The Reef

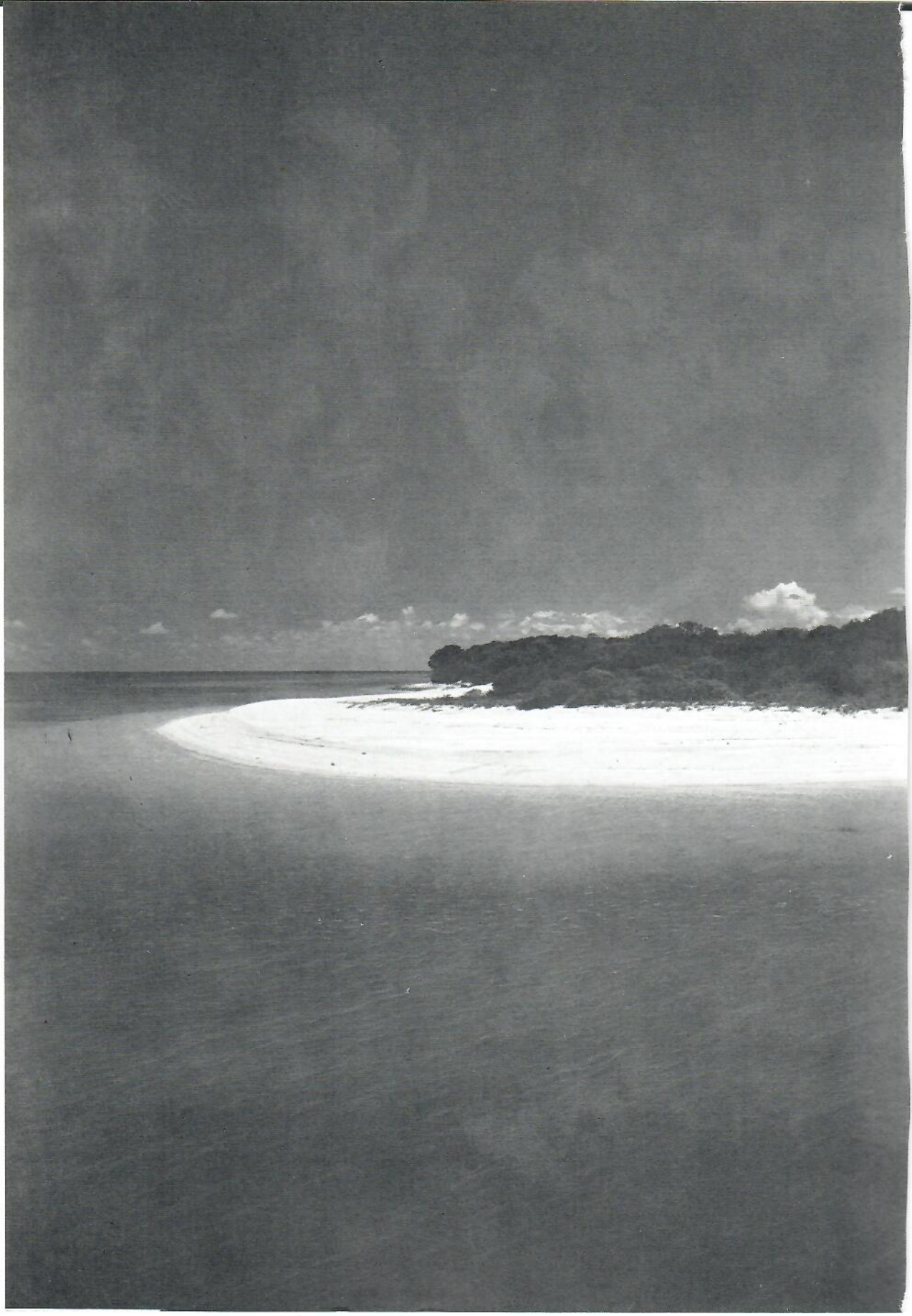
Uncertain Land of Plenty

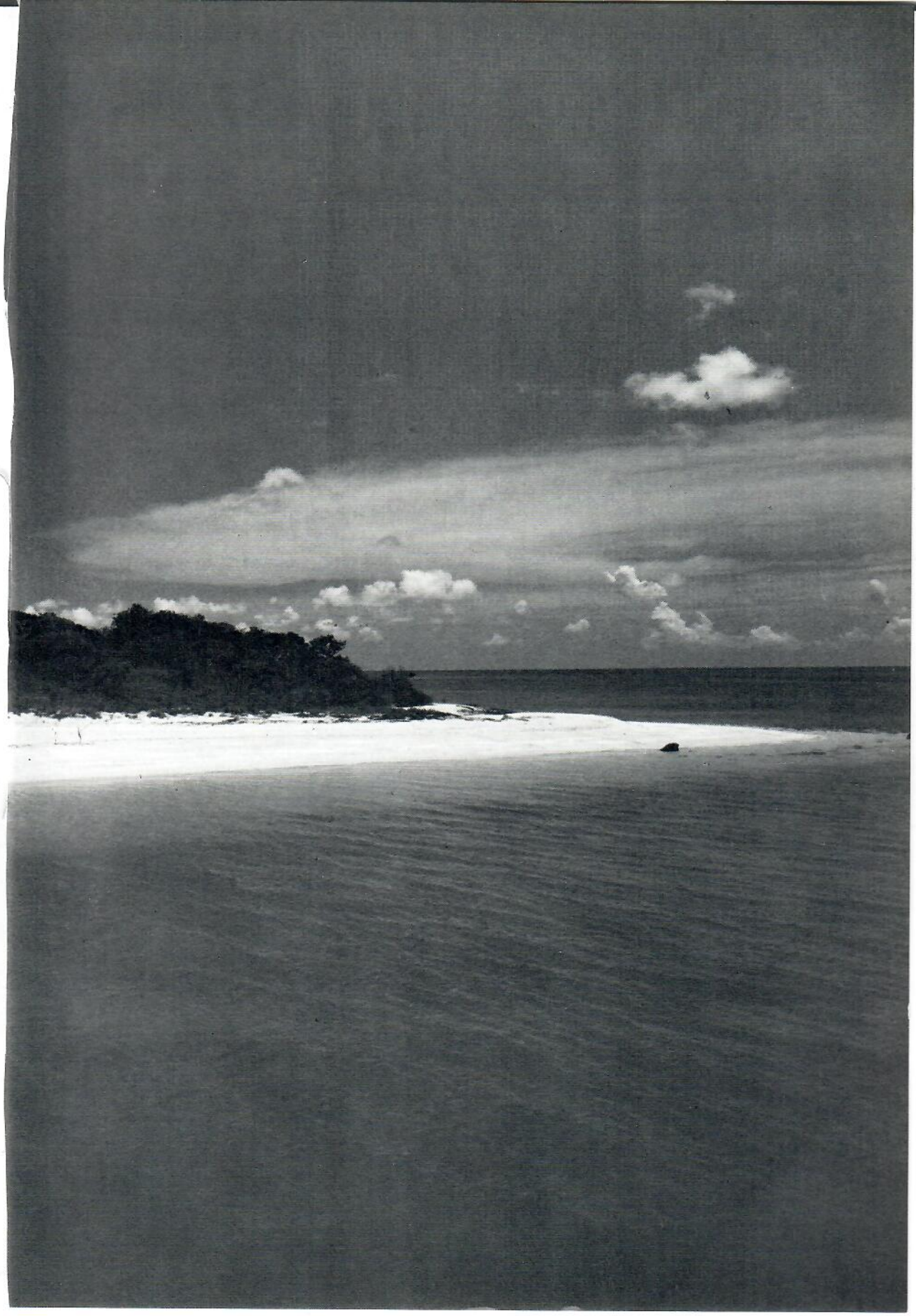
The Great Barrier Reef, one of the natural wonders of the world, extends along the Queensland coast for over 2,000 kilometres. By far the largest of its type, the next occurs along the coast of New Caledonia.

The Barrier Reef is not a single reef, but stretches more or less continuously from Bramble Cay and Anchor Cay in northern Torres Strait to Lady Elliot Island in southern Queensland, a maze of coral reefs and intervening channels and relatively protected shallow water areas.

This great reef complex is far from uniform; there are limestone hills and valleys with chasms and plateaux formed from the accumulated skeletons of corals and other marine organisms. The greater part of each reef is submerged at all times. Portions may be exposed by low tides, reef crests appearing from 0.5 to 1.5 metres above the low water spring tide level. The eastern and north-eastern boundaries are taken arbitrarily as the 200 metre-depth contour line, the edge of the continental shelf. Here a series of long curved reefs from 200 metres to 1,500 metres in width and as many as 25 kilometres in length, separated by narrow deep passages, are arranged more or less parallel to the coast. The outer edge of the reef slopes quickly away to the Pacific Ocean in the east, a depth of 2,000 metres being reached in some places not more than 7 kilometres away. In the west, the reef is bounded by the Queensland coastline. It is approximately 20 kilometres in width at its narrowest east of Princess Charlotte Bay, and about 320 kilometres at its widest part between Rockhampton and Mackay.

