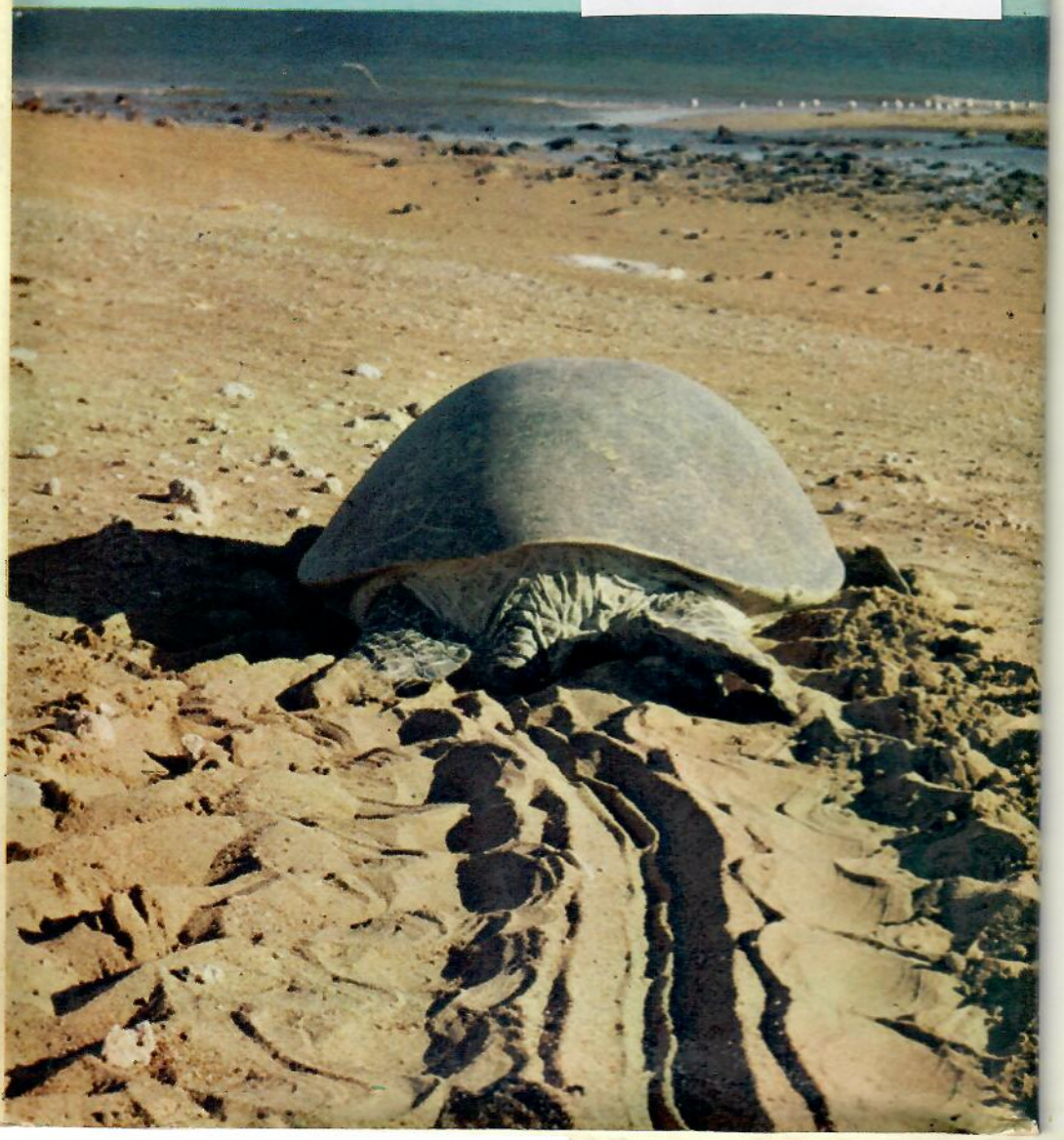
ROBERT BUSTARD

Sea Turtles

Their Natural History and Conservation

2 OF 2



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particular interest because they indicate that large numbers of baby turtles are being transported by the prevailing offshore currents.

When green turtles are about three or four years old one commonly sees them on the reefs of the Capricorn–Bunker cays. However, by this time they are well on the way to becoming adults.

CHAPTER 9

Our Research Programme

OUR basic research programme has been centred on Heron Island in the Capricorns over the last eight summers. The work involves tagging and recapturing all the turtles which come ashore to nest during a specified period each summer. Associated with the tagging programme we have collected extensive information on egg production. We have also carried out work on egg physiology and the natural nest together with some work on hatchlings. These latter aspects have been discussed in Chapter 8 and in Bustard (1972) and Bustard, Simkiss and Jenkins (1969).

The tagging work is extremely laborious and its efficient operation requires a high degree of dedication by the staff. Since almost all the results are dependent on its being carried out with a very high degree of accuracy, and with virtually no turtles being missed, the procedure followed is described first.

Turtles are tagged so that we can positively identify them at a subsequent encounter. The tags serve the added function of informing anyone who may subsequently encounter the turtle that we have tagged it so that, hopefully, they will report its tag number to us. The tags we use are cow-ear tags, made of monel metal, to withstand long-term submersion in sea water. Their application to turtles was devised by Tom Harrisson in Sarawak and all turtle workers now use these. Some, however, prefer to have the tags made of plastic.

There are few places to tag a turtle. An examination of the carapace shows that it is a mass of minor abrasions and that anything affixed to it would soon be damaged or lost. Similarly, it would be unwise to fix anything to the plastron lest it be lost when the turtle is resting on the bottom.

When Professor Archie Carr started tagging turtles in the mid 1950s, he bored two holes in the rear of the carapace and fixed a metal label to the shell by monel metal wire passing through these two holes. He did not obtain any recaptures, but in time did recover turtles with holes bored in the carapace.

Having discarded the shell, one is left only with the soft parts,

particularly the flippers. Harrisson picked on the front flippers, presumably since these are less frequently damaged, and selected the trailing edge. This proved to be an extremely wise choice. If one looks at a turtle during the nesting procedure, either when it is moving across the sand and/or negotiating rocks, or digging and subsequently filling in the nesting site, one is struck by the fact that only one area of the flippers is free from abrasion – namely, the trailing (rear) edge of the front flippers. The tag is best placed well in from the edge of the flipper. Different turtle workers, however, use different sites, some siting it well up the flipper near the 'shoulder' whereas we site it about mid-way.

Tags are applied using a specially designed pair of pliers. Once again practice here differs. Some workers prefer to make a hole first and then to insert the tag while the turtle is on its back awaiting the taking of various measurements. My own philosophy is rather different. As a population ecologist I like to think that I keep any possible effect on the animals I am studying to an absolute minimum. For this reason I never turn turtles over, and as described below, contact with them is reduced to a minimum. We apply the tag, which has a sharp piercing point, in one sudden motion. We do this just after the turtle has finished laying at which time it seems to be particularly insensitive to disturbance. Typically it either gives no noticeable reaction or shows a slight flipper withdrawal movement. Incidentally, it is extremely rare for any bleeding to occur when a turtle is tagged.

Let us now go back to explain the operation. Heron Island is some 1300 miles from my base (the Australian National University in Canberra). During the summer a number of assistants, usually promising zoology undergraduates or graduates, and myself, move up to live at the Research Station on Heron Island. Our first task is to become nocturnal since as mentioned in Chapter 4 green turtles do not leave the water during daylight hours. The task is somewhat more difficult than a straight shift of hours, since the work periods change virtually from night to night. On a coral cay with extensive associated reef, like Heron Island, turtles cannot come in on low or near low tides. The turtles show a well-marked response to the tide cycles, and about ninety percent come ashore between one hour before high tide to two hours after high tide. The time of nightfall and dawn are further complicating factors as the turtles show behavioural modification of the basic cycle firstly to avoid coming out of the water until it is dark and

secondly to reduce the amount of time they must remain ashore after egg laying in order to complete the filling-in process.

When high tide is about 11 p.m. we start work at 9.30 p.m. and patrol continuously round our area of beach. Patrols continue until we have tagged or noted the recapture of our last nesting turtle. However, the last patrol will not begin until at least 1.30 a.m. Clearly turtles which come in late or experience trouble in completing an egg chamber may keep us up most of the night.

When the time of high tide is between 3 and 4 a.m., a change in the beaching behaviour becomes noticeable in that turtles tend to come in rather earlier than one would anticipate. As high tides become later this trait becomes more pronounced so that when the time of high tide approximates dawn most of the turtles are up a couple of hours prior to high tide. On these tides we start work correspondingly earlier, and subject to turtle nesting activity, start the last patrol once it is broad daylight.

A similar phenomenon occurs in reverse when high tide is in the late afternoon before nightfall – turtles wait until it is dark to leave the water. Incidentally, there are three or four days in each fortnightly tide cycle when we have to work extremely long hours since turtles come in on both tides (there are two high tides every twenty-four hours). This is because one high tide occurs in the few hours preceding nightfall, and the tide is still high when darkness falls to activate turtles which are ready to lay. The other high tide, approximately twelve hours later, occurs in the early morning around the time of dawn bringing in turtles before first light. During these three days the turtles all switch over from the one tide to the next. The typical pattern is that on the first of the customary three days of 'double night tides' virtually all the turtles appear on the early morning high tide (which has been the only night high tide for about ten days). On the second day they are split fairly equally between this tide and the new evening tide, and on the third the majority come in on the evening high tide there being few on the morning tide. Since we are forced to follow the tides in order to see all our turtles, we work rather irregular hours, some days being up until after daylight and having worked through from sunset, perhaps with a rather annoying few hours' lull during the night. At other times we work in either the first or second half of the night depending on the stage in the fortnightly tide cycle.

The small size of Heron Island (beach perimeter just over one

mile) means that two trained observers can operate the tag-recapture scheme. When turtles are seen for the first time they are tagged on the left front flipper after egg laying. The left flipper is selected since this is much easier for a righthanded person to tag. The tag bears a serial number on the upper side and a return address together with the word 'REWARD' on the lower side. Currently we pay a reward of four dollars (Australian) – about £2 Sterling – for the return of the tag together with date and the locality at which the turtle was caught, provided the turtle has been legally butchered. Under Queensland law only aborigines and Torres Strait Islanders can take turtles, and then only for their own use. The reward scheme does not operate in the Capricorn Group of islands and people are requested never to remove tags from living turtles. Since human population density is low in northern Queensland, there are few recaptures other than those we record ourselves back at the breeding beaches. This topic is discussed further below.

When a turtle is tagged, a record sheet is completed on the individual as follows; tag number, date of tagging, species, length and breadth (measured over the curve of the shell), presence or absence of barnacles and their location if present, injuries if any, notes on coloration, carapace shape and number of postoculars (in the green turtle), and number of marginals and inframarginals in loggerheads. Subsequently this information is transferred to a card in Canberra which is maintained for each individual tagged turtle. Each time the turtle is recaptured the date is noted together with other relevant information such as whether the turtle succeeded in nesting, and, if the individual is under detailed study, the number and weight of the eggs laid may be recorded.

During patrols, as far as possible, the operators move without lights, although they are issued with dim torches for writing and reading tag numbers when necessary. On most nights moonlight is quite adequate for normal activities. Great care is taken not to disturb beaching turtles, which sit at the water's edge and scan the landward horizon before emerging. Similarly, turtles moving up the beach are avoided by entering the vegetation zone and thereby bypassing them. Patrols are carried out by moving along the top of the beach adjacent to the vegetation zone. The best way to scare away turtles which are moving shorewards to nest is to walk along the water's edge where one is clearly silhouetted against the white coral sand. This process can be made virtually one

hundred percent effective by periodically shining a bright torch on the water.

The above statement brings me to a question I am frequently asked – the effect of tourists on turtles. It is impossible to generalise as there are many variables. However, we have extensive experience of the effect of tourists on Heron Island as this is a tourist resort. On the whole, tourists have not had a deleterious effect on the Heron turtles. Firstly, they only go out to see turtles on nights when the high tide is in the early evening – only the keenest turtle watchers are prepared to rise in the middle of the night! Secondly, and most important, the owners of the resort have been most conscious that the marine life is their greatest potential asset and have been keen to preserve it. They have worked in with us to advise tourists how to watch turtles without frightening them. We give talks to tourists, as does the resort management, and most tourists meet some of my assistants on the beach within minutes of going out turtle watching. However, it must be remembered that Heron Island is a small cay situated about forty miles offshore. All tourists (other than scientists visiting the Research Station) must live at the guest house as the rest of the island is a National Park and camping is prohibited. The effect would be quite different on the mainland where people could drive cars down on to the beach. Without a full-time warden, a mainland turtle National Park would serve little purpose if the public were granted unlimited entry.

Over the years we have guided very large numbers of tourists round the Heron beaches. We have certainly met many charming people and we send our publications to a number of these. Apart from everything else, we feel that this meeting ground is an excellent way of making people aware of the problems of conservation. Many people, who had never seen a turtle before, go away thinking it a very great shame that these huge, harmless beasts should be killed for soup in most parts of the world. Since these people all have votes, the conservation impact must be positive. Overall we feel privileged to be able to work in an environment where we meet such interesting people and are able to tell them about our work. Quite apart from discussions on the beach, when time permits, we hold weekly or twice-weekly informal talks with tourists and any questions they may have relating to turtles are answered to the best of our ability.

Many people think of a Barrier Reef island as being hot at

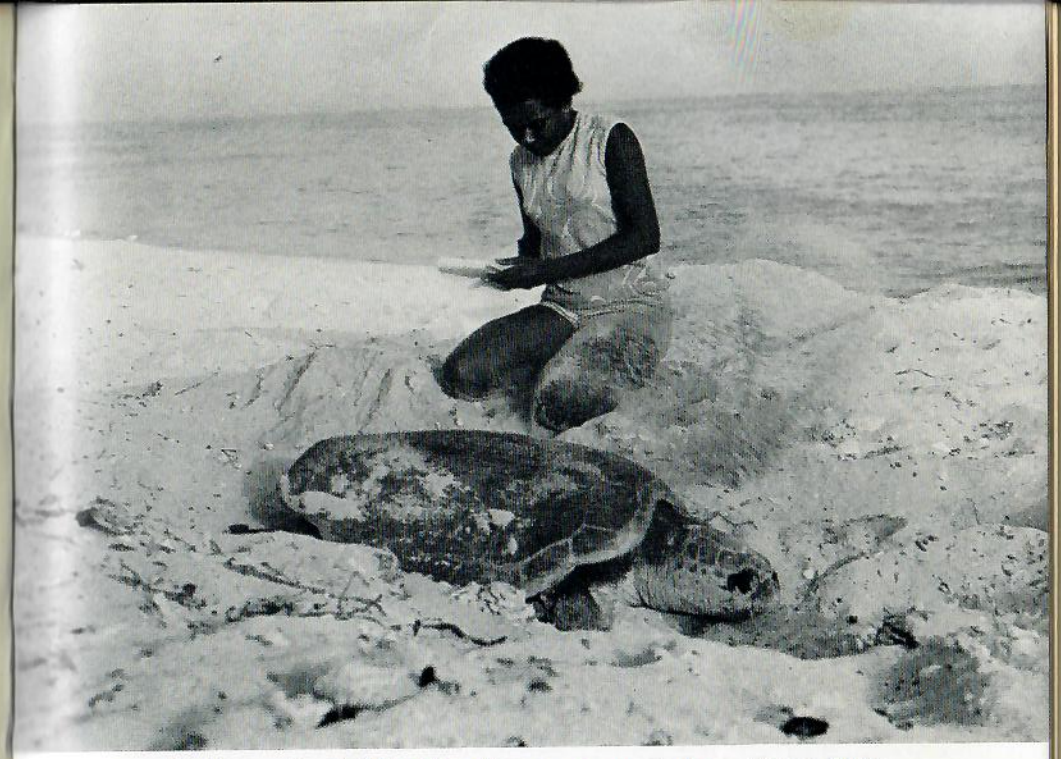
night. In fact after nightfall there is frequently quite a cool breeze and I wear a jersey most nights. Popular imagination also tends to omit thoughts of rain, often torrential downpours which soak you to the skin in seconds, and which may continue for a large part of the night. This is particularly the case in the latter half of the nesting season (January, February). It is remarkable just how put out man is by rain. Work becomes much more tedious. Wet sand seems to get literally everywhere. Note taking is much more time consuming. It is interesting to note that this also reduces the turtles' 'efficiency'. If they are already about to lay or at a subsequent stage in the nesting process they do not appear to be disturbed. However, turtles coming up during or following torrential rain usually wander about aimlessly and often return to the sea without attempting to nest. They appear to require dry sand in order to start to dig. Since this is an impossibility on such nights digging attempts are scant.

Earlier I mentioned that turtles can be frightened away before beaching by shining bright lights on the water. Consequently, they are greatly disturbed by lightning. Prior to severe storms, dry storms with thunder and lightning often occur. If these take place before the turtles have emerged from the sea beaching is greatly impaired.

Our initial contact with the turtles gives us a mass of information on physical features. Furthermore, by plotting the numbers of newly tagged turtles each night throughout the time we are there, we can show that we 'tag out', that is tag all the individuals. This is accomplished after about one month, commencing with a completely untagged population. The time taken to tag the population is a reflection of the interval between laying (discussed below), since, until they have beached on the island in order to lay eggs, we have no opportunity to tag them. For this reason the work is restricted to female turtles. During the first cycle, if the nesting female population is a large one, we may be unable to cope with every turtle. Those missed are then all caught up with the next time round.

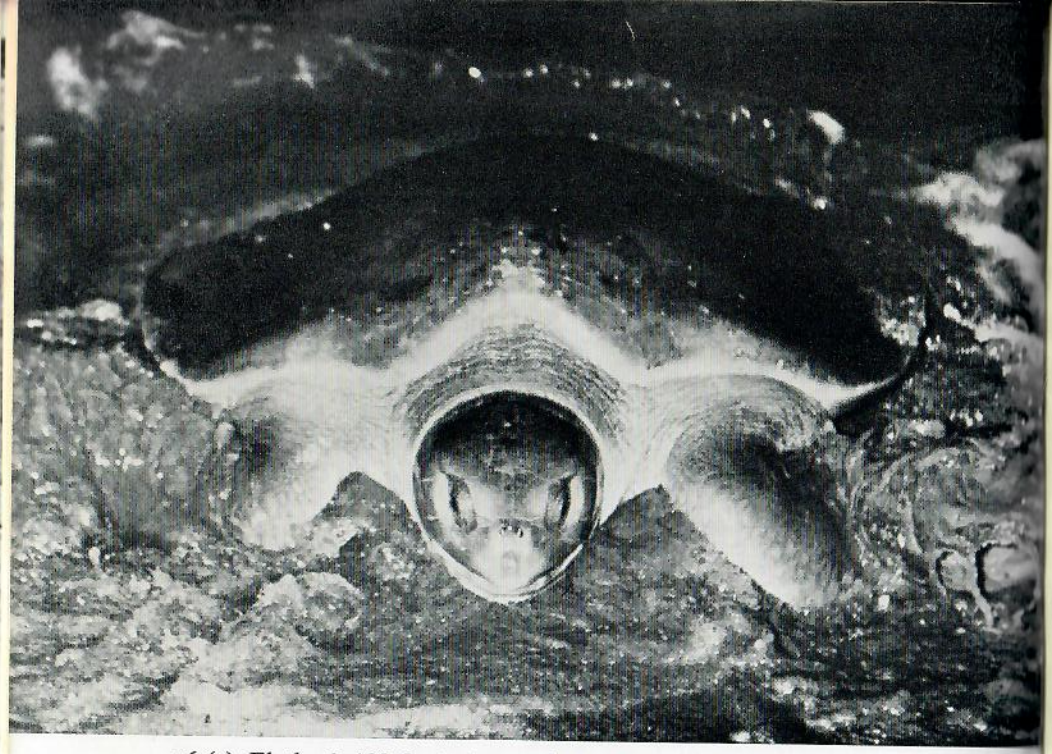
We have no data on weights because we have always felt that weighing constitutes a major disturbance to the turtle. Nevertheless, we now plan to weigh a small series for completeness of information on the population.

The 'green turtle' may constitute more than one species. Periodic attempts have been made to separate populations of this circum-



15. (a) Torres Strait Island turtle programme trainee, Nancy Pilot recording data on nesting loggerhead, Great Barrier Reef.

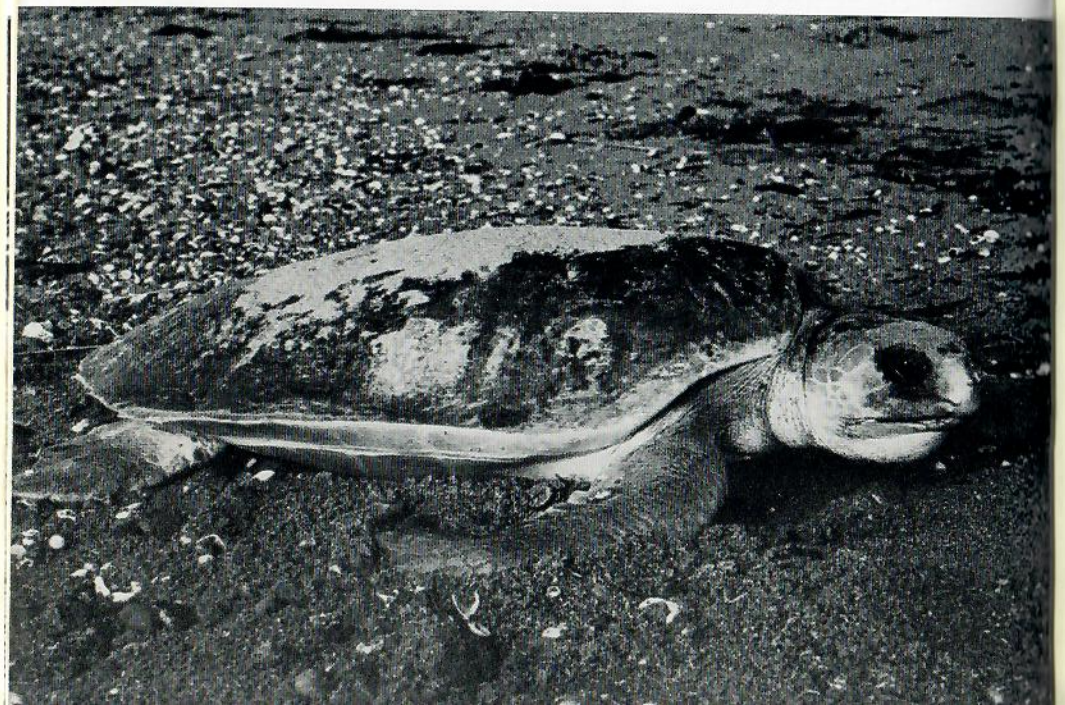
(b) Portrait of an old loggerhead. Note the pronounced 'beak'. Great Barrier Reef.



16.(a) Flatback (*Chelonia depressa*) emerging from the surf.

C. LIMPUS.

(b) Flatback (*Chelonia depressa*). Note the greatly flattened carapace, numerous small scales on front flippers and three large postocular scales immediately behind the eye.



global inhabitant of tropical and subtropical seas as a new species or subspecies. In view of this it is essential to have detailed information on the variation in features, which are used from time to time in attempts to separate populations, within individual populations. The shape of the carapace is one such feature which we have noted subjectively. For five years we recorded each turtle as having either a flattish, steeply rounded, or intermediately-shaped carapace. The information collected indicated that two-thirds of our green turtle population possessed intermediately-shaped carapaces with the rest split evenly between flat and steep. Of extreme interest was the fact that the percentages with each carapace shape varied greatly in different years. To demonstrate the significance of these variations a definite length/height ratio would need to be measured. Nevertheless, the crude observation made did not appear to be subject to bias especially since the same observers made the reports in several subsequent years and any new observers' data could be checked against this for bias. For instance, in years 1 and 2 the percentages with flat, intermediately-shaped and steep carapaces were 16, 35 and 49, and 25, 62 and 13 percent respectively – markedly different.

A feature often said to be diagnostic of the flatback is the presence of three scales behind the eye known as postoculars. Green turtles are said to have either four or five postoculars. This feature was checked in 1375 green turtles and 88 percent were found to possess four postoculars and seven percent possessed five. However, five percent possessed three as in the flatback. In a few individuals the postocular count differed between the two sides of the head.

In the loggerhead turtle populations a study was made of the number of marginal shields which edge the carapace and also the number of inframarginals which form the bridge joining the carapace to the plastron. A five-year count based on only 144 turtles indicated that 60 percent possessed 12 marginals, 22 percent 11 and 17 percent 13. Only one turtle was found with 10 marginals. The percentages varied between the populations visiting the island in different years. Twelve marginals was always the most common count but this varied from 51 percent in year 3 to 74 percent in year 5. The percentage of turtles with 11 marginals ranged from 12 to 32 percent and with 13 from nought to 37 percent. Eighty-three percent of the loggerheads examined in the five years possessed 3 inframarginals and 16 percent had 4. Only one turtle had an inframarginal count of 5. However, as in the

case of the marginals, there were differences in the relative proportions of 3 and 4 between populations of different years. In years 1, 2 and 3 respectively the percentage with 4 inframarginals was nought, 10 and 4 percent respectively whereas in years 4 and 5 it was 40 and 47 percent! Differences of this nature would seem to be the result of distinctive populations nesting in separate years. This topic is taken up again towards the end of this chapter.

During routine observations on each turtle, presence or absence of barnacles, and the location if present, was recorded. In both green and loggerhead turtles there was not a marked increase in the percentage with barnacles with increasing size (age) of the turtle as one would expect if the incidence of barnacle infestation was cumulative. In the green turtle the figure was similar in all size-classes of breeding females. In the loggerhead the figure appeared to fall somewhat as the turtles became larger. In both cases this would tend to suggest that either barnacles are acquired at a specific immature stage of the life cycle only, or that incidence of acquisition is balanced by rate of loss, either through barnacle death, or loss when scutes are shed. As was the case with certain other features described above the percentage occurrence of barnacles varied considerably between populations in different years.

There are several factors which affect the number of turtles coming ashore to nest each night in addition to the aspects of weather referred to previously. In my experience green and loggerhead turtles dislike high winds, probably due to wind action on the sand. Winds of velocity above 25 knots cause the surface sand to become airborne. Since the experience is quite painful to bare skin if one sits on the ground, the effect on turtles' eyes is probably severe. Turtles that emerge under such conditions invariably change direction so as to put their backs into the wind and shield their heads. This behaviour often results in them moving parallel to the beach. They may return to the water without reaching the vegetation zone. On windy nights the majority of the turtles which would be expected to arrive on the windy side of the island move round to the lee side and nest there.

Numbers of nesting turtles also vary greatly but predictably during each tide cycle. On Heron Island with a large nesting population the peaks are around one hundred turtles per night and the troughs less than ten. This has important bearings on survey

work – one must be able to specify the state of the tide at the time of the work. It is extremely important if only a few nights' observation are carried out, otherwise one could come away with a completely unrepresentative picture of the abundance of turtles. In our experience, the greatest number of turtles usually beach on the second night following the end of the double tides. The following night numbers are often considerably less, but still high, and numbers then generally remain similar for several nights before starting to drop off. Numbers may reach a low point about midway through the fortnightly cycle or this may not occur until the double tides. The phenomenon is well illustrated in fig. 6 based on the Heron Island green turtle data for summer 1965–6.

