoiled.





Sydney bats on the wing

by Roland Hughes

Masses of bats flying, silhouetted against the moonlit sky is a very familiar sight to Sydneysiders during the long summer months. Anyone walking underneath fig trees in the Botanic Gardens, Hyde Park and the Domain at dusk can't fail to notice the hordes of squabbling bats as they make each tree their roadhouse for the night.

However, this is all likely to change because the home and breeding ground of Sydney's 'flying foxes' or Grey-headed Fruit Bat, *Pteropus poliocephalus,* is in danger of being destroyed.

The Grey-headed Fruit Bat has only one known breeding ground in Sydney and that is the humid, heavily-wooded bushland surrounding Stony Creek Gully in the suburb of Gordon.

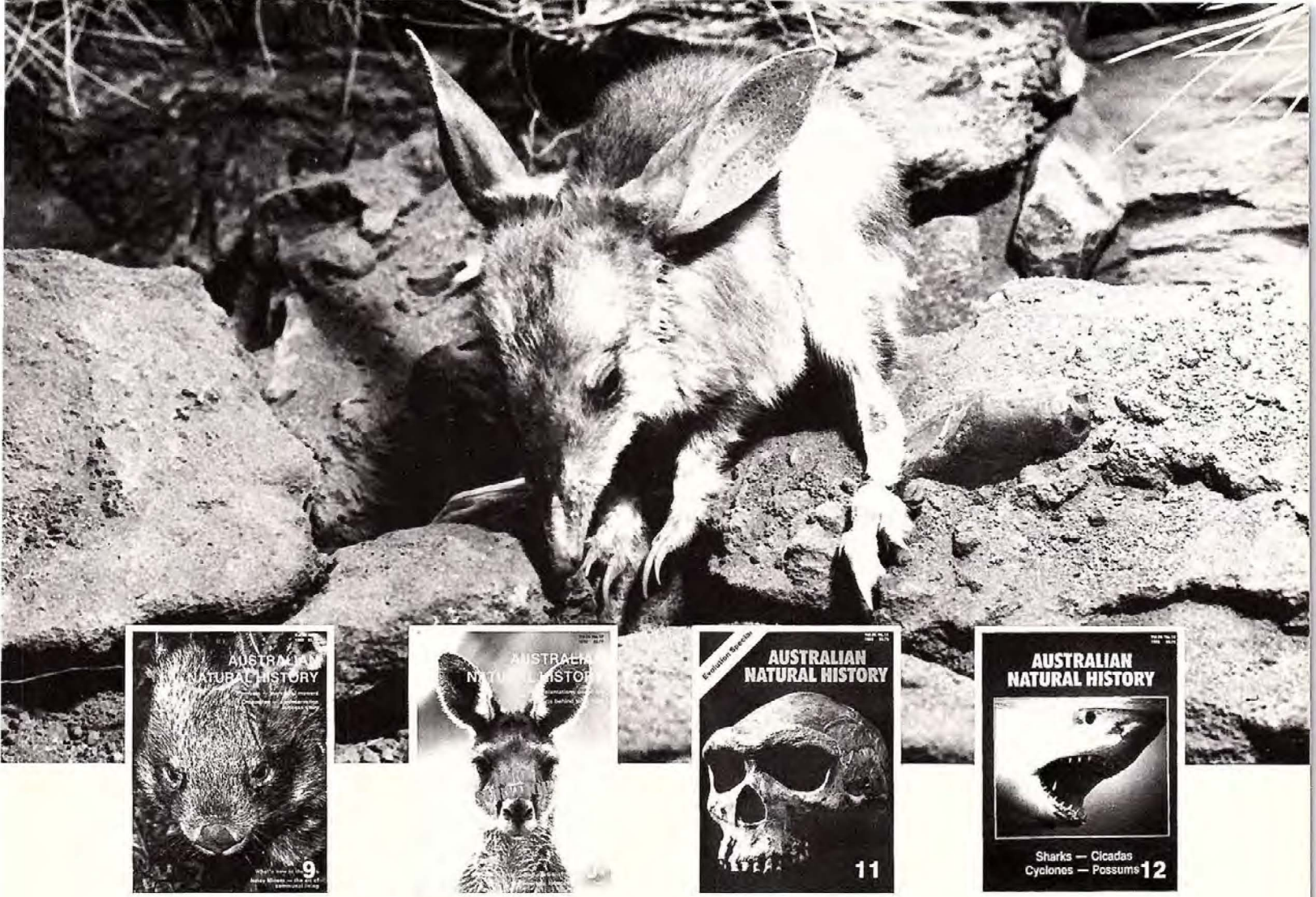
Ku-ring-gai Council, which controls this prestige upper north shore Sydney suburb, granted permission for sub-division of vacant land right on the edge of the bat's colony. Removal of even a few trees, all vital to the bats well-being, will upset the delicate balance of the colony to the extent that the bats will be driven out.