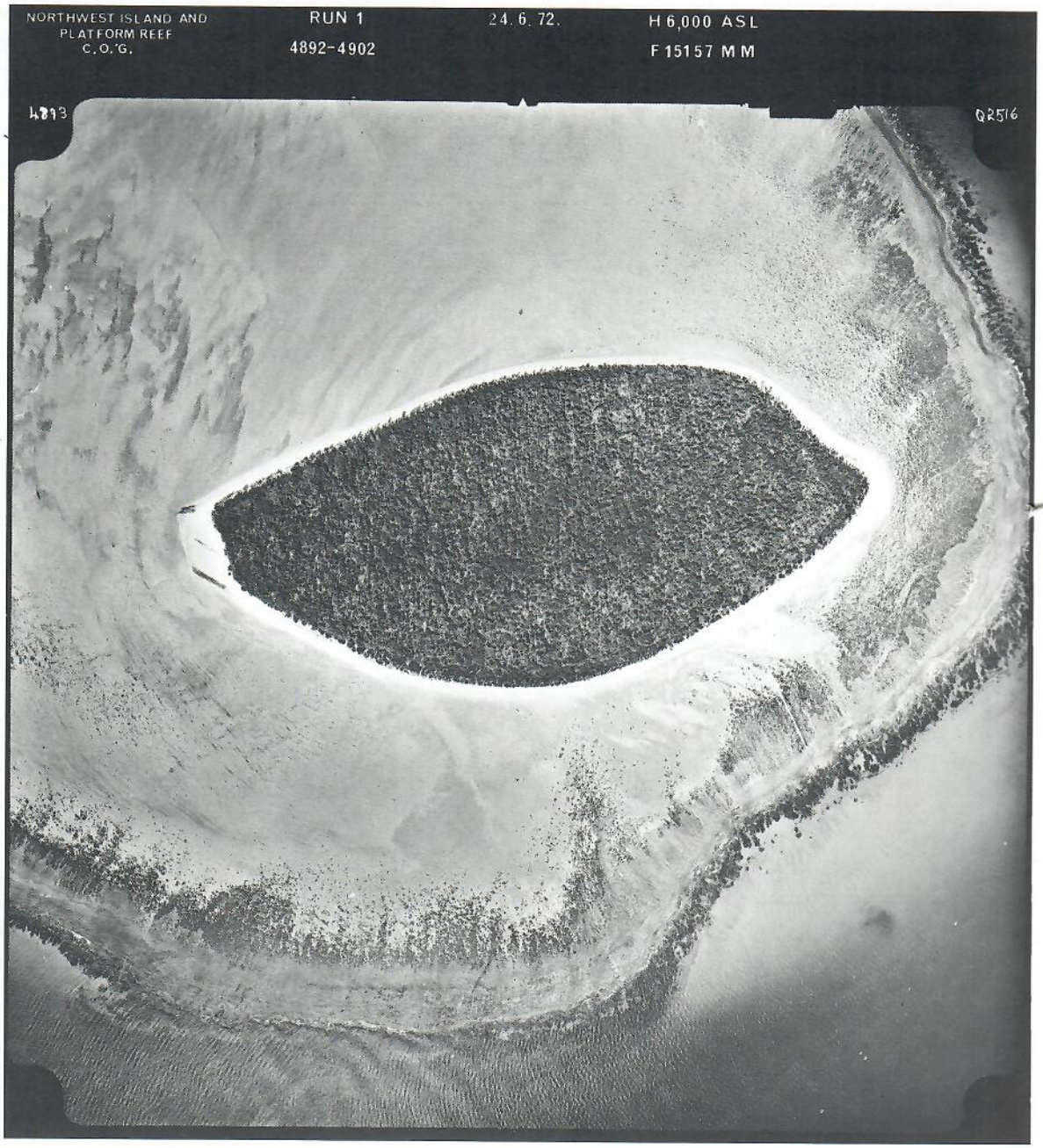
The Great Barrier Reef region or 'Province', quite distinct from the Coral Sea Platform group of islands such as Willis Group,





Herald Group, Coringa Group and Diamond Group, is divided into three regions. The northern region extends southwards to 16°S Latitude (about east of Cooktown) and comprises shallow water less than 40 metres in depth; the central region extends from 16° to 20°S Latitude on the shelf edge and to 21°S Latitude on the coast (about east of Mackay) in water usually 40 to 60 metres in depth over a less sloped submarine floor; the southern region consists of reefs that are more scattered and less linear and of water mostly more than 60 metres in depth.

Great outcrops of granite and other rocks characteristic of the continental mass break through this limestone veneer in places. Some are extensive, forming mountainous steep-sided islands such as Lizard Island, Hinchinbrook Island and Magnetic Island, and



the Palm, Whitsunday and Cumberland Groups of islands. These islands of rock that are continuous with the underlying shelf are termed continental islands. They contrast with the low islands of accumulated fragments of coral and shells termed cays, built up over the large limestone reef platforms, by the predominantly south-easterly currents.

Some cays are substantial; North West Island is 4,123 metres in circumference and, while the sand is only several metres above high tide level, its dense pisonia tree forest rises to more than 20 metres. In contrast, nearby Broomfield Reef has a sandbank which in recent years has been quite variable in appearance; in 1974 this sandbank was covered by most spring tides, while in 1976 there was sufficient land above high tide level for several sea turtles to use it as a nesting site. This 'Broomfield Cay' did not support terrestrial vegetation and, following heavy storm surges, it is again merely a sandbank submerging at hightide. Coral cays and sandbanks are mobile, existing through a dynamic equilibrium of factors causing deposition and erosion of sediments.

North West Island, the largest coral cay (82 hectares) on the Great Barrier Reef; the dense cover of vegetation provides shelter for tens of thousands of nesting sea-birds but cats, fowls, rats and mice also roam wild there. (Aerial photograph supplied by the Surveyor General, Queensland.)

Close inshore to the mainland, the water is often turbid and the bottom sediment is derived principally from the discharge of mainland rivers. Farther offshore, the water becomes clearer and the sediments change to those mainly derived from the marine organisms of the reef and surrounding waters; there is also an associated increase in the variety of species of reef-living animals and plants. Additional variation in the complexity of the reef results from a temperature gradient that exists from the tropical northern limits at Bramble Cay (approximately 9°S Latitude) to the southern limits at Lady Elliot Island (24° 07'S Latitude). This southern extremity of the Great Barrier Reef is largely determined by the inability of the reef-building corals to grow in waters with a minimum temperature below approximately 18°C. There is a considerable reduction in variety of reef-dwelling organisms down the length of the Great Barrier Reef, paralleling the decreasing temperature gradient from north to south.

Over all this variation in the reef habitat can be superimposed the occasional, though localised, catastrophic change that results from cyclone-lashed seas pounding an area of reef and islands. The consequent destruction of coral and other sub-surface (benthic) organisms is astonishing. Areas of lush growths of branching acropora coral thickets may be destroyed overnight; large blocks of coral are tossed and rolled, creating even more debris as these move. Great areas of sand disappear from the beaches into the pounding surf. The cyclone passes and, for that reef, the cycle of growth begins again. The Great Barrier Reef waters, covering an area of more than 200,000 square kilometres, present a great mosaic of environmental conditions, habitat types and associated fauna and flora.

It is in the context of this diversity that the sea turtles provide opportunity for closer examination of the interrelated nature of life on the Great Barrier Reef.

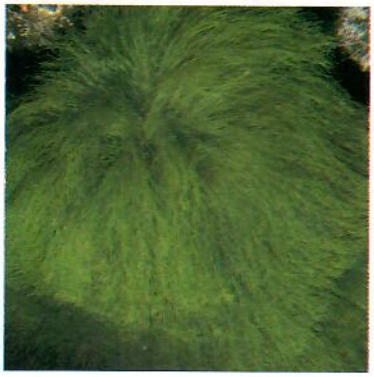
THE REEF TURTLES

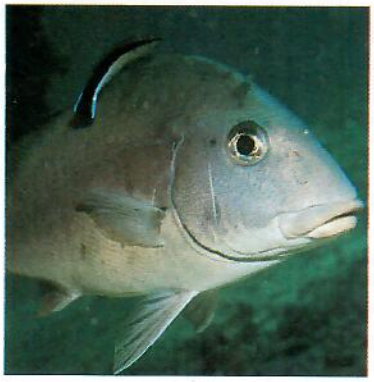
The Great Barrier Reef waters are rich in sea turtles. Of the world's seven sea turtle species, six are found in this region. The *green turtles* and the *loggerhead turtles* are so abundant that some of the



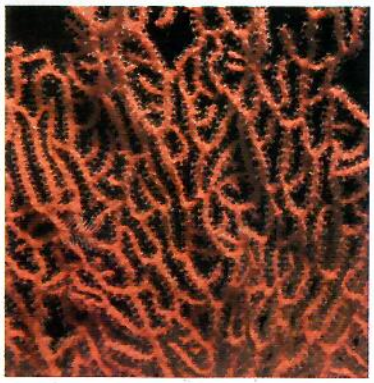






A sampling of the diverse life forms of the reef:
Pisonia tree
Tournefortia tree
Feather sea star
Soft coral
Elegant sea star



Tropic featherduster worm
Variegated sea cucumber
Volcano sponge
Pink sea fan
Reef clam

Sunshine coral
Turtle weed
Sea anemone
Blue angelfish
Horned butterfly fish

Slatey sweetlip
Harlequin tuskfish
Coral cod
Lurking moray eel
Porities bommie

largest nesting aggregations known for the species are found there.

One area well known for its turtles is Heron Island, a small coral cay situated in the Capricorn Group of islands towards the southern end of the Great Barrier Reef. The reef surrounding the island is about eight kilometres long and three kilometres wide. Like the neighbouring reefs, it rises abruptly to the surface from a relatively level sand- and silt-covered bottom at 40 metres in depth. Heron Reef can be likened to a large dish — a high reef crest exposing at low tide to form a rim around a shallow lagoon no more than four to five metres in depth and in many areas less than one metre in depth. Lagoons like this are year-round feeding grounds for hundreds of turtles.

The loggerhead turtles concentrate within the lagoon, feeding on the shelled molluscs that are so abundant in these sandy areas; densities of up to 160 molluscs per square metre have been recorded, all within the top few centimetres of sand. The loggerhead turtles walk slowly across the bottom biting up mouthfuls of these molluscs and of sand, blowing out the latter with water before crushing and swallowing the shells.

Turtles have no teeth. Instead their jaws are covered by horny sheaths. The jaw sheaths of the loggerhead turtle form broad thick plates enabling the animal to crush and so feed on molluscs and other animals with thick exoskeletons. Whereas loggerhead turtles feeding over the lagoon sands are feeding on horn shells, Heron Island volutes and bivalve molluscs, those feeding over the reef flat and reef crest at high tide select different molluscs. Ear shells, turban shells and the large clams ripped from the reef are crushed by their powerful jaws.

A loggerhead turtle spends much of its day foraging and feeding, its digestive tract containing up to 1,200 crushed molluscs at one time. The rate of passage of this food through the digestive tract remains unmeasured but an estimate is that an average-sized adult may be depositing 1 kilogram of mollusc fragments on the reef daily. Thus a year-round resident loggerhead turtle population of 250-500 for Heron Reef therefore could be generating 100 tonnes or more of mollusc fragments annually on to this patch reef.

This is, of course, only one source of calcareous debris from which the reef is built. Thousands of mollusc-feeding stringrays throughout the lagoons, coral-eating parrot fish and sea stars, and smashed and broken coral from cyclonic seas, are some other obvious sources of such sediments for the reef. The growth of the reef is the result of a balance between growth of the reef-building corals and their destruction, between deposition and consolidation of sediments and their dispersal from the reef.