We understand the fluctuations in number of nesting individuals of the much smaller loggerhead population at Heron Island less well. We have noted what we call 'loggerhead nights' on which a number of loggerheads come ashore to nest, whereas on adjacent nights there may be none. At the present time we are unable to explain these variations.

There is also a fluctuation in the number of turtles nesting throughout the season. Since all turtles do not arrive simultaneously, and depart together, there is a build up in numbers at the start of the nesting season and a gradual fall towards the end. The first green turtles to arrive are seen at Heron Island generally during the last week of October. For the first few days no nesting takes place, although some turtles may emerge from the water and crawl up the beach, only to return to the sea without making any attempt at nesting. By late November the population has built up to its maximum size and remains at this level until mid to late January when it starts decreasing. Some nesting, however, occurs until at least well into March and sometimes a few turtles are nesting until the end of April.

While on the subject of beachings it may be of interest to discuss exploratory beachings. This is the term we use for turtles which emerge, apparently to nest, but make no attempt to do so. Dampier (1697) noted the phenomenon. He wrote, 'sometimes they come up the night before they intend to lay, and take a view of the place, and so having made a Tow, or Semi-circular March, they return to the sea again, and they never fail to come ashore the next night, to lay near that place'.

These turtles frequently wander long distances in the course of which they often accidentally bump into other nesting turtles and

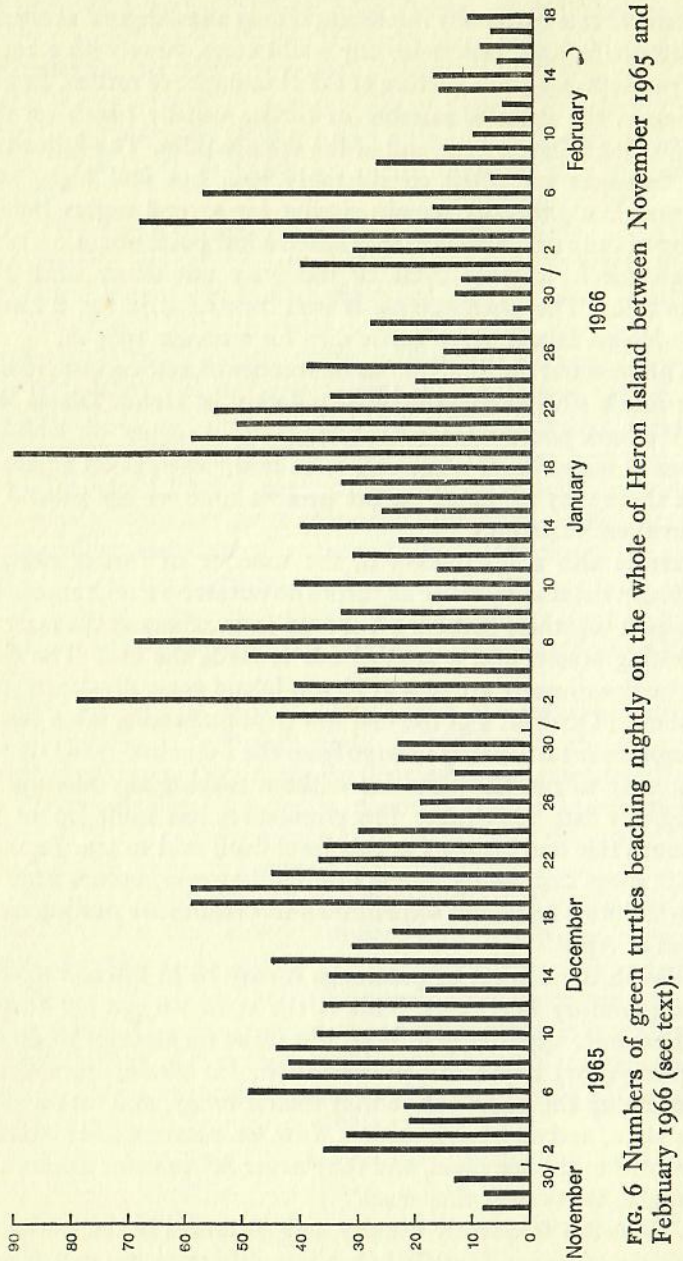


FIG. 6 Numbers of green turtles beaching nightly on the whole of Heron Island between November 1965 and February 1966 (see text).

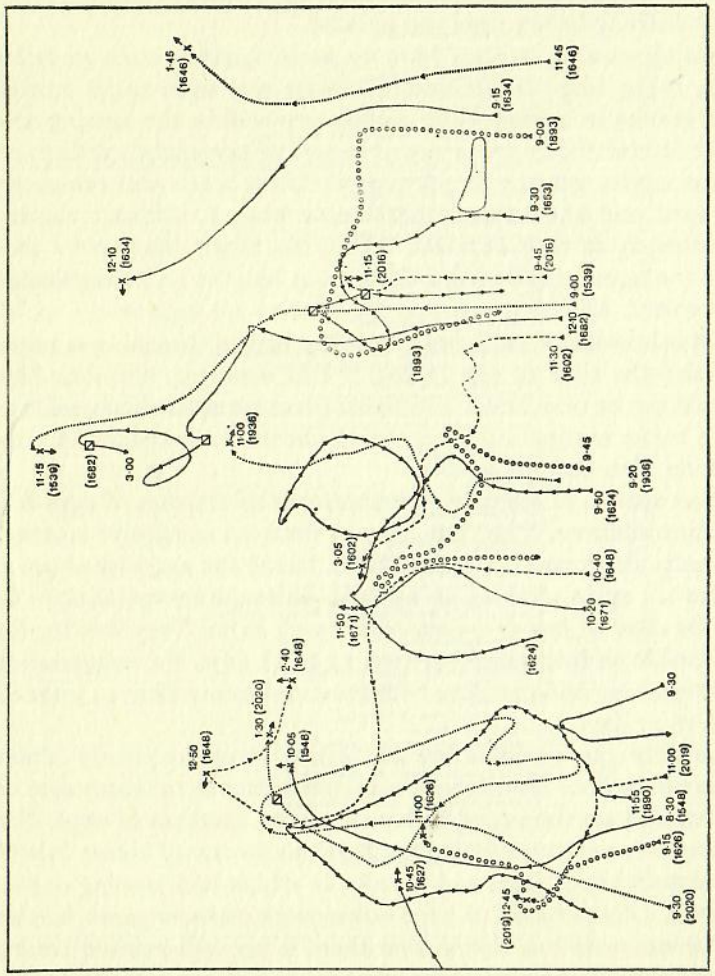
disturb them. During this wandering they either make no attempt to dig or make only cursory front flipper movements at a few sites before moving on again. Detailed observations have shown that these particular turtles almost always emerge again the following evening, haul-up just above the spring high-tide mark, and dig their nests at once with no exploratory activity. The marked contrast between the two nights' activity is most conspicuous. Provided weather conditions have resulted in the sand being suitable for nesting activity, we can only assume that on the first night they were not quite ready to lay their eggs whereas on the second night a strong laying urge was present.

During nesting, turtles have to avoid hazards such as fallen trees, roots, large impenetrable bushes and even other turtles. This results in considerable movements within the nesting area which is best shown by an actual record of one night's activity by all the turtles on the beach (fig. 7). This beach was accurately surveyed and the turtles' movements plotted, without causing disturbance, as they occurred during the night. As can be seen from the figure some turtles carried out lengthy and complicated movements. Different symbols are used to separate tracks which might otherwise be confused. Since the time of beaching is noted and also the time of egg laying, if this occurred, the time that elapsed can be calculated. The figure gives a graphic impression of green turtle nesting movements and should be examined in conjunction with Chapter 4.

Most species of sea turtle lay a number of clutches of eggs in a breeding summer. The time interval between successive clutches is usually about two weeks. At Heron Island the majority of green turtles lay again after 14 or 15 days, although exceptionally this may be after as few as 9 days or as many as 21. Very few turtles fall outside an interval of between 12 to 18 days. For loggerheads the mean interval is 15 days with most re-nesting after an interval of 12 to 17 days.

Probably the question we are asked most frequently about nesting behaviour is whether the turtles return to the same spot or general area on the island to lay successive clutches of eggs. For convenience we have divided the beach perimeter of Heron Island into sixteen beach areas and the area in which each nesting occurs is noted. Observations of 2120 subsequent nests of green turtles over three years has shown that there is no well-marked return pattern to the same area, although more return to nest in the same

FIG. 7 Turtle movements on an area of high beach platform at Heron Island on one night to show their complexity. Times at foot indicate emergence from sea, bracketed numbers are turtle tag number. 'X' indicates site of laying, time is given and the arrow shows direction of turtle's head. Square with diagonal line indicates unsuccessful nesting attempt. Records were made by watching turtles carefully at night.



area or area immediately adjacent thereto than would occur randomly. The figures recorded were as follows: returns to the same area 21 percent; to adjacent area 22 percent; to completely different area 57 percent.

Any mathematical calculations on the above data would be heavily biased by a number of factors. Firstly turtles do not beach randomly on Heron Island for nesting. Numbers are most dense in the Shark's Bay area where there is good access to deep water without intervening coral. On areas of the island where there is extensive beach rock (plate 1) the numbers nesting depends on the height of the night tide and, therefore, on the state of the tide cycle. When the tide covers the beach rock, nesting takes place at quite substantial density. However, when the high tide leaves large areas of beach rock exposed then much sparser nesting takes place in these sections of the beach. Green turtles will crawl across large areas of beach rock, but not unnaturally there is a tendency to avoid this where possible. Once they are on beach rock they will continue across it, but if the tide is below the start of the rock – which often makes climbing on to it difficult – they generally swim parallel to the beach rock looking for a way through. In our experience loggerhead turtles seldom cross beach rock, and since this occurs on a large proportion of the Heron beaches, their main nesting area is restricted to a small part of the island.

We have carried out considerable work on egg production by the green turtles at Heron Island. Production per female is the number of clutches produced in a season multiplied by the number of eggs per clutch. Information on the first is obtained as a result of the tag-recapture programme, but the latter requires counting eggs in successive clutches. Initially this work was greatly aided by the hatchery programme, described in Chapter 8, in which large numbers of eggs were collected from known females for hatchery incubation. All these eggs were counted during collection and a random sample from each clutch was weighed in order to establish the mean egg weight.

In the green turtle we have found that the mean number of clutches of eggs deposited differs between years. In three successive years it varied from between three and four to between five and six clutches. The third year was intermediate. In two of three years the greatest number of loggerheads were recorded only laying one clutch although some individuals laid as many as four or five times. In the remaining year most laid two or three clutches

of eggs. At the present time we are not able to explain these inter-year population differences. The observation period was the same in each year and there is no reason to doubt the efficiency of the tag-recapture operation in any year. It may reflect population differences, or perhaps is a result of variation in the quantity and/or quality of food supply.

We found that a number of factors affect clutch size in the green turtle. One of these is the size of the turtle, larger turtles producing larger clutches of eggs. Carapace length is plotted against clutch size for the green turtle population at Heron Island in summer 1965–66 in fig. 8. As shown in the figure large turtles lay up to twice as many eggs in a clutch as small females. Since turtles, like other reptiles, commence breeding long before they have reached maximum size (most reptiles subsequently continue to grow slowly throughout adult life) 'small' is probably equatable with 'young' and 'large' with 'old'.

The average size of the eggs remains similar despite changes in size of the mother. That is to say, larger turtles produce a much greater mass (weight) of eggs. Clutch size, in the sense of biomass of the clutch, is probably a result of the physical space available to house the developing eggs as well as a result of the amount of reserves which the turtle can make available for egg production. Both these factors would promote larger clutches by bigger females. It is not surprising that average egg size remains similar, as this will be determined by natural selection at a size which produces the greatest number of surviving progeny, bearing in mind that the amount of egg material is fixed and, therefore, that if the eggs were smaller there could be more of them and vice versa.

In the loggerhead the relationship between clutch size and carapace length is much less pronounced than in the green turtle.

In addition to studying the turtles' way of life at the nesting beach, we are interested in where they go and what they do while at sea for several years between nesting cycles. Tagging helps to provide some data on this as recaptures give an indication of the distance moved. Carr (1968) has shown that the Costa Rican green turtle population moves as far afield as Mexico, adjacent to Yucatan, southern Florida and Isla de Margarita, Venezuela. Furthermore, work by Carr and associates discussed in Carr (1968) has indicated that Brazilian green turtles travel to Ascension Island in the mid-Atlantic to nest. This information was gained by tagging green turtles on Ascension Island, where there are no

nearby feeding grounds. Turtles tagged on Ascension Island have been recaptured on the coast of South America and have also been recaptured nesting again at Ascension after an interval of several years. The shortest distance between Ascension and the coast of South America is about 1400 miles. Navigational problems in the journey to a small island like Ascension must be immense but turtles appear to be adept at this.

Recaptures of Australian tagged turtles are shown in fig. 9. In examining the figure one must bear in mind that the human population in Queensland is heavily concentrated in the south-east of the State. There is accordingly marked bias in reporting recaptures in the south as compared to the north. The fact that

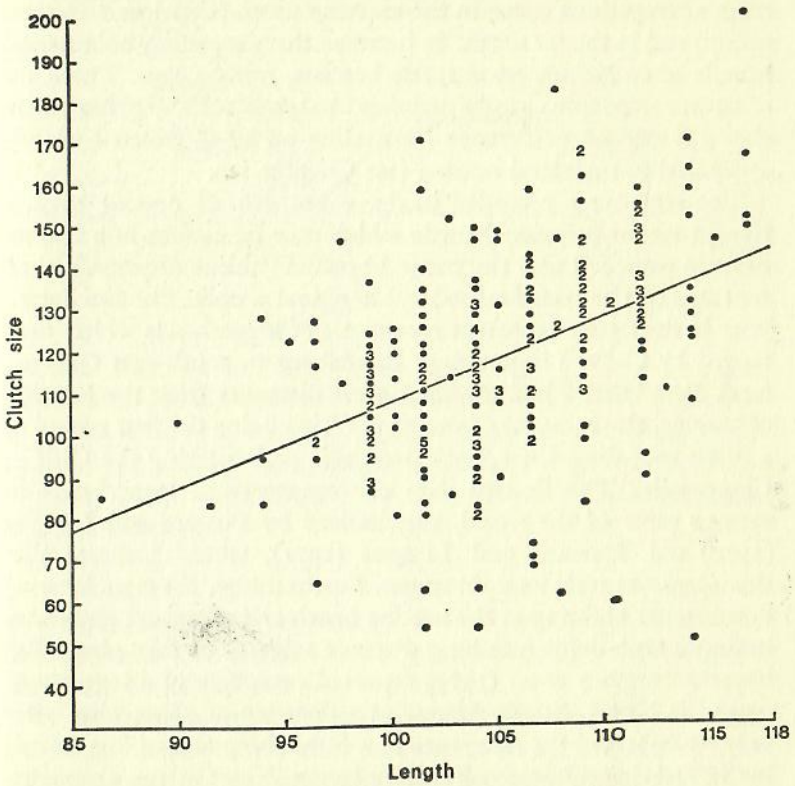


FIG. 8 Relationship between length and clutch size in a green turtle population at Heron Island showing that larger turtles lay appreciably more eggs. Numbers where several points are superimposed.

despite this bias most recaptures come from considerable distances from Heron Island is good evidence of lengthy migration by the vast majority of turtles. Apart from those individuals which move out into the Pacific (such as the three New Caledonia recaptures) the trend is unmistakably to move northwards. Some knowledge of local geography is necessary to appreciate this. The Capricorn–Bunker cays are situated astride the Tropic of Capricorn and as such are relatively far south for major green turtle rookeries. Certainly the major feeding grounds are well to the north. One might wonder why turtles feeding say, north of Townsville, would come as far south as Heron Island to nest. The reason for this is that cays which provide ideal nesting conditions for turtles are not common throughout the length of the Great Barrier Reef. The main aggregations occur in the extreme south (Capricorn–Bunker group) and in the far north. In between there are many continental islands often lacking good turtle beaches, but no cays. There are of course numerous sandy mainland beaches but the green turtle shows a marked preference for nesting on small isolated islands compared to mainland nesting (see Chapter 10).

The recaptures recorded in fig. 9 are not of nesting turtles. Except for an occasional turtle which may be caught in a net, its capture recorded and the turtle liberated (unless drowned), they are taken on the reefs for food by aboriginal people. The two dotted lines in the figure represent recaptures of loggerheads which were tagged by Colin Limpus near Bundaberg in south-east Queensland. Both turtles had travelled great distances from the location of tagging, the recapture from near Weipa being the first record of a turtle rounding Cape York peninsula and entering the Gulf of Carpentaria. The limited data on recaptures of loggerheads in various parts of the world, summarised by Bustard and Limpus (1970) and Bustard and Limpus (1971), would indicate that this species travels long distances. Furthermore, the time interval between last sighting at the nesting beach and recapture elsewhere indicates that deliberate long distance migrations take place. For instance Hughes *et al.* (1967) reported recapture of a loggerhead tagged in Natal, South Africa, at a distance of 1650 miles after only 91 days and the recapture of a Bundaberg tagged loggerhead in the Trobriand Islands off eastern Papua–New Guinea, a straight-line distance of 1100 miles, took place after a lapse of only 63 days. If, as appears likely, the turtle followed the coast for much of the way the distance covered would have been much greater – up to

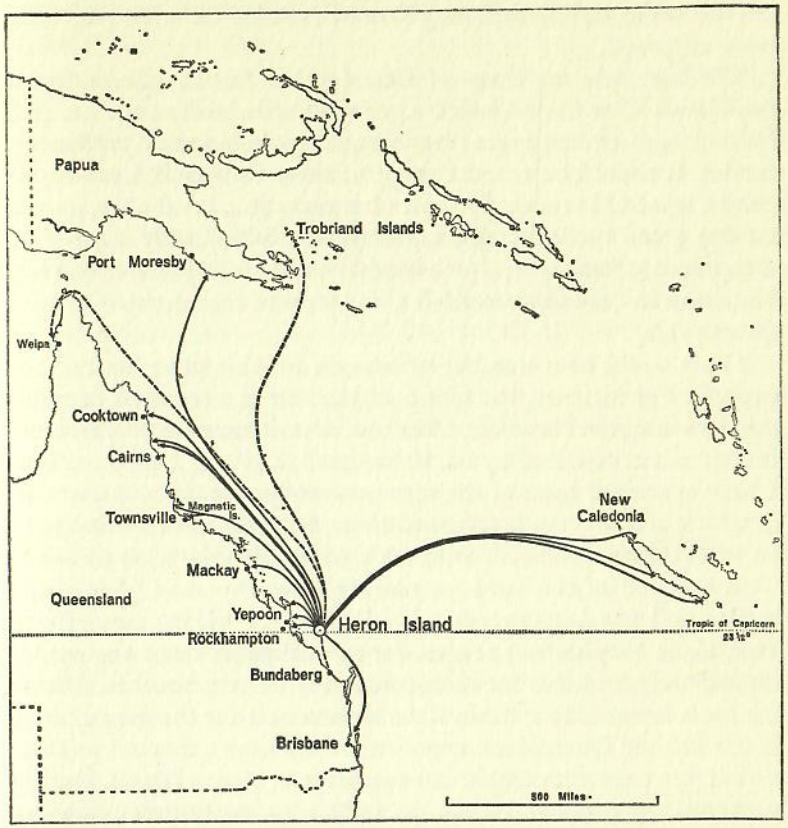


FIG. 9 Recovery sites of green turtles tagged at Heron Island and adjacent cays (continuous lines) and loggerheads tagged at Bundaberg on the mainland (dotted lines). The lines do not necessarily indicate the route followed.

2000 miles. Furthermore, at the time of year that the movement took place, the prevailing current is travelling southwards down the east coast of Australia, so, far from travelling on the current, the turtle would have to swim against it.

It has been known for many years that turtles may return to the same beach to nest in subsequent nesting seasons. This information has been substantiated by tagging programmes. However, most reports gloss over the very low proportion of returns recorded. The low returns are puzzling in view of the probable longevity of the adults and would tend to indicate that the return

pattern to the same island may be much weaker than has generally been supposed.

The best data are those of Carr (1968). For the Costa Rican population Carr has recorded 447 individuals back at the nesting beach in subsequent years from a tagged population of 5758 green turtles. It should be noted that 55 of these returns did not occur until a lapse of between five and nine years (Carr and Carr, 1970). Of 635 green turtles tagged on Ascension Island only eight were recaptured at Ascension after periods of two to four years. Similarly, Harrisson in Sarawak recorded a low level of recaptures in subsequent years.

There could be a number of reasons for this poor level of recapture. For instance, the tags could fall off as a result of destruction by sea water. However, I know of no evidence for this. Indeed, individuals recaptured by us, either back at Heron Island – where I have examined most of the tags personally – or taken elsewhere, in which case the tag is returned to us, have all shown the tags to be in excellent condition with no signs of deterioration or wear.

At the end of the 1969–70 nesting season we had 3825 green turtles and 665 loggerheads tagged in the Capricorn cays. However, since they do not re-nest for several years these are not all immediately available for recapture at the nesting beaches. Allowing for a lapse of four years – the commonest for the green turtle in our limited Queensland experience – we have a marked population of 859 greens 'available' for recapture at Heron Island. During summers 1968–69 and 1969–70 only nine recaptures were recorded. It will be recalled that due to the small size of the cay it is easy to see all nesting turtles at Heron Island. Furthermore, the fact that it is an island means that turtles cannot be missed by beaching just outside the study area as could occur on the mainland.

In 1965–66 we tagged 139 green turtles on North-West Island, the largest of the Capricorn cays. In summer 1969–70, four years later, only two tagged turtles were present in the nesting population.

Loggerheads appear rather more prone to return to nest subsequently than greens but even with them the percent recapture rate is low. In our experience they nest again after intervals of two or three years. On this basis we had 153 tagged individuals available for recapture by summer 1969–70 yet recaptures totalled only ten. One loggerhead returned after one year and laid, and

this same individual was recorded at Heron Island for a third season two years later.

The geography of the Capricorns – there are seven islands in the group used by nesting turtles – provides some additional information of great interest. One reason which could be put forward to explain the small number of returns to specific beaches in subsequent nesting seasons would be that turtles have a tendency to return, not to the exact location of previous nesting – perhaps they have difficulty in locating it – but to the same general area. Hence there would exist not populations of Heron Island turtles but Capricorn cay turtles. Since the various cays are situated only 8 to 17 miles from Heron – quite trivial distances in view of migrations of many hundreds of miles from the north – they provide an excellent situation to test this theory. One would expect many 'misses' in which turtles tagged on one island return four years later to another cay in the general area. During summer 1969–70 we were able to test this possibility since we carried out tag-recapture operations on four of the seven nesting cays. During the summer all recaptures bar one were made on the island where the turtles were originally tagged. The sole exception, a loggerhead tagged on Heron, was recaptured eight miles distant on Wreck Island. Hence, there is no question of most turtles returning to the general area but using another island. If they returned to the general area they nested on the same cay used several years previously. Despite this we have several records of turtles tagged on one cay subsequently nesting in the same season on an adjacent cay.

As stated in Chapter 2 the past fifteen years have seen a tremendous advance in knowledge concerning sea turtle natural history, particularly as a result of the work of Carr. The following accounts are of particular interest: Carr (1962), Carr and Giovannoli (1957), Carr and Ogren (1960), and Carr *et al.* (1966). Other important accounts include Harrisson (1951, 1954 and 1956) and Hendrickson (1958).

Our major interest in Queensland has been to utilise the large unhunted turtle populations to carry out a detailed population ecology study. This would advance knowledge very considerably without merely repeating in Australia work carried out or in progress elsewhere. Queensland offers very great advantages for this work not enjoyed elsewhere which is why we started the programme there. Firstly the State is huge with a seaboard of 3250

miles. We have assumed that most of our tagged turtles remain within or adjacent to Australian territorial waters throughout their life. There is no European fishery for turtles permitted in Queensland (see Chapter 10) and the aborigines no longer take many. This means that marked animals are not subject to a substantial but imprecisely known predation rate as a result of human hunting effort as occurs in most other countries. Furthermore, the small size of our study area, together with the information given above that turtles returning to the Capricorn Group of islands in subsequent nesting seasons return to the same cay once again, allows us to effectively monitor a discrete population.

As detailed above the reproductive pattern is now fairly well known. It is interesting to note that the length of the nesting season differs considerably in various geographic locations probably as a result of latitude. As one moves towards the equator the nesting season is prolonged and in such areas as Sarawak some nesting occurs in every month of the year but with pronounced peaks in certain months. As well as the spread in nesting season, the number of clutches laid by each female also shows geographic variation.

In view of a presumed optimum size (weight) for the egg as a result of natural selection (see discussion above) it is extremely interesting to note that egg weight and, therefore, size of the hatchling, varies in different localities. For instance, Hendrickson (1958) gave a mean of 36 grams (range 28.6–44.7) for Sarawak which compares with 51.6 grams (range 44.0–60.4) for the Heron Island population. This very substantial difference could perhaps be related to differences in the mean number of clutches laid by a female in a nesting year, however, this is not borne out by Hendrickson's data.

An extremely interesting facet of the population ecology is the enormous numbers of individuals nesting at undisturbed rookeries. The discrete nature of these rookeries, combined with the limited area available for nesting – a narrow strip between the spring high-tide mark and the vegetation zone – results in many subsequent nesting females digging where a female has previously deposited eggs. Thus appreciable destruction of incubating eggs occurs, as was first pointed out by Moorhouse (1933). We have studied this situation on Heron Island and using computer studies have confirmed that nest destruction is dependent on population density (Bustard and Tognetti, 1969). It may be that this phenomenon is

important in limiting production of any one rookery and hence playing a role in population regulation. However, the situation is extremely complex as the density of hatchlings entering the sea has also to be taken into account. For some time I have seen the progressive build up of a rookery, with the resultant flood of hatchlings entering the water, as an important way of reducing neonatal predation by flooding the area with hatchlings. The hatchlings are most vulnerable when still in fairly shallow water on and around the reef platform – that is, during the first few hours of life. When a rookery produces more hatchlings per night than the carnivorous fish on the surrounding reef can eat, then clearly many will certainly survive and reach deep water. As long as the numbers of hatchlings are inadequate to feed the local fish then any hatchling entering the sea has a finite chance of being eaten while crossing the reef. Clearly there must be a population level at which the reef platform is regularly flooded with hatchling turtles. The relative importance of egg destruction by subsequent nesting turtles will depend at what adult turtle population size 'flooding' by hatchlings occurs.

Where two species of turtles share the same nesting beach, competition between them for nesting space may be important, especially if their behaviour differs sufficiently for one to be markedly adversely affected by the other. Bustard and Matters studied the interaction of green and loggerhead turtles nesting at Heron Island where the loggerhead population is always much smaller than the population of nesting green turtles. The field data were simulated on the computer to provide extensive quantitative information. Loggerhead turtles usually nest much nearer the sea than green turtles. At Heron Island they usually lay just above the low bank which encircles the island. Some green turtles nest in this zone but most move farther inland. Hence the nesting loggerheads potentially affect only a fraction of the green turtles. Furthermore, due to the small numbers of loggerheads their effect is minimal. However, although many green turtles move considerably farther inland before nesting, they frequently dig a first egg chamber in the main loggerhead nesting area. Naturally this results in a tendency to dig up and so destroy incubating loggerhead eggs. Since green turtles are proportionally much more numerous than loggerheads, and since the total loggerhead lay is aggregated in this narrow area above the bank, the effect of the green turtles on the loggerheads is proportionately large.

