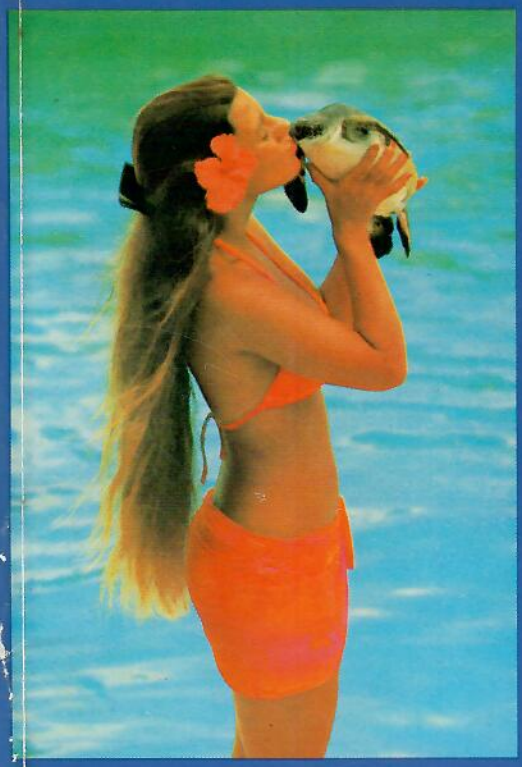
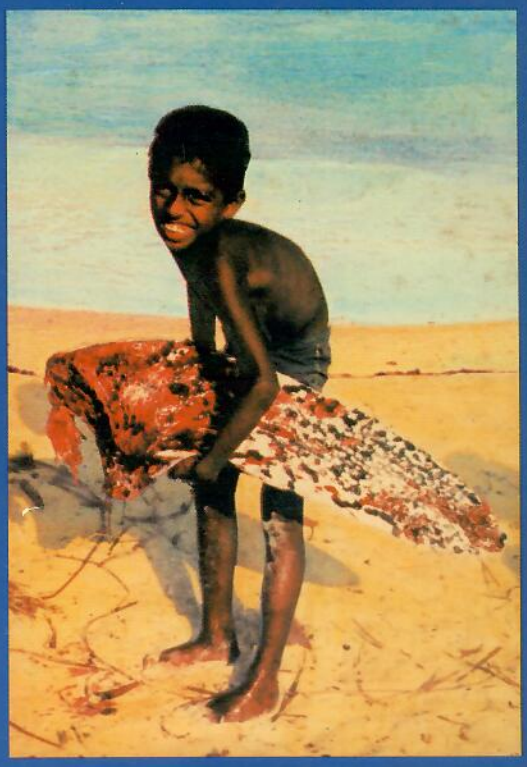
CONSERVING SEA TURTLES





N. Mrosovsky

10. DANGEROUS CATEGORIES

In some years the nesting of green turtles on Raine Island, Australia, is so dense that the easiest way to walk around the island is on the backs of the turtles. That is how Colin Limpus of the Queensland National Parks and Wildlife Service described it to a meeting of turtle biologists in Toronto in 1978.

Recent estimates put the number of leatherbacks coming ashore along the west coast of Mexico at 30,000 a year (Pritchard, in press). In French Guiana on the beach at Les Hattes 10% of leatherbacks dig up and destroy clutches laid previously by other females (Fretey and Lescure, 1979).

In Orissa, India, around 150,000 olive ridleys nest each year (Kar, 1980). There are also great arribadas (mass nestings) of this species in Costa Rica; within a few days more than a million eggs may be crushed by the turtles themselves, 15-30% of the total laid during a large arribada (Cornelius, in press).

Of course, numbers are not everything. Passenger pigeons were so numerous in North America in the last century that when they came in to roost the sky became dark and when they left the dung on the ground lay several centimetres deep. These sights were witnessed and recorded by, among others, James Audubon (1831):

> Every thing proved to me that the number of birds resorting to this part of the forest must be immense beyond conception.....The sun was lost to our view, yet not a Pigeon had arrived..... Suddenly there burst forth a general cry of 'Here they come!' The noise which they made, though yet distant, reminded me of a hard gale at sea, passing through the rigging of a close-reefed vessel. As the birds arrived and passed over me, I felt a current of air that surprised me....The Pigeons, arriving by thousands, alighted everywhere, one above another, until solid masses as large as hogsheads were formed on the branches all around. Here and there the perches gave way under the weight with a crash, and, falling to the ground, destroyed hundreds of the birds beneath, forcing down the dense groups with which every stick was loaded. It was a scene of uproar and confusion. I found it quite useless to speak, or even to shout to those persons who were nearest to me. Even the reports of guns were seldom heard, and I was made aware of the firing only by seeing the shooters reloading.

Well, they went on reloading all over North America and before long the passenger pigeon was extinct.

With turtles mere numbers are particularly deceptive as populations fluctuate erratically from year to year (Carr et al., 1978). The 1975-1976 season was a very poor one for turtles throughout much of Australia (Kowarsky, 1978). And yet that vast breeding aggregations can occur, in Australia, India, Costa Rica and Mexico, for instance, makes it at least respectable to question whether turtles really are endangered.

But what does being 'endangered' mean? There are 2 senses of the word. There is the general sense with which we are familiar and there is the endangered category enshrined by the Red Data Books of the International Union for Conservation of Nature and Natural Resources (IUCN). In Volume 3 (1968-1970, covering Amphibia and Reptilia), endangered was defined as follows:

> In immediate danger of extinction: continued survival unlikely without the implementation of special protective measures.

When this volume was revised in 1975, this definition was replaced. It was no longer necessary for the danger of extinction to be immediate. Endangered now meant:

> Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating.
> Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that are possibly already extinct.

A footnote pointed out that in practice the endangered category may include, temporarily:

> taxa whose populations are beginning to recover as a result of remedial action, but whose recovery is insufficient to justify their transfer to another category.

This definition is much broader than the previous one. It encompasses species possibly already extinct, those in immediate danger of extinction, those in danger at some later time and those beginning to recover. Therefore to say that a species is endangered may suggest urgency but

is not very informative. With sea turtles, leaving aside the perilously diminished Kemp's ridley, considered earlier in Chapter 7, when the details are examined there are reasons for doubting that most are in immediate danger of extinction. Let us look at them in turn.

Green turtle *(Chelonia mydas)*

Estimates of turtle populations are best given in terms of adult females. These can be counted when they come ashore to lay their eggs. Males are seen much less often and nobody knows what the sex ratio is. There are also many juveniles and hatchlings, especially just after the nesting season, but these are seldom observed after they enter the water. The number of breeding females, or adults of both sexes, assuming a 1:1 ratio, can still be used to compare different areas and species, and to assess population trends.

For the green turtle this can only be done on a regional and limited basis. There are not even semi-solid data on world populations. In 1974 Ehrenfeld estimated there were between 100,000 and 400,000 adult males and females. Five years later, Pritchard (1979a) suggested that they might number in the millions. Most probably there are now more than 400,000 mature green turtles. Assuming a 1:1 sex ratio, in the Arabian area alone there are thought to be around 109,000 mature green turtles (Ross and Barwani, in press), in the western Caribbean another 63,000 (Carr et al., 1978). Then there are the massive green turtle populations in Australia. But more important than there still being a fair number of these turtles is that their nesting beaches are widespread. They have not, like the passenger pigeon, put all their eggs into 1 or 2 national or environmental baskets. An atlas of sea turtle nesting beaches issued by the Sea Turtle Rescue Fund shows 144 nesting sites for green turtles; 41 of these are considered major (Sternberg, 1981). The atlas is careful to point out that it is not definitive. It is vague on what constitutes a major and minor nesting site and also on what constitutes a site; nesting at several points along a coast line could be scored in various ways. Nevertheless, without putting emphasis on the precise figures, it is incontrovertible that the green turtle still nests in many different parts of the world.

But there are more cogent reasons, beyond the numbers left and the widespread nesting, for thinking that the green turtle is not in immediate danger of extinction. Like some other sea turtles, it is not a

species whose hold upon this Earth is especially precarious. Despite intensive exploitation over several hundred years in the Caribbean there are still some green turtles left there. They have been drastically reduced, to be sure, but the real wonder is that there are any left there at all. They are survivors against great odds (Hughes, 1979). Laying so many eggs, sometimes on remote islands or inaccessible beaches contributes towards this biological resilience. Of course if all breeding females are killed year after year, then populations can soon be wiped out. Coming ashore to lay eggs is a liability; sea turtles are not aggressive and can easily be killed or turned over and dragged away. Turtles cannot withstand that kind of pressure any more than other species. There are limits to their resilience.

Finally, it should be remembered that green turtles will breed in captivity (Wood and Wood, 1980). They will sometimes lay eggs in zoos, and even in places as seemingly unpropitious as the cave at Devil's Hole Sink in Bermuda (Wingate, 1980). Their requirements for nesting areas are not dauntingly stringent. Mating may sometimes present more problems but there is the possibility of artificial insemination, now being studied at the Cayman Farm. Breeding in captivity does not necessarily safeguard the species. Captive stock have to have sufficient genetic variability to be viable. There are dangers of disease. But at least it is something to fall back on if the species really plunges to dangerously low levels in the wild.

In summary then, green turtles still exist in fair numbers, spread out in different parts of the world. They are biologically resilient and they breed in captivity. These points are well known and hardly add up to an immediate danger of extinction. Yet the public are told otherwise. A pamphlet sent out by the Sea Turtle Rescue Fund in 1981 says that the slaughter of sea turtles is of 'such magnitude that extinction looms only a few years away' and that sea turtles other than the flatback 'without immediate help will soon disappear from the face of the earth.' According to material accompanying a 1980 Cleveland Museum of Natural History exhibition of confiscated wildlife products, 'if present trends continue, this sea turtle [the green turtle] will become extinct by 1983.'

What about trends then? There may still be plenty of green turtles left, but if they are declining very rapidly, if the present 'causal factors continue operating,' then there might soon be none and an alarmist position would be justified. Trends in turtle populations are difficult to

assess because of the huge fluctuations in nesting from year to year and because few colonies have been monitored for long enough. The best studied green turtle populations are at Tortuguero in Costa Rica and in Surinam. If anything there are upward trends at both these places (Figures 4 & 5), but because of the problem of erratic fluctuations a more cautious statement is preferable: between 1971 and 1980 there was no downward trend in the numbers nesting at Tortuguero (Carr et al., 1978) and between 1968 and 1978 there was no downward trend in Surinam either (Schulz, 1980). There is no way that projections of regression lines for these data would intercept zero in a few years.