The horn shells, the principal component of the loggerhead turtle diet in Heron Reef lagoon, feed on delicate algae which grow on the sand surface of these shallow waters. During heavy seas, turbulence into this otherwise protected area stirs up the surface sand moving it about and breaking up the algal growth. The lagoon water at this time is clouded with a suspension of fine silt, much of which eventually will settle in the deeper, more protected northern part of the lagoon

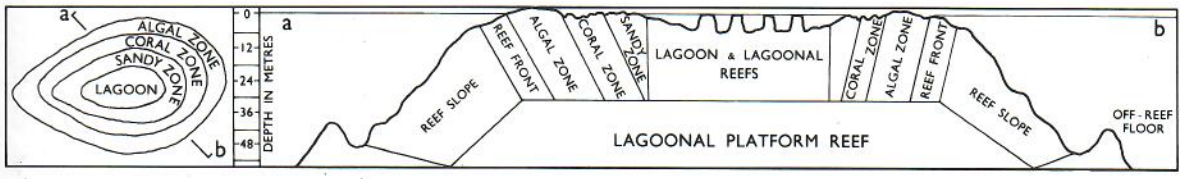
This deeper northern area (the 'blue lagoon') with its fine silt floor does not support the same dense growth of algae; nor does it have the high mollusc densities and the associated large

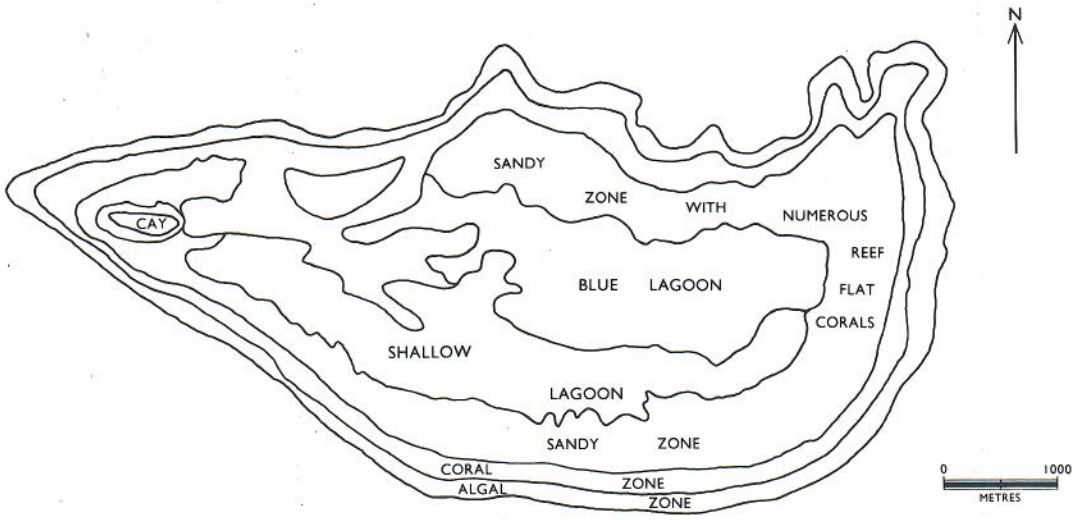
aggregations of loggerhead turtles that are a feature of the coarser sandy-bottomed areas of the southern side of Heron Reef lagoon (the 'shallow lagoon').

When quiet conditions return within a lagoon, the white sand bottoms to these shallows change to green and brown within days as the algae flourish again. Within a few weeks, sections of the once bare sand are carpeted with thick layers of fragile algae. With the blossoming of these algae come the roving schools of algal-feeding fishes such as the spinefeet as well as large numbers of the herbivorous green turtles.

The horny sheaths of a green turtle mouth are serrated and ridged as in pinking shears and this enables the turtle to crop the algae and sea-grasses which are its main foods. There are few sea-grass beds in the vicinity of Heron Reef and so here the great range of algae form the bulk of the resident green turtles' diet. Because the quantity of algal turf across the sandy lagoon floor is a function of recent weather conditions, the abundance of green turtles feeding in any particular part of the lagoon can fluctuate widely over a period. The green turtles also feed extensively on the algae of the small patch reefs scattered through a lagoon and on the algaes of the reef flat and reef crest. At high tide there can be anoticeable movement of green turtles from the lagoon and from deeper water

Zonation of a Great Barrier Reef coral cay Heron Island from vertical and horizontal views (after flood 1977)





outside the reef on to the reef crest and reef flat where these animals feed until the falling tide again forces a retreat.

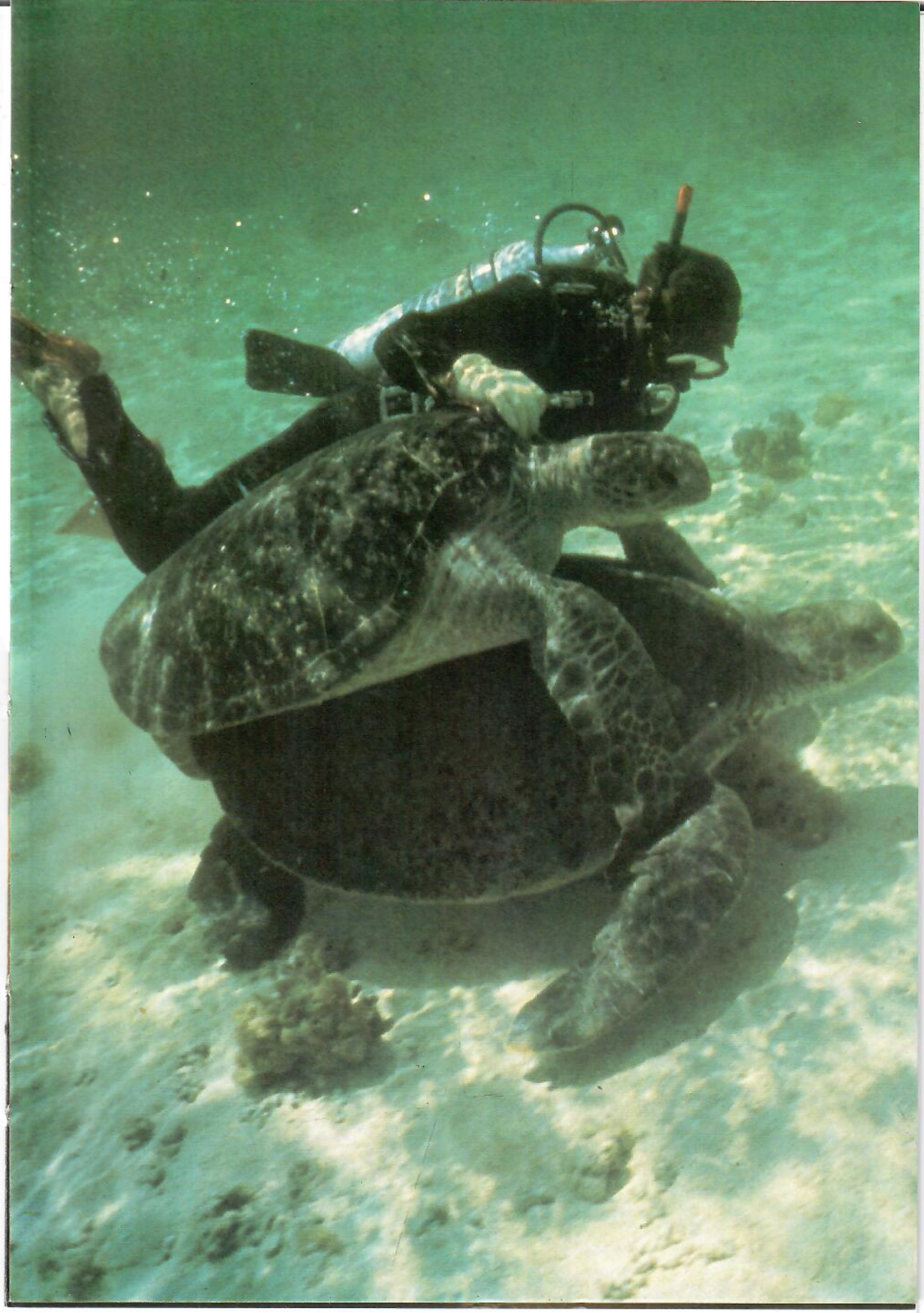
On calm days when large concentrations of planktonic organisms occur in the surface waters over the reef fronts, groups of green turtles, especially the immature animals, and occasionally loggerhead turtles can be seen 'hanging' in mid-water slowly moving from one jellyfish or sea-comb to the next. The smaller food items are swallowed whole. The jellyfish appear to form only a small part of the diet for these two turtle species. It is the need to feed on bottom-dwelling organisms as well as to come to the surface to breathe that restricts these sea turtles largely to the shallower parts of the continental shelfs. Without doubt, the shallow food-rich warm waters of the Great Barrier Reef Province are ideal for turtles.

One as yet unexplained observation is that the green turtles which live in the deep water of the reef front are mainly immature turtles (with a carapace length of 41-88 centimetres). This is in strong contrast with the green turtle population in the lagoons where more than one-half are adults (that is, with carapace shell lengths of more than 88 centimetres). Whether the separation into size classes reflects differences in diet, resting site selection, ability to cope with rougher water conditions or some unrecognized factor is unknown. In this, as in so many aspects of the underwater life of sea turtles, there is obviously much to be learned.

Estimates of the size of the total green turtle resident population for Heron Reef indicate that this reef supports more than 50 tonnes of green turtles of all sizes and these animals necessarily require much food.

Right: *Col Limpus monitoring turtle mating, Heron Island lagoon.*

A coral cay of the Great Barrier Reef. Note the widespread reef in relation to the small vegetated island at the north-east end of the central lagoon. Lady Musgrave Island, Bunker Group, December 1971 (Photo C.J. Limpus)



Another, less common turtle on Heron Reef is the *hawksbill turtle*, so named because of its narrow and pointed head with a slight down-curve on the tip of the upper jaw. The narrow pointed beak enables it to nose into nooks and crannies of the corals, biting off a great array of encrusting organisms for food — algae, sponges, ascidians, bryozoans and molluscs. While hawksbill turtles comprise about 1 per cent of the turtles resident on Heron Reef, they constitute about one-half of the turtles on the northern region reefs off Cairns, most of the others being green turtles. While climate appears to account for the concentration of hawksbill turtles, the specific factors are yet to be investigated.

Of other sea turtles throughout the Great Barrier Reef Province, the *flatback turtle* is encountered only occasionally in coral reef situations yet it may occur commonly in coastal areas inshore from the main coral reefs and in the vicinity of continental islands. The flatback turtle is known only in Australian waters; perhaps suprisingly, it has never been favoured for food by Aboriginal or European man. The cloudiness of its inshore habitat makes it infrequently observed by divers. Even less is known of its life in the sea than we know of the other species.