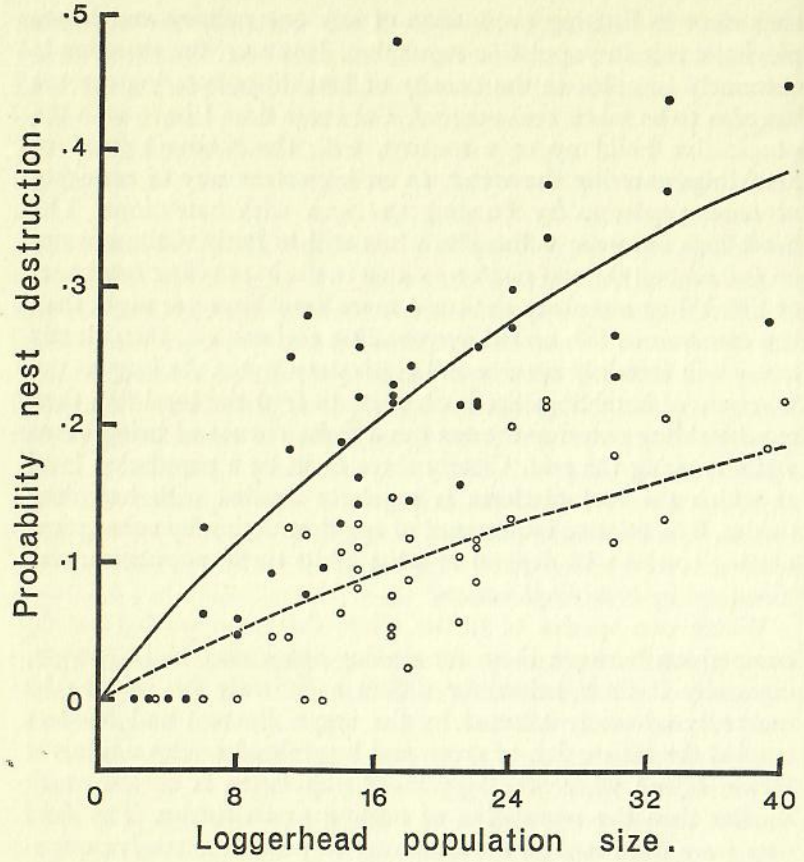


FIG. 10 The probability of nest destruction resulting from intra- and inter-specific competition for nesting sites on a cay (Heron Island). Graphed are the destruction of loggerhead nests by subsequent nesting loggerheads (lower broken curve) and total nest destruction suffered by the loggerhead population (upper continuous curve). The difference between the curves is the result of very substantial interaction (nest destruction) by a nesting population of green turtles.

The effect of this interaction is illustrated graphically in fig. 10 in which the probability of nest destruction (a figure of 1 would represent one hundred percent) is plotted against the size of the loggerhead turtle population. The lower dotted curve shows the loss of incubating loggerhead eggs as a result of destruction by

other nesting loggerheads, whereas the upper continuous curve shows the total level of egg destruction suffered by the loggerhead population. The difference is due to interaction with green turtles. As is shown in the figure the green turtle effect is substantial. For instance, with a loggerhead population of only 18 animals on the nesting beach studied, the probability of nest destruction by subsequent nesting female loggerheads is of the order of 1 in 10. However, the effect of the green turtles is to more than double the destruction to between 1 in 4 and 1 in 5. This is the same as saying that there is considerable competition between green and loggerhead turtles for nesting space and that the competition adversely affects the loggerhead population.

Growth is another fascinating topic about which little is known. A small number of turtles have been reared in captivity in various parts of the world. The resultant information is open to criticism on the grounds that there is no indication of the relationship of captive growth rates to growth in nature. Indeed it is known that captive growth rates vary enormously depending on the conditions under which the turtles are kept and the food supply.

On the basis of growth rates obtained by Les and Dorothy Tanis who provide ideal conditions for their turtles (see Chapter 10) I would give a tentative age at first breeding for Australian green turtles as not less than eight years. This is much slower growth than figures arrived at by Carr and Hendrickson and may merely reflect slower growth in captivity. Carr (1968) thinks that Caribbean populations of the green turtle reach maturity at about five years of age and Hendrickson (1958) has suggested between four and six years for Asian populations of the same species.

Turtles reared in captivity from hatching and then subsequently released into the ocean may maintain similar growth rates to captives kept under ideal conditions. Of a number liberated at the age of one year or more we have so far had only one recapture. The turtle was hatched on 24th March, 1965 and released at Heron Island on 9th January 1967. At the time of release it weighed $4\frac{1}{2}$ lb and had a carapace length of $9\frac{5}{8}$ inches. Another hatchling from the same clutch of eggs also reared in captivity weighed $9\frac{1}{4}$ lb and had a carapace length of $11\frac{3}{4}$ inches on 9th January. The foregoing turtle was recaptured on the reef at Masthead Island, Capricorn Group, on 6th May 1969 and sighted there again on 8th and 9th May. On 6th May it was measured, the length over the carapace being $19\frac{1}{2}$ inches. At this time the captive

sibling had a carapace length of 21½ inches. Hence, the overall difference in carapace length had remained similar indicating that the individual at liberty was showing a similar, or marginally better, growth rate to the captive individual.

There are no data as yet on growth to breeding size by wild individuals. In an attempt to get this information I operated a hatchery at Heron Island for three years from 1965–6. All hatchlings were marked immediately following hatching and then liberated into the sea at the water's edge. Recaptures will provide information on growth to maturity and hopefully also on survival. The hatchlings were marked by removing part of a marginal shield of the carapace. Evidence suggests that this does not regenerate well and that the clip can be picked out readily many years later. Use of a different marginal each year will allow us to age the individuals if these are subsequently recaptured.

On the Great Barrier Reef nesting female green turtles vary from 35 to 50 inches in carapace length (measured over the curve). The commonest size is about 42 inches, and above this size the addition of only one or two inches makes the turtle appear very much larger and greatly increases its weight. Tag recapture data can provide information on growth of these turtles between nesting seasons. Since reptiles, like other ectotherms, continue growth throughout life and typically reach sexual maturity long before attaining a 'maximum size' one would expect considerable growth to be recorded, at least among the smaller females. Once reptiles reach a certain size, often referred to as the 'adult size range', growth becomes extremely slow and indeed it may be difficult to measure. Young nesting female green turtles might be expected to show fairly rapid growth until they attain a size of 40 to 42 inches. Our very limited recapture data is extremely interesting but difficult to interpret. We have recaptured eleven green turtles after intervals of up to four years at sea. Nine of these definitely showed no measurable growth. In only one was there a strong indication of an increase of one inch, from 45 to 46 inches. The remaining individual apparently increased by 0.5 inches but since this is at the level of accuracy the apparent growth might have been due to experimental error.

The loggerhead recaptures provide similar information. In only two of eleven recaptures is there definite indication of growth. One increased by 1 inch from an initial carapace length of 41.5 inches and the other by 1.5 inches from 38 inches.

The above information can be interpreted as meaning that growth is generally extremely slow in both species once sexual maturity (minimum breeding size) is reached. On this interpretation large individuals are extremely old. On the other hand, the data can be taken to mean that there is markedly different growth during immaturity, perhaps as a result of food supply, with the result that size at sexual maturity varies widely. On the latter interpretation little growth would be expected after attainment of sexual maturity – only the extremely slow growth characteristic of reptiles throughout adult life. An age determination technique is required to settle this problem and we are currently investigating skeletal ageing techniques in sea turtles.

The frequent high density of nesting turtles on rookeries not subject to intensive human predation – which quickly wipes out the turtles if applied to the nesting females – leads to two important situations. Firstly one is usually struck by the shortage of nesting area. Only a narrow strip between the spring high-tide mark and the vegetation zone, the latter usually forms an impenetrable barrier, is available to the turtles. Furthermore, green turtles have a tendency to nest beside vegetation hence increasing egg destruction even further. It is possible to design an ideal beach which has a greater nesting area, with vegetation so arranged that the same area can support a much larger volume of developing eggs without a concurrent high rate of egg destruction by nesting turtles. Clearly this could have important practical applications. There is no question but that the productivity of most island (or mainland) nesting beaches could be increased at little cost. At the simplest this would involve removing debris in the form of tree trunks and the like from nesting beaches and laying areas. We have carried out an investigation of ideal nesting area configurations using computer techniques (Bustard and Matters, in prepn.). The other situation is beach erosion which was discussed in some detail in Chapter 3.

The relative occurrence of turtles of various sizes in the population provides additional information on the growth-age problem. In both green and loggerhead turtles at Heron Island there are extremely few individuals of about first breeding size, which may be young females breeding for the first time. This could suggest that few juveniles survive to join the breeding population which would, therefore, need to have a long life span. However, as mentioned above, it could merely mean that many females attain a

considerably larger size before commencing breeding. The size–frequency distribution data, shown in fig. 11, also show a very small number of large individuals. This means that most individuals are lost from the population before they attain a very large size. On the other hand this could reflect a fairly rapid loss, so that even with a recordable growth rate adults tend to be lost before a large size is reached, or it could result from a slow growth rate with the result that the turtles seldom live long enough to attain these large sizes. Once again only an ageing technique applicable to adults will solve this problem.

Some information can be obtained, however, by an examination of the information on injuries grouped according to turtle size. A cursory examination of these data show that incidence of injury is definitely not cumulative throughout life as could be expected. Injuries are highest in the smaller breeding female green turtles. As the turtles become larger the percent with injuries drops steeply and then remains similar throughout life. The fall in percentage with injuries above this size grouping is clear evidence that there is considerable loss of young breeding female green turtles from the population and that a lower rate of loss occurs throughout later life (to offset those contracting new injuries) or that sharks seldom attack larger green turtles. Both factors may be important. In loggerheads, injuries reach a peak somewhat more than half-way through the breeding size range. This would tend to indicate that little loss from the population occurs prior to the size (age) class represented by the peak but that after this size (age) is attained substantial losses occur. The above statements will only hold good if the hypothesis that the larger turtles are older is shown to be correct.

The problems raised above show that a great deal remains to be elucidated about the lives of sea turtles. Their relative inaccessibility during their life at sea is largely responsible for this paucity of information. However, greatly increased tagging effort at many more locations should provide considerable information to fill present gaps in our knowledge. For instance I have remarked above on the poor recapture rates recorded back at the nesting beaches. Do these reflect dispersal to other nesting beaches or death? This is yet another problem which we are not able to answer at present. The definite characteristics of a nesting population in any one year, outlined earlier in this chapter, together with the fact that these characters tend to repeat themselves when that population would

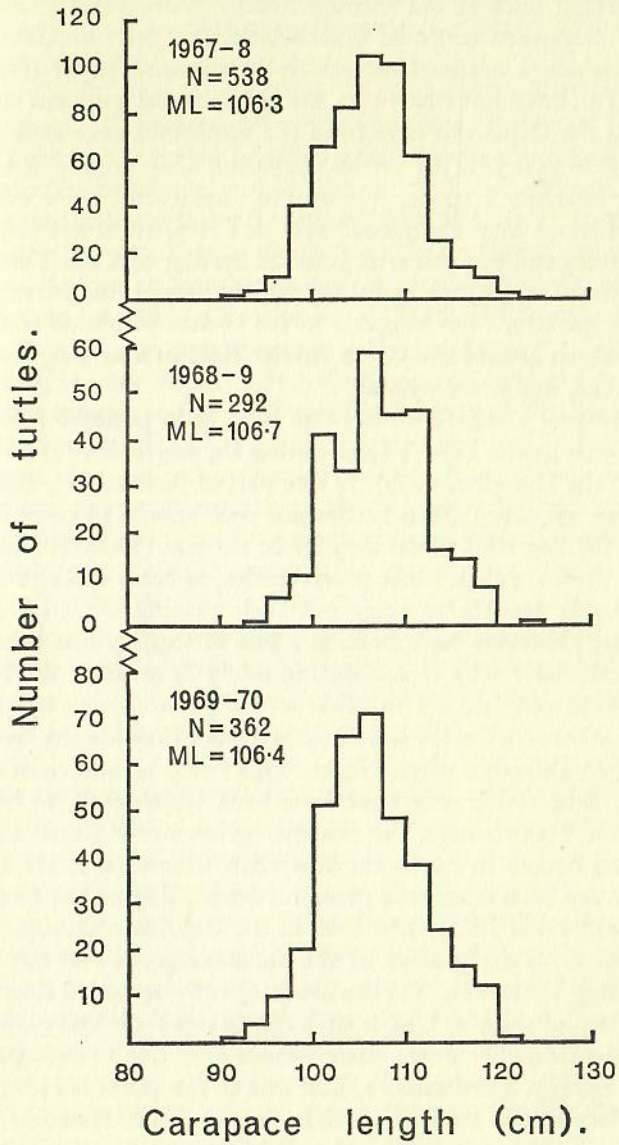


FIG. 11 Size-frequency histograms for three years' populations of the green turtle at Heron Island. The virtual absence of small breeding females (new recruits?) and the fall-off in size above about 105 cm (41.5 inches) should be noted.

be expected back at the nesting beach – four years later in the case of the green turtle in Queensland – suggests an interesting theory which I outlined tentatively in a review paper (Bustard, 1972). I pointed out that there are pronounced currents moving towards the Capricorn cays from the north and the north-east at the time of year that the turtles are presumably migrating to their nesting beaches. I wrote, 'Hence the Capricorn turtles could be parts of much larger populations which happen to get caught in this current and proceed with it to the nesting cays . . . The hypothesis raises a further question which cannot be answered at present, namely, what happens to the turtles which do not reach the southern area of the Great Barrier Reef in a nesting year? Do they breed, and if so, where?'

For several hundred years there have been periodic records of adult green turtles lying ashore during the daytime in areas of the Pacific (viz. Dampier, 1697). In one part of their range – the outer Hawaiian Islands – green turtles are well known to come ashore during the day time when they lie in the sun (Kenyon and Rice, 1959; Parsons, 1962). Since green turtles, as described above, take considerable trouble to carry out their nesting activities during darkness, observers have been at a loss to explain this behaviour and particularly why it is observed solely in areas of the Pacific. One would only expect to observe the phenomenon in isolated regions where turtles are not disturbed since they are shy creatures and very vulnerable when ashore. This could be sufficient reason for the trait, which may once have been widespread, to be little seen now. Furthermore, the evidence given below shows that the trait also occurs in northern Australian waters, and Mr Robert Poulson has seen numerous green turtles basking on the reef – out of the water – at Bloomfield Reef in the Capricorn Group.

The obvious explanation of the phenomenon is that the turtles are basking in the sun. Turtles are frequently recorded sleeping at the surface of the sea. Under such conditions their body temperature is considerably above water temperature due to absorption of radiant energy. Furthermore, heat loss to the water is reduced, as the surface waters are warmer than deeper down. However, basking opportunities are much reduced in the water compared to on land as heat loss to the surrounding water is always substantial. On land in the presence of a radiation source, heat loss is much reduced. Basking is well known in many reptiles as a means of elevating their body temperature. This can result in much faster

digestion. It would seem feasible, therefore, that after eating a large meal green turtles in remote areas haul out to lie in the sun in order to speed up digestion.

In 1969 the Lardil aborigines on Mornington Island told me that, during the winter, green turtles hauled ashore far from the settlement and lay on the beach during the day. In the course of a discussion I asked them why the turtles did it. Without hesitation they said the trait was only shown by females which came ashore to escape the attentions of the promiscuous males. I was most intrigued by this explanation which I had never heard advanced before and determined to investigate at the first opportunity.

In winter 1970 during turtle survey work I was flying over Mornington and neighbouring islands in the Gulf of Carpentaria and sure enough on the outer islands there were turtles lying ashore on the beaches. The following day we landed our light aircraft – a Cessna 182 – on the beach at Bountiful to investigate. I wandered up to two large turtles lying on the beach and to my disappointment both appeared dead. I gave one a push with my bare foot and to my surprise it quickly came to life, grunted and lumbered down the beach towards the sea. The other turtle responded similarly. Both were females. During our stay on Bountiful we walked right round the island's beaches and observed many turtles lying ashore in the sun often fifty to one hundred yards from the water. We were able to observe exactly what happened.

Firstly, we corroborated the Lardil story – all were females. In the morning we observed the situation just after the tide turned. High tide was about 8 a.m. Shortly thereafter turtles came up to the wave wash and generally turned round to face seawards where they remained stationary in extremely shallow water in which swimming was impossible. At this stage they were alert and the sight of humans sent them lumbering into deeper water where they swam out to sea. However, as the tide receded these turtles were left high and dry and by early afternoon many were considerable distances from the sea as we had observed the previous day. Since male turtles never leave the water there is no doubt about the efficacy of this behaviour against sexually active males. Indeed the females do not need to actually leave the sea to escape the attention of the males. Males cannot mount females unless they are in about two feet of water, and by resting in extremely shallow water in which males cannot swim, females can completely avoid their attentions. We observed many males swimming along parallel to

the beaches, in water just deep enough for efficient swimming, undoubtedly looking for females. They passed a number of females at the water's edge without noticing them. The fact that the females become stranded at some distance from the sea is quite incidental – the result of the tide cycle. Unless the females keep crawling seawards to compensate for tide fall this is bound to occur. As a result of these observations I am now convinced that my aboriginal friends are correct.

We have seen many female turtles deliberately enter shallow pools which become cut off from the sea by the receding tide. There is no basking advantage in these pools as their carapaces remain covered or largely covered all the time, although the shallow water becomes somewhat warmer than the sea. This behaviour, like stranding, is clearly carried out to avoid male attentions. Sometimes several males enter these pools before the tide cuts them off. Females cannot subsequently escape and there is pandemonium until the tide comes in or darkness falls. One can tell at a glance if males are also present. If not, the females are all asleep often with part of the carapace completely dry and projecting from the shallow water. If males are present the females' carapaces are usually wet due to continuous assault, and activity in the pool is generally pronounced.

Remarkably little has been written about sea turtle courtship. Indeed I know of no detailed account for any species of sea turtle. Photographs of copulating turtles are fairly common, as are accounts of several males swimming around a single female in the water. On remote Bountiful Island I was lucky enough to observe courtship and copulation many times, often from a distance of less than six feet. Incidentally, I had never observed this at Heron Island. This is because the main mating areas are often at some distance from the nesting beaches. In the Capricorns, Broomfield reef is renowned as a mating area.

When a male green turtle first approaches a female it swims round to face the female and nuzzles her head, rather like rubbing noses. Usually the female shows no response whatsoever. After a short period of nuzzling, the male then makes 'bites' in the region between the female's shoulder and neck. Little attempt appears to be made to actually grasp the female in the jaws. Rather the process is an extension of the nuzzling first observed but now no longer directed at the head. Undoubtedly the procedure is intended to arouse the female. After a variable time the male then

swims to the rear of the female and makes some biting actions at one of the rear flippers. Sometimes the flipper is taken loosely in the jaws. At this stage the female frequently swims away at speed, chased by the male. In the sea males are never able to mount an unwilling female, but due to their persistence and the fact that many males are always looking for females they must have very considerable 'nuisance value'. Presumably this explains the female haul-out behaviour. However, in land-locked pools the female is less readily able to escape from the male although she can certainly frustrate actual copulation attempts.

If the female does not swim away when the male nuzzles and bites a rear flipper, the male then attempts to climb on top of the female. This manoeuvre is only possible if the water is somewhat deeper than the depth of the female's carapace. Due to the highly domed carapace of the female and the bony plastron of the male, the manoeuvre is difficult at the best of times. The male attempts to gain momentum and literally swim up, and on to, the female's back. Once there he hooks on with the large thumb claws of the front flippers. These are hooked over the front of the female's carapace between the shoulder and neck region. As a result of this, nesting females are seen with anterior marginal areas of the carapace chipped and the soft parts raw from the male's claws during copulation. The male also maintains his position on the female by hooking the horny end of his tail under the posterior marginals of the female's carapace. The greatly elongated tail of the male has a pronounced horn-like distal portion. Sometimes a male may go right over a female and, following a chase, not infrequently fails to approach from behind but makes a sideways approach. This results in the male not being able to maintain his position and he slides off to try again. Once a male has firmly positioned himself on a female, copulation can begin. As pointed out above, males never succeed in reaching a stage where copulation is possible unless the female is a willing partner to the act. The courtship behaviour is illustrated in plate 6/7.

In view of the general paucity of information on sea turtle biology in many parts of the world, the small number of scientific turtle workers have an obligation to set some time aside for investigations outside their main study region. The large gaps in our knowledge reflect lack of personnel just as much as lack of funds. Indeed it would seem that personnel are more at a premium than availability of funds. However, the two are often related.

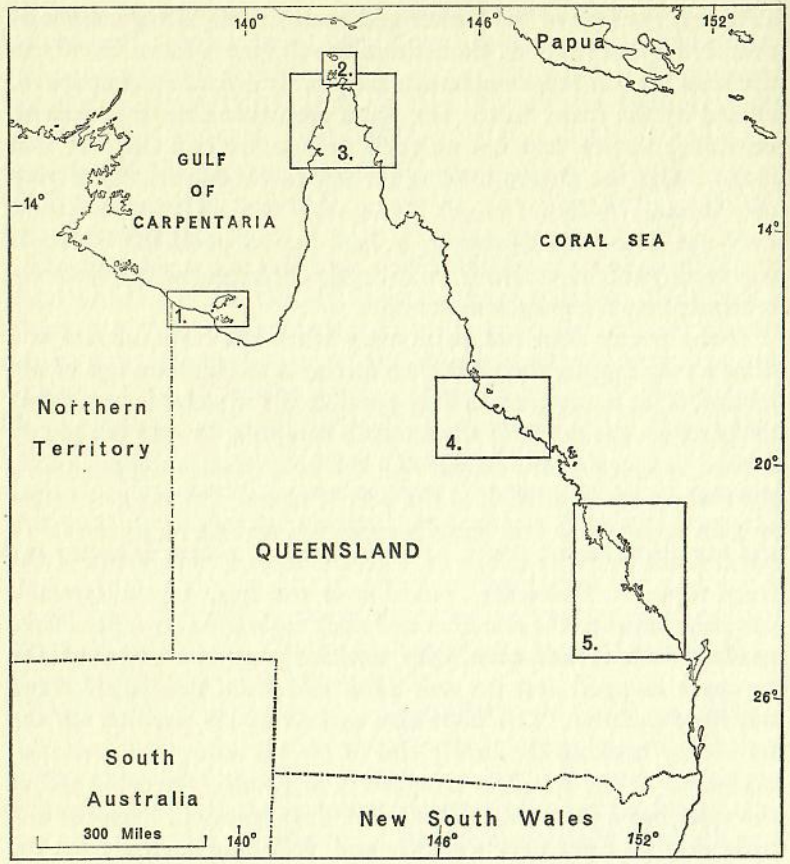


FIG. 12 Map of Queensland, Australia, showing areas (boxed) with turtle nesting aggregations in December 1969.

Perhaps it may be of interest to readers to know what we are doing in this regard. In June 1970, with financial support from the United States National Appeal of the World Wild Life Fund, we started an investigation of the sea turtle resources of the whole of Queensland. This work involved aerial surveys of all mainland beaches and off-shore islands together with extensive ground follow-up work and is expected to take about eighteen months to complete. When complete it will be written up as a report to the Government of Queensland and also published separately to act

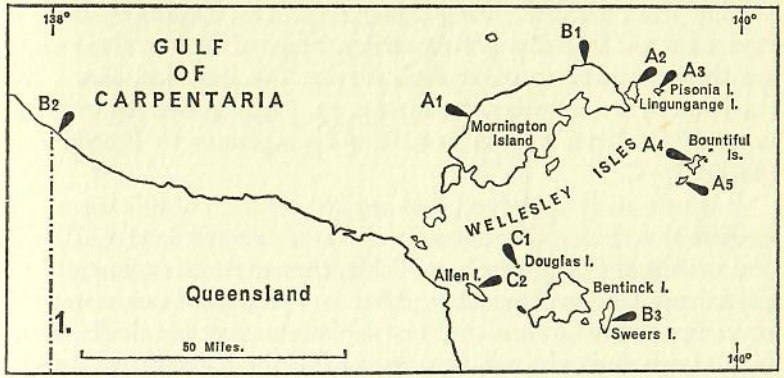


FIG. 13 Detail of area 1 of fig. 12 showing locations of specific rookeries, which are categorised A, B or C in descending order of importance. The Bountiful and Pisonia rookeries are large by world standards.

as a guide to others of how we feel this sort of work should be undertaken and the results evaluated.

It is readily possible from a height of about 500 feet to count individual turtle tracks from the air and usually to state the species involved. Before writing our report we will have seen all of the State's beaches and islands between three and six times from the air. Survey work has been arranged so that the various areas of the State are investigated at different periods of the breeding season since seasonal differences in time of breeding between species are known to occur.

A major result of the work so far has been to show that nesting only occurs to any extent in certain areas of the State and that, as anticipated the main rookery areas are closely circumscribed. This information has two important bearings on conservation or any rational exploitation schemes which may be investigated. It would be easy to virtually wipe out the present large turtle populations in Queensland. Alienation of only two rookeries – geographically very small – Bountiful and Crab Islands, would probably reduce the Queensland populations of green turtle – the economic species – by one half! On the other hand, since the important areas are small and remote, it would be a simple procedure for the Government to protect the turtle populations by declaring these remote areas, which form such key nesting rookeries, National Parks. In fig. 12 the main areas used by nesting turtles during the first surveys are indicated by boxes 1 to 5. Outside of these areas no

nesting was recorded during this survey. The Capricorn–Bunker cays were not included in this survey. Maps of each of these areas are then prepared to cover each survey. For instance, area 1 for the June 1970 survey is shown in fig. 13. Major rookeries are indicated by the letter A, smaller nesting aggregations by B and some nesting by C.

It is extremely important that applied research of this nature be carried out. Since the scientific workers are the best qualified, and usually the only people available, they must be encouraged to participate wherever possible. After completion of our statewide investigations in Queensland, I have plans to carry out similar work in Western Australia and then in the Northern Territory. I have also been providing some help to other turtle bearing countries overseas. For instance, during 1970 I spent several weeks in Fiji investigating the status of sea turtles there (Bustard, 1970b) and also visited the Trengganu rookery of the leathery turtle on the east coast of West Malaysia to see what could be done to further safeguard the future of that population (Bustard, 1971a).

PART FOUR

Turtles and Man

CHAPTER 10 brings together the many facets of sea-turtle conservation, past, present and future. Our own experiences in Queensland are used to illustrate the sort of problems which one encounters in this kind of work since these are of universal occurrence. We differ in that we have been exceptionally fortunate in the enlightened attitude we have encountered towards turtle conservation by the Government of Queensland and its officers.