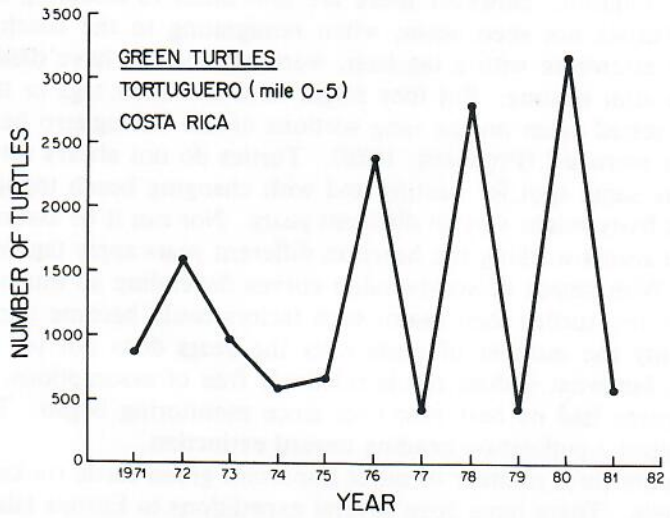


Figure 4. Numbers of green turtles (tagged remigrants plus newly tagged recruits) emerging on a 5 mile study area at Tortuguero, Costa Rica (data from Carr et al., 1978, Carr, 1980b and personal communication). The 5 mile (8 km) stretch is part of a 22 mile (35 km) long beach. The numbers nesting over the whole beach are much greater; for example in 1980 it was estimated that 52,046 turtles nest over the whole beach (Carr, 1980b). Because such estimates involve assumptions, data for the 5 mile stretch are better for showing trends.

But not too much faith should be placed in trends with species that mature slowly and live long. To take an extreme example, suppose from a certain day, forever after, every single egg laid on a given beach failed to hatch. With continued breeding by already adult turtles and

with hatchlings and juveniles from previous seasons coming along, it might take years before counts of nesting turtles revealed the disaster. By the same token, of course, stable or even declining nesting on beaches where turtles have been afforded protection could conceal a dramatic upsurge around the corner. So ideally information about population dynamics and age structure is needed to interpret trends. In an attempt to go beyond counts of nesting females, Bjorndal (1980b) has calculated the chances of adult green turtles at Tortuguero surviving in successive years from 1959 to 1972. The increasing death rate in recent years suggests that the situation there is less sound than the trends might indicate. However there are difficulties in assessing survivorship. Turtles not seen again, when remigrating to the beach or when caught elsewhere with a tag later, were assumed to have died in the first year after nesting. But they might have lost their tags or they might have nested again on the long sections of the Tortuguero beach not routinely patrolled (Pritchard, 1980). Turtles do not always return to exactly the same spot for nesting and with changing beach topography nest-site fixity might vary in different years. Nor can it be assumed that different teams working the beach in different years apply tags with equal skill. With slopes of survivorship curves depending so much on the relatively few turtles seen again, such factors could become important. Certainly the number of nests over the years does not tell the whole story, but what it does tell is relatively free of assumptions. In 1980 Tortuguero had its best year ever since monitoring began. That does not suggest a population heading toward extinction.

Information for a number of other important green turtle rookeries is less adequate. There have been several expeditions to Europa Island, in the Madagascar channel, but methods, months of the year covered and extent of the island surveyed differed. In a recent study there, the mosquitoes proved too nasty for the investigators and night work was limited. The numbers of new tracks seen each morning were the main data. As turtles often come ashore and return to the sea without laying, tracks cannot be equated with nests. Nevertheless, track numbers can be used for comparative purposes. The number of tracks made on the Plage de la Station for the month of November, near the height of the nesting season, for different years was:

1970:	52 per 24 hr	(Hughes, 1974a)
1973:	6 per 24 hr	(Servan, 1976)
1978:	24 per 24 hr	(Lebeau et al., 1979)

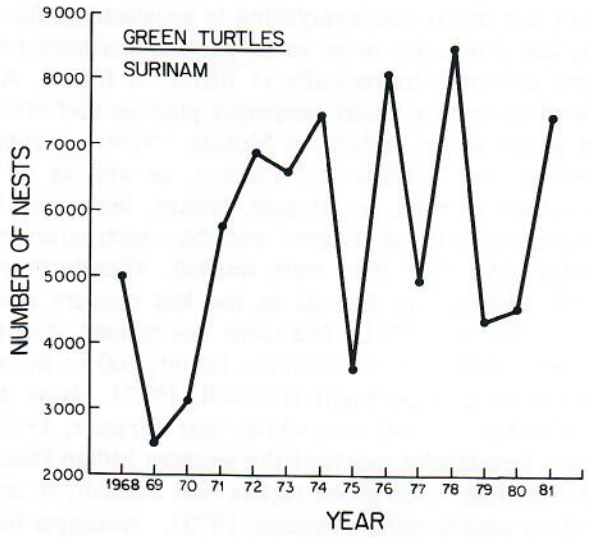


Figure 5. Numbers of green turtle nests on all the main nesting beaches in Surinam. Data from Schulz (1980) and Reichart, H.A. (personal communication). Individual turtles lay several times in a season so the number of turtles is less than the number of nests.

It is impossible to say whether these figures are just part of the now expected year to year fluctuations in nesting populations or whether, with an estimated 7,000 turtles of all sizes being taken each year around southwestern Madagascar (Hughes, 1971b), there has been a decline. The number of turtles emerging each night on the whole of Europa Island is more than 10 times the number of the Plage de la Station (Hughes, 1974a; Servan, 1976) so there were still many turtles left in 1978. Although recently some hatchlings have been collected for ranching, in the order of 20,000-30,000 a year (Chapter 14), the available data for this colony do not demonstrate a sustained decline.

The same is true of Raine Island, Australia. In fact in Australia as a whole, there is no reason to suppose that green turtle populations are crashing (Limpus, in press). Consideration of these few areas alone is enough to show that disappearance of the green turtle in the next few years is unlikely.

But that does not mean that everything is satisfactory, far from it. Even if over the last 2 decades or so some populations have held their own, others have declined dramatically in historical times. Audubon (see 1926), as well as writing about passenger pigeons and other birds, left accounts of green turtle nesting in Florida. 'Great numbers,' he wrote, 'are killed by the Turtlers and Indians, as well as by various species of carnivorous animals, as cougars, lynxes, bears and wolves.'- He also described the activity of 'Eggers' and the construction of crawls to keep the turtles alive until they were wanted. Clearly there was a major green turtle resource in Florida in the last century and this is now virtually gone (Rebel, 1974). The same has happened in the Seychelles. In the early 1900s, on Assumption Island, 200 or more green turtles came ashore in a single night (Hornell, 1927). Now there are only about that number of nests in a whole year (Frazier, 1975). And numbers are down throughout much of the western Indian Ocean. It is estimated that fewer than 5,500 green turtles nest annually in an area of more than a million square miles (Frazier, 1975). Attempts to portray these declines quantitatively for a particular island, Aldabra Atoll, have been made (Frazier, 1974, 1976) but criticized as being much exaggerated (Stoddart, 1976). Because beaches were not patrolled over a number of years, accurate assessments of what happened may never be possible. But to present some balance to the apparently healthy state of the Tortuguero and Surinam green turtle colonies, Figures 6, 7 & 8 show the declines in export of green turtle products from the Seychelles and the decline in egg production on the Turtle Islands in East Malaysia. Even in places where turtles are still taken in large numbers there may be hidden problems. For instance the annual catch of green turtles around St. Brandon, Mauritius, held up surprisingly well from 1937 to 1971 (Hughes, 1976), but if the figures have been maintained by increased and more efficient fishing, as seems likely, then they conceal a population decline. And East Pacific green turtles nesting in Mexico are currently under severe pressure (Pritchard and Cliffton, 1981). So there certainly have been drastic declines and some colonies of green turtles may soon be lost completely. But even if they are, with some 144 nesting sites at present (Sternberg, 1981), this would not put the species in immediate danger of extinction.

As to less immediate danger, the 'if the causal factors continue operating' part of the Red Data Book definition of endangered, this too is debatable because some of the present factors affecting green turtles

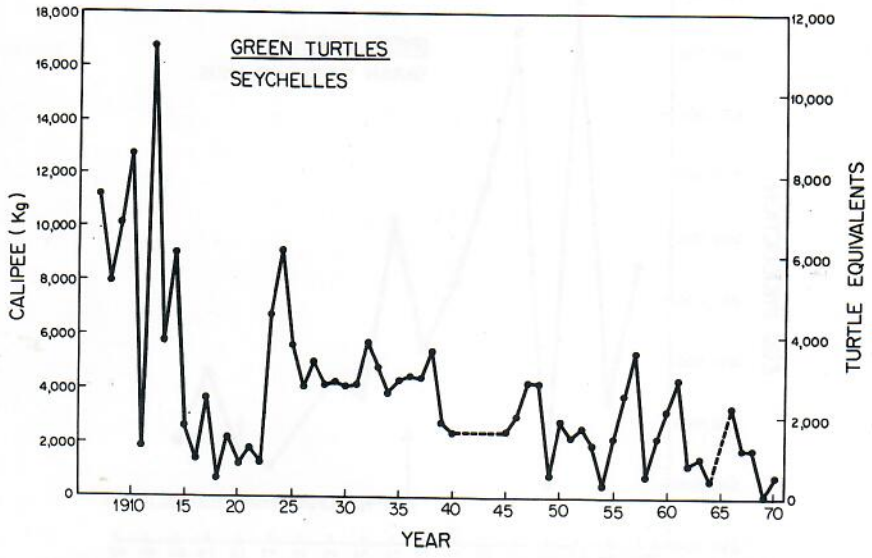


Figure 6. Exports from the Seychelles of calipee (part used for making soup) and equivalent in green turtles assuming one turtle provides 1.5 kg of calipee. Data from the Blue Books, Trade Reports, Seychelles, cited by Stoddart (1976).

are favourable. Some major populations of the species, in Costa Rica, Surinam, Europa Island, Australia, Malaysia and the Galapagos Islands receive at least a measure of protection. Tortuguero is a national park though fishermen are allowed to harpoon turtles beyond a certain offshore limit. In Surinam most of the turtles nest within the boundaries of nature reserves; populations are monitored and quotas of eggs taken and sold in the market can be adjusted accordingly. Europa is protected as much by the island's inaccessibility and fiendish profusion of mosquitoes as by regulations, though these exist. In Australia aborigines have traditional rights but otherwise taking turtles is illegal; the Raine Island green turtle rookery, the most important nesting site for green turtles there, lies among poorly-charted reefs way out in the Torres Strait and is difficult to reach (Lavery et al., 1980). There is no evidence that numbers of green turtles at any of these places are declining. If whatever causal factors responsible for this situation continue