While the flatback turtle is abundant in the inshore Great Barrier Reef waters yet rarely recognized, the *leatherback turtle* is scarce throughout the area yet readily recognised. It is the largest of the sea turtles, with carapace length as great as 169 centimetres. (The next largest is the green turtle with an average carapace length of 107 centimetres ranging up to 126 centimetres.) No other sea turtle is so large and black nor has such a conspicuously-ridged carapace; indeed, some fisherman near Lady Musgrave Island, seeing one of these basking on the surface for the first time, mistook it for an upturned dinghy. The leatherback turtle is not a resident of coral reefs but an inhabitant of the surface waters of the open oceans where it is thought to follow the currents, feeding on jellyfish and planktonic ascidians. The softness of its diet explains why this

Turtle tag

giant large-headed turtle has such feeble jaws; the elaborate notches of the jaws may merely enable it to grip a jellyfish while feeding.

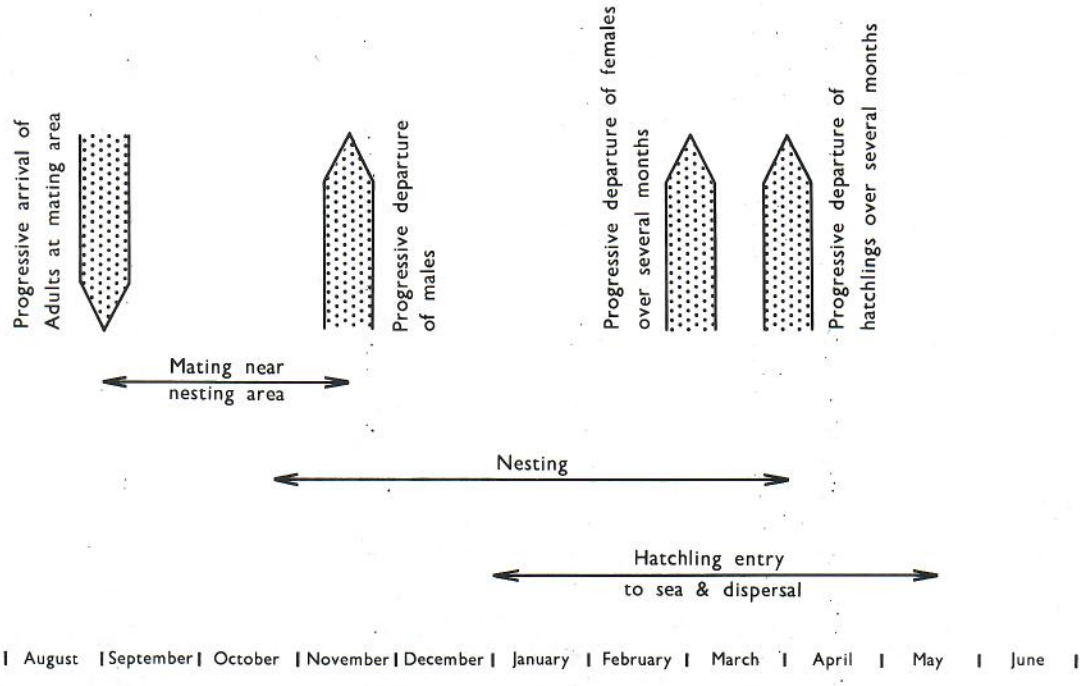
Like the flatback turtle, the *Pacific ridley turtle* is found more in inshore habitat types and has been recently identified from the coast near Cairns. It probably will be found eventually to be quite common in the bays and inlets farther north. In size and shape, the Pacific ridley turtle looks like an undersized, but grey, loggerhead turtle.

Overleaf: *Aquatic research procedure is affectionately known as the turtle rodeo. Author Col Limpus captures and examines a loggerhead turtle*

The study of the underwater life of the turtle is at its beginning. The clear shallow waters of the Great Barrier Reef, with the abundant turtles, make it relatively easy for such studies. The advent of fast outboard motors, skin diving and SCUBA equipment have created opportunities for investigating turtles other than when the female is ashore nesting,opportunities that were not available to F. W. Moorhouse when he began modern sea turtle research with his classic study of green turtles at Heron Island in 1929. Moorhouse, like most researchers studying the ecology and behaviour of sea turtles, based his study around the technique of tagging nesting females. He drilled holes in the carapace edges of 50 females after these had laid, and wired numbered copper discs to the turtles. Today the tags are made of less corrosive monel metal attached to the trailing edge of the front flipper.

Then, as now, the beaches were patrolled nightly to observe the nesting turtles hauling out from the shallows to cross a beach and nest among the trees and shrubs of the vegetation strand. Moorhouse soon found that some turtles returned to the island to nest every fortnight or thereabouts. This is now known to be the pattern of all sea turtle nesting. Each female nests repeatedly within a season at about fortnightly intervals — green turtles lay as many as eight clutches, averaging 112 eggs per clutch, loggerhead turtle as many as six clutches, averaging 127 eggs, and flatback turtles as many as four clutches, averaging 50 eggs.

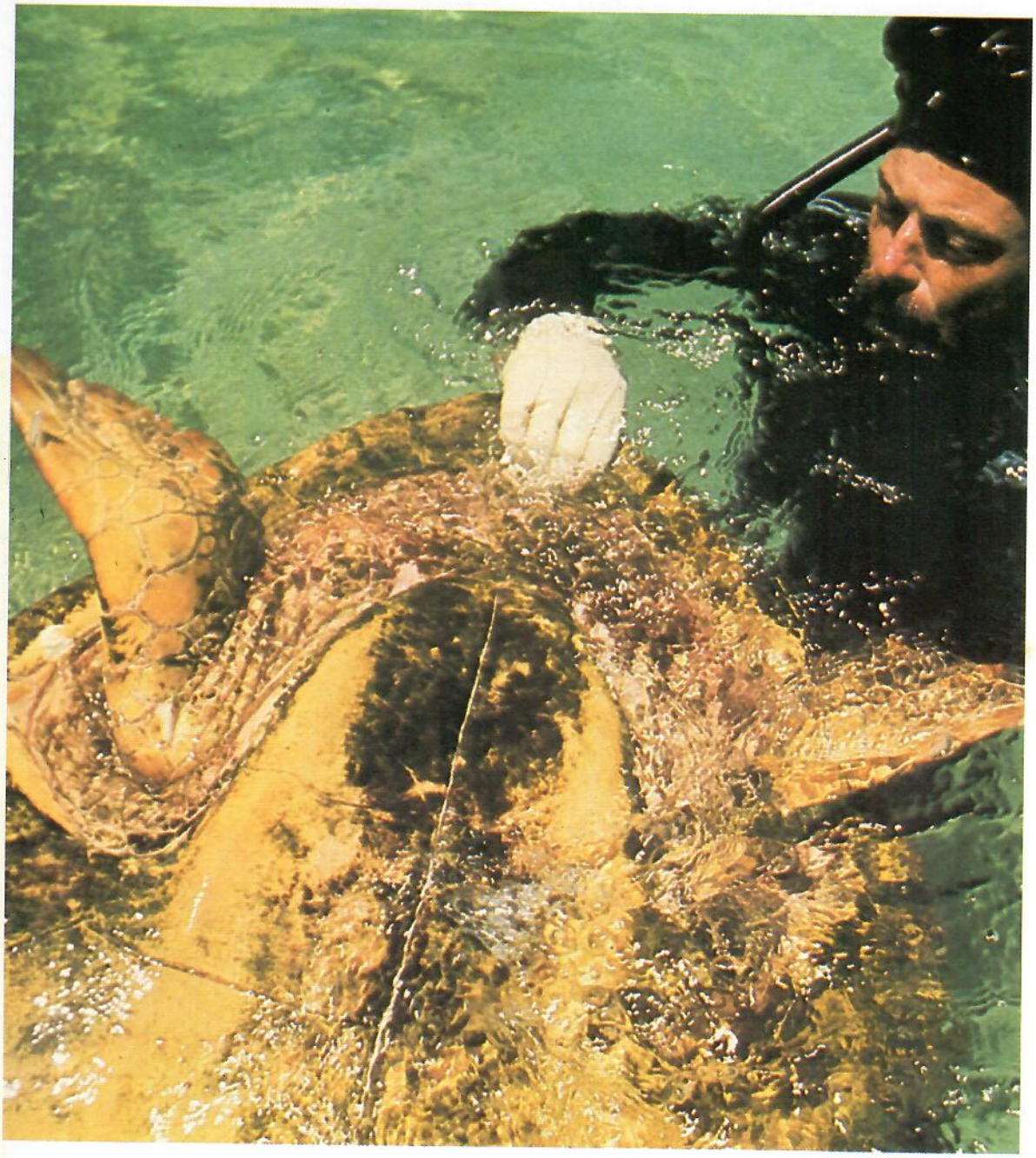
Diagrammatic annual breeding cycle of all sea turtle species in the southern Great Barrier Reef area











None of the turtles tagged by Moorhouse was found nesting in a subsequent season. Present-day studies show that on completion of the nesting season most turtles migrate to their feeding grounds with few ever returning to lay again in later seasons. Because the few recoveries of these turtles nesting in later years are from the tagging area, usually the same beach or island, it may be that the turtles do not usually breed more than once and that those few that do breed again usually return to a traditional nesting beach. This probably explains the puzzling behaviour repeated each summer by the turtle populations of Heron Reef and many other reefs of the Great Barrier Reef.

At breeding time a female turtle does not merely crawl up on to the nearest beach to lay its eggs. On the contrary, travels of perhaps thousands of kilometres to a particular beach or island may be involved. Turtles which are about to breed leave and migrate to distant rookeries while a different population of turtles immigrates from other feeding grounds to breed on cays such as Heron Island.

For example, a loggerhead turtle female (No. 5330) was tagged nesting on Mon Repos Beach (near Bundaberg) in November/December 1972; 2.5 years later it was captured in the lagoon on Wistari Reef (near Heron Island), 160 kilometres from Mon Repos; in December 1975 it was again nesting at Mon Repos; in May 1977 it was again recaptured in Wistari Reef lagoon.

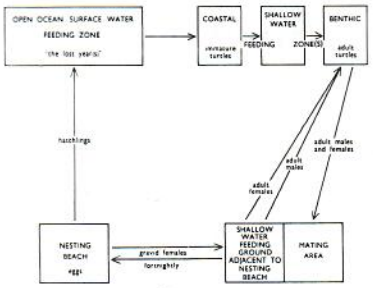
This apparently wasteful effort by the turtles seems strange, especially because the number of female loggerhead turtles that are resident on Heron Reef is approximately the number that will breed eventually on Heron Island each year. What must be remembered, however, is that the turtles occur world-wide and for *most* rookeries suitable feeding grounds are *not* immediately adjacent — the Great Barrier Reef is an exception. When migration to a rookery is due, the turtles conservatively utilize a behavioural pattern that has evolved to succeed throughout all situations that the species must exploit.