The chapter starts by reviewing past legislation. Current conservation achievements are then considered together with relevant background information. The chapter concludes with a species by species survey of the future of the world's sea turtle resources. Since turtle farming – by satisfying the demand for commercial turtle products – can greatly reduce the hunting pressure on wild turtles, and perhaps ultimately replace wild turtles as a source of commercial product, it is strongly linked to conservation in my view. Of course, the way in which the farms are run is vitally important and as always political considerations must also be borne in mind. Because of the future importance of turtle farming to turtle conservation, a section of Chapter 10 is devoted to this topic.

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CHAPTER 10

Conservation

Sea Turtle conservation prior to 1964

THE aim of this section is to outline the sea turtle conservation situation up till the time that I started an Australian research programme on sea turtles. This information provides a background to our own work and shows why I became interested in the conservation aspects of the study from the outset.

As Professor Archie Carr has pointed out, the legislation passed by the Bermuda Assembly in 1620 against the killing of young turtles below a specified carapace size was the first recorded conservation legislation for sea turtles anywhere in the world. However, the slaughter continued, in the Caribbean and elsewhere, as a source of fresh meat for European navies and garrisons. An early account of turtle taking is given by Fryke and Schweitzer (1700) in 'Voyages to the East Indies'. On arrival at the island of Onrust from Batavia they noted, 'the only pastime we could have was catching tortoises, of which there are vast numbers there. When it is fair, and the sun shines bright, they come out of the water, and lie in the hot sand. So when they were all very quiet and settled, we came upon them of a sudden with Sticks and Iron Bars.' It should be noted that early navigators frequently called sea turtles tortoises. Incidentally, this account also provides an early reference to diurnal haul-out, presumably by the green turtle. Power (1835) and Brandreth (1835) provided information for Ascension Island where during the height of the nesting season two men turned forty to fifty green turtles each night making a total of about 2500 a year. Brandreth noted, 'The numbers caught year after year have frequently staggered belief. The supply in general is so abundant as to be issued to the ships and troops as fresh meat.'

A masterly account of the virtual extirpation of the green turtle from the Caribbean was provided by Carr (1954). Writing of the Cayman Islands, Carr said, '. . . for three hundred years the vast "flotas" there – the fleets of breeding green turtles – were a prime factor in the growth of the Caribbean. As the settlements grew and got hungry, ships of half a dozen flags converged on the untended

islands in June. They took away as many as their holds and decks would carry. The turtle flotas were as infinite as herring schools. Or so it seemed.

'The vitamin hunger of sailors, which came from nowhere and made men's gums grow over their teeth, and could send a corpse a day sliding over the rail, practically disappeared in the Caribbean after the discovery of *Chelonia*, the green turtle. No other edible creature could be carried away and kept so long alive. Only the turtle could take the place of spoiled kegs of beef and send a ship on for a second year of wandering or marauding. All early activity in the new world tropics – exploration, colonisation, buccaneering and the manoeuvrings of naval squadrons – was in some way dependent on the turtle. Salted or dried it everywhere fed the seaboard poor. It was at once a staple and a luxury – a slave ration, and in soup and curries the pride of the menus of the big plantation houses. More than any other dietary factor the green turtle supported the opening up of the Caribbean.'

On the progressive loss of the green turtle from its Caribbean strongholds, Carr wrote, 'The documentation of the decline of *Chelonia* is voluminous and clear. One by one the famous old rookeries were destroyed. The first to go was Bermuda and next were the shores of the Greater Antilles. The Bahamas were blanked out not long after, and boats from there began to cross the Gulf stream to abet the decimation in Florida, where vast herds foraged in the East Coast estuaries and on the Gulf flats of the Upper Peninsula and a great breeding school came each year to Dry Tortugas.'

What was probably the earliest regular collection of statistical information began in Sarawak in 1927 under British guidance. These data have been assembled continuously since then. After the second world war until recently the Turtle Board was extremely fortunate in having the services of Tom Harrisson, Curator of the Sarawak Museum and Government Ethnologist. Mr Harrisson, who possesses tremendous energy and drive, has played the key role in the conservation activities on the Sarawak turtle islands as well as drawing attention to the plight of the green turtle worldwide. His pioneer role included the tag which most of us now use to permanently identify adult turtles and the operation of hatcheries whereby a percentage of the annual egg production was set aside for incubation in the absence of predators. The hatchling turtles were then liberated in deep water off the islands to reduce shallow

water predation by carnivorous fish. The aim of this programme was to try to offset, at least to some extent, the inroads made into the population by virtually total egg collection for human consumption.

In Sarawak turtle eggs are prized as food, and egg collection takes place to supply this market. Adult turtles, however, are never killed. It should be possible to sustain populations in which adults are safeguarded, and only eggs utilised, since the chance of any one egg producing a mature turtle is so small. However, the populations, judged by annual egg 'take', have declined sharply over the last forty years (Harrisson, 1962). On the assumption of a three-year breeding cycle, there are three populations using the Sarawak islands for nesting. The population which nested in 1927, then in 1930, 1933 etc., I shall call population A. Egg collection in 1927 was about 2.1 million, there are no data for 1930 and in 1933 the figure was 1.5 million. In 1936 it was 3 million. No data exist for the war years but it fell each time from 1948 to 1954 when it was 1.1 million. In 1957 the figure climbed marginally to 1.4 million and in 1960 and 1963 it was 0.5 million. Population B which nested in 1928, 1931 etc., has similarly shown an overall decline from 2.3 million in 1928 and 3.1 million in 1934 to 0.3 million in 1964. Population C (1932, 1935 etc.) has been erratic. However, once again an overall decline appears to have occurred. The figures were 2.25 million in 1932, 0.9 million in 1935, an estimate (judged to be low) of 0.7 million in 1947 with a climb to 2.35 million in 1950 and 2.05 in 1953. In 1956 the take was down to 0.7, in 1959 it rose to 1.3 but in 1962 was only 0.55 million. With the possible exception of population C, which might reflect merely a fluctuating population (except that the 1968 figure was down to 0.2 million!), the trend appears to be unmistakably downwards.

Harrisson's work attracted Hendrickson's attention to sea turtle ecology. Hendrickson's 1958 paper is a model for subsequent turtle researchers and Professor John Hendrickson has played an important role in green turtle conservation. He was also responsible for the initiation of the vital leathery turtle hatchery scheme in Trengganu, and has continued to play an active role in sea turtle conservation.

The motivation for conservation usually arose directly from economics, and in this Harrisson's work was no exception. Its special feature was that it was carried through over a period of many years and Harrisson himself was interested in fundamental

problems of turtle research. Many fisheries people have from time to time made recommendations for putting turtle fisheries on a rational exploitation basis, outstanding among which is Hornell's 1927 publication dealing with the Seychelles. However, as has happened elsewhere, Hornell's views were not acted upon. Similarly the extensive review assembled by Ingle and Smith (1949) for the Caribbean did not have the anticipated conservation impact.

The first major long-term investigation of sea turtle ecology divorced completely from economics came from Professor Archie Carr at the University of Florida. Carr started tagging turtles in Costa Rica, which is still his headquarters, in the mid 1950s. The greatest tribute one can pay to Archie Carr is to say that looking back to the mid 1950s it seems incredible just how little was known then about almost every aspect of turtle biology. Carr would say that we still know all too little to-day, but to my mind the significant thing is that solid foundations have been laid since then. The general natural history of at least some species is now well documented. Tagging programmes have provided a wealth of new information and above all there is a general awareness of the plight of the world's sea turtles. Professor Carr is the leading authority on sea turtles and is Chairman of the I.U.C.N. Marine Turtle Group. He is totally committed to turtle conservation.

The sea turtle conservation situation in Queensland is rather different for historical reasons. Australia was the last Continent to undergo European settlement. Although Dutch and Portuguese sailors had visited other parts of the Continent much earlier when trading with the Spice Islands (Indonesia) it was not until 1770 that the east coast of Australia was charted by Captain Cook. As a result Australia did not experience the gross over-exploitation of sea turtles by the navies of European powers in the sixteenth and seventeenth centuries which occurred in the West Indies. As mentioned in Chapter 2, Bermuda first gazetted protective legislation for the green turtle in 1620 by which time it was presumably becoming scarce.

Following settlement in New South Wales there was a period in which the Royal Navy was active in charting the Australian coastline. This was done by a very small number of extremely talented people such as Flinders who extended Cook's earlier work and is credited with first calling the Continent 'Australia'. The fact that Cook claimed the entire eastern seaboard on behalf

of the British Crown also resulted in little foreign shipping being active in the area.

After this period of early exploration little was heard about the Barrier Reef and northern Queensland. For instance the London Missionary Society – the first to reach the islands of Torres Strait – did not arrive at Darnley and Murray Islands until 1871 (a hundred years after Cook's voyage of discovery). Queensland, at first part of New South Wales, did not become a separate state until 1859.

In addition to late settlement of the Continent, two additional factors were important in greatly slowing down European interference with tropical fauna. Firstly, Australians settled in the south. This is still the pattern to-day. The capital city of Queensland, Brisbane, is in the extreme south-east of the State. Secondly, due to the small number of people, there was little incentive to push north in order to secure land. This is not to suggest that northern Australia to-day is all virgin bush – much of it is taken up by cattle stations, the larger the size of European kingdoms – but the population density in the north has remained extremely low. For Australia as a whole the figure was only 3.9 people per square mile in 1966. This compares with 575 and 54 people per square mile for the United Kingdom and the United States respectively in 1964.

Australia has not avoided what may be called the exploitative stage of development. It is fast coming, and mining ventures are rapidly springing up in many parts of the far north of Australia. The threats to the fauna are only now becoming obvious in the north and soon the pressure will be on, at least on the mainland.

Having put the subject matter in historical perspective, the object of this section is to explain what has and is being done to conserve sea turtles in Queensland and what action will be needed in the future.

Heron Island and North-West Island, off Gladstone in central Queensland, were the sites of turtle soup canneries in the 1920s and early 'thirties. An excellent account of what occurred at North-West Island was given by Musgrave and Whitley in 'From sea to soup' (1926), from which the following extract is taken,

'Turtle-hunters patrol the beaches of the islet nightly, turning over all the turtles they find *en route*, and leaving them out of reach of the tide. There they are helpless, and lie on their backs, their

flippers scooping up the sand with great force, until exhausted. They are often left in this position for a whole day or more, in the heat of the tropical sun, and their plight as they lie with drooping heads, often gasping for breath, is one which cannot fail to excite one's pity. Later, several members of the party left the islet in a boat carrying a load of turtles to Rockhampton. The unfortunate animals lay on their backs arranged around the decks between the deckhouse and the railings, ever and anon emitting long-drawn sighs or slapping their flippers against the decks or their plastrons. The hold, too, was full, and on the trip over several died. With their eyes exuding long trails of mucus, and so distended with blood that they protruded beyond the orbits, these helpless creatures aroused our sympathy. During a night spent on the boat, the turtles kept up an incessant tattoo against the sides of the deckhouse, making sleep an impossibility.

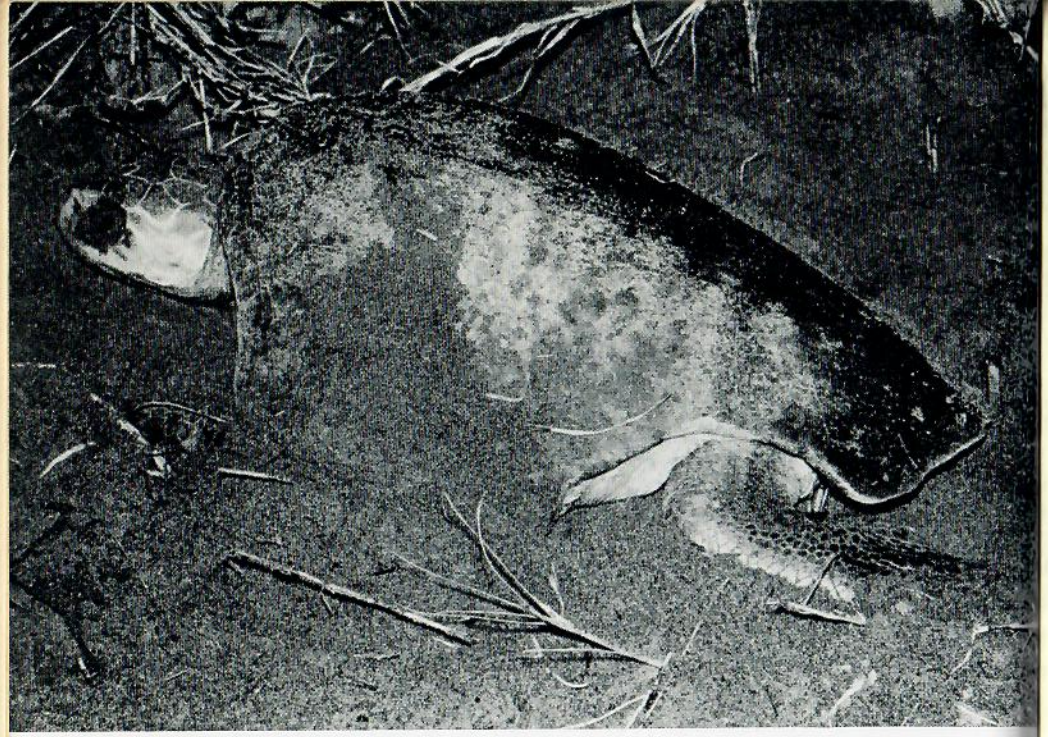
'The turtles are killed by decapitation, and later butchered. First the lower shell or plastron is cut around and lifted off like a lid. Then the limbs and flesh are removed; the head and entrails, including the ovaries with their numbers of unlaid eggs, are buried in the sand. The shells and flesh are loaded into a punt, and towed to the wharf near the canning shed, where fifteen men are employed. Here the meat is cut off the bones and boiled slowly in large wooden vats overnight, forming the soup which passes into a galvanised iron tank where it is flavoured with pepper, onions, arrowroot and other herbs. It is poured into sixteen ounce tins and sterilised for forty minutes before being sealed up. The tins are then labelled and ready for sale. Twenty-two to twenty-five turtles, a good day's catch, produce about nine hundred tins of soup. Last season (1924–1925), thirty-six thousand tins were prepared.'

These statistics indicate that about 1000 turtles were taken from North-West Island during summer 1924–5 which approximates the size of the entire breeding population at the present time. Clearly the removal of virtually the whole breeding population each year was the surest way to wipe out the resource! Musgrave and Whitley continued,

'Besides soup the turtle furnishes many by-products. The flesh of the breast, called calipash, is dried and used to make mock-turtle soup. That of the flippers is called calipee, and is sold dried and makes excellent eating when cooked, having the appearance of fried fish and tasting almost exactly like veal. The green fat of the

17. (a) Legalised egg collecting by licensee at leathery turtle rookery near Dungun, Trengganu, West Malaysia. The eggs are taken as the turtle lays them.

(b) Leathery turtle laying eggs. The turtle's tail is to the right of the back projection at the rear of the carapace.



18. (a) Nesting olive ridley (*Lepidochelys olivacea*) in Surinam. Note the large area of the carapace missing above the hind leg. This is almost certainly the result of shark attack. P. C. H. PRITCHARD.

(b) A group of olive ridleys (*Lepidochelys olivacea*) nesting at Eilanti beach, Surinam, South America. This species, like Kemp's ridley, nests in groups or 'arribadas'. P. C. H. PRITCHARD.

turtle is rich in flavour, and lubricating oil is extracted from it, while fertiliser is made from the shell and bones.

'Each of the twenty-five odd turtles which are killed daily during the breeding season, is the potential mother of about one hundred and fifty young (they did not realise that multiple nesting occurred) so that unless drastic measures are taken, the species in the long run will become extinct.'

This article, and others like it, were important in creating an atmosphere receptive to conservation. When authoritative statements are made, even though they seek no specified solution, they can do a lot to achieve public and Government awareness. Indeed when no particular solution is proposed the authors may have even more influence since clearly they have no personal axe to grind. Important pioneer work on sea turtle biology was carried out on Heron Island during a three-and-a-half month period in summer 1929-30 by Mr F. W. Moorhouse, a Queensland Government biologist. The fact that the Queensland Government initiated an investigation on sea turtles showed that they were conscious that the resource might be being over-exploited.

Moorhouse was alone in carrying out detailed field work. Other fishery people had superficially investigated the problem of over-exploitation in other parts of the world. In some instances, such as Hornell (1927), excellent and detailed reports had been published but without the results of detailed field work to back them up. Moorhouse had field information to back up his recommendations that some degree of protection be given to the green turtle and, furthermore, he did not make the mistake of asking for too much all at once.

In my opinion it was no accident that Moorhouse's pioneer field work resulted in the first conservation legislation for sea turtles in Queensland being introduced by the State Parliament, while Hornell's recommendations were ignored for forty years until I drew the British Government's attention to the report. Moorhouse's success illustrates the effectiveness of using information from the field to document (support) a case for conservation. He wrote,

'Canning of turtle soup had been carried on at Heron Island for some years, work commencing early in November and finishing in February. During the 1928–29 season, so scarce did the turtles become towards the end of the season that periodic visits had to be made to the neighbouring islands in order to obtain sufficient

animals to keep the factory in active operation. In view of the facts that the last season's animals were wiped out and that there was a considerable number present this season, one deduction is that turtles seen in any one season on any given island do not necessarily return the following year to lay, but that there is a period of rest between laying – that laying seasons are separated by some years. This is offered tentatively and can be proved or disproved only after some years of investigations.'

We now know that Moorhouse was correct in deducing that there is an interval of some years between nesting seasons for any given turtle (see Chapter 9).

By marking animals Moorhouse was able to record that many animals laid up to seven times in a single season, which at Heron Island commenced in late October and lasted until mid-February. He pointed out that the breeding population of any one island is very much smaller than would appear to be the case, as so many of the females lay six or more times in a season. Moorhouse's work had important conservation impact both in Queensland and overseas. This concept of a limited number of breeding females and not an inexhaustible supply was to prove a vital starting point for conservation in Australia, and I am accordingly quoting his conclusions in some detail:

'The following definite results are here presented for the first time:
(a) A very limited number of animals visit any one island during the breeding season.
(b) The same animals return again and again, seven being the maximum returnings recorded.

With this information now available these deductions can be drawn:

1. The idea now prevalent that there are thousands of turtles visiting any one island during the breeding season is quite erroneous and must be replaced by *a limited number of turtles make many visits to any one island during the breeding season.*

2. Had the factory on Heron Island operated right through the 1929–30 season, there would have been seen towards the middle of the season that dearth of animals that has marked previous years when continued canning operations were carried out, mention of which was made in the Introduction of this paper (quoted above).

3. Since the 1928–29 season's limited number of animals that visited Heron Island was completely wiped out, and yet some hundreds of animals were seen there the following season, then we are confronted with the following probabilities:

(a) Turtles do not lay every season.
(b) Turtles that laid on an island in one season go to some other island the following season.
(c) Sufficient young mature each season to take the place of those adults killed during the immediate past season.
(d) There is a combination of (b) and (c) – i.e., some turtles that laid elsewhere during the previous season, together with some lately-matured young, go to any one island for the next season;
or
(e) Turtles that laid some seasons ago, together with some lately-matured animals, visit an island during the season.

Of the five points in No. 3, all that can be said at present is that (c) is the only point that can be definitely ruled out, for the turtles that came up to lay during the season varied, as shown in an earlier portion of this paper, from 35 to 48 inches in length of carapace, so that all those laying were not newly matured; in fact, only a small percentage of the laying females found on Heron Island was of such a size as 35 inches. It is a tentative hypothesis that 35 inches is the size of newly-matured animals – i.e., in so far as Heron Island observations allow, green turtles first mature when they have reached a length of 35-inch carapace measurement.'

Moorhouse made recommendations for conservation of the green turtle in Queensland. Writing in the same paper, he said:

'At present in Queensland there is no restriction on the taking of turtles, and there is further no regulation forbidding fishermen from taking animals before they have laid the eggs that they have come to the island to deposit. Though the short-sightedness of killing the turtles before they have laid is admitted, even by the hunters themselves, this unwise practice is still followed. If it is continued, especially early in the breeding season, it must in the very near future deplete our stock of turtles to such an extent as to wipe out this branch of our fishing industry; therefore, a regulation should be framed in order to prevent the extermination of the turtle.

'Any regulation regarding the taking of turtles should be such that a breach of it will become patent without the added expense

of policing the waters to enforce it. In so far as turtles are concerned the matter appears simple. At Heron Island turtles are taken on the beach as they come to lay, and since the laying season commences at or about the close of October in these waters, no turtles are seen upon the beach before that date. It is not till the middle of November that all the animals have been to the island to lay the first batch of eggs, so that by preventing the taking of turtles till the close of November all will have had the opportunity to have laid once, while many will have laid their second set. (N.B. – At the commencement of the season turtles were scarce, five or six being the normal number seen each night. The numbers gradually increased till early in January, when as many as fifty-one were seen on the beach in one night, after which the numbers began to decrease again rapidly till towards the close of the season only six or seven were seen each night.)

'But the coast of Queensland is some thousands of miles in length, so that what applies in southern Queensland does not necessarily apply in the north. The writer saw turtle eggs that had been laid in May in the Torres Strait islands, so, either the season is much more protracted in north Queensland or it occurs in different months. If, then, regulations are to be framed they must state clearly that they apply to that part of the coast of Queensland south from Cairns at least (or latitude 17 degrees South) until such time as the length of the season in North Queensland is definitely known.

'The regulation recommended should, therefore, be similar in form to that suggested hereunder:

> "No person, south of latitude 17 degrees South, shall take, or offer for sale, and no person shall purchase, kill or attempt to export, between the dates of 30th September and 30th November of each year, any turtle of the kind known as the Green Turtle (*Chelonia mydas*). Penalty £10 for each animal found in possession."

'This close season is absolutely essential, for it is the only definite means of ensuring the laying of some of the eggs normally produced by the turtle. But if the fishermen and factory authorities could be compelled to plant the eggs from the killed animals, since it has been demonstrated that such action is advisable and profitable, then the yearly production of young turtles can be appreciably increased. It does not appear wise at the present juncture,

owing to insufficient knowledge, to frame regulations to limit the *number* of turtles that shall be taken each season, or the *size* of animals permitted to be taken.'

Then, Moorhouse greatly strengthened his case by citing many instances of protective legislation then in force in other parts of the world, notably the West Indies where turtle stocks had been greatly depleted by centuries of over-exploitation.

Moorhouse's recommendation of a close season during the early part of the nesting season was accepted by the Queensland Government and legislation was gazetted to provide for this south of latitude 17°s. To the best of my knowledge no investigation was ever carried out in north Queensland – it was certainly not published – and until 1968 all legislation was restricted to south of 17°s.

The close season during October and November which resulted from Moorhouse's work permitted some eggs to be laid before the breeding female turtles were butchered. In normal years the first turtles reach the Capricorn cays about the end of the third week in October, but it is some weeks before large-scale nesting gets underway. Thus the turtle canneries could obtain virtually no turtles during October anyway. Closure during November was important, and would allow each female to deposit an average of two clutches of eggs before being killed. However, in order to be strictly objective one is forced to state that populations subjected to such a regime would still be exterminated, although more slowly than if butchered before any eggs were laid. This is because turtle populations are not geared to withstand a virtual total loss of their reproductive females in each nesting year. Furthermore, hunting effort was still concentrated exclusively on the females. Moorhouse's work did not, therefore, solve the green turtle conservation problem, but it did provide a secure foundation on which to build. It provides a valuable lesson for conservationists, namely that some legislation is better than none, and that once legislation is on the statute books it can be improved upon. This is usually much easier than getting over the initial hurdle of successfully introducing legislation where none exists.

Professor Tom Harrisson told me that his own work on sea turtles was greatly influenced by Moorhouse's pioneer study. Professor Harrisson has had a great impact on the sea turtle conservation problem. Furthermore, it was Tom Harrisson's work which first attracted me to sea turtle research. Hence Moorhouse's

influence, through his pioneer field work on Heron Island, has played a key role in sea turtle conservation. Needless to say the fact that Moorhouse's early work had been carried out on Heron Island, now largely a National Park, influenced me in favour of making this cay the headquarters of my own research.

The next phase in sea turtle conservation in Queensland did not come for about twenty years. It has been carefully recorded by Frank McNeill (1955) in an article entitled 'Saving the green turtle of the Great Barrier Reef'. Frank McNeill, lately Curator of Invertebrates at the Australian Museum, began his interest in the Great Barrier Reef over 40 years ago and was a member of the 1928 expedition to the Low Isles. This British expedition organised by the Great Barrier Reef Committee was the most exhaustive expedition yet to visit the reef.

In McNeill's words,

'In a corner of Gladstone Harbour, Port Curtis, "the creek" is a backwater flanked by a big sprawling mud bank. From seawards it gives ready access to town for dozens of fishing and pleasure craft which moor at the small wharves and jetties or tie up along the opposite bank to numbers of tall piles provided for their accommodation. Most activity centres around the so-called town jetty, and on a steaming hot mid-day in January 1950 this place presented a sorry sight. Lying helplessly on their backs upon the decking under the sub-tropical sun were eleven live Green Turtles. All were in an exhausted and pathetic state, with mucus streaming from eyes and nostrils. The spectacle was only too familiar to most local residents and caused them little or no concern. But by a strange quirk of fate, this particular occasion was not to pass unnoticed. It was to prove fortuitous for future generations of green turtles along Australia's Great Barrier Reef – a day which was to mark the turning point in the heartless suffering and trading of harmless creatures long prized as one of our major tourist attractions.

'By chance some strangers were destined to come upon that deplorable scene. They were among a number of passengers who disembarked from the motor cruiser *Capre* – holidaymakers homeward bound to a southern State from coral-girt Heron Island in the Capricorn Group. Away from the tempering sea breeze, the general discomfort of the still heat caused an immediate and sympathetic reaction to the plight of the suffering turtles. The newcomers watched resentfully while a miserably small stream of

water from a hose was played on the captives by a woman in attendance. Instead of alleviating the creatures' distress, it seemed only to aggravate their disablement. They impotently responded by thrashing about with their flippers and struggling in a hopeless way to escape from their tormentors. Here was proof of an ill-considered and cruel exploitation – a practice calculated to endanger the very existence of a quaint edible marine reptile in one of its last world-strongholds.

'Cruelty of this kind has a way of continuing unabated until noticed by somebody determined enough to take decisive action. There were two people among those eye witnesses from the *Capre* who made an immediate resolve to bring to official notice the alarming details of a trade that was long overdue for correction. One was a university Professor of Zoology; the other a museum curator having accredited affiliation with the government-sponsored Great Barrier Reef Committee of Brisbane. No time was lost in gathering convincing data for the strongest of protests. It was learnt that a dozen to eighteen green turtles came through Gladstone every week during the summer egg-laying season and passed on south by rail to Brisbane. The agony endured by the luckless overturned reptiles during lengthy and changing forms of transport must have been intense. Some crude rope bridles looped behind the front flippers and still attached to the captives seen at Gladstone were proof of the painful manner in which they were dragged and hauled about on their backs. The tragedy of the trade was the senseless capturing of only breeding females as they came ashore to deposit their eggs in the sands of the coral island cays; the smaller bodied males avoid the land and are quite inaccessible. While ashore the females face the risk of being rudely overturned and rendered helpless, often immediately upon leaving the water and before their eggs are laid.