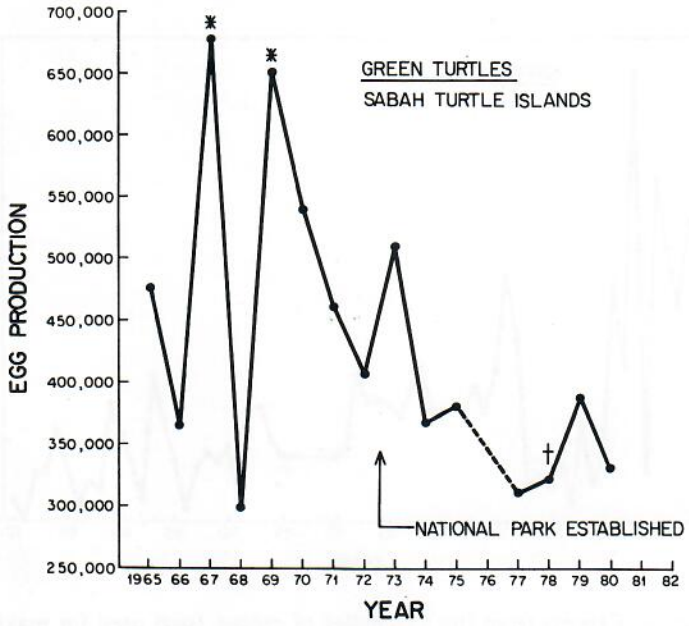


Figure 7. Egg production on 3 of the Sabah Turtle Islands (Selingaan, Bakkungaan Kecil and Gulisaan). Nearly all are from green turtles but a few from hawksbills may have been included. Prior to 1973 eggs were harvested under licence; a small percent were put into hatcheries. Some figures may be inaccurate because licencees tend to under-report the number of eggs they take. After 1973 most eggs were transplanted to hatcheries. *harvest checked by government personnel. †some stolen eggs not included. Data from de Silva (in press, personal communication).

operating, what is the basis for the IUCN Red Data Book classifying this species as endangered? In fact, a draft version (1982) for a revised data sheet for the green turtle tentatively changed its status to vulnerable, but after some debate the latest Red Data Book (1982) edition left this species in the endangered category.

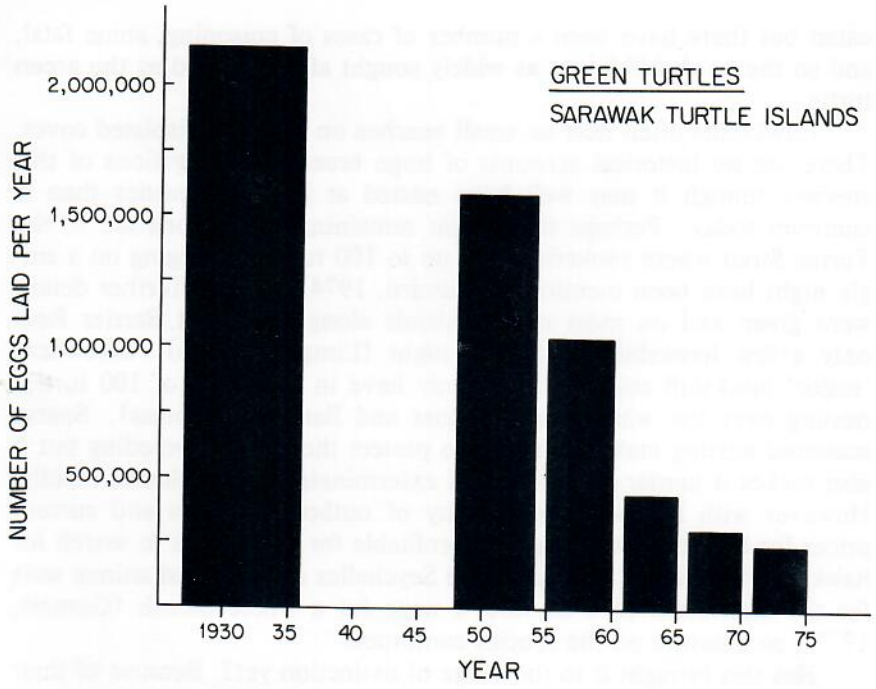


Figure 8. Number of eggs laid on the Sarawak Turtle Islands, East Malaysia. Each bar shows annual averages based on different number of years. Data from Harrisson (1976).

Hawksbill *(Eretmochelys imbricata)*

The hawksbill is also currently listed as endangered by the Red Data Book and was so even in 1970, before the definition of this category changed. This implies that the hawksbill is considered in immediate danger of extinction, unless the prospects for this species suddenly happened to brighten around the time the definition of endangered changed in 1975, and nobody has asserted that.

The main demand for hawksbill stems from the value of its shell. Japan imports large quantities, for instance more than 40,000 kg a year from 1976 to 1979; this is equivalent to more than 44,000 animals a year (Anon., 1977; Mack et al., in press). The meat is also sometimes

eaten but there have been a number of cases of poisoning, some fatal, and so the hawksbill is not as widely sought after for food as the green turtle.

Hawksbills often nest on small beaches on islands or isolated coves. There are no historical accounts of huge breeding aggregations of this species, though it may well have nested at greater densities than is common today. Perhaps the largest remaining populations are in the Torres Strait where rookeries with up to 100 turtles emerging on a single night have been mentioned (Bustard, 1974). But no further details were given and on most of the islands along the Great Barrier Reef only a few hawksbills nest each night (Limpus, 1980b). Elsewhere 'major' hawksbill colonies today only have in the order of 100 turtles nesting over the whole season (Ross and Barwani, in press). Sparse scattered nesting makes it harder to protect the species' breeding but it also makes it harder to exploit and exterminate whole colonies rapidly. However with increasing availability of outboard motors and current prices for the shell, it is easy and profitable for individuals to search for hawksbills in remote places. In the Seychelles a good-sized animal sells for the equivalent of a labourer's wage for a whole month (Garnett, 1978), so pressure on the species continues.

Has this brought it to the verge of extinction yet? Because of their low nesting densities, hawksbills are not attractive for investing time in the kinds of long-term detailed studies that have been made on the other sea turtles. So, for example, there are few data on nest-site fixity and it is not possible to assess what the likelihood is that following elimination of hawksbills from one area others will move in from adjacent places. Population estimates also become exceedingly difficult.

Nevertheless, even if not numerous, the hawksbill still occurs in many parts of the world. Sternberg's (1981) atlas lists 95 nesting places. As with green turtles, the exact number is not important because it depends on definitions, but it is clear that hawksbills still breed in many parts of the world. With this kind of distribution, even if some colonies disappeared altogether, the species could still survive. 'Immediate danger of extinction' seems rather an exaggeration.

As for trends, detailed data of the kind obtained for some green turtle rookeries, spanning a decade or so, are only available for 2 hawksbill breeding areas, both protected. In neither are declines evident (Figures 9 & 10). But hawksbill nesting in Surinam is minor; and on Cousin Island the increase since a resident warden was installed

could be the result of turtles moving in from other areas. Hawksbills do not always nest on the same island in the Indian Ocean (Diamond, 1976). Yet that nesting on Cousin Island has not actually decreased is encouraging because protection there is only partially effective and many reproductive females are killed throughout the Seychelles, as many as half the breeding population each year according to some tentative estimates (Garnett, 1978). Despite these pressures the latest surveys find that hawksbills are 'still relatively numerous' in the Seychelles (Mortimer, 1982).

However, if one bases more on general reports of declining numbers of hawksbills throughout the world, and if the demand for shell goes unabated or undiverted, then there is some danger the species will become extinct. Certainly control of exploitation of the hawksbill is urgently needed.

Olive ridley *(Lepidochelys olivacea)*

The nesting strategy of this species is very different from that of the hawksbill. Instead of scattering over wide areas, it specializes in huge arribadas of thousands and thousands of animals all stranding at the same time. Synchronous nesting makes the olive ridley a tempting target for exploitation and poachers. As many as 500 a day have been killed at Escobilla, Mexico, as they gather offshore for nesting (Cahill, 1978; Pritchard, 1978). Even away from the nesting grounds many olive ridleys have been taken in recent years, in the order of 100,000 a year in the late 1970s by the Ecuadorian leather industry (Green and Hurtado, 1980). That Ecuador was a member of CITES did not prevent the products being exported.

Many eggs have also been taken. Prior to 1967 nearly all of those laid at Eilanti, Surinam, were collected by Carib Indians who divided up the beach among themselves for this purpose. Competition for eggs was so intense that the proprietors of a particular section used to go out with brooms and sweep the beach clear of any debris that might discourage turtles from nesting there. Many eggs have also been taken in Mexico. Mass nesting also attracts animal predators. Coyotes, racoons and opossums dig up the eggs; black vultures and ghost crabs attack the hatchlings. On the 1,300-m beach at Nancite, Costa Rica, there are about 2,800 ghost crabs large enough to catch a hatchling; that means there is a crab for every half metre of beach (Hughes and

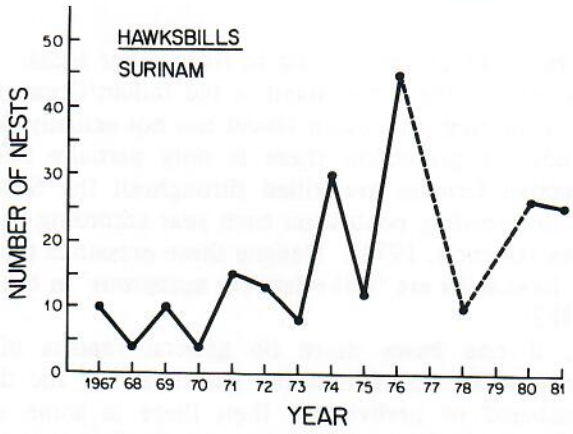


Figure 9. Number of hawksbill nests in Surinam (Bigisanti and Galibi beaches). Data from Schulz (1980) and Reichart, H.A. (personal communication).