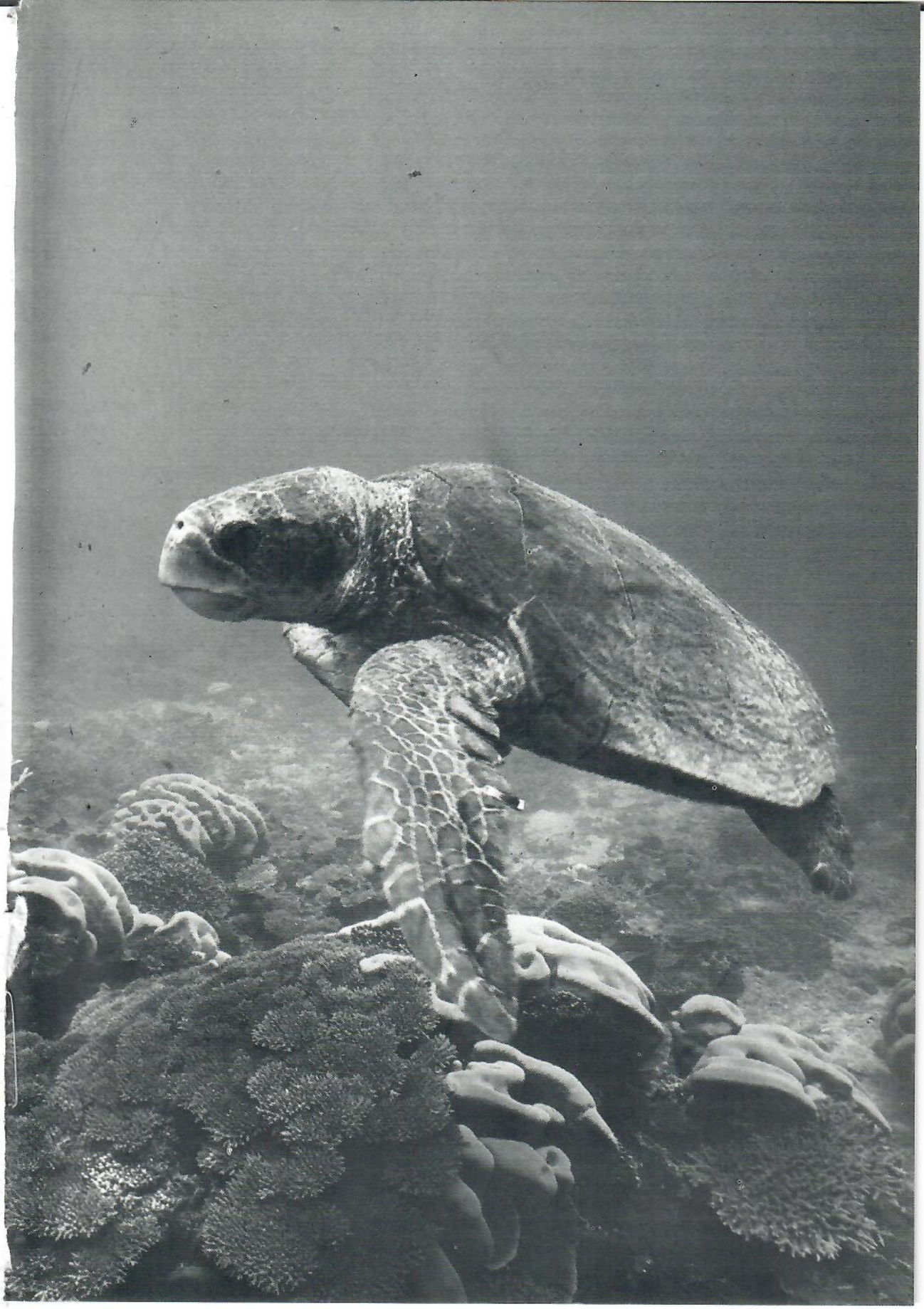
Long-distance tag recoveries from turtles originally marked on the nesting beaches indicate the area to which female turtles may disperse at the completion of laying. For instance, green turtles tagged nesting on Heron Reef or on adjacent cays have been recovered in the region bounded by New Guinea, New Caledonia and the Queensland coast, and tag recoveries for loggerhead turtles from these same rookeries have come from the same region as well as the eastern Gulf of Carpentaria and the Trobriand Islands in north-eastern New Guinea. Surveys of the recovery localities initially suggested that merely the distributions of trawling grounds and areas where turtles are taken by islanders for foods were being plotted. Yet, recoveries from green turtles tagged at Raine Island in the northern Great Barrier Reef are mostly towards the Arafura Sea. Hence, the long-distance tag recoveries reflect real differences in the dispersal of turtles from these two rookery areas at either end of the Great Barrier Reef. Moreover, none of these turtles captured away from the original nesting beach was nesting at the capture site.

The questions confronting the researcher are thus overwhelming. What are the relationships between turtles on a reef and on an adjacent rookery? Do they live on one reef and invariably go

Right: *Tagging a green turtle*

Schematic life cycle of a sea turtle





A female loggerhead turtle searching for a nesting site on a small cay in the Swain Reefs was observed approaching the massed nesting site of about 1,000 crested terns. In the dim moonlight it could be seen that as the turtle came within a metre or so of the terns most were not scared away. Instead they stood over and around their eggs, raised their wings and called loudly. Some terns were flying up and settling down among the others. The turtle confronted with this large moving, noisy white 'object' turned away and sought a nesting site further along the beach. In contrast the more widely spaced nest sites of the black-naped and roseate terns on the dune area of Lady Musgrave Island are regularly invaded by nesting turtles which leave a trail of broken eggs and crushed chicks as they crawl through the tern rookery. (C.J. Limpus, Townsville)

Capricorn Group of islands; for the most part, however, muttonbirds prudently dig their burrows in the interior of the islands away from the strand zone where most turtle nesting occurs. Common noddies nest in thousands in the grasses of the beach platform of Raine Island; their young have fledged before the turtles, in turn in their thousands, invade this area and uproot the entire beach. In these ways sea birds are adapted to reduce the destructive effects of nesting sea turtles to a minimum.

Heron Island supports a lush closed forest of pisonia trees bedecked by thousands of white-capped noddy and reef heron nests and undermined by muttonbird burrows.

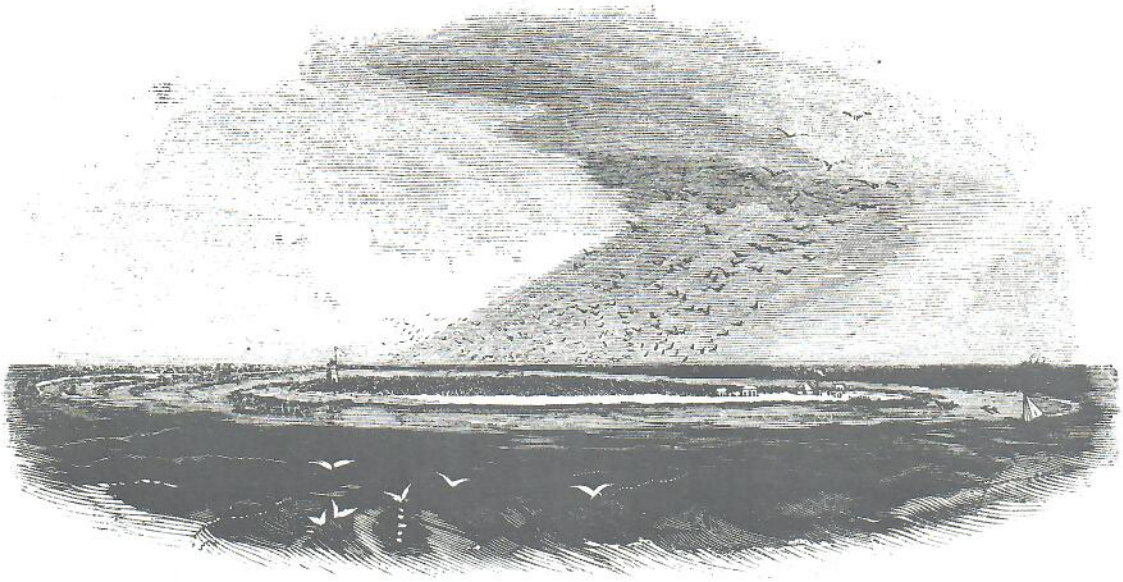
Green Island supports a dense, mixed vine forest with far fewer birds — reef herons and some Torres Strait pigeons are the obvious nesting birds while flying-foxes roost and feed in the tree canopy.

Of the spectacular pigeons, the largest rookeries are found in the mangrove islands of the inner shelf reefs of the northern Great Barrier Reef. To these islands each summer, hundreds of thousands of Torres Strait pigeons migrate south from Cape York and New Guinea to breed in the mangrove trees. Their daily flights to the mainland each morning to feed in the rainforests and return each evening are an unforgettable sight. A count of more than 24,500 of these pigeons arriving at (and about 1,500 birds departing from) Hannah Island between 4.30 pm and 6.45 pm in late November 1976 does insufficient justice to the spectacle of the small flocks of these black and white birds flying in unending procession as they rose over the tree-tops of the island edge then flew on unerringly to join their mates at nest.

Raine Island is the most dramatic island of the Great Barrier Reef in its appearance, so different from that of the well-known coral cays usually depicted by Heron Island or Green Island. It is like none of these islands, being instead a treeless sandbank two kilometres in circumference with a broad beach from 30-100 metres in width surrounding a central rock platform 1-2 metres above the beach level. This rock platform is rimmed by a dune one-half to seven metres high around a central depression. Dominating the scene is a great tower, 13 metres in height and 10 metres in diameter (at its base), built from limestone blocks by convict labour in 1844 as a beacon for shipping.

The island is the largest green turtle rookery so far discovered; one evening in 1974 more than 10,000 turtles were counted ashore in one walk around the island by a group of University zoologists. Little wonder that the ornithologist Dr W. D. K. MacGillivray had trouble when he pitched his tent on the beach on 4 December 1913; he records that the turtles were so numerous that 'We remained on the Islet for eight days, absorbingly interested in its wonderful bird-life during the day and tormented at night by the resting turtles, who would persist in trying to walk over or under our sleeping shelter'. Raine Island is the most important seabird rookery in the Great Barrier Reef Province; it is also quite remarkable for the almost total use of its surface for fauna breeding purposes.

Because of the great number of birds and turtles on Raine Island, events which are infrequent or less obvious elsewhere are often commonplace, or at least appear so. The partitioning of the



RAINE'S ISLET.