Lacking tails and with fox-like faces, Grey-headed Fruit Bats lead a communal life spending the daytime hanging upside down in the upper branches of Stony Creek Gully's trees.

The size of the colony or camp as it is known, varies enormously. At the height of the breeding season a camp is estimated to reach 30,000 animals.

At dusk the bats fly out on well-established fly-paths in search of ripe fruit and flowering trees. Apart from descending on the fig trees in the centre of the city, bats are seen as far south as Cronulla, west to Liverpool and as far north as Palm Beach. Their favourite feeding trees are native hardwoods such as Blackbutt, Bloodwood, Flooded Gum, Grey Box, Gum-topped Box, Spotted Gum and Tallow-wood. They also monopolise native fruits such as figs, lillipillies and when food is scarce a number of cultivated soft fruits.

Some Grey-headed Fruit Bats in their Sydney home. These 'flying foxes' have a claw on the end of their elongated first digit which enables them to hang upside down all day. The second digit is clawed as well and is used as an aid for climbing among the branches. Grey-headed Fruit Bats have long grizzly fur, with grey heads and bodies, and golden to copper-yellow shoulders. The camp at Gordon is probably the most southern in Australia and the only home of these sociable animals in Sydney. Photos Kathie Atkinson.



The world of Australian Natural History

No. 9 *Wombats — Amiable Native Lawnmowers.* **Famous for their large burrows, wombats are the largest burrowing herbivores in the world. Also included in the issue are articles on astronomy in the southern hemisphere, those irrepressible honeyeaters — Noisy Miners and** *A Look at the Freshwater Crocodile.*

No. 10 *Pinus radiata — a Million Hectare Miscalculation?* **By the year 2000 Australia will bristle with over one million hectares of pine plantations mostly containing Monterey Pine,** *Pinus radiata.* **Already there are over 500,000 hectares of land under pine and with an annual growth of 30,000 hectares, extensive areas of native forest are threatened with extinction. Other articles include** *How Toxic 1080 Selects its Targets,* **a look at the Numbat,** *Tomatoes, Tobacco and Intoxicant Weeds* **and more on astronomy.**

No. 11 Evolution Special. 1982 was a very important anniversary in the history of science. It was just one hundred years ago that Charles Darwin (1809—1882), the famous English naturalist who soundly established the theory of evolution, died. This issue seeks to honour Darwin by presenting the modern view of evolution and the history of life. The magazine looks at man's origins on the continent and tells how new finds are placing Australia in the forefront of study on human evolution. It also describes how Darwin formulated his theory of evolution, as well as the evolution of Australia's mammals and plants, the development of animal behaviour, the impact of the latest discoveries in genetics and Australia's fossil record.

No. 12 Sharks and shark attack — an up-to-date coverage of the most threatening sharks off Australia's coast as well as possible reasons for shark attack on man. Also *It's an Ill-wind that Blows in the Tropics,* **covering that summer phenomenon — cyclones, Part I of** *Possums in Australia,* **Red Back Spiders, treecreepers and every schoolchild's summer delight — cicadas.**