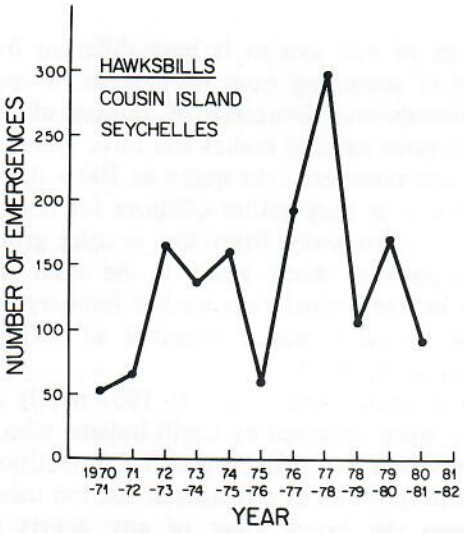


Figure 10. Number of emergences of adult hawksbill turtles on Cousin Island, Seychelles, since a resident warden was installed there by the International Council for Bird Preservation (ICBP). Both the number of nests and the number of turtles making those nests are smaller because turtles often return to the sea without laying and individuals can lay several times. Data from Garnett (1978), Diamond (1976 and personal communication) and reports of the Scientific Administrator (ICBP), Cousin Island. There are some minor discrepancies between these sources. The main nesting season is from September to February each year.

Richard, 1974). But with the vast numbers of baby turtles emerging, some manage to reach the sea. Satiation of predators is presumably the survival value of arribadas. The ridleys put all their eggs into one basket, but they make it so heavy that the thieves cannot carry it away, or not all of it.

But as a strategy to satiate predators mass nesting may perhaps have a serious biological weakness. Going back to pigeons for a moment, the courtship displays of the male bird are able to initiate ovulation in the female (Erickson and Lerhman, 1964). Such stimulation, and this is speculation, could have been especially important in triggering and synchronizing breeding in the passenger pigeon. If so, once their numbers fell below a certain threshold value, even though they were no longer worth going after with guns, there might have been too few to create the necessary excitement for breeding, and recovery would have been impossible. Perhaps something like this occurs in turtles. It is not known whether the timing of arribadas depends on propitious weather or on some kind of agreement among the turtles offshore, some urge to move inland that is induced by the very intensity of stimulation from the great numbers of other turtles. Strong offshore winds have been thought to be involved (Pritchard, 1969; Schulz, 1975), but their association with arribadas does not hold up in Costa Rica (Hughes and Richard, 1974; Cornelius, in press). Moreover the arribadas at Nancite and Ostional occur at different times, even though these beaches are only a 100 km apart and subject to similar tidal and weather regimes (Hughes and Richard, 1974). It is conceivable therefore that despite their great numbers, even because of them, olive ridleys have a more precarious hold on Earth than hawksbills. However, ridleys do come ashore in small clusters or individually in places, for instance at Bigisanti in Surinam and at Nancite, though in the latter case the number nesting singly or in small groups is less than 1% of that at arribadas (Hughes and Richard, 1974). But it is disquieting that despite having received considerable protection since 1967 (Pritchard 1979a; Schulz, 1975), the number of Surinam ridleys is dwindling (Figure 11). Is incidental catch by shrimping vessels taking more than protection on the shore saves? Or, following erosion of the beach at Eilanti (Schulz, 1975), have they moved not to other beaches in Surinam but elsewhere? Or have they fallen below a critical number necessary to sustain themselves? But too little is known about arribada formation to pursue these speculations.

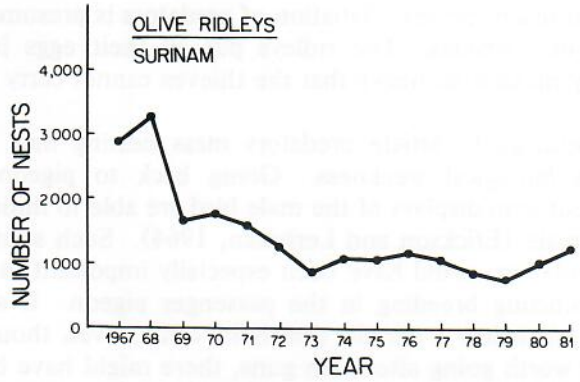


Figure 11. Number of olive ridley nests in Surinam (Bigisanti and Galibi beaches). Individual turtles sometimes lay more than once in a season so that the number of turtles is less than the number of nests. Data from Schulz (1980) ant Reichart, H.A. (personal communication).

Whatever is responsible for arribadas and whatever untoward is depressing the Surinam ridleys, there remain huge numbers elsewhere. At the Gahirmatha rookery in Orissa, India, there are 100,000 nesting turtles a year (Kar, 1980) and at Nancite, Costa Rica, 96,000—the average of 3 arribadas in 1971 (Hughes and Richard, 1974). These estimates may be inflated by some turtles returning to the sea without laying and then reappearing on shore the next day (Cornelius, in press). The multitide of turtles arriving at the same time saturates the biologists as much as the predators and makes it impossible to keep an accurate tally on everything. Even so, there are surely tens of thousands of individual females nesting at Gahirmatha and Nancite and another huge arribada in Costa Rica at Ostional (Richard and Hughes, 1972). Reports are just coming in of a second mass nesting site in Orissa (Kar, 1982) and there are 45 other places in the world where the species nests in lesser numbers (Sternberg, 1981). To call the olive ridley endangered is a poor way of reflecting these facts.

Nevertheless, even if the species is not about to become extinct, there are serious problems. True, the arribadas at Nancite and Ostional

(Robinson, 1982) benefit from a considerable measure of protection; and at Gahirmatha egg collection has practically stopped but adults are still being taken at sea there (Kar, 1980; Bhaskar, in press). Further north, at Digha in West Bengal, large numbers of ridleys are being slaughtered (Bobb, 1982). Altogether there is a flourishing illegal fishery of ridleys off the coast of West Bengal, Orissa and Andhra Pradesh (Bhaskar, in press). In Mexico, at Escobilla, there is a huge harvest of breeding females and many biologists consider the quotas far too high (Chapter 14). In Ecuador the ridley leather industry was officially closed in 1981 (Hurtado, 1982) and exports are well down from the record high of more than 130,000 in 1979. However, in 1981 skins from more than 56,000 turtles were still exported from Ecuador; it appears most of these originally came from a turtle fishery in Colombia (Hurtado, 1981). Many of these developments are recent and their outcomes unsettled. With vast numbers of olive ridleys still remaining, there are tremendous and pressing opportunities for conservation.

Leatherback *(Dermochelys coriacea)*

In the 1960s the leatherback colony at Trengganu, Malaysia, was the only known one of any importance. With that running at only 1,000-2,000 nesting adults a year, it was felt to be the species' last stand against extinction (Wyatt-Smith, 1960). Since then many other breeding populations have been discovered, some of them far larger than that at Trengganu. In French Guiana 5,500 females nest each year (Fretey and Lescure, 1979), in Mexico as many as 30,000 (Pritchard, in press). A new colony has just been found in Irian Jaya, Indonesia, rivalling the one at Trengganu in size (Salm, 1981). There are numerous minor nesting sites. Sternberg's (1981) atlas lists a total of 64 leatherback beaches.

Obviously the critically endangered three-star listing of 1968-1970 for the leatherback is no longer appropriate. But there remain at least 5 prominent adverse factors for the species:

1. The discovery of the huge breeding aggregation off the west coast of Mexico has a darker side: several hundreds of nesting females are being killed on the beaches there each year (Pritchard, in press).

2. Contrary to what has been often said and thought, leatherback meat is widely eaten (Mrosovsky, in press a). There is even a village, perhaps several, in Indonesia where a subsistence culture revolves around hunting leatherbacks: at Ohedertutu, Kai Cecil, the islanders kill about 100 adults a year (Compost, 1980). However, although leatherbacks are widely sought at local levels for their meat and oil, there are no large-scale commercial operations for their products.
3. In addition to the excessive egg harvest in Malaysia, leatherback eggs are collected on many other beaches.
4. Like other sea turtles, they are victims of accidental entanglement in fishing gear and many are drowned.
5. Unlike other sea turtles, leatherbacks are exceedingly difficult to keep in captivity. Self-inflicted injuries when they swim incessantly against the walls of their tanks are a particular problem. It is unrealistic to think that breeding leatherbacks in aquaria or farms is anything to fall back on if disaster overtakes them in the wild.

To what extent these adverse factors are depressing leatherback populations is unknown. In 2 places where leatherbacks are protected and have been studied for a number of years, Tongaland (South Africa) and Surinam, numbers nesting are stable or even increasing (Figures 12 & 13). But not too much should be made of these cases. The Tongaland rookery is a minor one, right at the southern edge of the species' breeding range, and the Surinam leatherbacks cannot be considered in isolation from those in French Guiana because there is interchange between beaches in the 2 countries (Schulz, 1975). Monitoring on the French side has not been going on for nearly as long as in Surinam (Figure 13). Moreover, the Tongaland and Surinam cases can be offset by a probable decline of leatherbacks in Malaysia. It is impossible to assess the situation there accurately because much is based on reports from the licensed egg collectors and they have reasons for falsifying the data: if their stretch of beach yields fewer eggs they may be able to hire it for less the next year. However, one estimate gives a 66% decline in egg production between 1956 and 1978 and there are reasons for thinking that this was not just because 1978 was a poor year (Siow and Moll, in press; Mrosovsky, in press a).

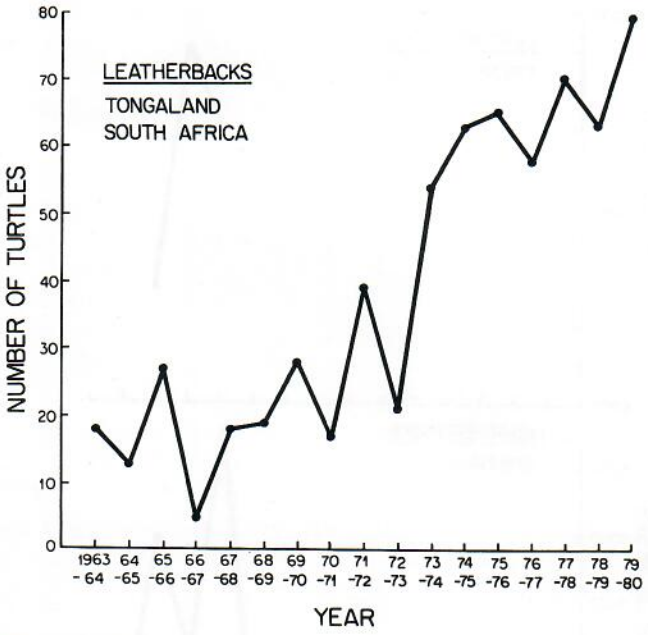


Figure 12. Number of leatherback turtles (remigrants plus new arrivals) seen in Tongaland, South Africa. The main nesting season is October-January. In 1969 the area routinely patrolled was increased from 32 to 56 km. Data from Hughes (1974b, in press a and personal communication).