'Inquiries made in Brisbane disclosed that the turtles arriving there were slaughtered and shipped to England, and probably elsewhere in Europe, as a luxury export. A news item, detected in the local press of a few weeks before the Gladstone incident, carried an illustration of overturned turtles lying forlornly on a factory floor. Finally, in Sydney more details were gathered from reliable sources, and a protest sent in the strongest possible terms for consideration by the Great Barrier Reef Committee. This had been preceded by a report to the Royal Society for the Prevention of Cruelty to Animals. It was represented to the Committee that

over the previous forty years the green turtle population of the Capricorn Group area had been systematically exploited with either indifferent or no planned official supervision. The result had been a marked reduction in numbers, slow but inexorable. No sooner had the population partially recovered from one period of concentrated butchering than another began. At least three island processing factories had been operating prior to 1930, and had failed – two on North-West Island and one on Heron Island. In addition, certain large meat works on the mainland had, over the years, been buying turtles from fishermen. These turtles were sent as carcases overseas direct in the refrigeration holds of ships which transported export beef. A special point made to the Committee was that reasoning local residents had expressed their distaste of the cruel trade. Some had voiced their relief that only a few fishermen had been tempted to cooperate. They predicted dire results if higher payments were to attract a greater number of turtle hunters. . . .

The deliberations of the Great Barrier Reef Committee on the question of turtle slaughter took place in May, 1950. By that time newspaper publicity had attracted the attention of the Queensland Government Department of Harbours and Marine, a body concerned with the control of fisheries and relevant matters. The combined interest in the humanitarian campaign produced spirited and lengthy discussion. The cruel nature of the trade was given particular emphasis. A parallel was drawn between it and whaling, sometimes stated to be one of the cruellest forms of hunting. It was disclosed that green turtles were protected in Queensland waters by government regulation for two months of the year – October and November – *and that some sort of investigation on their numbers and habits had taken place, but had not been completed.* (My italics.) A healthy reflection voiced at the meeting was that the tourist trade was likely to outweigh the turtle trade by ten to one. On a sounder basis it was argued that in the past every form of exploitation of other than domestic animals had been unconsidered, and that this lack of concern had led in all instances to population disturbances which had had a very deleterious effect upon the trade concerned. It was felt that, as the revived turtle trade was in an early stage of development, it should be placed on a reliable and scientific basis before it increased.

The final and welcome outcome of the Committee's discussion spelt success for the campaign. Recommendations (carried unanimously) were that *an investigation into the ecological and economic status of the green turtle along the Great Barrier Reef should be undertaken, and that, pending the investigation, the green turtle should be placed on the list of protected animals under the relevant Government Act.* (My italics.) Crowning success came on September 7, 1950, when a Queensland Government Order in Council was gazetted. This rescinded the earlier Order relating to the taking of green turtles and stated that the law 'doth absolutely forbid the taking of any of the species of Turtle known as 'Green Turtle' (*Chelonia mydas*) or the eggs thereof in Queensland waters or on or from the foreshores of or lands abutting on such waters'. This legislation only referred to south Queensland.

McNeill's account is particularly interesting and shows the part that tourist interest played, and has continued to play, in conservation of the Barrier Reef. Experts are, of course, needed to make authoritative statements and to provide advice, but public interest once aroused is an excellent way in which to ensure Government action. It is interesting to note in McNeill's article (first italicised section) that Moorhouse's work had never been completed; in fact, no investigation had taken place in the north of the State in the intervening 20 years. Furthermore, the ecological and economic status survey of the green turtle along the Great Barrier Reef was not initiated prior to the commencement of my own work in 1964.

This section may tend to give the appearance that little was achieved prior to 1964 and that when I became interested in turtles the situation was rapidly deteriorating. While the latter is true, the former is far from being the case. It is only fair to point out that Harrisson had to operate a Turtle Board whose main responsibility was to provide eggs for human consumption. Similarly Carr, an American citizen, was operating in Costa Rica, where obviously he had to move with great diplomacy. The pioneer work, particularly by Harrisson and Carr, had wide repercussions on the international scene. Perhaps this can best be illustrated by pointing out that at the 1969 I.U.C.N. Turtle Specialists Working Meeting eight representatives were present from six countries where active sea turtle conservation programmes were being practised, namely, Australia (Queensland), Costa Rica, Malaysia (Sabah, Sarawak and Trengganu), Mexico, South Africa (Natal) and Surinam. Additional research workers presented reports on other areas of the world. Furthermore, the work of Moorhouse had provided a firm basis for sea turtle conservation in Queensland.

Recent Conservation Achievements

There has been a marked increase in sea turtle conservation in recent years largely as a result of Professor Archie Carr's eloquent pleas on the turtles' behalf. Very recently (since 1969) the work of I.U.C.N. and its sea turtle group has made an important contribution to conservation. This contribution will continue to expand.

In December 1964 I commenced a long-term study of green and loggerhead turtles in Queensland with field headquarters at Heron Island. At the outset the Government was informed that it was envisaged the work would extend over a period of ten to twenty years. When in summer 1967–68 Mr G. T. T. Harrison, Chief Inspector of Fisheries in Queensland, was on Heron Island seeing our programme, he asked whether we had yet come to any conclusions on the conservation requirements of the species. Mr Harrison is deeply interested in conservation. It was clear that any depositions which would be made were to receive the most careful consideration. It was answered that our work had confirmed earlier feelings that it was not practical to operate a fishery based on taking breeding female green turtles from the nesting beaches. Turtle populations could not sustain any substantial loss resulting from such activities. Therefore, a total protection for the green turtle was favoured in order to conserve the substantial Queensland populations of this species until such time as turtle farming had been scientifically worked out. Approved farms, which would have their own breeding stock and which thus would not cause any depletion of natural populations, could then be licensed by the Government. As most Queenslanders do not know the differences between the six species of sea turtles occurring in Queensland waters, protection if it were to be effective should be extended to all species and in the whole of the State. These proposals were duly accepted by the Government, and legislation to this effect was gazetted on 18th July 1968.

This conservation action by Queensland is by far the most significant legislation in the field of marine turtle conservation that has yet been enacted anywhere in the world. Six species of marine turtles are now totally protected (except from aborigines, see below) along a coastline of 3,250 miles, as well as along 1,250 miles of the Great Barrier Reef. This immense area embraced by

the Order in Council guarantees the future of very substantial turtle populations.

Part of the significance of the legislation results from the fact that large populations of several species of sea turtles presently occur in Queensland waters. So often legislation does not come until the species in question are greatly decimated or even on the verge of extinction. This is not the case with the sea turtle legislation in Queensland. I doubt that our Queensland populations are bettered anywhere in the world. The wise action by the Queensland Government has incidentally safeguarded an important tourist attraction. The tourist potential of the Great Barrier Reef, which is just starting to be tapped, is truly enormous, and every tourist wants to see turtles. Tourists want to be able to go out at night and watch nesting turtles and to be able to see these huge creatures swimming lazily on the reef platform during the day. They can certainly do this in Queensland, where seeing turtles is an integral part of a Barrier Reef holiday.

The importance of the 1968 Queensland sea turtle conservation legislation will become more apparent later in this chapter when it is seen in the context of the overall plans for sea turtle conservation in the State. Firstly, however, I would like to mention some other conservation achievements elsewhere.

Professor Archie Carr has stimulated the Costa Rican Government, through his intensive studies at Tortuguero, to declare a reserve over part of the beach where he works and to prevent the harpooning of turtles immediately offshore. This is a most valuable achievement. Professor Carr has also played a key role in trying to bring about an international agreement to control sea turtle harvests between the Governments of Costa Rica, Nicaragua and British Honduras under United Nations (F.A.O.) auspices.

Dr Pritchard has been responsible for protection of sea turtles in French Guyana where there is an extremely important leathery turtle rookery. Indeed it is fair to say that every member of the I.U.C.N. sea turtle group is trying to bring about conservation legislation, have important rookeries created reserves, and, by pure or applied research, improve the survival outlook for the world's turtles.

Since 1966 the Fisheries Department of the Government of Mexico has been carrying out large-scale research on its turtles, particularly the Pacific ridley (*Lepidochelys olivacea*). The sheer scale of operations is most impressive. Although the work was

initiated to conserve a resource which had suddenly become in great commercial demand, many basic data are being collected. Since the work is being carried out on the Caribbean coast of Mexico as well as on the Pacific the very localised Kemp's ridley (*Lepidochelys kempi*) is also being investigated.

In 1962 Mexican sea turtle products became an important commercial product. In the 1950s the annual capture was about or below 600 tons. In 1962 it was 1,400 tons, in 1965 2,200 tons and in 1968 15,000 tons! Their takes consist almost entirely of Pacific ridleys.

In 1965 much of the beach area of the country was explored in order to locate the main nesting areas. The next year turtle camps were set up at some of the major areas in order to protect the eggs from human collection and the nesting females from slaughter. The turtle camps include a detachment of Marines and Infantry soldiers who patrol the nesting beaches and guard the camp. In 1966 three such camps were established one of which had the purpose of protecting nesting Atlantic ridleys (*Lepidochelys kempi*). The camp observed and protected 1,265 Atlantic ridleys and transplanted 29,937 eggs for hatchery incubation. The two other camps hatched 25,000 Pacific ridley eggs. Nineteen sixty-seven saw a huge increase in activities with six camps established, 375,000 eggs of various species transplanted for safe incubation, and about 25,000 natural nests protected from human and animal predation resulting in a total hatch of 1,600,000 young turtles. In 1968 the scheme resulted in more than 9 million hatchlings reaching the sea and in 1969 (the last year for which data are available) more than 4 million hatchlings resulted from hatchery schemes together with protection of natural nests.

From 1966 to 1969 inclusive 3,688 nesting turtles were tagged, 61 of which have been recaptured.

The Mexican fisheries biologists hope to see positive results from this programme starting in a modest way in 1972, by which time they calculate the hatchlings released in 1966 should have reached sexual maturity.

The Mexican Government is to be congratulated on the way in which it has accepted the challenge of utilising its sea turtle resources in the most effective manner. This is not to suggest that all the problems have been overcome – they are well aware that management of this kind is only in its infancy – but an important

start has been made and large sums of money are being expended annually on sea turtle biology and conservation.

When I started my research programme, Queensland had a history of protective legislation for the green turtle extending back to the 1930s as a result of Moorhouse's work. Thus I was building on what had gone before as did those who secured the 1950 legislation. Secondly, the legislation would not have come about without the active conservation interest of the Chief Inspector of Fisheries, Mr G. T. T. Harrison. It was further aided by Dr Robert Endean, then Secretary, and now Chairman of the Great Barrier Reef Committee which has long been active in safeguarding the Great Barrier Reef and in carrying out, or providing facilities through its Heron Island Research Station for others to carry out, research on the Great Barrier Reef.

This was a particularly happy occasion in that no outside support was necessary. So often in Australia overseas advice or appeals seem to be essential to obtain Government action. In this case everything took place within Queensland.

An important result of the 1968 legislation is that it legally prevents people from 'interfering with' sea turtles at any time. Prior to this legislation it was not possible to prevent vandalism from taking place even when one was aware that it was of common occurrence. I shall quote one example. At the Mon Repos loggerhead rookery near Bundaberg, it was common practice extending over many years for boys to dig up turtle nests, collect eggs, and throw them at each other on the beach. Such fights, I am reliably informed, resulted in the destruction of very substantial numbers of eggs. The local Inspector of Fisheries can now prevent any such activities since they are a breach of the law.

Most tourist resort islands take a responsible attitude to conservation. This is clearly in their own interests since tourists come to the Great Barrier Reef to see the remarkable fauna and flora. It is essential, if the management are to remain in business, that this is safeguarded for future visitors. However, it is often difficult for them to assume the role of policemen with their own clients. Hence protective legislation, which can be prominently displayed and quoted in their brochures, plays a most useful role.

Interference with sea turtles is clearly going to grow with increasing tourism and population expansion on the eastern seaboard. Further safeguards are needed for the turtles in the form of

National Parks. Several exist at present and others are now being actively sought.

In the Capricorn–Bunker Group of Islands at the south of the reef (where development threat is high due to proximity to centres of population in the south) most of Heron Island is a National Park. The exception is five acres leased to a tourist company and several acres leased to the Heron Island Research Station of the Great Barrier Reef Committee. Lady Musgrave Island has been declared a National Park recently. Two other islands in the Group are wanted as National Parks because of their sea turtle rookeries but, of course, their gazetting would serve a much wider purpose. There are extremely few examples of the Capricorn–Bunker cay-type on the reef, and there is an urgent need to see that several of these are rigidly protected.

The experiment of having a tourist resort permanently sited on a National Park Island (Heron) has been shown to be only a partial success. In the case of Heron Island the National Park area is littered with rubbish from the resort including many piles of old building material, old trucks, tyres and other waste which should have been otherwise disposed of. The National Park has doubtful value except that it does prevent the spread of actual buildings. There is, of course, a need for such inland National Parks to be subjected to thorough inspection from time to time. Certainly such a state of affairs would not have been allowed to happen on one of Queensland's well known mainland National Parks. However, surely the real lesson is that these tiny cays (Heron is forty-four acres) are just too small to allow any development without contaminating the whole cay. Once this view is generally accepted by the Government we can perhaps proceed to develop some islands for tourism but ensure that other similar islands nearby are rigidly protected. At present, far from this being the case, the 'contamination' of a tourist resort is not restricted to the island on which it is sited.

Taking the case of Heron Island once again, the resort uses another island regularly for picnics (Wilson) and sometimes goes to different islands such as Wreck. Wilson Island shows the signs of these activities, bottles, beer cans, and other debris spoiling the glade formed by the *Pandanus* vegetation which is dominant on the island. Recreational use of such islands by established companies should be strictly on a 'no rubbish' basis. Periodic inspections must be made. Furthermore, Heron Island tourist resort

wanted to site an air strip on an adjacent island (Wreck). Wreck is a narrow sand bar rising to about thirty feet. Once an air strip was built (which would require the island to be 'levelled') there would be nothing left. Permission to go ahead with this project was granted and then speedily withdrawn. Had it gone through as planned then one resort would have seriously contaminated two islands and a third to a lesser extent. The Queensland Government are to be congratulated for saving Wreck Island from that hazard.

Wreck Island was also the site of oil drilling in recent years. Fortunately nothing was found, but the activities resulted in the introduction of rats to the island where they are now extremely numerous. Rats pose a real threat to ground nesting birds such as mutton birds (*Puffinus pacificus*) as well as attacking hatchling turtles making their way across the high beach platform to the sea. The rats are excellent climbers and probably enter the nests of the white-capped noddy tern to eat the egg or the chick.

Wreck Island is an important rookery for both green and loggerhead turtles – in summer 1969–70 we tagged 413 greens and 289 loggerheads during a 3 week period – as well as being an interesting island structurally. Its very small size (6 acres) precludes any economic development, and I am pressing for it to be gazetted a National Park. An attempt will be made to exterminate the rats using an anti-coagulant bait.

North-West Island, the largest of the Capricorn–Bunker cays (227 acres), is the most important green turtle rookery known to us in the whole of eastern Queensland, south of Coen, a north-south distance of 1000 miles in a straight line. Its declaration as a National Park would be of great value to the future of the green turtle throughout eastern Australia and simple to plan but for the fact that the Heron Island tourist resort has a ten-year lease over part of the island. Were they willing to relinquish this, then presumably it would be possible to have North-West made a National Park.

Hence the total number of cays which are 'affected' by the Heron Island resort is four. This is out of a total of eleven cays in the whole of the Capricorn–Bunker Group excluding North Reef which is little more than a lighthouse. One-tree cay totally lacks sand, it is difficult to land at tiny Erskine (5 acres), and Fairfax is used as a bombing base by the Royal Australian Navy. Against this utilisation only Lady Musgrave, extensively damaged by goats,

Fairfax (the effect of the nearby bombing range is unknown) and Hoskyn, all in the Bunker Group, are uninhabited National Parks. Clearly there is urgent need for the National Park situation to be strengthened by the designation of further cays in the Capricorn Group.

It is, of course, much easier to get land set aside as National Parks before there is any demand for land development in the area. Australia has the great advantage that there are still substantial tracts of Crown Land available, particularly in the north. These areas can be gazetted as National Parks at a stroke of the pen without the huge costs involved in land purchase which characterise the creation of National Parks in so many parts of the world today. (Crown Land is already vested in the Government and no purchase costs are involved.)

Already, in the south of Queensland, development greatly complicates the issue. For instance, following the discovery of flatbacks nesting at Mon Repos beach, near Bundaberg in south-east Queensland in 1968 (see Chapter 6), we tried to get the area set aside as a National Park. Mon Repos is also the site of an important loggerhead rookery, and under proper management the rookery could have been an important tourist attraction like the fairy penguins on Phillip Island in the Bass Strait. We needed only about 100 acres of coastal sand dune, consisting of a strip about one mile long, going far enough back from the beach so that lights could not prevent the orientation of hatchlings towards the sea or frighten adults coming out of the water to nest. However, some of the land was already owned by the Woongarra Shire Council and most of it was owned by a sugar cane grower who was not using it and was prepared to sell to the Government at a fair price. However, there was a fly in the ointment. An individual had purchased between five and ten acres in the middle of the proposed National Park for real estate development (beach-side houses). He was not prepared to sell at a reasonable price. Furthermore, it turned out that the local council had plans to build a scenic road right along the top of the unconsolidated sand dunes, and greatly favoured obtaining revenue through collecting rates from beach-houses instead of the establishment of a National Park.

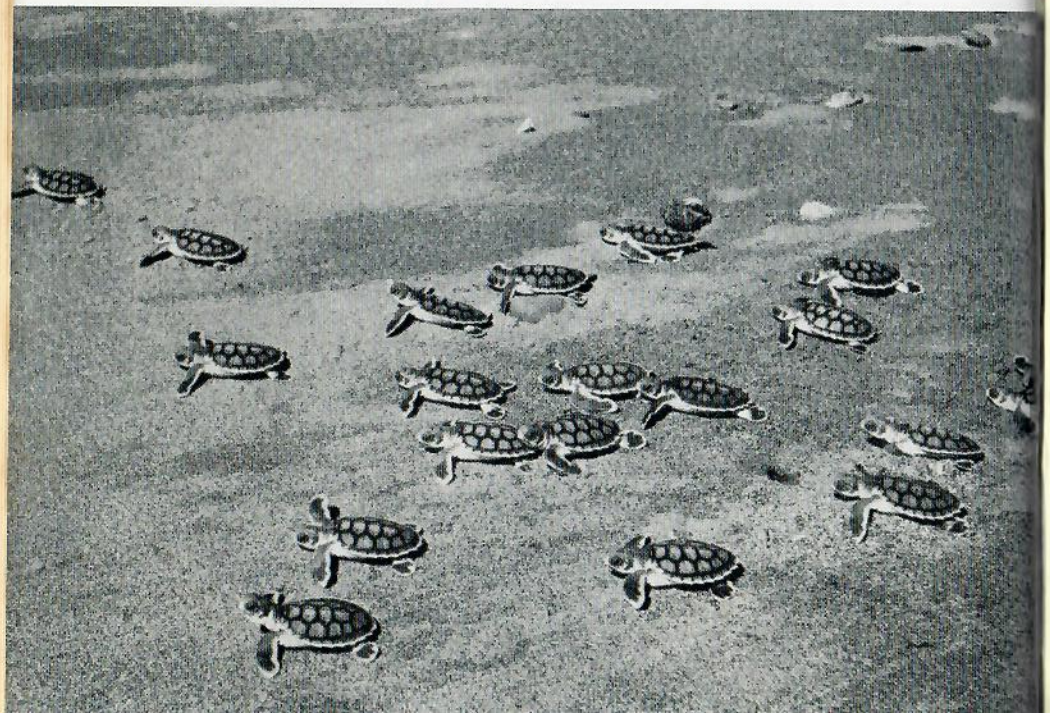
Mr Allan Limpus of Bundaberg organised a very active 'Mon Repos National Park Committee', and their representations, backed by various other organisations and myself, resulted in the Minister for Conservation announcing that Cabinet had agreed to the

19. (a) The forerunners of a nest of green turtle hatchlings breaking through the sand surface.

(b) The same hatchlings photographed only seconds later; already the first ones are completely out of the nest and beginning to disperse.

20. (a) Hatchling green turtles scuttling across the beach to the sea.

(b) Baby flatbacks moving to the sea at Mon Repos beach, near Bundaberg, S.E. Queensland. C. LIMPUS.



proposal for a Mon Repos National Park. This statement was bitterly opposed by the Woongarra Shire Council together with the local Member of Parliament. Although I met the full Council I was uncertain what their objections to the scheme really were. I did learn that an important objection was that since the National Park was sited on their land they would lose revenue from rates, whereas any tourist activity which the National Park might generate would flow into Bundaberg (a different Council)! Financial considerations, therefore, appeared to be at the root of their objection together with the desire to build a scenic road along the top of the dunes.

At the time of writing (October 1970) Mon Repos has still not been officially designated a National Park, although the statement of the Cabinet decision was issued by Mr Richter, then Minister for Local Government and Conservation, in November/December 1968. Clearly the lesson of Mon Repos is that it is much easier to obtain land for National Parks before the land speculators and energetic councils move in! This brings us to our present programme.

Two years ago I decided it was now urgent to carry out a sea turtle resources study throughout the whole of Queensland. This investigation would be spread over at least 18 months due to the enormity of the project. The major purpose of the work would be to map all the important rookeries for sea turtles throughout the State. This information would then allow applications to be submitted to the Government to gazette key areas as National Parks now before development threatens the rookeries. This work was made possible by the World Wildlife Fund which is interested in conservation of animals and habitats worldwide. Its associate, the International Union for the Conservation of Nature and Natural Resources (I.U.C.N.), operates a Survival Services Commission which has Specialist Groups for threatened animals or groups of animals. The S.S.C. has a Sea Turtle Group of which I am a member. The World Wildlife Fund operates National Appeals in many countries (unfortunately Australia is not yet among these), and support for the Queensland sea turtle study came from the United States National Appeal to which I am greatly indebted.

The programme includes aerial surveys of the whole of the mainland beaches (Queensland has a coastline of 3,250 miles) together with many offshore and Great Barrier Reef islands. By flying at about five hundred feet at a speed of about 140 miles per

hour one can readily detect and count fresh turtle tracks on the beaches. Flights are carefully planned to take place in the early morning when the tide is low following a night high. Work can only be done at a certain time in the fortnightly tide cycle when the tide has receded considerably before the turtles are returning to the water so that they traverse an area of sand on the beach, leaving distinctive tracks, before re-entering the sea. Since the survey work is carried out before the tide rises again these tracks are all exposed.

To date aerial survey work has been carried out at two times of the year (November/December and June). All mainland beaches and most offshore islands in the State have been examined at least twice and many as often as four times. In general, little mainland nesting was found to occur despite the presence of many miles of ideal beach with no habitation within miles. Most rookeries, and all important ones, were located on islands. Apart from the Capricorn–Bunker cays, there are few suitable islands on the southern half of the reef. There are many islands, but they are of mainland origin with steep sides and generally little or no beach area. By far the most important rookeries outside the Capricorn-Bunker Group occurred in the Gulf of Carpentaria. These were on Pisonia Island, 15° 30′S, 139° 48′E, and Bountiful, 15° 40′S, 139° 51′E (see Chapter 9), where 250–300 and about 600 tracks respectively had been made over the two preceding nights when the islands were flown over on 31st November, 1969. (The figure for Bountiful includes adjacent Rocky Island). Both Bountiful and Pisonia are Aboriginal Reserves which cannot be developed. However, they are no longer used by aborigines and it seems that Bountiful never was (Chapter 9). It is important to ensure that if, and when, they cease to be Aboriginal Reserves they automatically become National Parks. A legislative arrangement to try to ensure this will be worked out if at all possible.

A third island, equally important as a major sea turtle rookery, is Crab Island situated off the coast of the north-west of Cape York (north-east of the Gulf of Carpentaria). Crab Island, 11°S, 142° 6′E, was covered in a mass of tracks when examined from the air on 14th December, 1969. Indeed it was impossible to obtain a reliable count, but tracks from the preceding few nights appeared to number many hundreds. Crab Island is also an Aboriginal Reserve.

Once a suitable series of sea turtle National Parks have been gazetted by the Queensland Government sea turtles will be com-

pletely safe in this large region of the world. The present legislation providing total protection is insufficient by itself, although, of course, it prevents any commercial exploitation. The habitats must also be protected. 'Protect the habitats' is now a familiar cry among conservationists. However, sea turtles are perhaps fortunate that their rookeries are relatively few in number and occur in discrete, usually small areas. The total land area required to protect most of the important rookeries in Queensland is smaller than the acreage required for *one* viable mainland National Park for a large macropod (kangaroo).

Undoubtedly the greatest threat to the future of Queensland's large sea turtle populations is land alienation – development of the rookery sites. Since, as pointed out above, three key rookeries are situated on islands in the far north of the State, all of which are Aboriginal Reserves, this threat is not as serious as it could be. However, the discovery of a commercial oil well in the vicinity of any of these islands would spell the end of the rookery. On the Great Barrier Reef itself, both the Commonwealth Government, following personal interest shown by the Prime Minister, Mr Gorton, and the Queensland State Government, appear to be taking a hard line towards oil drilling. It appears likely that no further drilling may be permitted. For some time now no further oil lease applications have been granted on the Great Barrier Reef and the problem has hinged round what to do about leases granted previous to this decision. Public opinion in Australia has crystallised and hardened against drilling on the Reef, partly as a result of the wide publicity which followed the Torrey Canyon Disaster in Cornwall and the oil leak near Santa Barbara in California.

On the mainland, coastal development, particularly in the form of beach-side housing developments and mineral sands mining, will accelerate. Any areas needed for National Parks must be gazetted soon. We are fortunate that most rookeries are situated on islands. This also prevents interference from introduced and native predators (dingoes, fox, pigs, monitor lizards (goannas)).

Although it would appear unlikely that a fishery for the green turtle on the previous basis will ever be permitted again in Queensland, certain other types of fishery activity result in turtle deaths. Offshore trawling over sandy bottoms results in many loggerheads being taken in the trawls and drowned.

In the future it is to be hoped that applications to take turtles can perhaps be channelled into farming ventures. However, I am not

in favour of this being undertaken in Queensland until the methodology has been worked out fully and the financial return is known. This preliminary stage should be carried out by non-commercial bodies. Needless to say, I would not back any farming venture which intended to parasitise the natural populations for eggs and was merely a 'rearing station', thereby imposing yet another drain on natural populations. However, it would be permissible to take a quota of wild laid eggs if a specified percentage of the resultant young were liberated, at say the age of one year, *provided it could be clearly shown that these survived and offset the eggs taken by the commercial enterprise.* The key point is that farming must not impose any further drain on the already depleted wild populations. Ideally a farm should have its own breeding stock (taken initially under permit) and, after an initial period, produce all the eggs it requires in the farm. In this way the enterprise can be carried out without jeopardising natural populations (see next section).

Effective conservation of the major green turtle rookeries becomes all the more important in view of the sustainable value of the resource when it is exploited by farming techniques. The potential for a turtle farming industry in Queensland is very substantial.