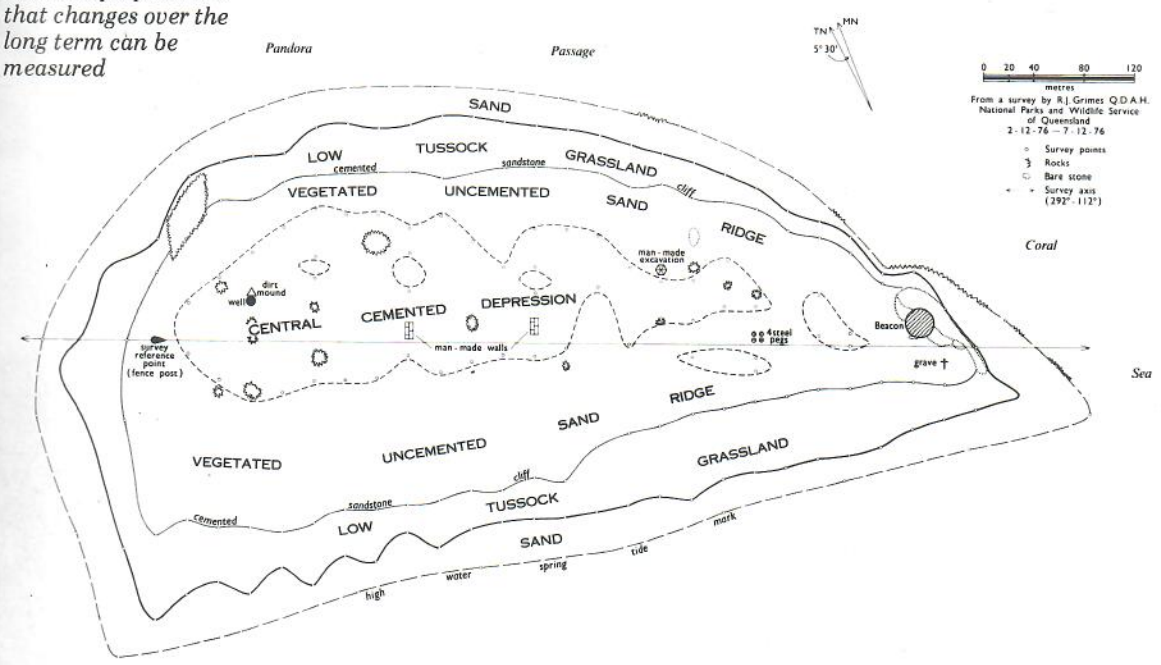
Raine Island as seen from H.M.S. Fly *by J. Beete Jukes in July 1843 (from* Narrative of . . . H.M.S. Fly, Vol. 1, *1847); and a similar view from* M.V. Kurrakajarra *by National Parks and Wildlife Service surveying zoologists in December 1976.*

island by the nesting species is obvious. Brown gannets and masked gannets nest throughout the floor of the central depression, frigate-birds nest on the inner slopes, wedge-tailed shearwaters burrow throughout; and red-tailed tropic-birds nest beneath the rock overhangs. To a large extent, this rock cliff prevents most turtles from entering the central area, the main nesting site for most birds.

A feature of Raine Island is its 'permanent' turtles, everything from dying turtles and bloated carcasses to bleached bones; turtles that have fallen over ledges, turtles misoriented, and turtles dead from heat exhaustion. Jukes in 1843 misinterpreted these turtles deaths, thinking the island to be a 'graveyard for turtles', a place where turtles came to die. Current estimates are that less than one per cent of the turtles nesting on Raine Island die on its beaches, probably no more or less than anywhere else, but with such great numbers, naturally, they are frequent enough to be noticed.

The reef heron so characteristic of the wooded cays is absent from Raine Island and its place is taken by the nankeen night heron. Several thousands of these nest on Raine Island in February and March each year. Their nesting is timed to coincide with the hatching of the turtles and each evening the night herons patrol the beaches, gathering up the first of the hatchlings crossing the beach. It is probably the only abundant bird on Raine Island that makes sea turtles a major part of its diet. Each morning these birds are accompanied by banded land rails and silver gulls that scavenge among the debris from the previous evening's turtle nesting,

Raine Island, the principal turtle and sea-bird breeding station of the Great Barrier Reef; the map has been prepared so that changes over the long term can be measured









feeding voraciously on turtle eggs dug out and killed by other turtles intent only on depositing their own next clutch of eggs.

Birds of the reef: White-capped noddy; grey phase reef heron; wedge-tailed shearwaters

TURTLES AND OTHER NATURAL PREDATORS

A clutch of turtle eggs incubates in the heat of the surrounding sand to hatch in about eight weeks. Clutches laid early in the season when the sand is cooler take longer, as do clutches laid on the southern, more shaded sides of wooded cays. The movement of the first hatchling to cut its way from its egg shell stimulates adjacent eggs to hatch, and so on. Thus the hatching of the entire clutch is co-ordinated and this enables the group of hatchlings to dig to the surface together; one hatchling has difficulty digging the half metre or more to the surface alone.

Red-footed gannet; brown gannets with chick; red-tailed tropic bird

After two to seven days of digging the hatchlings reach the surface. If the hatchlings approach the sand surface during daylight hours they usually lie quiescent just below the surface until night fall. High sand temperature (about 31°C) has been suggested as the cue stimulating the inactivity during daylight hours; even at night, however, the sand temperature in a group of hatchlings digging to the surface may be between 34°C and 36°C; as in most aspects of turtle biology the situation is far from simple.

Where measured in the southern reef rookeries, less than five per cent of hatchlings emerge from their nests in daylight hours. In this way, most hatchlings avoid the lethal high daytime surface beach temperatures and predation of birds. Predation by crabs and birds while the young cross the beach is characteristically low, at less than 2 per cent. The loss is insignificant compared with the loss of eggs prior to hatching. Death then is due to infertility, structural damage to the embryo when dropped at laying, or to congenital defects in the embryo. At most rookeries, 80-90 per cent of eggs hatch from an undisturbed clutch and produce hatchlings to the beach surface. On the other hand, entire clutches may be lost through predation (goannas, pigs, dingoes, foxes and man), through nest destruction by other later-nesting turtles, and through inundation by high tides. Salt water causes dehydration by exosmosis of the eggs and hence death. For hatchlings digging to the surface, inundation causes salt water to fill the air spaces in the sand and suffocate the young. Predation rates on eggs are high on some mainland beaches but characteristically low on the majority of islands where most of the main turtle rookeries occur.

Frigate-bird colony

Estimates at present indicate that for many of the rookeries, especially the less dense ones, between 60-80 per cent of the clutches produce hatchlings each year. These better years counterbalance the poorer years when cyclones strike at a time of high density of eggs on the beach; wind-whipped seas can erode and flood the nesting areas. At Mon Repos beach in January 1976 approximately 80 per cent of the clutches for the season were destroyed in three days by cyclone David. Most of the other turtle rookeries on the southern Great Barrier Reef were similarly devastated by this cyclone.

The other period when massive losses occur is after hatchlings have entered the sea. Here they fall prey to all those animals large enough to consume them. Loss to fish and to sharks may be great as the hatchlings cross the shallow reef flats surrounding the coral cays. A wide range of cod, sweetlip, tusk fish

Overleaf: *Mon Repos beach during cyclone David (Photo C.J. Limpus)*

and trevalley join the sharks, sometimes in a spectacular frenzy of feeding that can be seen from the beach. Careful measurements are required to assess the significance of these losses; no such heavy predation seems to occur off the mainland rookery of Mon Repos.

As the sea turtle is followed back into its aquatic life we are again faced with physical barriers to acquiring knowledge. The difficulties of measuring the survival rates, growth rates and dispersal paths at sea have so far remained insurmountable. It is possible to swim with the hatchlings from the beach across the reef flat and follow these, if they are not eaten by fish, out beyond the reef crest; a young turtle at all times swims directly away from the land, correcting course each time it surfaces for air. The hatchling is soon lost to sight. In a usual nesting season in the Capricorn Group of islands perhaps one to two million hatchlings enter the surrounding ocean. After the hatching period, not one of these young turtles will remain locally. Where do they go?

We again have to assume, based on the infrequent discoveries of small turtles at sea, their occasional appearance on distant beaches after storms, and their absence from the feeding grounds frequented by larger turtles, that a turtle for the first year of its life drifts in open sea currents as part of the surface plankton, feeding in and on these mostly small surface animals and plants. This time is often referred to as 'the lost year of the turtle'. It is only when the turtle is larger than a dinner plate that it reappears in the shallow-water feeding grounds of the Great Barrier Reef and is once again available for study.

Attempts to bridge the gap in time and knowledge have given rise to special techniques particularly seeking to identify individual hatchling turtles. In the most recent method adopted, scales are cut from the margin of each hatchling to denote the year and rookery of birth. So far more than 140,000 hatchlings have been marked and released from Heron Island and Mon Repos in the past 13 years. Recoveries are still to come!

TURTLES, THE REEF AND MAN

Tagging and recapture studies of the turtles on Heron Island and Heron Reef and adjacent reefs have demonstrated clearly that an older turtle will spend many months, even years, at the one feeding ground. So restricted are the movements of most of the turtles tagged on Heron Island Reef during these times that they are rarely found even a few kilometres from Heron Reef on Wistari Reef. The two reefs are separated by a channel about 30 metres in depth by one kilometre in width, with a four-knot current reversing with the tides. Such a small stretch of water between adjacent reefs offers no barrier to turtles, yet few resident turtles cross it. With turtles so localised in movements at a feeding ground, it is to be expected that local populations can be greatly reduced by over-fishing at least seasonally.

This is noticeable near some of the Aboriginal and islanders' settlements along the Great Barrier Reef. These indigenous peoples have been efficient hunters with canoes and spears; they have had to be to survive. Turtles were considered a delicacy. These same peoples are over-efficient hunters when equipped with outboard motors on dingies and armed with steel-tipped spears, rifles and shotguns. The older hunters of settlements now will reminisce

Turtles and lights

Probably the most insidious effect that man can have on a turtle rookery is to alter the brightness of the horizon at night. Hatching turtles, and adults after they have laid, move towards the low-elevation bright areas; under natural conditions this usually leads them to the sea. Bright street lights, house lights and other artificial lighting alters the scene perceived by the turtle and causes it to move away from the sea.