With a generally positive situation in Tongaland and Surinam and a deteriorating one in Malaysia, and trends elsewhere mostly unknown, it is fair to say that 'certainly it is impossible to document an overall decline, and indeed the more we seek them, the more leatherbacks we find' (Pritchard, in press).

Although little is known about trends, there are now 2 recent estimates for the total number of mature female leatherbacks in the world, 115,000 (Pritchard, in press) and 70,000-75,000 (Mrosovsky, in press a). Agreement is somewhat better than for vicuna population estimates and quite encouraging considering different assumptions were made in deriving total numbers of individuals from numbers of nests in one year. The agreement on the numbers of nests in a year is closer.

So we have a species with many and widely distributed nesting sites, not demonstrably declining, and a world population in the order

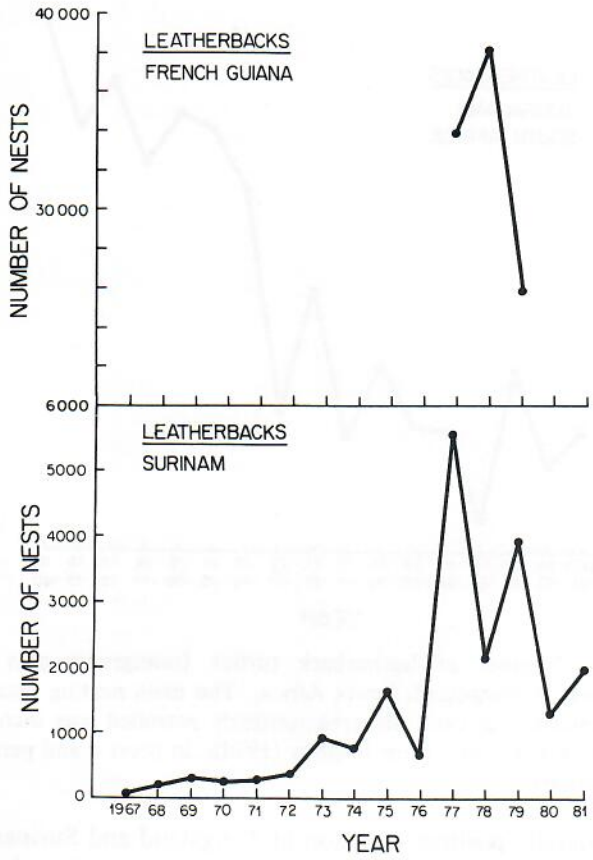


Figure 13. Number of leatherback nests in Surinam (data from Schulz, 1980 and Reichart, H.A., personal communication) and in French Guiana (data from Fretey and Lescure, 1979). Note that the scale for the two areas is not the same.

of 100,000 mature females. Endangered?

Yes, says Pritchard (in press), though tentatively: 'on consideration of all available data, I am inclined to believe that endangered status for the leatherback is still justified.' No, contends Mrosovsky (in press a): the appropriate category is vulnerable, not endangered. The 1975 Red Data Book defines vulnerable as follows:

> Taxa believed likely to move into the endangered category in the near future if the causal factors continue operating.
> Included are taxa of which most or all the populations are *decreasing* because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously *depleted* and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are *under threat* from serious adverse factors throughout their range.

The last sentence sums up the leatherback's present predicament, as far as it is known, and also that of some of the other sea turtles. But the latest edition of Red Data Book (1982) retains the endangered status for the leatherback.

Loggerhead *(Caretta caretta)*

The loggerhead is also classified as vulnerable and rightly so. It does face several threats. When feeding off crustaceans and molluscs on the bottom of the sea it comes fairly close inshore and is liable to be swept into shrimping trawls and held under water. Off the coast of Georgia, U.S.A., an estimated 778 turtles were drowned in 1976 (Hillestad et al., in press). This figure does not even reflect catches by vessels fishing off Georgia but unloading elsewhere. If 778 turtles are drowned off just one state, then shrimping in the U.S.A. as a whole, including the Gulf of Mexico, probably accounts for several thousand loggerhead turtles each year. Most of these are sub-adults.

Loggerhead nesting habitat is also being destroyed by sea walls, motorways and condominiums. 'Photic pollution' disorients the hatchlings. Many eventually find the sea but others are attracted inland and crushed on the highways (Mann, 1978). Even in more isolated areas such as Little Cumberland Island where turtles have been totally protected for almost 20 years and many eggs saved from racoons, nesting has not yet obviously increased (Figure 14). Perhaps this is only because a long maturation time has delayed the appearance of the beneficial effects of the conservation programme there (Richardson and Richardson, in press).

If these various threats cannot be kept in check and numbers nesting decline, the option of transferring the species to the endangered category remains. But at present the loggerhead is widely distributed with 64 listed nesting beaches (Sternberg, 1981). Most of these are in

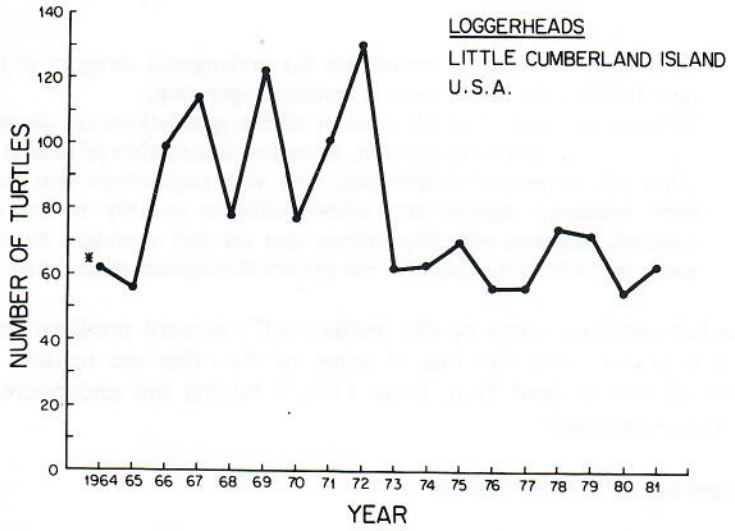


Figure 14. Number of loggerhead turtles emerging (remigrants plus new arrivals) on Little Cumberland Island, Georgia, U.S.A. *tagging only started 6th July, well into the season. Data from Richardson and Richardson (in press and personal communication).

the temperate rather than the tropical zone. This fortunate nesting preference has placed loggerheads in a number of countries that are able to afford total or considerable protection. Sizeable loggerhead populations occur in Australia, the United States, Oman and South Africa. And the numbers nesting in South Africa are either level, as level as is ever the case with turtle populations, or even creeping upwards (Figure 15). The loggerhead rookery on Masirah Island in Oman, probably the largest in the world for this species, has about 30,000 turtles nesting a year; many eggs are carried away by high seas but exploitation by people there is minimal (Ross and Barwani, in press).

Flatback *(Chelonia depressa)*

Flatbacks nest only in Australia. They are not uncommon in the Torres Strait and off Queensland but the 1975 Red Data Book listing of 'rare' is appropriate because of their limited range. The 1982 Red Data Book does not include the flatback, but nevertheless protection in Australia is essential to its survival. Fortunately the main flatback beaches are in sparsely inhabited regions. However, the aborigines have

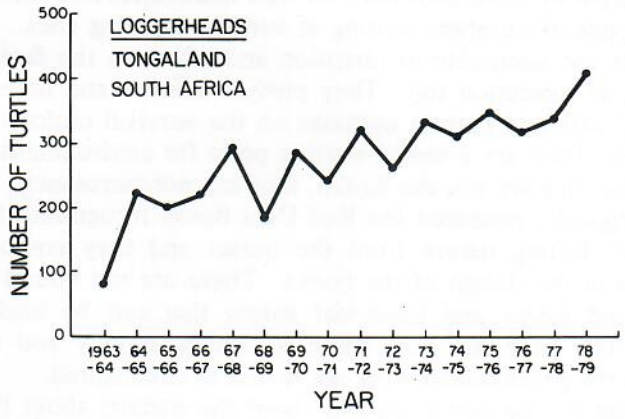


Figure 15. Number of loggerhead turtles (remigrants and new arrivals) seen in Tongaland, South Africa. The main nesting season is October-January. The low figure for 1963-1964 reflects less systematic study that year. In 1969 the area routinely patrolled was increased from 32 to 56 km. Data from Hughes (1974b, in press a).

traditional hunting rights and many now own outboard motors. Sometimes they take nesting females, more often the eggs, especially on Crab Island, the largest known rookery for flatbacks. But how many are collected each year is uncertain (Parmenter, 1980a,b). With a restricted range, excessive harvesting of eggs, or a deterioration in food supply or some other environmental change could be disastrous. So although at present there need be no special concern about losing the species, better monitoring of populations and more research are needed. There may come a time when aboriginal hunting rights should be curtailed.

In summary then, except for Kemp's ridley, and conceivably the hawksbill, none of the sea turtles are *at present* endangered in the Red Data Book sense of that word. This is not necessarily a criticism; it often takes time for new findings to be assessed and for information to reach the compilers of these volumes. It would only be discreditable if

revised editions failed to reflect the current situation as accurately as possible, failed to make allowance for new discoveries and accumulating data on trends of numbers nesting at various breeding sites. The Red Data Books are admirable in intention and often, in the face of great difficulties, in execution too. They provide officials and others with a synopsis of data and current opinions on the survival outlook for various species. They are a useful starting point for environmental impact studies. But they are not the Koran, they are not sacrosanct. The people who originally produced the Red Data Books recognized their temporary and shifting nature from the outset and they embodied this recognition in the design of the books. These are not bound but consist of a red folder and loose-leaf sheets that can be unclipped or replaced. The time has now come to unclip, modify and replace a number of the pages categorizing sea turtles as endangered.

It would not be worth arguing about the matter, about the subtle differences between being endangered and being vulnerable, any more than it is worth arguing about the precise rating of some rare wine, were these categories not used as a basis for action. People often take the word 'endangered' as sufficient without going beyond it into details. Categories like 'endangered' have their uses as starting points, or quick summaries, but they become a liability if they become autonomous from the facts, with an existence of their own. It is facts we need as the basis for action. Labels have their uses but sooner or later we have to unpack the parcel and see what is really there.

The real situation is that most of the sea turtle species are not in immediate danger of extinction, nor even, probably, in danger if the factors presently affecting them continue operating. Nesting is widespread and some sizeable rookeries remain. But overall numbers are far less than they were in former times and some populations are under great pressure and may soon disappear. This should be the starting point for formulating conservation measures, not misleading alarmism, nor the previous IUCN endangered label which for all but one of the sea turtle species is now questionable.