The status of the Australian aborigines and Torres Strait Islanders and their effect on conservation programmes deserves explanation, particularly for the benefit of non-Australian readers. Aborigines and Islanders are exempt from the fauna laws in all States. This means that they can take totally protected fauna at any time *for their own use.* It is illegal for them to take it and sell it. However, as can be imagined, the law is open to flagrant abuse. Europeans wanting to take protected game (in small quantities, of course) may employ an aborigine as a 'front'. Furthermore, aborigines sometimes offer meat from protected game for sale to Europeans. It is difficult to bring about alterations in the conservation laws in the present social climate since governments are loath to introduce any legislation which might appear to penalise aborigines.

While it is clearly correct for aborigines living a tribal way of life to be able to continue to take their normal food even when this is totally protected from use by Europeans, it is not correct for assimilated aborigines to be able to do this. The law makes no distinction between a completely tribal aborigine and an aborigine living in a residential area in a large city. The latter, living in

Brisbane for example and drawing the same wage as a European on a similar job, is still allowed to go out and harpoon turtles at the week-end although any European found doing this would be prosecuted at once. Together with many conservationists, I feel that this situation is quite wrong and poses a serious threat to the safety of certain native fauna. Aborigines who adopt a European way of life must forfeit their rights under the Act. The ambivalent position of detribalised aborigines presents numerous fauna problems which require urgent action. Basically, I am advocating that once aborigines and Islanders voluntarily leave their reserves they should automatically forfeit their rights to take protected game.

This situation becomes absolutely crazy in Fauna Reserves or National Parks since, under the Acts, aborigines are not disallowed from taking *totally protected game while it is in the sanctuary of a Fauna Reserve or National Park.* As I wrote in a previous book (Bustard, 1970), 'Under the Acts, aborigines can come into a National Park in a vehicle, blast away at the relatively tame game, and go away again having undone the painstaking efforts of many years' conservation effort in a week-end'. I even know of cases where their European Mission superintendents, who should know better, have driven them to such localities 'in order to get their own food'. This behaviour shows a total lack of responsibility.

Looking at this from a turtle conservation viewpoint it means that if and when Mon Repos is declared a National Park there will be nothing to prevent families of aboriginal descent from entering the National Park to collect eggs.

The obvious solution to the problem would be for the Commonwealth (Federal) Government to take the initiative in calling a conference of State Fauna Authorities to clear up this anomalous situation.

Overseas colleagues often see the aboriginal situation as a serious loop-hole in the Queensland turtle legislation and frequently ask me about it. In practice it is of little importance for sea turtles at the present time. I would see its major disadvantage as coming when most aborigines are assimilated and become a rapidly growing segment of the Australian population. They will still retain privileges enacted originally to help tribal aborigines. It is at this stage that a serious conservation threat could arise.

Turning to tribal aborigines, which occur only in the interior and in extreme northern Australia, where most are now settled

around Missions, I consider that in general they now pose little threat to the native fauna including sea turtles. Most of these as yet unassimilated aborigines are rapidly losing their ancestral ways, and instead of going out to hunt for food they prefer to accept meals from the Missions or buy tins in the Mission or Government store. This has resulted almost everywhere in reduced hunting pressure even though they are now equipped to go further afield due to the possession of outboard motors. The Mornington islanders provide a good example of this situation. When first contacted by Europeans they possessed only rafts – dug-out canoes were not known to these people – and most of the turtles were taken when ashore laying their eggs, although they were also speared from rafts whenever possible. The aborigines are now losing their skill at, and incentive for, hunting. This is somewhat offset by the possession of dinghies and outboard motors which allow them to reach the turtle feeding grounds much more rapidly. However, the availability of beef (the Mission raises cattle) and tinned foods means that failure to catch wild game does not mean that the family group will go hungry. Hunting has become rather more a spare time occupation, almost a form of relaxation. They enjoy hunting but are no longer prepared to put into it the time and effort which formerly was necessary to obtain sufficient food.

Turtles usually do not nest close to permanent settlements, hence on Mornington and many other islands a walk of some miles may be necessary before one reaches the main nesting areas. It is amazing to me how seldom many aboriginal groups now make this sort of effort even though they may have little else to occupy their time. They are happy to take visitors, such as myself, to these places but seldom now go there themselves. The overall picture is, therefore, one of increasing settlement and reduced hunting. Most Torres Strait Islanders also now hunt turtles much less than formerly.

I would summarise the future outlook for sea turtle conservation in Queensland as follows: Provided the most important rookery areas can be gazetted as National Parks, and provided these Parks remain inviolate from mining and oil seeking interests, the outlook looks extremely secure, comparing very favourably with anywhere else in the world.

There is a marked reaction in Queensland, as elsewhere in Australia, to what might be termed 'mining unlimited'. The tre-

mendous mineral discoveries to date, together with the overall strength of the Australian economy, means that it is not imperative to exploit and hence destroy all the virgin land. Australians are becoming aware that not only do they want to set aside areas of Australia which remain more or less as they were before colonisation, but that Australia is a rich nation with plenty of land and can well afford to do this. Hence the 'ifs' at the start of this paragraph may not be insuperable and we can conclude the section on a cautiously optimistic note.

Turtle Farming

By turtle farming I mean an establishment in which all turtles used to produce commercial products are hatched from eggs laid in the farm by a captive breeding stud. A 'farm', therefore, operates quite independently of natural resources. Establishments which merely parasitise wild populations for eggs were designated as 'ranches' by the I.U.C.N. sea turtle specialists meeting in 1971. The meeting deplored ranch-type activities, except on a pilot research level, as they place a further strain on rapidly depleting natural turtle populations.

It is important to explain at the outset that for about fifty years scientists have thought that turtle farming was feasible, and that it was probably the best way in which to exploit sea turtles commercially, nor had people been slow to push the idea. For instance, Dresden and Goudriaan (1948) writing about turtles in the Netherlands Antilles said (in translation), 'Systematical breeding of turtles deserves serious consideration with regard to both meat and shell. In a period of 3 years the turtle already has grown sufficiently (approximately 55 lbs.). For breeding purposes certain parts of a bay should be fenced in and closed off with wire-netting. Personnel would be required to guard against thieves . . . For further protection it would be advisable to prohibit buying and selling of turtle eggs and turtles, as well as having them in one's possession with a view to sell them. An exception could be made by the issuance of permits.'

It would seem that Dresden and Goudriaan, who were not zoologists, supposed that it was sufficient to fence off a bay and add some turtles to have a turtle farm. Following a report by Bocke (1907) an attempt at turtle farming was made in Curacao but this failed. It is, of course, essential that any farm have the best

scientific advice and if possible be under scientific direction until the teething problems have been overcome.

After spending a year on the Great Barrier Reef, C. M. (now Professor Sir Maurice) Yonge wrote (1930) of the green turtle, 'Turtles are very numerous in the northern regions of the Barrier and in the Torres Strait, and again in the far south' (the latter refers to the Capricorn cays). He also wrote, 'If some measures were taken to protect the young turtles in this early stage of their existence their numbers, and so the potentialities of the fishery, would be greatly increased. *Fortunately there is every hope that this will soon be done*'. (My italics.)

Yonge's remarks did not lead to any action to protect young turtles in Queensland waters or elsewhere. Indeed the world's first properly planned turtle farm was only recently established (in 1968).

When I advocate farming some animal, I am often asked why farming was not started a long time ago. There is no adequate answer to this question except to reply that man has been exceptionally conservative in this respect, and throughout recorded history the number of animals which have been domesticated has remained extremely small. An outstanding example of this is the way in which cattle adapted to the British climate, were taken to many parts of Africa where tsetse and other ailments afflicted them, and to tropical Australia. It is only very recently that people are realising for example, that the native antelopes of Africa may offer much better opportunities for beef production than cattle, while in Australia Brahmin and other tropical-adapted crosses are being introduced in increasing numbers. The list of animals that could be farmed is extensive. With a little experimentation many of these would amply repay the investment. For instance in Australia attention should be directed at various sea foods, such as crayfish, as well as sea turtles, and certainly at crocodiles and kangaroos.

Returning to sea turtles it is important to appreciate that growth rates of captive turtles are generally poor. The majority of turtles have been kept in zoos where the conditions are very far from ideal. Turtles may live for many years under such conditions, but growth is poor, and those obtained as juveniles frequently become stunted. The best growth rates will occur in the tropics, not in aquaria in temperate climates. Growth in reptiles is extremely dependent on the conditions being right. This is demonstrated by crocodiles, which when kept in small aquaria, may show extremely

little growth over long periods of time. Even in the better zoological gardens crocodile growth is generally slow. The heated reptile houses are cramped and often badly designed. This has led people to question if a farming venture could expect a growth rate of even a foot a year while the crocodiles are in their maximum growth phase. I have frequently been told this is too optimistic. Yet the world's only commercial crocodile farm raises saltwater crocodiles (*Crocodylus porosus*) to a belly skin width of 12–20″ at two years old and 20–30″ at three years old, achieving much faster growth rates than occur in the wild. Furthermore, farm-reared crocodiles are of a stockier build than wild ones. This means that they reach a specified belly size at a considerably smaller overall length than wild individuals. However, these belly sizes are equivalent to wild saltwater crocodiles of between about five feet to seven feet six inches and seven feet six inches to ten feet respectively!

In view of my remarks above I reserve judgement on the growth potential that turtle farms could obtain. However, it is my belief that it would be adequate to make them an attractive commercial proposition.

I would like to digress at this stage to provide some information on captive-reared Australian turtles. These turtles were not overfed to try to obtain maximised growth, and although heating was provided during the winter, the turtles were not nearly so warm as they would be in Torres Strait for instance. However, every care was taken to see to their welfare and detailed data were kept on their growth and weight increases.

It was in summer 1964–5 that I met Les and Dorothy Tanis who had holidayed at Heron Island each year since 1946. They had been keen observers of marine life including the turtles for many years, and Les Tanis knew more about the Heron turtles than anyone else alive, with the possible exception of F. W. Moorhouse then in retirement in north Queensland. The Tanis's had collected a hatchling green turtle when it emerged from its nest and reared it in Brisbane. The baby turtle, christened 'Tommy', had hatched at Heron Island on 11th January 1963, so was almost two years old when I first saw it. Clearly it was in superb condition – so different from the stunted unhealthy young turtles which are the result of most captive rearing attempts under quite unsuitable conditions. I was so enthusiastic about this that I talked the Tanis's into rearing additional turtles in conjunction with us. I say 'in conjunction

with us' but since the Tanis's kept the turtles and had all the day to day problems, I certainly had the easiest end of the stick!

We were keen to know more about growth rates and their variability under different conditions. I wanted to have some loggerheads reared and, furthermore, to be able to observe the appearance of clips made in the marginals of day-old turtles some years later. This work could be so much better attempted in Brisbane than in southern Canberra, where, being an inland University, we lack marine facilities.

In this brief account I will only refer to green turtles, although I find it hard to disguise a marked partiality for loggerheads.

Tommy increased from about $\frac{3}{4}$ oz. at birth to $13\frac{1}{4}$ oz. at one year old, 6 lb at two years old, 20 lb at three years old, $42\frac{1}{2}$ lb at four, 103 lb at six and 131 lb at seven. Now at an age of $7\frac{3}{4}$ he weighs 140 lb. I say 'he', as before the age of five his tail started to elongate and well before six was quite unmistakably the tail of a male turtle. It is only fair to point out that subsequent turtles (with my encouragement the collection increased from 1 to 21 turtles!) probably as a result of ever increasing 'turtle know-how' on the part of the Tanis's, showed more rapid growth rates. Furthermore, it is difficult in a private home in Brisbane to provide facilities to sustain rapid growth rates once turtles reach a comparatively large size. Let it suffice to say that the Tanis's subsequently succeeded in at least doubling the growth rate of young turtles compared to Tommy. At present the record stands at just over 2 lb at the age of one year. Furthermore, I am convinced that under tropical conditions, caged in the sea, we can do substantially better than the best growth rates obtained in aquaria in Brisbane. This has now been verified, as described below.

The major contribution of the Tanis's has been a mass of detailed information on changes which occur with growth – in appearance, habits, and relative growth of parts. By their skilful rearing of day-old hatchlings they were able to demonstrate the effectiveness of our marginal clipping procedures. Quite apart from greens they have reared a fine pair of loggerheads, now $5\frac{1}{2}$ years old and a flatback now $2\frac{1}{2}$ years old.

In 1968 the world's first turtle farm got underway at Grand Cayman Island in the British West Indies. The concern – Mariculture Ltd. – contends that 'the once great turtle fleets of the Caribbean may be brought back in a short time by rearing large

numbers of hatchlings in protective custody, then releasing them on the *Thalassina* beds at a year of age'.

Dr Robert E. Schroeder, then Managing Director of Mariculture Ltd. wrote to me (May 1969),

'At present our eggs come from natural rookeries, although we intend to establish our own breeding colonies as rapidly as possible. In return for 15,000 Costa Rican eggs, for example, we are returning 500 yearling turtles that will be tagged and released on the rookery beach. The turtles to be returned were hatched naturally and allowed to enter the water before being caught and pen-reared. We have a similar arrangement with Ascension Island.

'The balance of the turtles we rear are to be released around Grand Cayman Island. The site was chosen because it is surrounded by deep sea. At a year of age, the turtles will, presumably, be ready to stay in the grassbeds. The Cayman government has passed the necessary protective legislation, and extended to us the requisite franchise, to make such "Open-range ranching" of the grassbeds feasible.'

I cannot do better than let Dr Schroeder explain how it all came about in his own words.

'My wife and I got hooked on green turtles quite by accident while working on the ecology of the trematodes of lutjanid fishes in the Florida Keys. One of Archie Carr's some-time students (Wayne King) gave us a few hatchlings.

'They grew so well in a spare fish pen that we got 600 more from Archie the following year. Then, rather as a lark, we went to Tortuguero to photograph his work for the National Geographic Society. There we found ourselves in the thick of discussions with Archie and his associates that covered the Caribbean turtle problem from ecology to sociology.

'It became clear to us that no conventional conservation methods will do much good in Central America. There is a population explosion unmatched elsewhere in the world. Grinding poverty is the rule. Law enforcement along the wild, primitive coasts is all but non-existent. The number of nesting turtles falls markedly each year.

'I have data on survivorship in captivity, and tag returns from all over the Florida Keys, the Florida Gulf Coast, Cuba, Honduras, and Nicaragua. I cannot give figures on the survivorship of released pen-reared turtles, but my data do make me dead certain that they do a whole lot better than hatchlings just out of the nest. A

little simple arithmetic shows that hatchling survivorship cannot exceed four or five per thousand, and probably is more like two per thousand. Otherwise there would be plenty of turtles. My data suggest that at least 40 or 50% of released pen-reared yearlings survive a year of freedom. Unless there are some very radical kinks in the survivorship curve, pen-rearing must increase overall survivorship something like 50 to 100 times.

'A pen-reared turtle does not behave exactly like a wild one, but its behaviour when released is wild enough. Later, it may calm down and even hang around a wharf as does no wild turtle. About 80 yearlings released nearby in Florida Bay returned to our dock, and hung around waiting for a hand-out. Twelve of these were from a group of 67 released 35 miles away across the bay. We recaught and weighed many of these turtles repeatedly. Obviously they were not behaving like wild turtles, but they were not suffering any noticeable predation either. All were in excellent health.

'Tag returns from the Keys and from the Gulf Coast all came from turtles that were caught on a hook and line from docks. Wild turtles never are caught in this fashion, but all were in good condition except for a hook hole in the side of the mouth. All had grown at rates comparable to captive turtles of similar size. The random scattering of recoveries suggests that the turtles that found their way home probably did so by accident, following the chain of keys until they blundered back to our dock.

'Many turtles released in the vicinity of the dock did not hang around but established themselves in the local shallows. Although I was not able to study their progress statistically, survivorship appeared good. As they grew larger, they gradually moved out into deeper grassbeds. That they did not return would indicate that perhaps the majority of turtles released took up a normal chelonian existence, rather than coming home to beg.

'Last September we released 125 two-year-old turtles and 250 yearlings in Grand Cayman waters. We have recovered 47 yearlings and 16 two-year-olds during the past 10 months. All were in good health and growing rapidly. We occasionally see turtles bearing our tags in the Great Sound of the island, a shallow grassbed area of about 20 square miles. They are found in areas of a depth and bottom type characteristic of turtles of their sizes.

'Tag returns from Cuba and Central America indicate that even small green turtles will cross sizable bodies of deep open water, which I did not expect from juvenile turtles ready to live in the

grassbeds. Perhaps the establishment and maintenance of migratory patterns is more complex than I suspected. The sustained level of tag returns suggests that the released population probably remains essentially intact.

'Turtle farming deserves a fair chance to prove itself. Mariculture Ltd., will give it that chance. I have very little patience with theoretical objections, especially from people whose answer to the problem is to dump cans of turtle soup on the floor in supermarkets. If the species does not become extinct, I do not believe the motives of the people who save it will make very much difference an eon or two hence. If it does become extinct, it will be extinct forever more, the grand gesture of the indignant notwithstanding.

'As Archie Carr pointedly wrote to our Directors, "If Mariculture does not breed turtles in captivity, it has no future." We certainly cannot rely on wild populations indefinitely to supply us with eggs and hatchlings, even though the number of eggs we take right now are inconsequential. In a very few years, despite our best efforts, the natural rookeries no longer will support us. We are spending fifty thousand pounds on experimental breeding facilities during the next three years. We hope to fly wild breeders here from Costa Rica in August or September. Our first pen-reared breeders should be old enough to breed in three years.

'Each year we return 250 tagged yearlings to Costa Rica for release on the rookery beach. These turtles are reared from a special stock, hatched on Tortuguero Beach, and given their first swim in Tortuguero water. These yearlings serve two purposes: they recompense the Costa Ricans for the eggs they give us, and they eventually should give us some data on this means of restocking.

'Mariculture Ltd. is intended to be a profit-making concern, and will rear turtles for slaughter. Its investors are business men who look forward to a return on their investment. But they are not small businessmen: they are thinking of the day when the Caribbean will be a vast turtle ranch producing millions of turtles per year. They realise this will be possible only if the survivorship of hatchlings is raised many times by a year's headstart in captivity, and if adequate legal protection can be obtained for the stock.

'They are not interested in exploiting wild populations. The new Cayman Islands turtle law, which we wrote for the Cayman government, gives the wild turtles absolute protection. We will be

entitled to turtles bearing our tags only. As this industry grows, the old-style turtler will be run out of business in any case.

'I do not believe that natural populations, even very large ones, can support a satisfactory sustained yield. The animal's reproductive ecology is predicated upon the adult's having a long reproductive life. Natural predation on adults is small, and recruitment correspondingly low. Unsupported populations, therefore, will not stand up to harvesting of adults. But the marine grassbeds will rear and support huge numbers of turtles, provided that recruitment can be raised.

'If Mariculture is successful, nothing will prevent others – governments, granting agencies, private investors – from taking advantage of the knowledge that it can be done. They all will know that the great turtle fleets of the past can be brought back and maintained by headstarting. Everybody, including the I.U.C.N., will get that much for free. If we are not successful, *all* our data will be available for other approaches.'

I have been extremely enthusiastic about Dr Schroeder's work since it first came to my notice. This is because I believe that in the long term farming the green turtle will prove to be the most effective method to conserve this animal. Farming must, however, be under proper Government control so that after a 'breathing space' of several years the eggs come from a captive breeding herd. If the commercial demand can be totally or largely met from farms then wild populations will not be hunted to extinction.

Mariculture has now moved all its turtles into tanks on the land and does not plan in future to liberate turtles to feed and grow on the natural grassbeds. Excellent growth rates are currently being achieved – between 60 and 80 lb net weight at two years old and about 120 lb at age three.

However, there is another reason for my interest in turtle farming. Farming ventures offer employment and a cash crop to maritime people, and in the tropics these people are usually very poor. Yet they are living on the edge of riches. If farming is to be carried out solely by large international corporations, then I think a great opportunity to help these people help themselves will have been lost. This is not to suggest for one instant that I am in any way opposed to Mariculture Ltd. However, I want to see large and small farms operate side by side much as happens on the land. The rights of the original inhabitants may need to be safeguarded by legislation.

The results of my own work will be made available to help Torres Straits Islanders set up turtle farms. My role will be simply that of advisor. To get the programme under way it has been agreed that for an initial period of about three years the farms will be under my direct supervision and the people running them will work for a salary. However, after the farms are demonstrably viable operations it is hoped that these Island farmers, and many others who have been interested observers as the scheme got under way, will elect to become turtle farmers in their own right. The first farms are scheduled to commence in December 1970. Initially there will be six pilot schemes three each on Darnley and Murray Islands in eastern Torres Strait. It is intended to investigate both battery-type pen-rearing to a commercial size, and free range farming, from the outset. In the latter, the hatchling turtles will be pen-reared for about one year during which they will be fed fish then tagged and liberated. As pointed out by Schroeder, pen-rearing for a year should increase survivorship by an astronomical fifty to one hundred times! In the free range farming venture each farmer would own those turtles bearing his tag number. Only tagged turtles could be used for commercial purposes but untagged, that is wild turtles, could still be used for food by the local population. The costs of the programme are being met by grants from the Commonwealth Office of Aboriginal Affairs.

Quite apart from carrying out pilot farming investigations, we intend to monitor the wild populations in the area most carefully from the outset. We want to know exactly what effect our operations have on them. For instance can the productivity of the turtle grassbeds withstand this phenomenal increase in turtle numbers? Furthermore, we must show that our activities are not deleterious to the natural population. Initially we will use wild-laid eggs. Subsequently eggs may come from a domesticated breeding stock. It would be invaluable to know the effect on the natural population of taking a certain percentage of the eggs and subsequently releasing a known percentage of the hatchlings at an age of one year old. Present arguments about the effect of actions of this nature on the wild populations are futile since the information is simply not available. Until the effects are known conservationists have no alternative but to adopt an extremely cautious attitude.

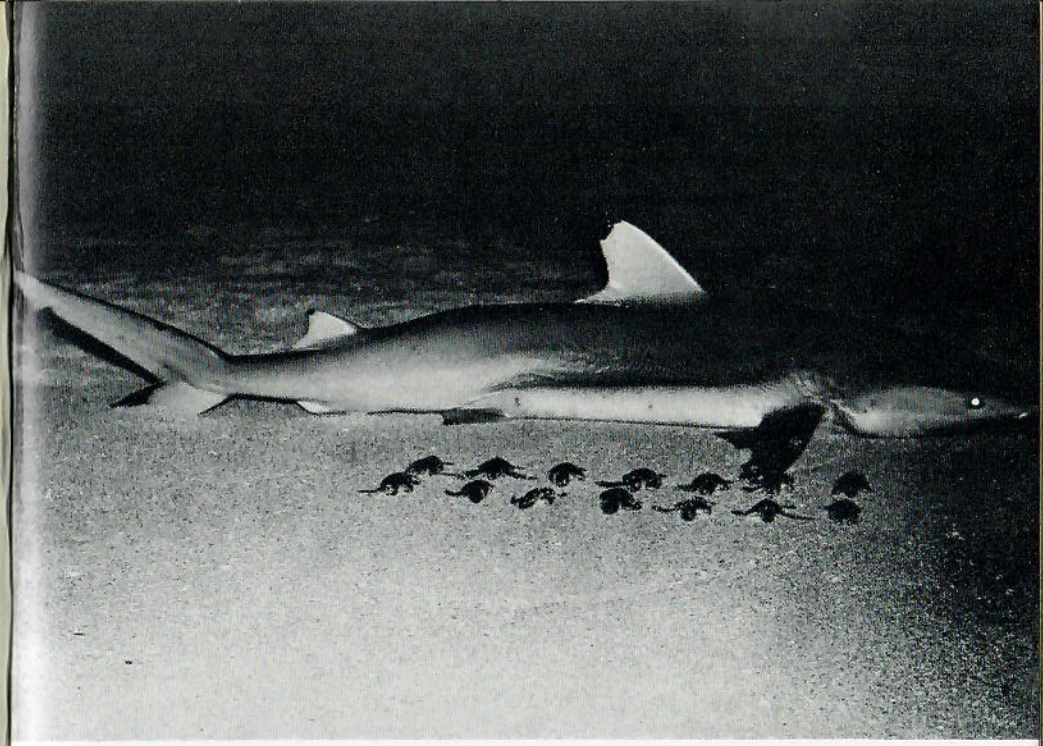
What is proposed, therefore, for Torres Strait, is turtle farming ventures, initially of a pilot nature, to enable the people to become used to the idea and develop the necessary expertise. However,

this work will not be carried out in a vacuum. We will carry out extensive research in the area as an integral part of the proposed development so that we will hopefully be able to predict the turtle carrying capacity of the area, and to meet potential problems before they arise.

Since all species of turtles are totally protected in Queensland (see below) the pilot research farms can only be operated by means of annual permits issued by the Queensland Government. These permits will be subject to receipt of satisfactory annual reports. Hence the Queensland Government is in a position to ensure that the proposed farming ventures and commercial farms which may result from them, do not in any way conflict with the Government's role in conserving sea turtles throughout the State.

I am extremely confident that the turtle-farming scheme will be a great success. Its ultimate success or failure will probably depend on the people initially selected as farmers, and for this reason we are choosing these people with great care. The Torres Strait Islanders are a delightful people – happy, intelligent and without a grudge against the world despite their socio-economic problems. Lack of jobs has caused a drift away from the islands and a separation of families as men move south to find work. It is my hope that turtle farms will provide sustained employment enabling at least some communities to continue to live on their islands yet achieve a satisfactory level of income. Incidentally turtles are something for which the Islanders have a strong affinity, and I anticipate that they will show considerable aptitude for work with them. It is only just that they should be helped to exploit their own resources on a sustained yield basis for their own good.

Further encouraging success has been achieved recently of major importance to long-term farming of the green turtle. The species has now laid eggs in captivity. That this has never occurred in any zoological garden is further evidence of the totally inadequate conditions provided. Professor Hendrickson in Hawaii was the first person to succeed in getting green turtles to lay in a pool with an artificial beach. This success has since been duplicated by Mariculture Ltd. in the Cayman Islands. It seems that it may not be long before the green turtle is added to the short but growing list of animals domesticated by man.



21. (a) A 59″ black-tipped reef shark (*Carcharinus spallanzani*) with 14 green turtles hatchlings removed from its stomach.

(b) A ghost crab (*Ocypoda ceratophthalma*) with a hatchling green turtle making ineffectual attempts to escape.

22. Katie Pau, a turtle farming trainee from Darnley Island, Torres Strait, with a four-year-old partial albino green turtle reared by Mr and Mrs O. L. Tanis.

The Future of the World's Sea Turtle Resources

The Survival Services Commission of the International Union for the Conservation of Nature and Natural Resources (I.U.C.N.) held a working meeting of marine turtle specialists at Morges, Switzerland in March, 1969. The following are among the proposals which were deemed necessary to safeguard the future of sea turtles:

1. increased incubation and hatchling programmes, using proved techniques;
2. study and analysis of world exploitation patterns;
3. beach surveys where data are lacking, followed up by expert advice as required;
4. establishment of special sanctuaries under scientific management.