On Heron Island during the turtle hatching period

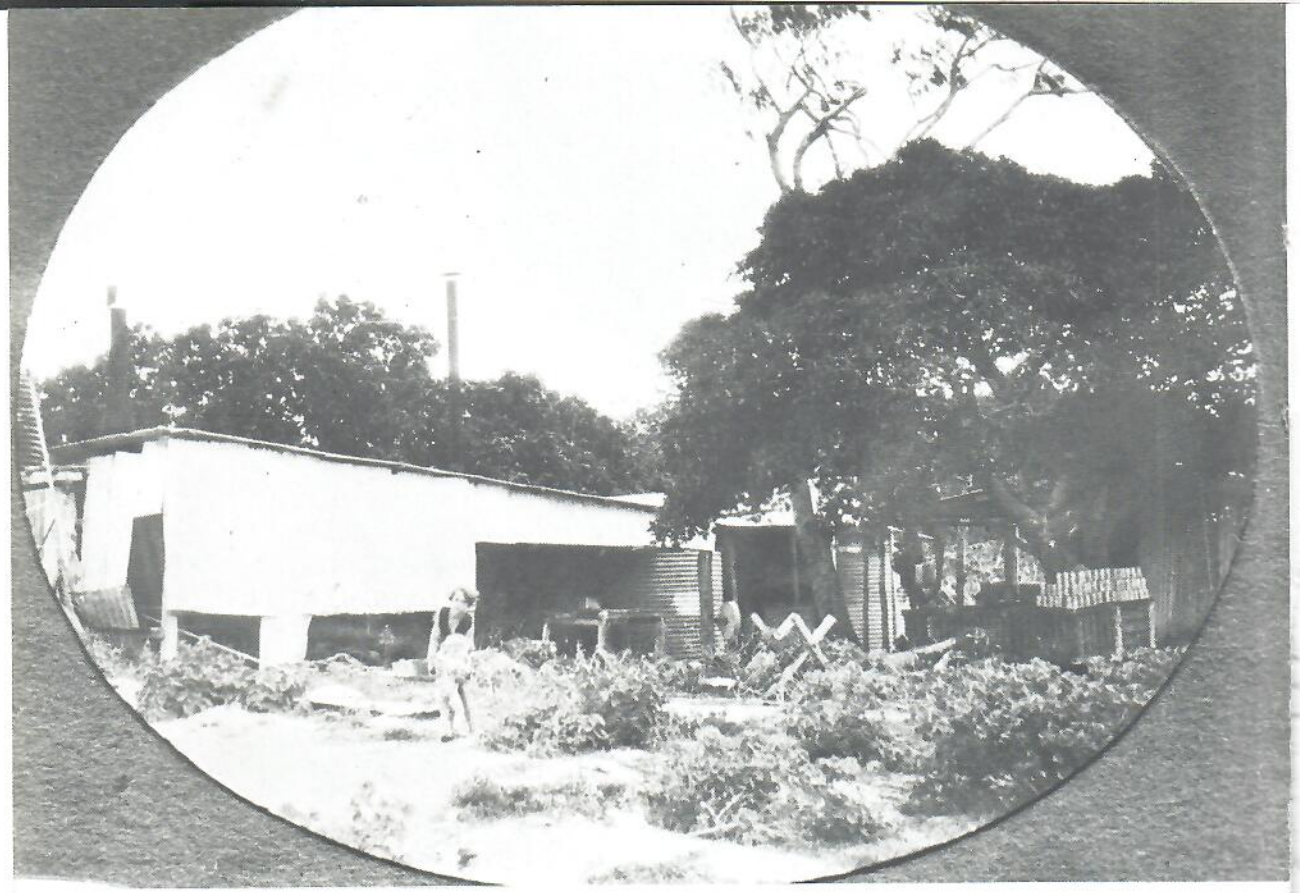
disoriented young turtles are a regular sight. Resort lights and navigation lights attract whole clutches of hatchlings back from the water. In a productive nesting season, resort staff have gathered hatchlings from around the buildings in rubbish bins such were the numbers. While this may be entertaining to tourists it is quite disastrous for the turtles.

The hatchlings spend longer on the island with increased activity and hence are weaker if they eventually do find the sea; many are lost and, come daylight, die of heat exhaustion. The hatchlings are more likely to be on the beach at daylight, increasing predation by birds and thus reducing the effectiveness of their nocturnal emergence from nests. Because the lights hold the hatchlings over the shallow reef flat areas longer than normal, there is an increase in predation by fish. This is probably the zone of most intense predation in the life of the turtle.

Can you imagine the effect if the light attracting the hatchling turtles was a street light on a busy road? This situation in other countries has caused the slaughter of immense numbers of young.

The problem can be solved. Ideally, lighting should be kept away from the turtle nesting beaches. If not then it should be set at as low an elevation as possible, with associated screens or shades so that the effect on the beach is reduced. Dense vegetation between lights and the beach can be a most effective light barrier. Where lighting can not be screened from the beach it can be placed on a time-switch allowing the major part of the darker hours for turtles to reorient themselves and reach the sea. The navigation lights at Heron Island can not be treated in this way; of course, a horizontal shade beneath each, casting a shadow out as far as the reef flat, would be effective and inexpensive.

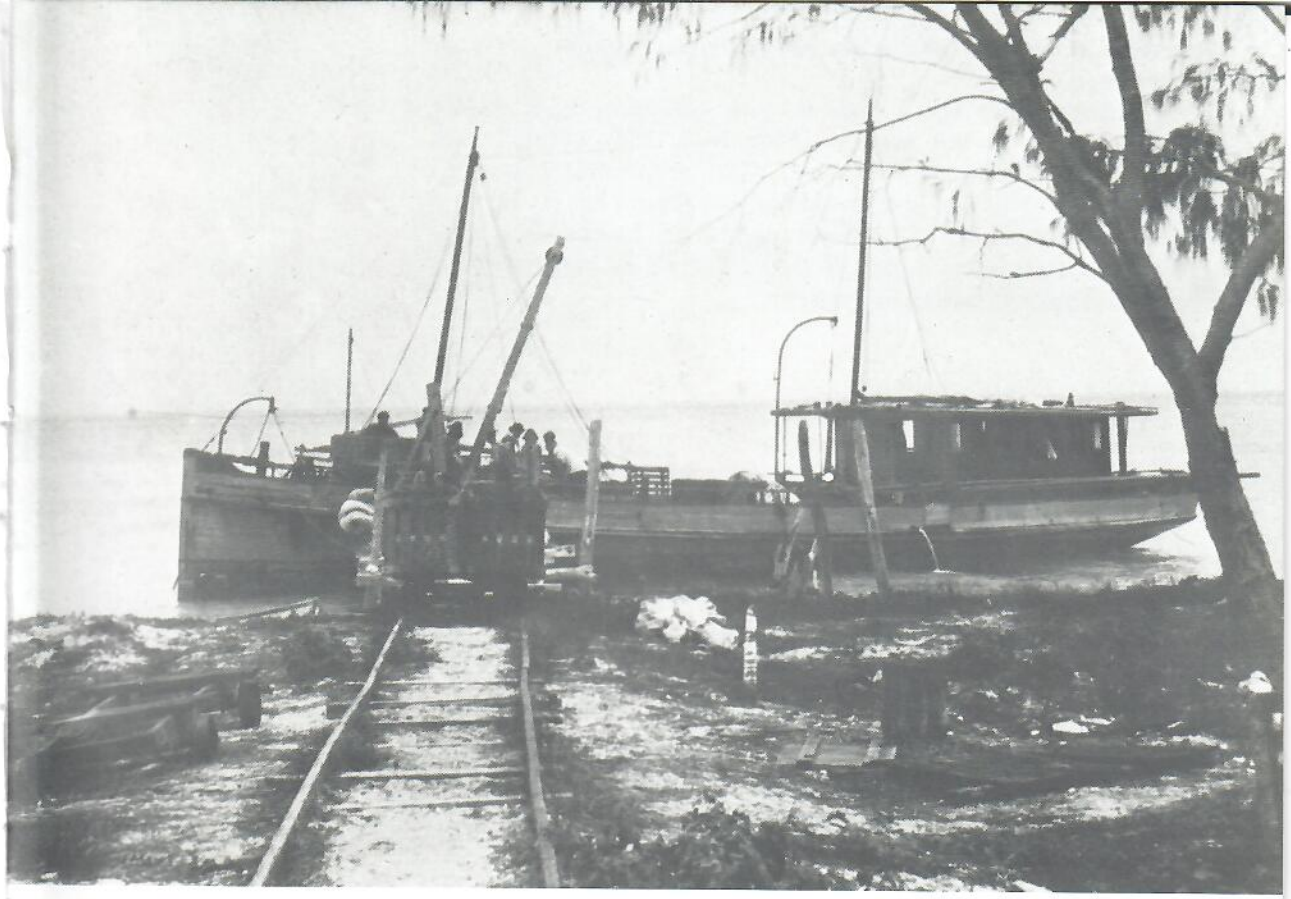
It is possible with planning to eliminate the damaging effects of the artificial lighting on all turtle rookeries.
(C.J. Limpus, Townsville)



about the times when turtles could be found on reefs close at hand, and tell of the difficulties today in finding turtles on the same reefs. To prevent harvest rate from exceeding recruitment rate of turtles at a feeding ground, presumably what must be measured is the rate of arrival and departure of the feeding population. It may be possible to determine a turtle harvest rate that does not appreciably deplete the local stocks.

Unlike the population declines witnessed in most major turtle populations in other countries this century, the Great Barrier Reef nesting populations have remained relatively unaltered. The coastal Aboriginals and the islanders have traditionally hunted green turtles as well as the eggs of all species for local consumption. The early European explorers from the time of Captain James Cook caught green turtles as fresh meat supply. By the mid-19th century, tortoise shell (thick scales from the hawksbill turtle) was harvested widely in the northern Great Barrier Reef along with beche-de-mer. Tortoise shell then could be harvested readily for export because it could be dried and stored; in the days before refrigeration, on the other hand, turtle meat had to be shipped as live (green) turtles. Attempts to harvest green turtles for soup manufacture from North West Island and Heron Island between 1904 and 1929 were beset with problems of water availability and quality on islands devoid of permanent freshwater supplies. The industry collapsed finally during the economic depression of the early 1930s.

Although sea turtles are now all protected by law in Queensland waters, the most effective protection has been by the Great Barrier Reef itself. This vast area of water is notoriously



Turtle factory on North West Island circa *1925; M.V.* Ethelberg *loading turtles at North West Island, same period (Photos. reproduced by permission of Miss Betty Tait, Gladstone).*
'One year several hundred turtles were exported shell and all to the London market, and I believe they were a feature of the Lord Mayor's banquet' (C.H. Holmes We Find Australia, *Hutchinson, London, 1933)*

'To make one ton of extract it takes 440 turtles at 12 a day or 36 days. 100 cases of soup takes 228 turtles at 8 cases a day or 26 days. I propose taking 50 cases of extract and 50 cases of 1lb. soup to Brisbane. The wages and keep would amount to £19 a week'.

'We note the remarks you make in your letter of 15th December that Mrs Owens has no turtles' extract available until next season. We have communicated with our friends, but they are not yet in a position to give us an order to telegraph you. We shall, however, give you the earliest possible information.'