In a more general sense of the word, of course, turtles are endangered. So are many species if human beings continue to breed so rapidly and destroy habitats and spread chemicals around the world and release radioactive wastes. Some conservationists may still wish to use the endangered label as they do a preventive medicine or as a self-negating prophecy. If you call a species endangered, then it can be

saved. If you do not call it endangered, then it will be. But there should also be room for a scientific approach, for starting not with fear but with facts.

11. THE ALARMIST STRATEGY

Conservation biology has some strangely unscientific manifestations. One is to start with convictions and then produce authoritative-sounding assertions to support them. The alarmists, it seems, start with the conviction that killing turtles and trade in their products should be stopped. They then produce assertions to support this position: the green turtle will be extinct by 1983 if present trends continue (Cleveland Museum exhibit, 1980), turtles will be wiped from the face of the Earth in a few years. The 1981 pamphlet of the Sea Turtle Rescue Fund is rich in this kind of material (Chapter 10). Such assertions are false.

So are others, some appearing in reputable conservation publications. In 1978 an article with the title 'Sea-turtle Faces Extinction in India' was printed in Environmental Conservation (Davis et al., 1978). In this it was said that in 1977 not a single turtle nested at Gahirmatha, the main beach for olive ridleys in Orissa. A similar article (Davis and Bedi, 1978) appeared in Environmental Awareness, and this was the basis for further reports in Hamadryad and in the Marine Turtle Newsletter. But ridleys did nest at Gahirmatha in 1977, more than 150,000 of them. Apparently Davis and Bedi had only been on the beach for a few hours (Kar, 1980). Certainly the colony was not wiped out because the following year more than 200,000 nested there, and more than 100,000 in the year after (Kar, 1980).

An article in the IUCN Bulletin (Anon., 1979) on the killing of olive ridley turtles in Mexico stated that there was no arribada in 1978 in Oaxaca and that ridleys were almost rare in these waters. On the same page a caption to a photograph said that during the 1978 season 350-550 ridleys a day were processed by the Pesquería Industrial de Oaxaca (PIOSA) plant at San Augustinillo. This IUCN article was later criticized for containing 'totally inaccurate doomsday cries' (Frazier, 1981, 1982).

A letter by biologists active in sea turtle conservation in Mexico stated that: 'with the exception of those in Australia, all six species of sea turtles in the world are in imminent danger of extinction.' Referring specifically to Mexico's great sea turtle herds they said: 'if their reprieve does not come before the next breeding season -- summer 1978 -- turtles will disappear from Mexico's seas within three years' (Felger et al., 1978).

Why don't conservationists always start with the facts and formulate their plans accordingly rather than adopting this apparently unscientific reversal of the process? Out of ignorance? Perhaps in some cases that is the answer. Another interpretation is that they are often well aware of the facts but sometimes use hysteria about extinction as a weapon to achieve their aims. By making people think all sea turtles are about to disappear forever they might be able to better the survival prospects for some of the truly endangered populations. It is difficult to stop trade in some turtle products from some parts of the world while permitting it from other places. Turtle steak from one species, or even shell sometimes, resembles that from another species. Enforcement is simpler with blanket restrictions on all turtle species and products. Whatever the reason may be for the appearance of exaggerated statements about the precariousness of sea turtles, there can be no doubt that they are sincerely motivated by a desire to save these species and backed by much hard and unglamorous work. Perhaps on some occasions they are even effective in saving turtles. It is nevertheless legitimate to question whether such exaggeration is ultimately of value.

The main drawback of alarmism is that it focusses attention on the wrong issues. The real issue here is that it is difficult to distinguish turtle products from each other. Perhaps this situation can be ameliorated if it is not neglected. It may be difficult to solve the problem altogether, just as there will always be an arms race between the mint and the forgers, but much could be done with better marking systems, limitations on ports of entry for turtle products, tighter documentation and research in biochemical methods of identifying meat and shell from different sources. Some retailers will prefer reliable legal delivery, even if more expensive, to cheaper but riskier shipments of illegal produce (see also Pickett and Townson, 1980b).

The alarmist strategy may work for a while but it is dangerous. What will people think about assertions that sea turtles are in danger of extinction in the next few years if they read about the breeding colonies of green turtles in Australia and Europa Island and the arribadas of olive ridleys in Costa Rica, and learn about the measure of protection these populations are receiving? They may not care to believe anyone who is talking about the biology of turtles, or of other animals for that matter (Frazier, 1980b). It would be ironic if this happened to the Sea Turtle Rescue Fund, one of whose main aims is public education,

public awareness they call it.

And just who in this case is most in need of that extra measure of awareness? Convictions in various parts of the world may be rather different from those animating people in North America. In many places people do not want a hands-off type of conservation or bans on trade. On the contrary they need trade, sometimes desperately. Trade can be part of subsistence. And in formulating where use of resources can be supported and under what conditions and where sanctuaries are essential, people need accurate dependable information, not misleading alarmism. Help in management techniques and biology from places with the expertise are more likely to be appreciated and more likely to be effective than any 'international action and awareness campaigns', any I'm-more-environmentally-conscious-than-thou attitude.

12. PROBLEM RESOLVING

The Sabah Turtle Islands lie out in the Sulu Sea some 30 km from Sandakan, East Malaysia. If you want to watch green turtles nest there, you sail out of Sandakan harbour, past the corrugated iron roofs of the kampong with its maze of interconnecting planks and wharfs, past the large boats with black and rust-coloured hulls, and the medium boats with wooden deck houses and the small boats with nothing but an awning and a put-put-put engine, past the gaunt rock face of Berhala and then out to sea. There the poisonous-looking orange-brown water of Sandakan gives way to blue. Around the horizon are many dark little patches, mostly craft of varying sea-worthiness on errands of varying legality, but others gradually become larger, more stable—these are the Sabah Turtle Islands. But make sure you have a good chart or are with someone who knows the region. Make sure you go to Selingaan or Little Bakkungaan, not to Big Bakkungaan Island because that belongs to the Philippines, not Malaysia. The turtles don't know that of course. They nest on islands in both countries, sometimes moving from one to another within a season. That is the problem. Taking of eggs and turtles is prohibited on the Sabah Islands and this is reasonably well enforced there by the presence of wardens. But these efforts are undermined by the uncontrolled situation on the adjacent Philippine Turtle Islands. So some joint management and enforcement programme is needed. Easier said than done! The government of the Philippines is more concerned about rebels than turtles. The region is politically unstable: with a large Moslem population in Sabah there have been fears of secession from Malaysia and union with the Moslems in the Philippines. There is smuggling, lingering piracy and general lawlessness on the Sulu seas. Park wardens need backing to be effective. Their boat has come under fire on occasion. A government licensed egg collector was killed in 1964 and in 1977 on one of the turtle islands there was a battle between pirates and police (de Silva, 1969, in press).

Undaunted by such details, sitting in the comfortable chairs of the State Department at Washington, the delegates to the World Conference on Sea Turtle Conservation voted for the following Action Project:

> Urge the governments of the State of Sabah, Malaysia, and the Republic of the Philippines to jointly establish an international turtle sanctuary embracing the Sabah Turtle Islands National Park and the Philippine Turtle Islands to conserve sea turtles of all species in areas to be demarcated.

No laughter in the back row please, this was one of the more realistic resolutions! It was actually accompanied by some recognition of costs and difficulties:

> IUCN and World Wildlife Fund should provide support for a working group from the Philippines and Sabah to meet in early 1980 and discuss the procedures or requirements necessary for the implementation of an international turtle sanctuary between the two countries.

But the essential requirement for establishing such an international sanctuary is already perfectly obvious: goodwill and political harmony between Sabah and the Philippines. And with that lacking, not surprisingly nothing has happened.

There is a great vogue among conservationists at present for planning and for strategies. In the last few years there has been the Marine Programme and the World Conservation Strategy, and all the associated national conservation strategies and action plans. Action is one of IUCN's favourite words. Action priority. Action point. Action plan. Perhaps it creates some comforting illusion.

At the Washington sea turtle conference, as the delegates rushed breathlessly through some 90 resolutions on the last afternoon, encouraging, commending, urging, recommending, a lone voice was raised: who was going to pay for all these projects? What about implementation? Well, the strategy had anticipated that. It had included a section in which UNEP and FAO were 'encouraged to provide financial and programmatic support to this global conservation program.' Besides there was to be a standing committee to monitor and facilitate implementation. The committee would meet in New Delhi before the CITES conference in early 1981 and prepare a report on progress. That never happened.

Perhaps it is wise to have documents of this kind, to have even seemingly unattainable aspirations down on paper. It may help give people a sense of purpose. It may help someone raise money for a project if they can say it was recommended by a conservation strategy. And yet there is also an aura of fantasy about such proceedings, and about 'ecocrats' travelling around the world commending, recommending and resolving, talking to themselves.

Here are some more of the resolutions adopted by the World Conference on Sea Turtle Conservation:

> Rapidly establish complete protection for *Chelonia m. agassizi* in all its habitats in east Pacific waters (e.g., Mexico and Guatemala).

But those actually working on the west coast of Mexico will be doing well if they manage to establish a 750-m stretch of beach as a reserve area (Pritchard and Cliffton, 1981). Most Mexicans probably do not want complete protection anyhow.

> Develop realistic population models for the Pacific green turtles and olive ridleys being exploited by Ecuador and Mexico.

This proposal is equally futile. After years of tagging and study at Tortuguero and at Little Cumberland Island and at Trengganu, there are still no adequate population models (Carr et al., 1978; Pritchard, 1980). Perhaps what is meant is that unrealistic population models should be discarded.

> Urge all workers in sea turtle research to publish their tagging results on a frequent and regular basis.

Now there is an interesting one. The problems of expensive research going to waste because data are not published, and of notched turtles being released without the details being put on record, are very real. The editor of the Marine Turtle Newsletter has also for some time been doing some urging and encouraging on the matter of lost data but at best with only modest success. But here the Washington meeting achieved something far beyond the scope of its resolution. What biologists or government departments would want an account of their conservation programme omitted, simply not mentioned in the proceedings of the World Conference on Sea Turtle Conservation? By holding out a carrot to investigators who prefer walking the beach to writing up their results, the conference organizers obtained not only tagging results but a wealth of other data and findings, conveniently assembled in one volume (Bjorndal, in press), a spectacular success.