The situation varies so much in different parts of the world that it is extremely difficult to generalise. There are also species differences which tend to complicate the situation further. To simplify this I am considering each species separately below, and in a preamble I am giving examples of the types of situation facing sea turtle conservation in different parts of the world. I will start with Queensland, Australia, where my own knowledge is greatest.

In Queensland, the 1968 legislation protecting all species of sea turtles and their eggs throughout the State prevents any commercial exploitation. Clearly it is impossible to detect every infringement – if someone wants to take a turtle for meat there are many areas of the State where the chance of detection is low. However, infringements of this nature are considered to be insignificant at present. Aborigines and Torres Strait Islanders may still take turtles for their own use but their effect does not appear to impose any problems for the turtles at the present time.

The greatest threat to sea turtles in Queensland has yet to come but will not be long delayed. This is from development, particularly in the form of mineral exploitation. Huge areas of the State, at present virgin bush, will be exploited in the next decade. When these areas involve beach-sand mining operations, then they pose a real threat to any turtle rookeries in the area. A less immediate, but none the less extremely serious threat on the longer term, is pollution, particularly in the case of small islands.

Real estate development is also important although its effects will take longer to reach the north of the State than mining

activities. Seaside homes are always popular and significant areas of nesting beach can be quickly alienated as a result of their development. Tourist activity, unless most carefully planned, can also quickly spoil the natural resources of an area of beach or an island. This is particularly the case with small islands which form key breeding places for sea turtles.

In view of these threats, and to determine where the best nesting places were in the State, and what action was needed to conserve them, I commenced a detailed sea turtle resources study of the whole of Queensland with financial support from the World Wildlife Fund (United States National Appeal). It is hoped to submit a detailed report to the Premier of Queensland early in 1971. However, I have already been able to state that a number of rookeries are of such importance that they should be gazetted as National Parks without delay. These proposals are currently under consideration by the Government. The reason that I am discussing this work here is to give an example of what would be the ideal. Protective legislation, which is uniform throughout such a huge area as Queensland (coastline 3250 miles, plus 1200 miles of the Great Barrier Reef), is extremely meaningful biologically. If one can complement this by gazetting the key turtle rookery areas as National Parks then one has the maximum possible safeguards to ensure the turtles' future. Of course, there will always be other problems to face, such as pollution, but these are part of a much wider canvas.

I am not against rational exploitation and will return to this topic later. Firstly I would like to give an example of a situation which on a world basis is certainly much more typical of the problems facing sea turtles than the Queensland picture. The following quote is from Professor Archie Carr's book *The Turtle* which gives an eye-witness account of poaching near his sea turtle research headquarters in Costa Rica. Professor Carr was walking some visitors along the beach to see nesting green turtles when they saw the torch of a poacher up ahead. Professor Carr takes up the story,

'I thought of the mess he would have left, and again was about to say maybe there was no use going any farther, when I saw the backwash curling white fringe around a dark body on the sand ahead, and then it was too late.

'It was a calipeed turtle. I ran up and pulled at one of her limp flippers, and there was no life in it and the head was washing

loosely with the surf. So at least the turtle was dead. They were not always dead when you come on them that way. You can find them lying there back-down with the belly shell gone, the flippers waving, the many-coloured viscera glistening, and the heart beating staunchly on in the ruin.

'Everybody crowded around the corpse . . . I turned the other way and trotted on up to the point alone. I found two more turtles both dead. It was a humane poacher, this time; but the point is, for the sake of half-a-peck of hard gelatin to be sent off to make soup for a few people thousands of miles away, three full-grown, nesting female turtles that weighed, say three hundred pounds, had been killed and left for the next morning's buzzards to fight about. And this had taken place on the only remaining breeding beach of the green turtle in the western Caribbean, on a shore that is better protected from poaching than almost any other sea turtle beach anywhere. Dried on a rack in a secret place and taken out to Limón or Barra del Colorado, where nobody can tell illegal calipee from that of turtles lawfully harpooned or netted, those scraps of cartilage would bring more money than the poacher could make in any week of other work he would be likely to find.'

Professor Carr in the above statement has summarised the crux of the problem facing sea turtle conservation in many parts of the world – the turtles' economic value. Particular attention should be directed at the last two lines of his statement. This situation provides a classic case of the incentive to poach. What can be done about it?

Legislation is relatively worthless (except as evidence of an enlightened Government) if the animal it supposedly protects is subject to large-scale poaching and the legislation is unable to deal effectively with this. Unfortunately this is all too frequently the case. This is such a fundamental point that it deserves some elaboration. Clearly it will never be possible to catch all poachers all the time. Success can be claimed if one catches a substantial proportion of poachers some of the time. Poachers weigh up the possibility of being caught (and convicted) against the potential gain from poaching. Hence effective legislation involves much more than an honest, hard-working cadre of fauna wardens who manage to catch a substantial proportion of the poachers. In the most 'advanced' countries magistrates only too often impose only nominal fines against poachers whose income from poaching may be many times that of the magistrate. Clearly fines which can be

recouped by part of one night's poaching are no deterrent to the poacher. Worse, they ruin morale among the fauna wardens. What is the point of tracking down and apprehending poachers, tedious and usually difficult work at the best of times, if you know that they will receive only a nominal fine? The warden has a good knowledge of the profitability of poaching, he also knows the effect that it is having on the animals he is supposedly there to protect. Can you wonder at his bewilderment and dismay when only nominal fines are imposed? In time he comes to realise that all the dice are stacked against him and in favour of the poacher and becomes apathetic about his work.

Any government passing protective legislation must be prepared to follow through and see that realistic fines are imposed. In saying this I am fully aware that this can be a complicated task as many magistrates have no interest in conservation and are quite likely to consider someone who poaches, for instance, a rare species of crocodile, as doing a service to mankind! However, it is quite wrong to ignore these issues. They must be brought out, discussed, and means found to remedy them. Wherever possible, statutory minimum fines should exist, and these should be substantial enough to actually deter poaching. However, they must be accompanied by information to the magistrates to advise them of the potential gains to be made from poaching. The main problem in a number of areas where I have acted as adviser is that the poachers are streets ahead of the conservation service, and more particularly the law, in terms of professionalism. Almost all of this can be attributed to the failure of the Government to secure adequate fines when poachers are convicted.

In deciding on the level of fine to be levied, which will, of course, differ from case to case, one should carefully weigh up not only the number of animals with which the poacher is actually apprehended but his probable activities. Minimum fines for first offence convictions should be sufficient to more than offset several months' poaching revenue. Unfortunately many, if not most, magistrates still seem to think that if they confiscate the proceeds of a single night's poaching and impose some trivial fine, the person will be deterred from further poaching. Of course, this idea is quite erroneous as any fauna warden can confirm!

A crocodile shooter, who agreed with me in strongly advocating a Fauna Reserve for the saltwater crocodile (*Crocodylus porosus*), and who knew the way poachers' minds work, appealed to me to

tell the Government to impose fines ten times greater than normal for any poaching within the Reserve. Needless to say few governments would be prepared to take such action.

To summarise: poaching is a fact of life. However, it can be greatly reduced – hopefully to a level that the protected animal population can withstand – by efficient apprehension of poachers combined with stiff penalties from the Courts for those convicted of poaching.

Rational exploitation

No sensible conservationist is against rational exploitation. By this I mean exploitation adjusted so that the species or population in question can maintain its numbers and withstand continued exploitation in the future. An analogy can be made with mining – a once-only operation, equivalent to shooting all the animals in the population – as compared to carefully husbanding the breeding stock and culling off only the surplus each year. Of course management can greatly increase the annual 'surplus'. Although man has practised this with domestic stock for a very long time the idea of applying it to natural populations of animals has been extremely slow to catch on. The mining approach is usually still dominant even to-day.

Ecological studies have now progressed to a stage where it is often possible to manipulate the population to maximise the production of the particular end-product sought, that is to produce much more of it than would be produced in a natural population of the species. Unfortunately, the necessary legislation and controls to make this sort of operation possible usually require Government action and governments have been extremely slow to take the necessary steps to make this sort of approach possible.

It is essential to face up to the fact that the operation of any 'rational exploitation' schemes require careful policing and hence Government interest if they are to succeed. The problem is particularly difficult politically when the resource to be cropped has already been heavily over-exploited (this usually happens before expert advice is sought). Clearly it may be politically and socially unpalatable to take the obvious remedy and completely close the resource for a number of years until it has recovered.

Faced with these problems several alternatives are open to the sea turtle conservationist. He will say that the critical situation

facing sea turtles to-day is a result of the fast growing demand for turtle products – calipee for soup, oil for the cosmetics industry, leather for modern accoutrements, meat for tourists plus rapidly growing coastal human populations. Thus he may decide to try to depopularise turtle products – which to me is a negative approach. Alternatively he can try to devise and implement a scheme whereby certain areas are set aside as total sanctuaries whereas other areas are exploited. Such a scheme has the inherent weakness that unless the sanctuary areas are uninhabited and outside the hunting province of the neighbouring people it will appear that they are being made to leave the turtles in order to benefit someone else (which may indeed be the case). The conservationist may decide that he should try to combine the above with quotas on the catch permissible from the non-sanctuary areas.

There is yet another possibility – to realise that the demand exists for turtle products and that properly utilised, these products can provide a valuable cash crop for people living adjacent to tropical and subtropical seas, who are themselves often intimately connected with turtles through tribal customs. In this approach one will go all out to meet the demand. This positive approach has a number of decided advantages. First and foremost rational exploitation of the resource, conservation, and a cash crop and/or sustenance for the local people, can all go hand in hand. This approach is based on farming.

As described in Chapter 8 sea turtles produce very large numbers of eggs. In nature a large proportion of the natural egg lay is destroyed by predators and the loss from predation is very high in the hatchlings. If one could prevent or greatly reduce egg predation and completely prevent predation on the very young turtles, then the high reproductive rate of the species would quickly result in the world's oceans becoming clogged up with turtles! In my belief farming offers this sort of solution.

In this chapter I have briefly described work that is getting under way in Australia under my guidance. Quite apart from substantially helping Torres Strait Islanders and Australian aborigines, it is my belief that this is a very important development for conservation generally.

Clearly farming must be controlled. As delegates to the Morges sea turtle specialists' meeting were quick to point out, farms which merely rely on the collection of vast numbers of naturally laid

eggs will wipe out the species just as surely as a high level of human predation on the adult turtles. The meeting took the view that all such farms should have their own breeding stock so that they operated completely independently from natural populations. This is the wise international aim. However, purely scientifically, there are other ways that farms could be managed. The above-mentioned method is to be preferred because it obviates the need for many controls and political decisions.

Scientifically, farms could operate under permits which allowed them to collect a specified number of naturally laid eggs provided they liberated a proportion of their juveniles at an advanced age to offset the eggs taken. The figures could be set under the terms of the permit to take eggs. This is the way in which the world's first sea turtle farm (Mariculture) got under way at Grand Cayman Island in the West Indies. However, this farm is already starting to experiment in producing eggs from captive breeding stock.

Starting with the eggs, there would appear to be two ways in which farming can proceed, subject to large, readily caught supplies of fish throughout the year. It is essential in initiating any farming scheme to collect freshly laid eggs and to protect these from predators during the incubation period. It is equally important that the hatchling turtles be pen-reared at least to get them through early infancy, when, as a result of their small size, they are extremely vulnerable to a large number of predators. However, when they are about one year old, two alternatives become possible. They can be pen-reared until they reach an economic size for utilisation, or they can be tagged and liberated to be fished at a later date.

Much of the knowledge needed to conserve sea turtle populations is already known. As is clear from the previous statements, the big hurdle facing conservation is political – the implementation and enforcement of suitable legislation by governments.

However, knowledge is still inadequate to permit scientific management of any sea turtle resource. For instance no one has data to allow one to state confidently that x turtles liberated at an age of 1 year are equivalent to Y hatchlings. Information on the subsequent survival under natural conditions of pen-reared hatchlings is still inadequate. This is one field where further data are urgently required.

The seven species of sea turtles are discussed separately below:

THE GREEN TURTLE

In planning for the conservation of the green turtle it is important to realise that a number of well-differentiated populations exist and what is currently called the 'green turtle' could prove to be a composite of two or more quite distinct species. It is not enough, therefore, to say, for instance, that there are plenty of green turtles in Queensland so the future of the species elsewhere does not matter. Every effort should be made to see that each well differentiated race survives.

The green turtle is the main commercial species (see also the hawksbill) being in great demand for traditional purposes such as meat and calipee for turtle soup as well as for more recent uses including oil for the cosmetic industry and leather which affect the other species to a varying degree. This is obviously the species to use for any research farming efforts (see above).

The maintenance of substantial populations in a number of world locations will require well co-ordinated international action as well as dedicated work by individuals. It is my belief that farming offers the best middle-term solution for this species. If it proves practicable to farm the animal on a sufficiently large scale then demand can be supplied entirely from the farms and the incentive to hunt wild populations for commercial purposes will decline. This process can be hastened politically once the farming outlet is available. Whereas it is politically very difficult to cut off access to a resource, particularly if traditional usage is involved, if people are given a clear-cut alternative such as farming, it would then be possible to cut off or greatly restrict access to natural populations after a period of years. People who had not followed the farming alternative would have only themselves to blame.

There is a further consideration. I am firmly in favour of rational exploitation of animal populations where this is clearly practicable on a sustained yield basis because politically it is most useful to have an actual price tag placed on a species or population. Most governments act to a large degree on expediency, motivated by a cash consciousness, so that it is much easier to obtain legislation for a 'useful', that is, exploited, rather than an unexploited species. Furthermore, once it is demonstrated that a species can be cropped or farmed successfully, governments are prepared to put teeth into legislation in order to make it effective, with the motive of protecting the 'industry'.

While farming ventures are still at the research stage every effort must be made to bring down protective legislation and to see that this is accompanied by some well-policed National Parks so that at least parts of the populations can be protected. In my view an important task of the Survival Services Commission Sea Turtle Group, and particularly of the Executive Officer, is to keep a constant check on legislation in force throughout the world and to encourage, through people on the spot wherever possible, improvements in the legislation and its enforcement. Properly carried out, this work would have tremendous conservation impact for all species of sea turtles.

In some areas of the world such as the Caribbean and the western Indian Ocean (the Aldabra rookery) the green turtle has been almost exterminated. Conservation can hope to encourage the regeneration of the remnants of once huge populations by explaining the eventual benefit to the local inhabitants. Once again the possibility of farming ventures when the populations have made substantial recovery is a sound argument for conservation now.

The Red Data Book of I.U.C.N. lists the green turtle as status category 3. This reads as follows: 'Depleted. Although occurring in numbers adequate for survival, the species has been heavily depleted and continues to decline at a rate substantially greater than can be sustained.'

THE FLATBACK

Species like the flatback and Kemp's ridley, both of which have a very restricted distribution, are potentially extremely vulnerable and in my view should not be exploited at all. I.U.C.N., through its Survival Services Commission, should ensure that the respective governments, where these species occur, accept full responsibility for them and guarantee to ensure that exploitation is totally prohibited.

So far as is known, the flatback nests only in Australian waters and even the adults do not appear to move away from Australia. Part of our work in Queensland is directed towards finding out more about the biology of this species and also seeing that important breeding rookeries are set aside in perpetuity as National Parks.

The flatback has never been subject to any substantial level of

exploitation in Australian waters. Its flesh does not have the appeal of the green turtle to Europeans nor indeed to most aborigines, but its large eggs are eagerly sought by aborigines, as are those of all species of sea turtles. However, at present this does not constitute a threat to the species since much of its nesting occurs in uninhabited areas which are rarely or never visited by aborigines.

The flatback also occurs in the Northern Territory and possibly also in Western Australia but I know of no positive records. Now, while the species is not subject to any commercial exploitation whatsoever, would be the ideal time for Queensland, the Northern Territory and Western Australia to agree to a convention. In Queensland, as with all sea turtles, the flatback and its eggs are totally protected throughout the whole State at all times (aborigines are not subject to the Fauna Acts). Nevertheless, this does not ensure that exploitation could not take place at some future date if a commercial use was found for the species.

Undoubtedly the main threat to the flatback turtle will come from land alienation which is why we are hoping to obtain National Parks as soon as possible.

THE LOGGERHEAD TURTLE

The loggerhead is not an important commercial species, but like all sea turtles suffers as a result of the human population explosion and associated seaside development projects. Much of the nesting of the Atlantic race of the loggerhead occurs in the United States and until recently these populations appeared to be in no serious immediate danger. However, the situation has recently changed for the worse as a result of two factors. Professor Archie Carr in his book *The Turtle* wrote: 'These are the rapid development of coastlines as real estate and recreational areas, and the marked expansion of racoon populations. Because the racoon is able to live well with man the two factors often operate together against the loggerhead (racoons eat turtle eggs), and in spite of the laws on the books (to protect the turtles), the hold of *Caretta* on shores of the United States is slipping fast. Many of the best of the old loggerhead beaches have become cluttered with people and the constant traffic of cars. Even where the beach itself is not invaded, lights along coastal highways confuse the turtles when they come ashore to nest, or draw the emerging hatchlings away from the sea to be mashed by the thousands on the highways. Even in places in

which good will towards sea turtles is highest, the nesting females are interfered with by well-wishing posses who walk the shores at night, and arrange themselves in rings around every turtle that comes out.'

I have quoted Professor Carr as there is a lesson here. Perhaps it can be learned by the rest of the world which has not yet 'developed' to the extent of the United States? It is most encouraging to discover just how much the effects of urban sprawl and industry can be ameliorated at no extra cost by a little foresight. Coastal highways are a case in point. Surely it is possible for conservationists and planners to get together so that development goes ahead while minimising the impact on the natural resources of the country. This is equally important in a developed country with a high standard of living, or in a developing country, where unspoiled beaches cluttered at night by stars and turtles rather than motor cars, are an important ingredient in tourism.

The racoon situation is an example of human interference with the balance of nature having wide repercussions. Professor Carr continued, 'At most of the loggerhead beaches in the United States the racoon has become an important obstacle to protective measures. In primitive times racoons were no doubt kept in check by natural predators. Certainly, for instance, they are a favoured game of the few remaining pumas . . . racoons are more abundant than anybody ever heard of in the old days.

'To racoons, turtle eggs are manna from heaven. Being bright animals, they harvest them with deadly efficiency. On one stretch of Hutchinson's Island in St Lucie County, Florida, that I traveled not long ago, eight loggerheads nested before midnight and every nest was destroyed by racoons before daylight . . . The magnificent Cape Sable beaches lie within the Everglades National Park. The cape is almost completely free of human interference of all sorts. In a recent study, however, Ranger Max Holden found that of 199 loggerhead nests on a five-mile extent of the east cape beach, 140 were destroyed by racoons.'

In Australia substitute 'pig' for 'racoon' and you have a description of the situation on huge areas of mainland north Queensland. The pigs, feral descendants of escaped animals brought to Australia by British settlers, patrol the beaches and detect fresh turtle nests by sight and locate the actual position of the eggs by smell. During aerial survey work in north Queensland in 1969 and again in 1970 we commonly saw bands of pigs on the beaches, numbering up to

fifteen individuals in a single group, and evidence of nest destruction was very extensive. Certainly pig tracks were much more numerous than turtle tracks even at the height of the turtle nesting season!

The abundance of pigs in north Queensland makes the creation of mainland National Parks for turtles of doubtful value. For this reason we are concentrating most of our effort on islands which, fortunately are usually much more important rookeries in Queensland and, unless very large, usually lack introduced predators. In the south of the State, foxes, likewise introduced from Britain, destroy many nests. Dingoes, probably introduced to Australia by Australoid man, may also be an important predator in parts of Australia.

Large monitor lizards have always been a deterrent to mainland nesting in Australia and may be a reason why most important rookeries occur on islands. However, in recent times as a result of human introductions, the odds have been biased much more heavily against successful incubation of eggs deposited on mainland beaches. I am sure there are many other similar examples in different parts of the world. In any consideration of the influence of man, his effect on the species' balance by introductions (as in the case of pigs and foxes to Australia) or by destroying natural predators as has happened with the racoons in the United States, must be considered together with other factors such as land alienation.

To summarise, the loggerhead has no problems which are peculiar to its species. The Red Data Book lists the loggerhead as status category 3 like the green turtle.

KEMP'S RIDLEY

This species, like the flatback, is particularly vulnerable as a result of its very restricted distribution. The best solution to a situation such as this is for I.U.C.N. to arrange by a Convention that the Government of Mexico accept full responsibility for the species and guarantee that exploitation of a commercial nature will be totally prohibited at all times.

This species has a remarkably aggregated nesting behaviour in that virtually the entire breeding population of the species nests in the one locality, and furthermore, at the one time (see Chapter 7). The turtles almost all come ashore to nest on the same day.

The nesting locality is in the Mexican state of Tamaulipas. As pointed out by Professor Carr, this concentrated reproductive activity, which makes Kemp's ridley an extremely vulnerable species, also makes it the most susceptible to protective supervision.

'All that would be required would be systematic patrols of some sixty miles of shore during the months from March through June. The failing colony now gets no protection at all. . . . Only a consistent, careful vigil along the shore will save the species; and obviously, only Mexico can patrol a Mexican beach. It is very seldom that the fate of a species has so clearly depended upon the prompt and wholehearted application of a simple enforcement operation.' (Carr, 1968). The Red Data Book lists Kemp's ridley as category 1, which reads as follows: 'Endangered. Actively threatened with extinction. Continued survival unlikely without the implementation of special protective measures.'

PACIFIC RIDLEY

The conservation of this species is complicated by the fact that it has been consistently confused with the loggerhead so that many literature references are of doubtful validity.

To some extent its wide distribution reduces its vulnerability. However, the species is subjected to a great deal of uncontrolled exploitation, for the turtles themselves, for the eggs, or for both turtles and eggs.

The Pacific ridley is known to lay in northern Australian waters; however, no information on its numbers is currently available. The species is totally protected, along with all other sea turtles, in Queensland, and there would appear to be little difficulty in ensuring that any important rookeries which may be discovered in Queensland, the Northern Territory, or Western Australia are safeguarded. Undoubtedly action of this kind is needed and efforts should perhaps be concentrated in areas of stable government where important conservation can result from sound scientific advice.

The Pacific ridley is protected at Bigi Santi in Surinam but not farther east where there are important breeding aggregations. Although there is protective legislation in West Africa, Burma and India, legal harvesting occurs and it is extremely difficult to police the exploitation.

The Red Data Book lists the Pacific ridley as species category 2. This reads as follows: 'Rare. Not under immediate threat of extinction, but occurring in such small numbers and/or in such a restricted or specialised habitat that it could quickly disappear. Requires careful watching.'

THE HAWKSBILL TURTLE

The situation facing the hawksbill is typical of many animals whose fate has depended on the vagaries of fashion. From earliest times the species was hunted for its shell (tortoiseshell) but the development of plastics took the hunting pressure off the species and for a time it appeared less threatened than many other sea turtles. This is because the adult turtles are not eaten by most people although the eggs are used for food as with all species. Furthermore, the hawksbill nests very rapidly, and nesting is more diffuse than in most other species both seasonally and geographically with the result that a substantial proportion of the natural egg production is not molested.

Unfortunately the demand for tortoiseshell has returned. Calipee from the hawksbill turtle is also in demand now to augment decreasing quantities of green turtle calipee, and the skin from the soft parts can be sold to leather manufacturers. Professor Archie Carr is highly doubtful that the presumably small world populations of hawksbill turtles can long survive the spread of this new commerce. Writing in the Bulletin of the International Union for the Conservation of Nature and Natural Resources in January 1969 he said, 'This drain (imposed by the growing demand for tortoiseshell), stimulated also by the calipee and leather trade and combined with the constant raiding by egg hunters, makes *Eretmochelys* seem *one of the most clearly endangered genera of reptile in the entire world.*' (My italics).

What can be done to save this, the most decidedly tropical of the world's marine turtles? Apart from trying to bring about an improved conservation situation worldwide, by encouraging rationalised exploitation based on sound scientific advice, and backed up by effective legislation to control the level of exploitation, there are two main lines of action in my view. Firstly one should ensure that hawksbill rookeries in 'safe' areas are mapped and brought to the attention of governments so that they can be protected. This would appear to be obvious but requires to be

stated as it has not been done. Australia provides an excellent example of this. We are just becoming aware of all the most important green turtle rookeries in Queensland. As yet no important Australian rookery for the hawksbill has been reported in the literature. Work has not yet begun to delineate the main turtle rookeries in Western Australia and the Northern Territory, yet Australia as a Continent is rich in sea turtle resources, as they have been little exploited.

This situation is particularly topical at present regarding the hawksbill as we have only this year got clear evidence of the first important rookery areas in Australia. These are on islands of the Torres Strait, northern Queensland. We will carry out work on these islands later in the year.

The other situation which requires investigation is the possibility of farming hawksbills to provide tortoiseshell etc. without slaughtering wild individuals. The hawksbill is very easy to rear in captivity and if farming proved to be a commercial undertaking wild populations would soon return to the situation they enjoyed following the advent of plastics. The aim would be to satisfy the commercial demand for tortoiseshell from the farms. This would result in depressing the price for tortoiseshell, which is high as a direct reflection of short supply, and falling prices would surely result in reduced hunting effort. Conservation must at all times try to take a positive stand.

The Red Data Book lists the status of the hawksbill as species category 1 (the highest priority category) which reads as follows: 'Endangered. Actively threatened with extinction. Continued survival unlikely without the implementation of special protective measures.'

THE LEATHERY TURTLE

For some considerable time I have been particularly worried about the future of this species of turtle, which is the only member of its family. Its problems have been overlooked in recent years as a result of the fact that it is not being actively worked upon by anyone in a position to loudly pronounce upon its status, and because the most famous rookery (that at Trengganu in East Malaya) is the subject of intensive, but apparently well organised, exploitation.