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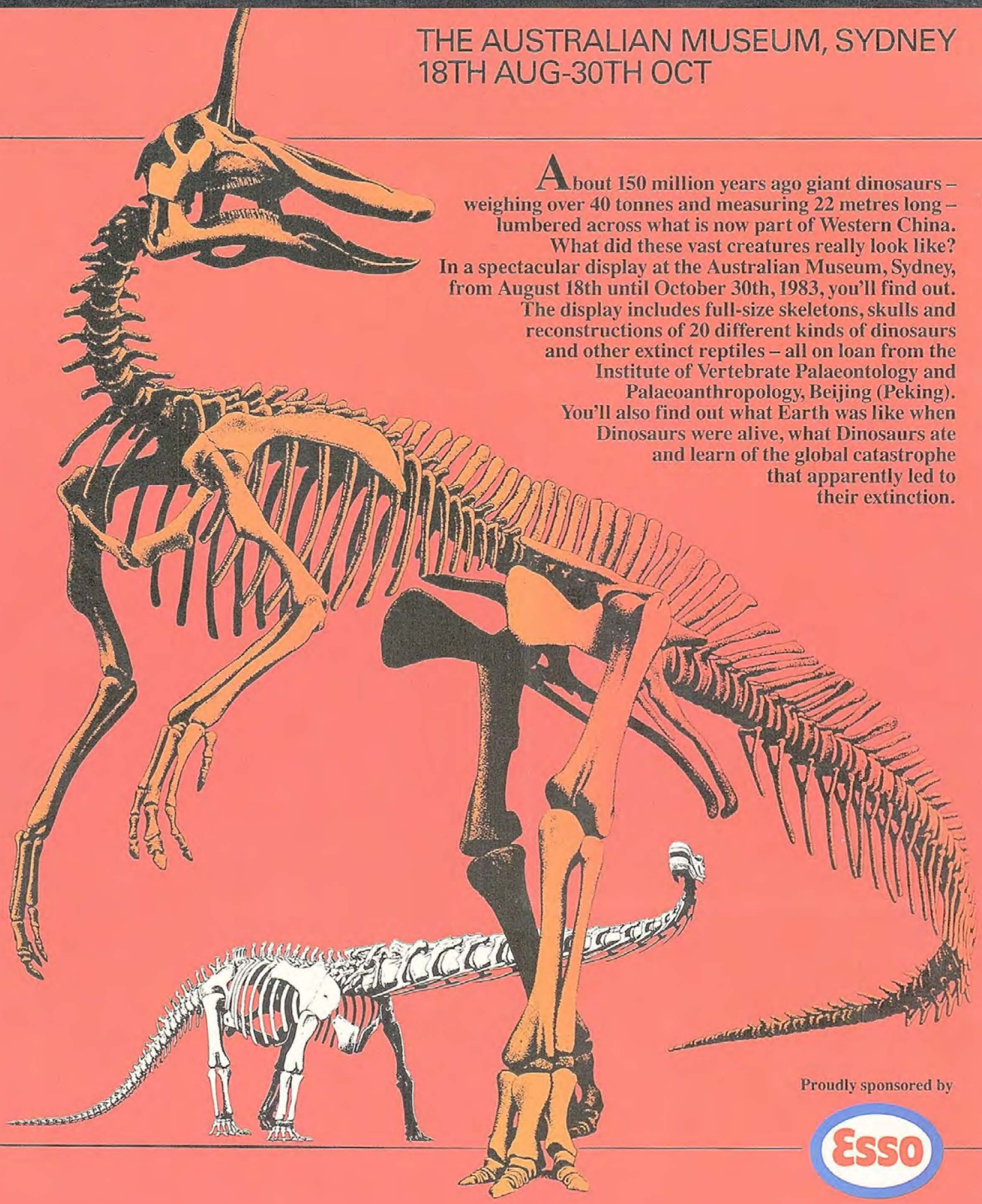
DINOSAURS FROM CHINA

THE AUSTRALIAN MUSEUM, SYDNEY
18TH AUG-30TH OCT



About 150 million years ago giant dinosaurs – weighing over 40 tonnes and measuring 22 metres long – lumbered across what is now part of Western China. What did these vast creatures really look like? In a spectacular display at the Australian Museum, Sydney, from August 18th until October 30th, 1983, you'll find out. The display includes full-size skeletons, skulls and reconstructions of 20 different kinds of dinosaurs and other extinct reptiles – all on loan from the Institute of Vertebrate Palaeontology and Palaeoanthropology, Beijing (Peking). You'll also find out what Earth was like when Dinosaurs were alive, what Dinosaurs ate and learn of the global catastrophe that apparently led to their extinction.

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