13. SPLITTING: STRATEGY OR SCIENCE?

Suppose that green turtles, what we call green turtles today, are not just a single group but are really composed of several genetically different forms, then the number of animals in any particular group must be less than the total in all the groups. If so, then statements that green turtles are widespread and still quite numerous (e.g., Chapter 10) appear in a different light. Even when a particular form is abundant locally, if it is different from other green turtles and cannot be replaced, then its status becomes more precarious. So it is not surprising that a handout to delegates at the start of the World Conference on Sea Turtle Conservation listed the splitting of turtles into sub-groups, the 'Taxonomic problem', as one of the most pressing:

> --how to deal with the status of separate populations of the 'same' species, especially in the case of the green turtle. Lumping all populations into the same statistic is dangerously misleading because we have not been able to restore extinct populations by transplantation of individuals from other populations. Even if we could, we would be dealing with a biologically different animal.
>
> (Ehrenfeld, 1979)

Probably later opposition to the Cayman Farm release of yearlings stemmed in part from worry that it could make splitting more difficult (Chapter 9). At the conference itself, however, the taxonomic problem received minimal attention and that is not surprising because it is a difficult one.

The ingredients of the matter are:

1. There are differences in size, shape, colour and behaviour of different populations of green turtles. Some are quite obvious, some subtle and hard to discern.
2. Female turtles return to the same nesting beaches. For example, green turtles tagged at Tortuguero have never been found nesting in Surinam or on Ascension Island, even though all 3 populations share sea-grass pastures off Brazil for feeding.

The questions to be answered are:

1. If green turtles nesting on a particular beach are wiped out altogether, can they be replaced there by other forms?
2. Should some populations of green turtles be designated as sub-species, or even be accorded full species status?

The present position on these problems is:

1. Nobody knows if a colony can be re-established once it is gone. Operation Green Turtle has not given positive results, not yet at any rate, but with other methods transplanting might perhaps be successful.
2. There is a consensus that the East Pacific green turtle, with its smaller size, darker almost black colour and more domed carapace merits sub-species status. It is called *Chelonia mydas agassizi* to distinguish it from other green turtles, *Chelonia mydas mydas.*

This helps: in the 1975 Red Data Book the East Pacific green had its own page. But it still does not go very far toward fractionating the green turtle complex. Although there are some size differences, for instance Ascension Island and Surinam green turtles are large, 'the amazing thing about the remaining populations--for example those of Costa Rica, the Seychelles, the Great Barrier Reef, and the Sarawak Turtle Islands--is how very similar they are; what differences may exist have yet to be elucidated' (Pritchard, 1979a). People have been sniffing around the problem for some time without coming up with anything definitive.

In 1975 Carr proposed, as an interim measure till careful taxonomic work was done, that green turtles should be divided into 4 subspecies:

1. *agassizi*, in the eastern Pacific, Galapagos and Hawaii;
2. *japonica*, in the western tropical Pacific and Indian Ocean;

3. *mydas*, the Ascension Island population;
4. *viridis*, in the western Atlantic.

Referring to small differences in structure, behaviour and physiology, he added:

> Once these have been clearly demonstrated, and trenchant differentiation of the Ascension and Tortuguero green turtles is shown, the latter will be designated *Chelonia mydas viridis* (Schneider) and both it and *mydas* will automatically lay claim to endangered status.

This was written before the green turtle was transferred from the depleted to the endangered category, but the thrust of the argument is the same:

> It seems clear that if *Chelonia* is to get its share of concern as a group of vulnerable, threatened and endangered forms of life, the composite nature of the *mydas* complex must be made known to conservationists and legislating governments.
>
> (Carr, 1975)

How impressed governments will be with sub-specific differences is uncertain. Many biologists at least do not take sub-species designations very seriously as they do not imply genetic isolation between the various forms. In the case of turtles there might be a single population with different local forms, either genetic or depending on available diet, that interbred at their margins. In the Galapagos paler turtles with *mydas*-like characteristics occur as well as the typical darker *agassizi* form (Pritchard, 1971b). There is no evidence that they do not interbreed.

But, *if* there was *no* gene flow between populations, if they could be accorded full species status, then the whole argument would become more compelling. If, for instance *viridis* and *mydas* were as different from each other as loggerhead is from the olive ridley, then there would be all sorts of possibilities for generating interest and funds. There could be extra support forthcoming, international concern, a *viridis* recovery team. The easiest first step, however, toward giving various of the green turtles full species status, is to elevate the East Pacific green and make *agassizi* a full species. It is the form with the

most obvious external differences from other green turtles. It is a tempting idea and one that cannot readily be disproved. So it should not be altogether surprising that in 1982 there appeared a poster, sponsored by the Sea Turtle Rescue Fund and the National Marine Fisheries Service, showing 8 species of sea turtles, with *Chelonia agassizi* as the newcomer. Proclaiming new species by public poster is not the most orthodox scientific way of designating them but never mind, the East Pacific green looks rather more different from the other green turtle than does the Kemp's ridley from the olive, and doubtless the public will be convinced. Few will pay attention to the note: 'Not universally recognized as a separate species.' Then what? Well, then there could be a 9th species. And why stop there?

But wait a moment please! We never did get that careful taxonomic study, that 'trenchant differentiation' needed to establish even sub-species differences. So before becoming too sure that the East Pacific green is a separate species, let us return to basics: for species status we need evidence that it is reproductively isolated. When we look for that in this case we find there are hints but no proof.

The dark *agassizi* form, with its high domed carapace, only occurs in certain parts of the world, it is true. It is not found in Surinam or Costa Rica, for instance. But, even assuming that no males, about whose movements we know nearly nothing, sneak over to other rookeries now and again, the dividing line between the dark and the pale forms is blurred. Green turtles with somewhat dark *agassizi*-like characters nest on the Lacépède Islands off western Australia (Carr, 1975), and in the Galapagos, as mentioned, dark and pale turtles are found alongside each other. The data on the distribution of *agassizi* do not preclude gene flow between the forms.

But if the *agassizi* form was so clearly different in structure, behaviour or biochemistry from the other green turtles, then that could constitute evidence for reproductive isolation, even if their distributions overlapped geographically. The question then is, just how different is *agassizi*, or more generally, how are differences between animal groups quantified? To go to an extreme example, confronted with an ostrich and an ocelot, one can be pretty certain just by looking at them that they belong to different species. But with animals resembling each other more closely, like the various forms of green turtles, it is necessary to study a large number of specimens. Armed with an appreciation of the variation in colour, and of other characteristics too ideally, one

can then go on to ask if the differences between the East Pacific and the other green turtles are as great as the differences between known species, between the green turtle and the flatback, for instance. If they are, it becomes reasonable to call the East Pacific green a different species too. But such extensive detailed work has not been done yet, and it is definitely necessary because colour variations within populations of green turtles nesting in the same area are known to be considerable (Frazier, 1971).

A similar systematic approach is needed for the hawksbills in Australia. In the wake of the ill-fated Torres Strait farming venture (Chapter 5), it was noted that shell patterns and pigmentation of hawksbills from different islands were strikingly different (Carr and Main, 1973). To be sure that the forms from various islands are truly different, there should be data on the variation of patterns within single islands. If too few animals from each island are examined, with some of the specimens from a given island coming from the same clutch perhaps, then differences between islands may appear larger than they really are.

Returning to green turtles, suppose after extensive measurements and systematic work it was shown that the East Pacific form was as different from other greens as they are from flatbacks, the difficulties in demonstrating reproductive isolation might not be entirely at an end. Differences between *agassizi* and other greens, especially those in colour, might result from the environments they encountered in their respective areas rather than from genetically different constitutions. Perhaps something in its diet makes *agassizi* darker. When some hatchlings on the Galapagos Islands were examined and measured, they were rather small but their colour was not markedly different from that of other green turtles (Pritchard, 1971b). Nor are hatchlings from the Lacépède Islands superficially remarkable (Carr, 1975). However, again it is necessary to study a large series of animals, from different clutches, before drawing definite conclusions.

None of this disproves that the East Pacific green is a full species. It looks more or less different, breeds in different places and might be reproductively isolated. Sometimes there are no easy ways of telling whether animals are separate species or not. These points are not made to deny *agassizi* species status but to emphasize that the data are not yet in to clear up the matter either way. Suppositions become statements of fact and statements of fact become weapons all too easily. That is

what happened with the idea that sperm storage from one season to the next was important in fertilization (Chapter 8). There are temptations to endanger turtles by dividing them into sub-groups, but if the strategy of splitting outran the science too much, it would be no more truthful than alarmism.

Nor should the problem of replacing former turtle colonies be tied too closely to the species question. Transplantation of breeding populations from one beach to another is an empirical matter. The experience of Operation Green Turtle suggests it cannot be done quickly or easily. Transport of eggs rather than hatchlings may be a better approach. This is being tried with green turtles, loggerheads (see Pritchard, 1980) and Kemp's ridley. Some biologists would have preferred to concentrate on the more abundant species and not to experiment with Kemp's ridley (Chapter 7). Nevertheless if a new colony is established on Padre Island, regardless of whether that is the best or most cost-effective way of saving the species, it will be instructive.

The outcome of such experiments will depend on what it is that keeps turtle populations apart in their breeding. If this occurs because the migratory instructions are ineluctably handed down by the genes, unsusceptible to modification by anything the animal experiences, then transplantation would not work, except through the slender chance of some fortunate mutation arising. But if return to the natal beach depends on some imprinting early in the animal's life, then it might be possible to re-establish turtles in areas where they bred formerly. They would probably not be exactly the same kind of turtles. That again depends on how reproductive isolation is brought about. If different early imprinting experience was the only important factor, then transplanted populations might be very similar to the old ones. But that is rather unlikely. More usually there are several barriers keeping populations apart. In addition to imprinting as an isolating mechanism, the genetic make-up might contribute towards differences in feeding patterns, in how much fat was put on before migration started, in the timing of migration, in selection of nest site on the beach, in pivotal temperatures for sex determination and much else. The transplanted turtles might then be unable to make the best of their new breeding area. Even if turtles nested again on the site of a former colony, there could be a loss of genetic diversity and the new population would be different.

But, it may be protested, giving sub-groups of turtles different names is precisely a way of emphasizing such population differences, of

pointing out that with green turtles we are dealing with a composite group; conservationists are not just concerned with preservation at the species level but with populations too. If a particular distinct breeding aggregation is wiped out, that is a tragedy, whether it is a species, a sub-species or different in ways that cannot be easily categorized. There is a decrease in genetic diversity in each case.

Yes, of course populations should be saved. Nor has any objection been made to splitting if it is scientifically based. Splitting could be valid science *and* a conservation strategy. But will it be? There are indications that this difficult matter might be prejudged by a particular approach to conservation.

And anyhow the effectiveness of this approach toward saving the sea turtles may be overrated. *Japonica, agassizi, mydas* and *viridis*, these are lovely poetical names, but the authorities in some countries may be rather less impressed by the sonorities of scientific nomenclature or the slight genetic idiosyncrasies of their turtles than by demonstrations that preserving them has cash value.