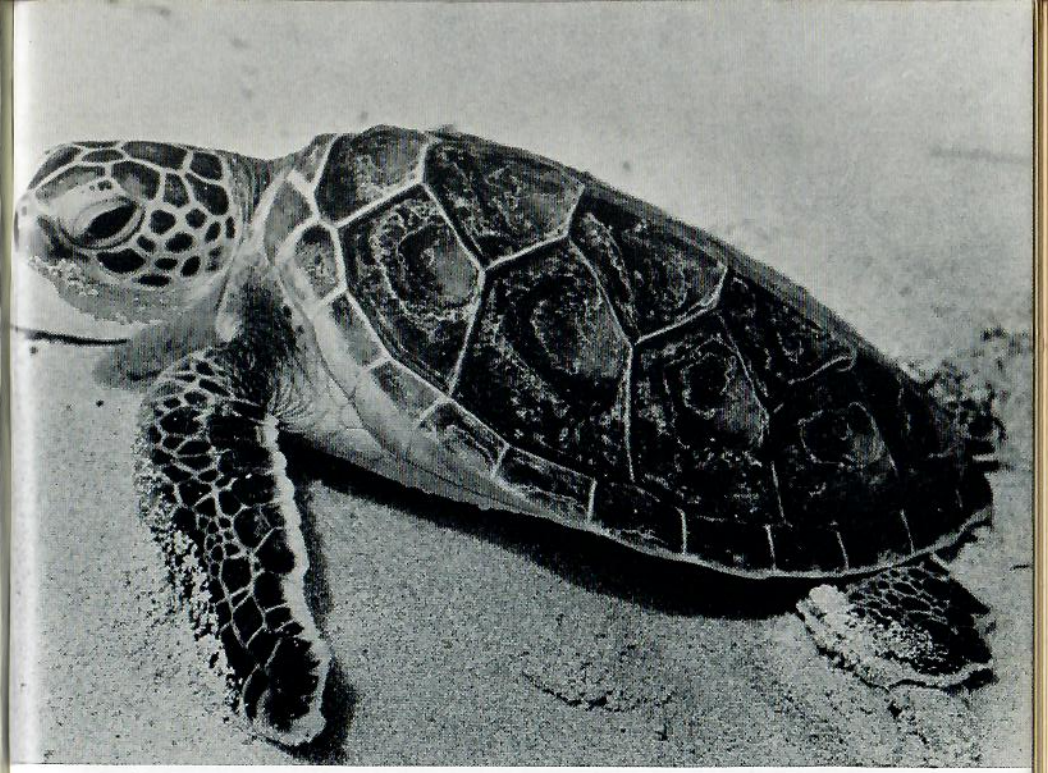
My own view is that the situation at Trengganu is unsatisfac-

tory. Virtually every clutch of eggs laid on the beach is taken by licensed egg collectors for sale for human consumption. Against this a small conservation scheme operates in which eggs are protected until they hatch and the hatchlings are then liberated. There is no evidence that this scheme is protecting sufficient eggs to offset the very efficient egg collection. Indeed a few simple calculations with pencil and paper will lead any competent ecologist to believe the reverse to be the case. The conservation programme there released 26,581 hatchlings in the five year period 1961–65, and about 48,000 in the three years 1966–68. Pritchard (1971) points out that 16,000 hatchlings would represent the production of only two or three good nesting nights and, of course, the turtles nest for many months. It is essential, therefore, that the conservation effort be greatly increased. I have visited the Trengganu rookery and prepared a plan for its future (Bustard, 1971a).

The leathery turtle, like the hawksbill, is listed in the I.U.C.N. Red Data Book as category 1. However, it is also given what is called 'star listing' (the data are listed on a pink page) together with Kemp's ridley which means that the species is critically endangered. Yet little appears to be being done to improve its status!

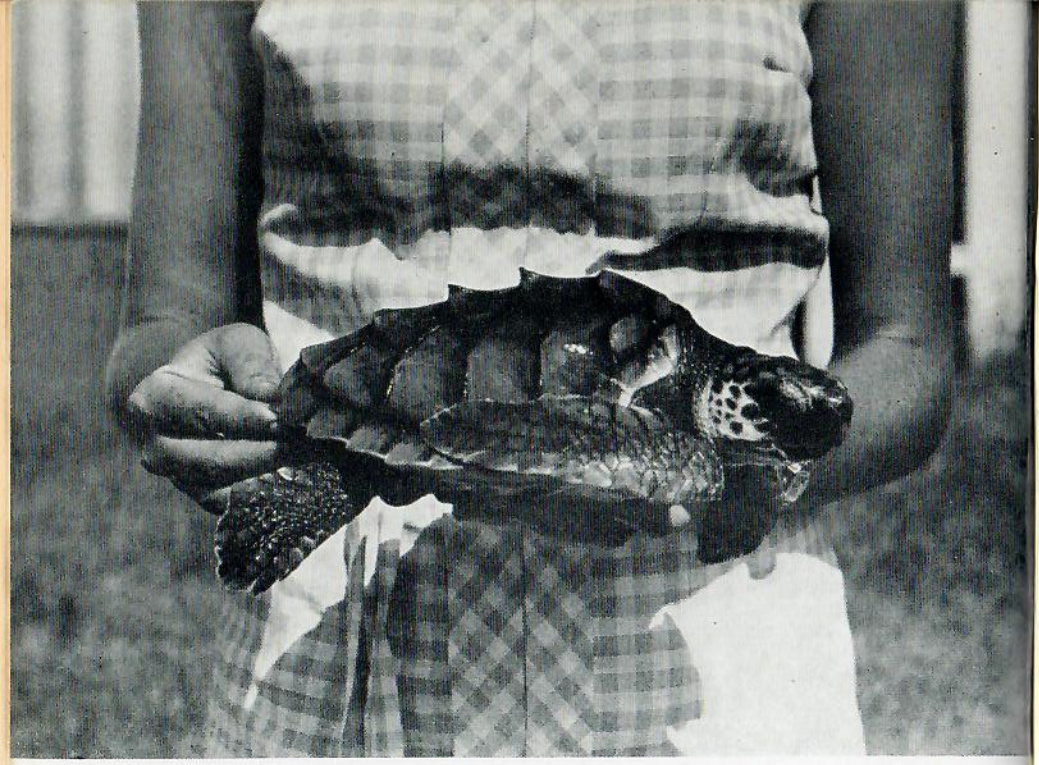
Part of the confusion surrounding the status of the leathery turtle stems from a reappraisal of Anon's (1961) estimate of possible world stocks. At that time the evidence available suggested there might be as few as 1000 mature females in the world. Recent information has permitted this figure to be revised upwards. However, in the absence of tagging work, population estimates must remain extremely tentative. It seems that world populations of mature females may number of the order of 20,000. This estimate could be too high, it could also prove to be slightly conservative. However, for a species with a world-wide distribution, this is certainly not large. Indeed it is disturbingly small when one recalls that at one of the two major world nesting beaches for the species (Trengganu) it is subject to virtually 100 percent egg collection.

In a world survey of the status of leathery turtles' nesting beaches Pritchard (1971) makes the following comments: 'Egg collectors are probably still a serious problem in Costa Rica . . . In Trinidad the present situation is not very hopeful . . . The main hope is for parties of sightseers and tourists to gather round each nesting turtle in such numbers that no poacher would dare

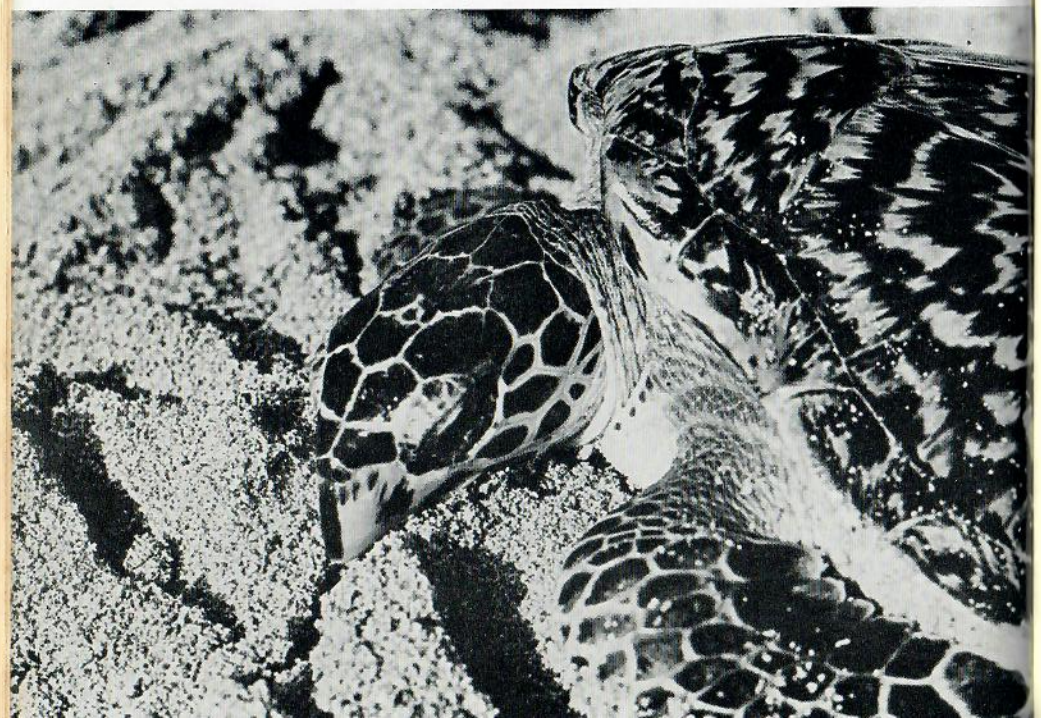


23. (a) One-year-old Heron Island green turtle, reared in captivity by the Tanis's.

(b) Katie Pau meets a five-year-old green turtle reared by the Tanis's.



24. (a) One-year-old loggerhead raised by the Tanis's. Note the prickly posterior edges of the carapace shields, particularly the centrals, at this age.
(b) Close-up of an Australian hawksbill turtle showing the pronounced 'beak' of this species.



attempt to kill the turtle. In Guyana the situation is probably hopeless, and many – possibly most – nesting turtles are killed quite legally ... In Surinam the leatherback enjoys complete (effective) protection. In French Guiana (where there is an extremely large rookery) sea turtles and their eggs are now protected by law; there are no enforcement personnel, but the beach where most of the leatherbacks nest is so remote that egg collectors are very rare ... Nothing is known of the survival situation or prospects of the eastern Atlantic leatherback colonies, though it is very likely that human predation is intensive.' Pritchard notes that the small rookeries in Tongaland (Natal) and Mexico are probably safe with little poaching. Finally he states, 'Koford's discovery in September 1969 of remains of at least 28 slaughtered leatherbacks on one kilometre of beach ... in Peru may indicate that a nesting colony there is being decimated.'

The above is not pleasant reading. In addition to confirming a very high level of predation on the species it demonstrates how little is yet known about its rookeries. Without this information it is totally impossible to plan concerted world-wide action to save the species. In view of the above statement by Pritchard it is extremely curious that he writes elsewhere of the leathery turtle, 'In fact it may be the least seriously threatened of the sea turtles' (Pritchard, 1969), and that Professor Archie Carr stated that the leathery turtle 'may have the least dreary outlook' (Carr, 1968). In my opinion, we have a larger population of green turtles in Queensland than *the total world population of the leathery turtle.* Since the green turtle is totally and effectively protected throughout Queensland at all times and the leathery turtle, as Pritchard has shown, is subject to intensive depredation by man almost everywhere, these figures are even misleading.

There is an urgent need to awaken informed interest among conservationists and people interested in nature world-wide to the real situation facing the various species of sea turtles. If the turtle experts themselves cannot agree on the basis of the available data then hope for a wider dissemination of information is indeed grim.

Carr (1968) after stating that eggs not adults form about the entire harvest of the leathery turtle commented as follows:

'The mild optimism I expressed over the survival outlook of the leatherback is based on the belief that cutting off the egg traffic could be done without great effort or expense. At the big Malayan

rookery, for example, the whole operation could probably be bought out for a few thousand dollars.'

In my view optimism should be curtailed until this has been achieved. The fact remains that this has not yet been done. If, as Professor Carr believes, it could be done 'without great effort or expense' then it would appear that conservationists are not very active in trying to save the leathery turtle!

Professor Carr continues his statement as follows: 'At the African and Surinam colonies the problem appears to be arranging effective patrol of the beaches. In Costa Rica the situation is somewhere between those of Malaya and Tongaland. Taking any turtle eggs is against the law in Costa Rica; but the Matina beach remains wholly unguarded and the *veladores* – the egg hunters – do as they please. Eggs are bootlegged out on mule cars and in canoes and sold with only moderate surreptition in the coastal towns, and clandestinely, even in the capital.'

In view of this statement the reader may be excused if he is somewhat dubious that the egg traffic could be cut off quite simply.

The reader will appreciate that there are many different ways in which particular problems can be tackled. In the above chapter I have merely stated what in my view would seem to be priorities for action and how best the problems can be overcome or at least greatly reduced. I do not think for a moment that my ideas are the only possible solutions. They are put forward as a plan for positive action.

APPENDIX

Identification Key for the World's Sea Turtles

Shell covered with horny scutes (tortoiseshell), a claw present on each forelimb I
Shell without horny scutes, forelimbs lack claws II

I. A. Four costal scutes on either side of carapace (Fig. 14a, C_1–C_4); nuchal (N) separated from the first costal (C_1) by first vertebra (V_1).

1. One pair of elongated prefrontals (Fig. 15a, pf), scutes of the shell do not overlap.

a. Scales on upper surfaces of distal half of front flippers large (Fig. 16a). Areas of much smaller scales between the phalanges lacking. Postocular count usually four. Shell coloration usually light to dark brown with darker markings giving a mottled effect.
green turtle (*Chelonia mydas*) Plate 2/3

b. Distal half of front flippers with single rows of large scales extending along phalanges. Many minute scales or wrinkled skin present on intervening areas (Fig. 16b). Three postoculars. Shell greatly depressed, marginals (M) curve upwards. Shell coloration olive-grey.
flatback (*Chelonia depressa*) Plate 2/3

2. Two pairs of prefrontals (Fig. 15b, pf); scales of the shell overlapping like the tiles on a roof. Shell coloration amber with streak-like markings of red-brown, black and yellow.
hawksbill (*Eretmochelys imbricata*) Plate 2/3

B. Five or more costal shields on either side of carapace (Fig. 14b–c, C_1–C_5); nuchal (N) in contact with first costal (C_1) (Fig. 14b–c); two pairs of prefrontals or a group of five or more shields and scales on the prefrontal region (Fig. 15c).

1. Five (rarely six) costal shields on either side of carapace (Fig. 14b, C_1–C_5).

a. Shell always considerably longer than wide. Inframarginal scutes lack pores. Shell coloration reddish brown to brown. loggerhead (*Caretta caretta*) Plate 2/3

b. Carapace extremely broad in relation to its length; may be even broader than long. Inframarginals with a pore (minute opening) at hind border. Carapace grey-brown to blackish or olive-green.
Kemp's ridley (*Lepidochelys kempi*) Plate 2/3

2. Six to nine costal shields on either side of carapace (Fig. 14c). Shell relatively broad. Shell coloration grey-green to dark brown. olive ridley (*Lepidochelys olivaceas*) Plate 2/3

II. Shell covered with a thick leathery skin and strongly tapering towards rear (Fig. 14d). Forelimbs lack claws. Coloration of upper parts blackish. Small irregular white or pinkish spots often present.
leathery turtle (*Dermochelys coriacea*) Plate 2/3

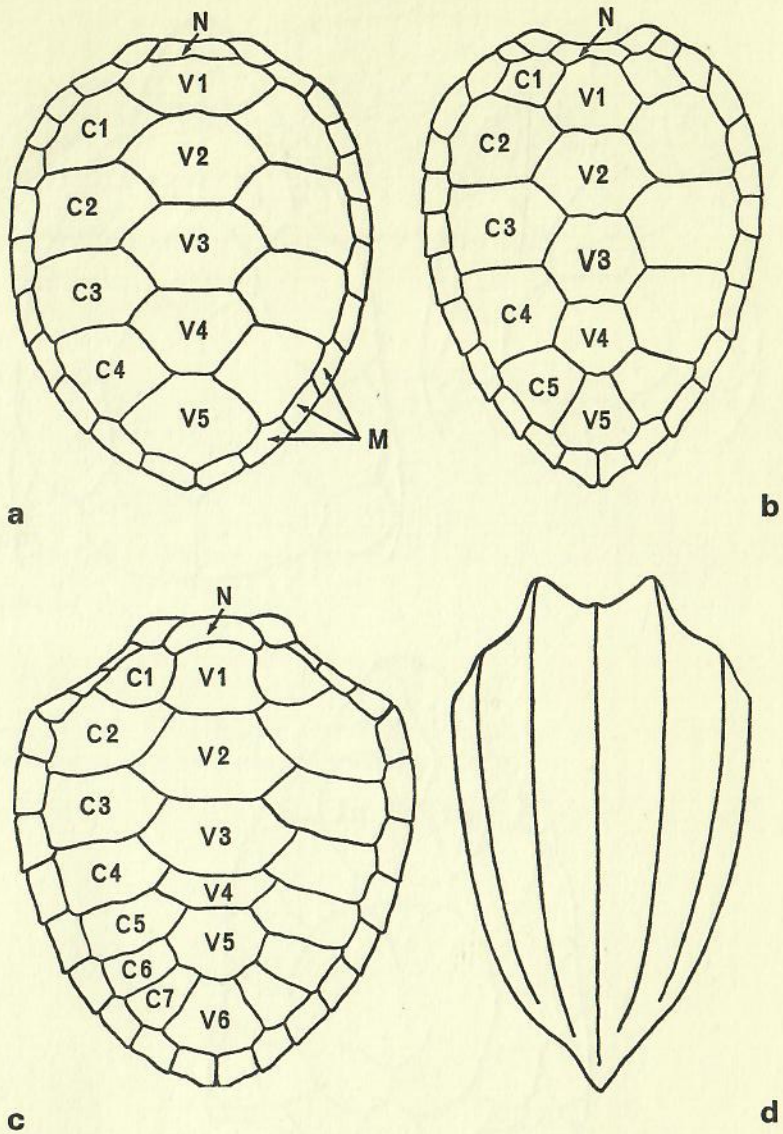


FIG. 14 Appearance of carapace and arrangement of shields, (a) in *Chelonia* and *Eretmochelys*, (b) in *Caretta* (*Lepidochelys kempi* has similar shield arrangement but carapace is much broader), (c) in *Lepidochelys olivacea*, and (d) in *Dermochelys coriacea*. N – nuchal, C – costal, V – vertebral, M – marginal.

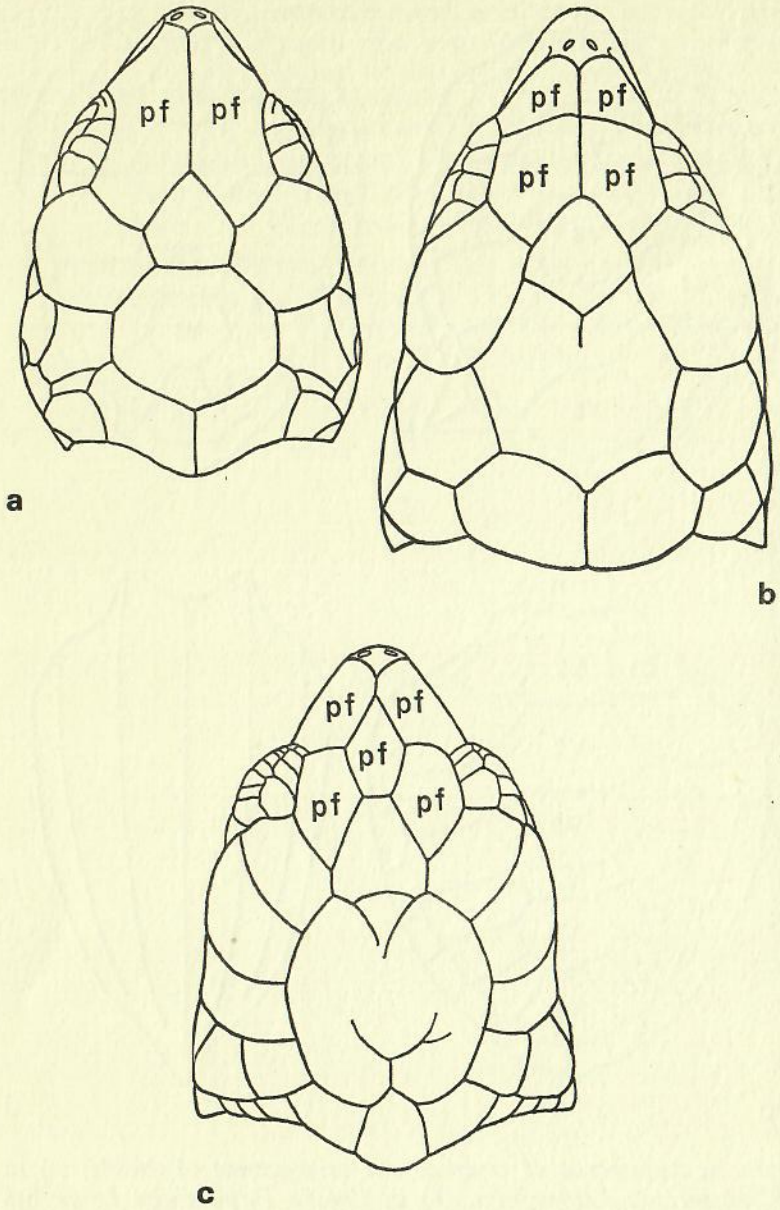


FIG. 15 Arrangement and appearance of head shields, (a) in *Chelonia*, (b) in *Eremochelys*, and (c) in *Caretta* and *Lepidochelys*. Pf – prefrontals.

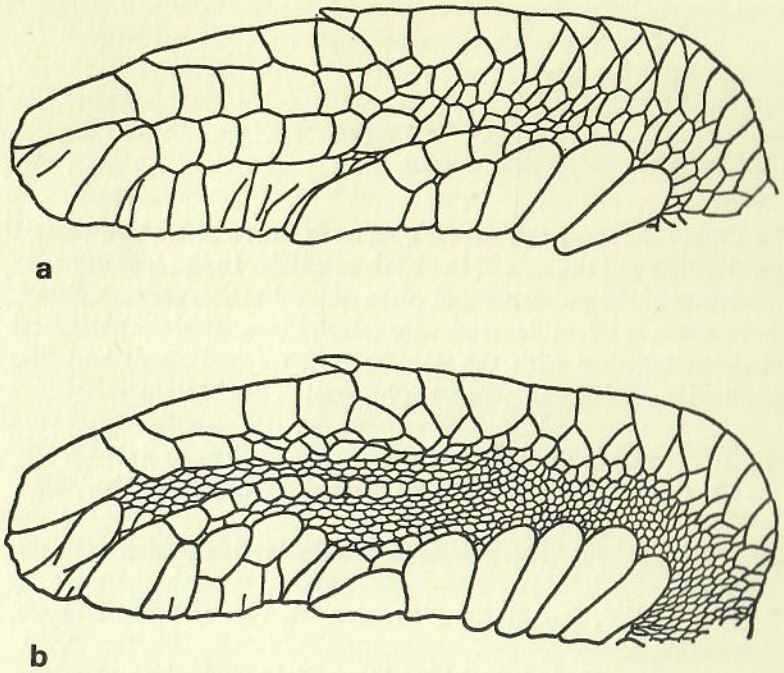


FIG. 16 Left front flipper of (a) *Chelonia mydas* and (b) *Chelonia depressa* to show difference in scalation.

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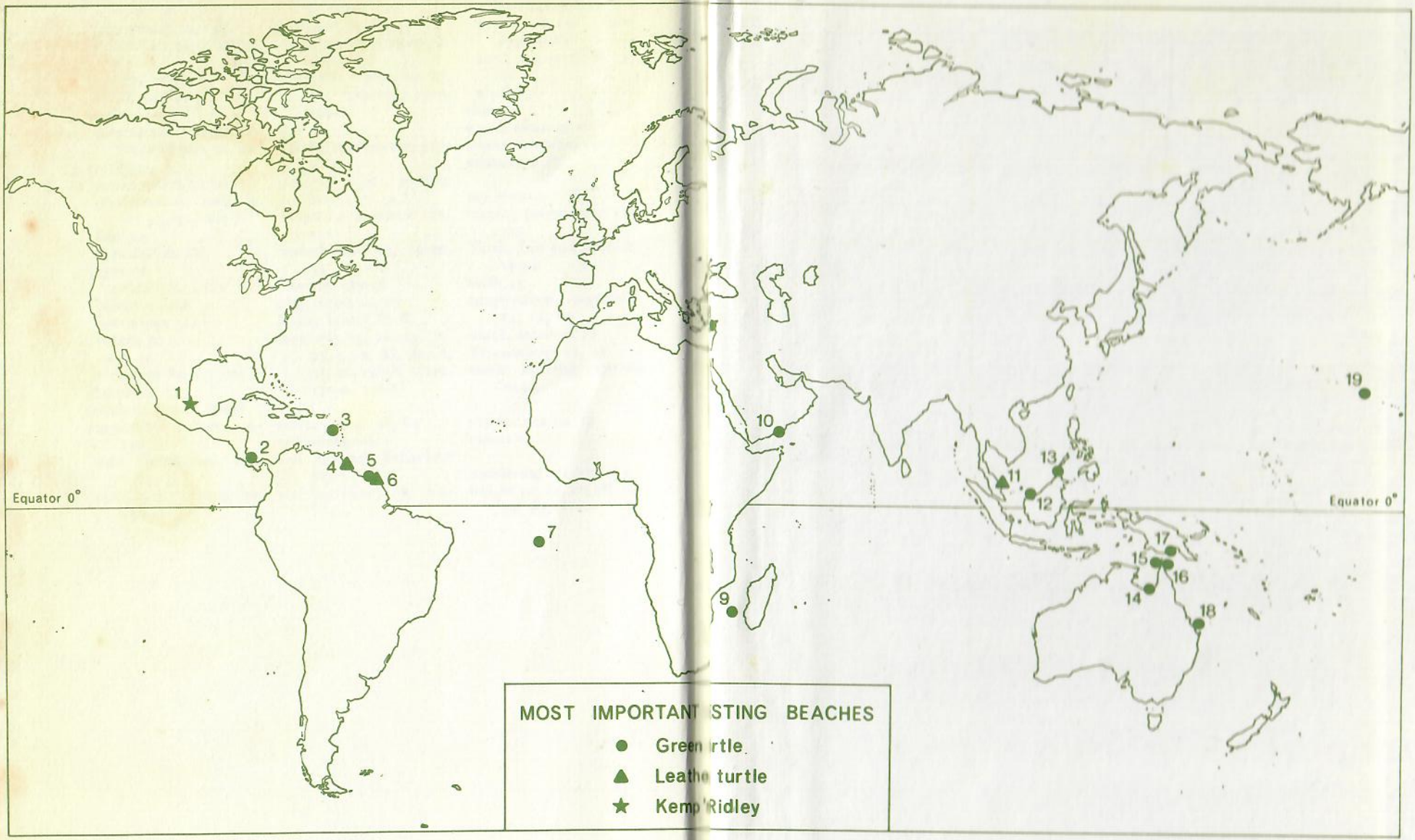

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Robert
Bustard

Sea Turtles

Collins

TROPICAL QUEENSLAND
by
Stanley and Kay Breeden

In the tropical north-east of Australia, along the strip of Queensland coastline running 700 miles from Townsville to Cape York, lies one of the least known and most varied of all the natural regions of Australia. Not only does it contain the richest variety of wildlife on the continent, but also the tropical rainforest of the kind that exists in this area is the most luxuriant, diverse and complex plant community on earth.

Australia does not possess a range of wildlife on the same grand and spectacular scale as some of the other continents of the earth. No great predators or huge herbivores; no lions, giraffes or elephants roam the eucalypt forests or scrub-covered plains. Cut off from the land mass of Asia in prehistoric times, a unique pattern of wildlife has evolved in Australia which is quite distinct from the rest of the world. Because many of the animals are shy, small and nocturnal and do not survive outside their own natural environment, the general public knows little about any except the commonest species, and even less about the way they live.

To present a total impression of this unique part of Australia, demonstrating the interrelationships of climate, soils, topography, plants and animals, the authors spent several months in this field in remote areas working often in conditions of considerable hardship and danger. They studied and photographed the animals in their natural environment, many for the first time, as they wished above all to show wildlife in its living context. The result is a magnificent record in words and pictures of a world few people know and even less have written about. A world, unfortunately, now seriously threatened by the growth of civilisation and the depredation of man.

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