'We hope that there will be no more turtle soup coming home for a time, as the last lot is very difficult to move; in fact, it is described as turtle stew, and is not at all liked.'
Extracts of 1913 correspondence in relation to Owens' North West Island turtle factory, (Mrs P. Land, Brisbane)

hazardous to shipping and is for the most part relatively remote even today.

Unfortunately sea turtles do not recognise international boundaries; they do not remain within Australian waters where protective legislation is available. Tag recoveries attest to harvesting of Australian-nesting sea turtles in New Caledonia, New Guinea and Indonesia. The coastal peoples of these regions may need to be relied upon to ensure that the rookeries of the Great Barrier Reef are retained in perpetuity.

George,

Best wishes. Hope you enjoy this overview of Queensland's wildlife

Col Limpus 20 Apr. 79

Exploration North

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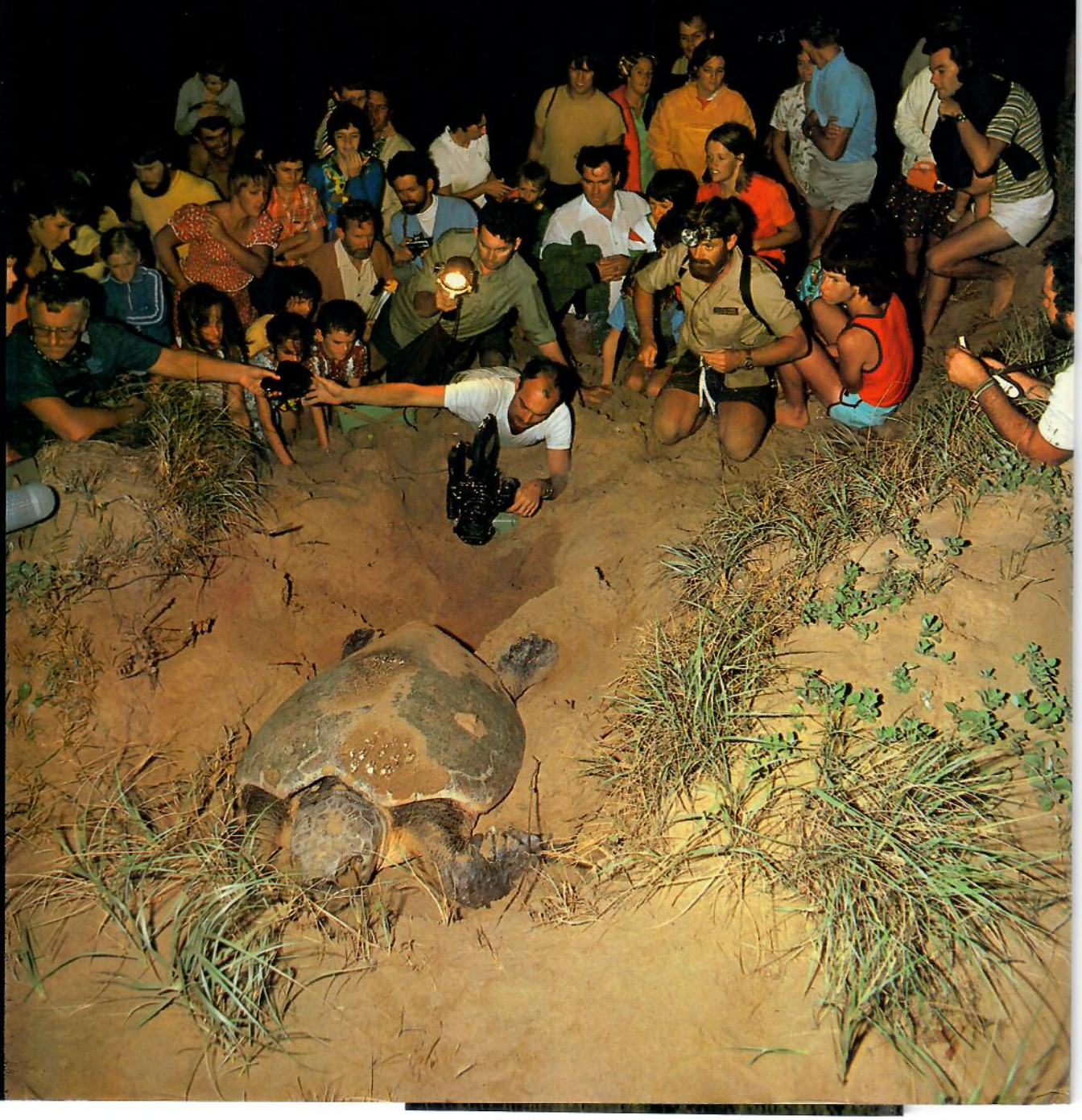

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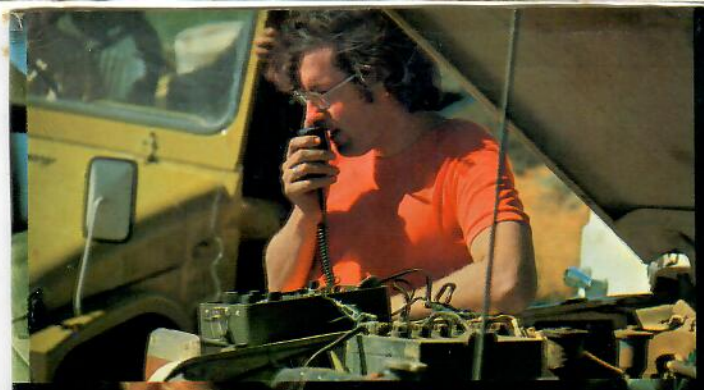
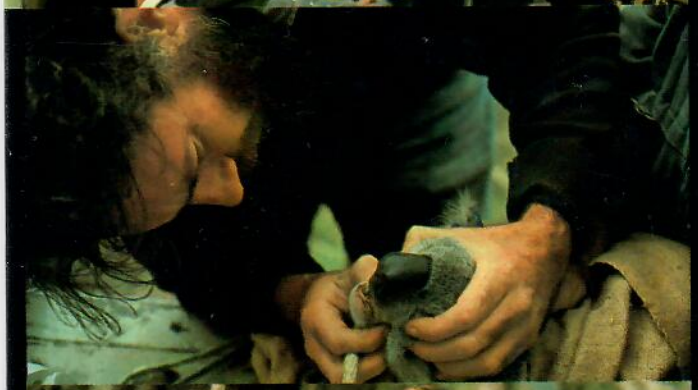
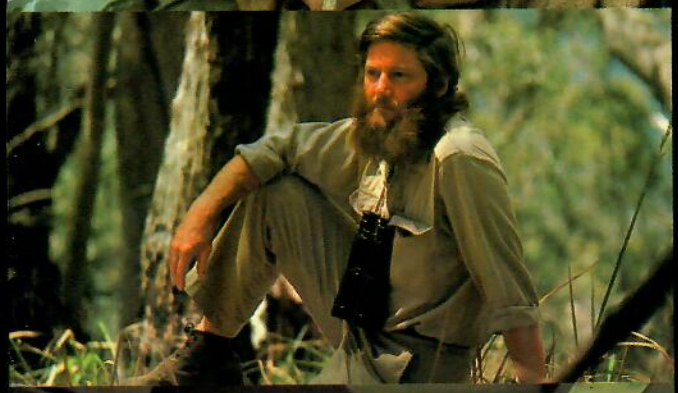


Martin Denny has lived for years in the heart of Australia studying red kangaroos. His familiarity with the area, its floods, its fires and its fauna have led many authorities to his 'office in the mulga' for advice.



Greg Gordon has widely travelled the bush to encounter hairy-nosed wombats, bridled nail-tailed wallabies, rock rats and spiny bandicoots. His interest in these scarce and little-known animals balances an enduring interest in koalas, which he has been studying for nearly a decade.



John Winter's scientific investigations of possums are as detailed as any ever made. More recently the phenomenon of endemism, why peculiar animals have evolved, has led him into the limited rainforests that are the tourist's delight in north Queensland.

Gavin Blackman has spent his life among waterbirds, from a youth indoctrinated in the local ways of duckshooters to a biologist now in his seventeenth year of association with the everchanging habitat of the coastal swamps.

Col Limpus, as a boy, enjoyed finding turtle nests on beaches near Bundaberg. This early interest has brought him to cover the entire marine shoreline of Queensland and its islands, tagging as many as 30,000 turtles a year.

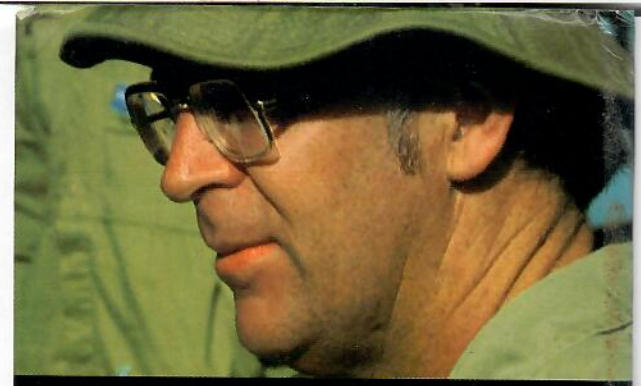
Join a 'turtle rodeo' in the waters of the Great Barrier Reef; roll out of your blanket at dawn to watch the brolgas dance; trek apprehensively through the depths of the northern rainforests; scan the endless miles of the mulga for red kangaroos.

Exploration North is the journal of a new breed of Australian explorers, bushman-scientists working in the field, who introduce the reader to this land of contrasts as it was and as it is today; from the monotone red plains of the mulga to the technicolour world under the waters of the reef.

This book, and the ABC Television series it complements, is a fascinating record of exploration of the natural environment across one swathe of territory as the writers observe, chart, photograph, tag and record in a microcosmic survey of most of the important species of fauna and flora of the entire Australian continent.

There are pictures of species rarely photographed or published — the northern nail-tailed wallaby, the spectacled hare wallaby; there are detailed accounts of techniques for learning more about animals such as the sea turtles; there are graphic stories of personal experiences; and the book concludes with a discussion of ideas and problems in conservation.

Exploration North, with over three hundred photographs and illustrations is a book for all Australians interested in the natural life of our own country today, and it is an ideal introduction to the unique Australian environment for those overseas.



Hugh Lavery has initiated and has been involved in many studies of birds, from reefs to wetlands, to rainforest and to the bush.
As Director, Research and Planning of the National Parks and Wildlife Service of Queensland, Dr Lavery's interests now embrace all aspects of his State's landscapes, fauna and flora.

Stephen Parish has had wide experience as an underwater naturalist, journalist and wildlife photographer. He is currently photographer in the National Parks and Wildlife Service of Queensland.