14. AN EGG-LAYING MACHINE

> Sustainable utilization is somewhat analogous to spending the interest while keeping the capital.
>
> (World Conservation Strategy, 1980)

The reader may have formed the impression, perhaps justifiably, that so far these reflections on conserving sea turtles have been rather negative and pessimistic in tone. In one sense that may be true. Pulling down obstructions, clearing away undergrowth, sweeping out cobwebs are destructive but in another sense they are positive actions, based on optimism. If we reject the spread of semi-science and repudiate the tactical hoax—if that is what it is—that most turtle species are at present in danger of extinction, we find a situation that, though serious, has many hopeful elements, a sky full of lowering clouds but enlivened by patches of sunny blue.

In the long run man's dominance on Earth restricts the kinds of creatures that will survive here. Animals that are dangerous, physically or economically, are under the greatest pressure. This is the predicament of so much of Africa's wildlife. With human populations expanding and needing more and more space for crops, the clash between animals and agriculture has become so intense that for some conservationists only one option remains:

> ... wildlife in Africa should be commercialized in many places—exploited for every last nickel of income. In certain key ecological areas, it should be totally protected. Elsewhere, the sooner Africans enjoy gazelle goulash and wildebeest casserole, and the sooner the trade in zebra skins is regulated and expanded—rather than decried and suppressed—the sooner a more hopeful era will dawn for African animals.
>
> For those Africans who try to live alongside wild animals, there are sizeable personal costs. The only way these people can be persuaded to live and let live is for them to realize some personal benefits as well.
>
> Wildlife in Africa is being elbowed out of living space by millions of digging hoes—a far greater threat than the poachers' poisoned arrows. When zebras chomp up livestock's grass, when elephants drink dry savannahland water supplies, when buffalo herds trample maize crops and when lions carry off prize steers,

> the animals must go—unless they can pay their way.
>
> (Myers, 1981)

This may sound offensively radical but the realization that national parks alone are inadequate and that utilization helps preserve species like antelopes and gazelle is becoming widespread (see Hughes, 1979; Coe, 1980; Worrall, 1981).

But what of the sea turtles? Their prospects for living alongside mankind are really very good. The turtle is gentle and unaggressive, it does not trouble campers as do bears, it carries no known diseases, it does not interfere directly with agricultural efforts as do rabbits and woodchucks, or compete with domesticated herds for pasture as do vicunas; although it sometimes takes food eaten by man, such as shellfish and jellyfish, it does not raid and trample his crops as do elephants. Besides that, a nesting turtle is an intriguing sight to watch, an attraction for thousands of tourists (Fretey, 1981; Siow and Moll, in press), safe for children. But most important of all perhaps is the food turtles provide. They arrive on our shores at predictable seasons and places and leave behind protein in convenient packages, all ready for handling and marketing (Hendrickson, 1958). Turtles are magnificent egg-producing machines. This is their best hope for survival.

It has been said that the green turtle is the most valuable reptile in the world (Carr, 1952). But in cash terms it is only valuable if exploited. Its exploited value provides the incentive for producing more turtles for future exploitation. Exploitation and conservation go hand in hand. The best hope for sea turtles is to concentrate on the positive aspects of the situation, principally their uses. The priority should be to demonstrate how much money or nutritional value can be derived from turtles by managing them as a renewable resource. This will be more effective than shedding tears about how numerous turtles were in the days of Christopher Columbus.

But devising management methods brings us right back to practical considerations. It is all very well to say that conservation and exploitation should go hand in hand but how exactly are utilization and protection to be balanced? What percentage of eggs can be safely harvested? 10%? 50%? 90%?

Suppose, as commonly happens on turtle beaches, that many eggs are taken by predators or washed away by high tides, then could one go far wrong by saving as many as possible of these from destruction and allowing some to augment the naturally surviving eggs and keeping

others back for human consumption? More hatchlings would reach the sea than without this human intervention. But there might well have to be additional provisos about the harvesting. Not all eggs should be collected from one part of the beach or at one time of year otherwise spatial and seasonal temperature differences, however slight, might bias the sex ratio of the embryos in the remaining eggs. For similar reasons the incubation of eggs kept for conservation should be as natural as possible. Simple protective measures such as disguising the scent or other cues by reburying the eggs close by on the night they were laid might be favoured. Who would have thought, 10 years ago, that temperature could determine the sex of sea turtles? The lesson to be drawn from this is not just the need to check on the thermal aspects of artificial incubation methods but also to accept that a natural environment may be important in ways of which we have no conception. Perhaps characteristics of the sand other than temperature contribute to optimal development. To allow for our ignorance, the balance between protection and use should be struck in a conservative way. Just as an engineer, after calculating the stresses and strains on a dam or bridge, doubles or even triples the strength of the supports, so of all the eggs saved from destruction more than twice the number taken for consumption should be set aside for the conservation programme.

A programme incorporating both collection of eggs and transplantation of doomed eggs has been operating for more than 10 years in Surinam. In the last few years about 250,000 green turtle eggs have been harvested annually (Reichart, in press). Formerly more than 400,000 were taken each year (Schulz, 1975). There are, very roughly, about 250,000 doomed green turtle eggs in Surinam (Reichart, in press). For the years 1970-1973, 284,500 per year (37% of the total) were laid below the high tide line (Schulz, 1975). So currently there is an approximate match between the number of doomed eggs and the number harvested. But there are some problems nevertheless. The quota has been arbitrarily set (Schulz, 1975), not indexed to the number of eggs transplanted. And although the logistic achievement of putting beach patrols on all the major Surinam beaches has been accomplished, in fact doomed nests are not always transplanted. Finally, there is no safety factor to guard against the unknowns of transplantation and selective egg collecting; ideally the number of eggs saved should exceed the number sold. So, quantitatively, the Surinam programme is not—or not yet—a completely satisfactory model.

Therefore a hypothetical example of how an egg harvesting scheme might operate will now be considered.

Along the eastern seaboard of the United States racoons dig up many nests of loggerhead turtles. In some places as many as 93% of the eggs are destroyed, in other places it is much less but still high at 55% (Stancyk et al., 1980). Eggs are also washed away by high seas, in South Carolina as many as 10% of them at Cape Romain (Caldwell, 1959) and 25% at Sand Island (Hopkins and Murphy, 1981). On some beaches there are already protective measures. For instance on Little Cumberland Island, Georgia, the residents' association organizes a hatchery and monitors the population. With people wanting to support total protection there is no need for selling eggs. But in other places the racoons are going unchecked. Suppose on a particular hypothetical barrier island racoon predation is estimated at 75%, then if this could be eliminated altogether, 25% of the eggs could be harvested leaving an additional 50% in the ground. The money from selling the eggs would go toward the conservation programme. Of course the details of the costs would be critical. There are some simple ways of protecting turtle eggs such as surrounding the nest with wire netting, taking the eggs to a central hatchery or reburying them in the sand close to where they were laid. Such measures do not demand great skill but need only the wages for a reasonably conscientious person who likes walking the beach by night. With no costs for feeding, battery cages, lighting or medication, it is not unreasonable to think that turtle eggs obtained in this way might compete successfully with hens' eggs. People in North America would probably pay more for turtle eggs, as they do in other places. In Malaysia leatherback eggs cost five times as much as hens' eggs (Siow and Moll, in press), although they are less than twice as large. Even the smaller ridley eggs sometimes fetch as much as a hen's egg (Carr, 1952).

Even if economically viable, there could still be some technical problems in the actual harvest. In theory, in the hypothetical example proposed, it may be that if protection is given to 50% of the eggs, then another 25% can be safely collected, but how does a person on the beach coming across a newly laid clutch know if it is one of the 75% that would have been taken by racoons? If all the nests found were automatically given protection against racoons, some additional allowances in setting the quota for harvesting might have to be made for eggs that did not need that protection and might have done better

without it. Merely moving eggs from one place to another reduces hatch rates in some circumstances (Limpus et al., 1979). Also some procedures afford only partial protection. For instance Stancyk et al. (1980) found that reburying eggs close by reduced racoon predation to only 6-19% but did not eliminate it altogether (in this case hatch rates of the transplanted eggs were not lowered). So if reburying eggs was the conservation method of choice, then perhaps only 18% (75-19=56; divided by 3=18) of the eggs should be taken for human use. Also the more nests that are left on the beach, the greater the chances are that a turtle arriving later in the season will dig some up. If, on the other hand, some clutches are moved off the beach, then denying these eggs to predators could increase the pressure on other eggs.

Adopting a conservative balance between protection and use, such as the 2:1 ratio proposed above, provides some safeguard for these kinds of contingencies. Even so additional precautions would be desirable. There should be monitoring of population trends. If there was a sustained crash, the quota could be adjusted or suspended, even though the reasons for the decline were unconnected with the harvesting. Plotting long-term trends is easily combined with egg collecting simply by recording the number of nests laid each year (Chapter 3). Finally, leaving some areas as nature reserves, without intervention, would serve as a small insurance policy and would provide a reference site against which to compare the situation on managed beaches. If numbers rose and fell on both the managed beach and the reference area, it would be unlikely that the harvesting was responsible.

A combination of monitoring, a few reserves and putting back twice as many of the eggs saved from predators or high tides as one takes is a very conservative exploitation policy. Nevertheless, there will doubtless be objections to the idea of legalizing the sale of turtle eggs in the United States, even with careful controls. The sentiment there seems to be more for severer penalties for poachers. Trying to clamp down on poachers, blaming wildlife problems on poachers, is a common attitude among conservationists but there are few examples where it is successful (Graham, 1973). Perhaps one will be the activities at Rancho Nuevo on behalf of Kemp's ridley. With so few animals left there, stringent control of poaching is essential. But in the United States putting people in jail for taking turtle eggs or fining them several thousand dollars may provide a few symbolic victories, but it is illuminated expressways and buildings, high tides and racoons that are the worst

enemies of turtles nesting there. Escalating the penalties on poachers is of marginal value. Developing conservation through use is likely to be much more effective in the long run.

And in parts of the world where poaching is considered to be a major problem, it has to be asked which of the following is more likely to be successful: having national parks without funds to ensure adequate enforcement—and that is often the reality with wildlife sanctuaries—or putting officials on the beach to organize egg harvesting and protection? Simply having more people on the beach discourages poachers, and egg sales could also subsidize enforcement directly. Where possible, of course, controlling access to the nesting beach and selling eggs only at government-licensed outlets may be useful adjuncts. Even so, it is seldom possible to eliminate poaching altogether. But it is not obvious that allowing some eggs to be sold makes it any worse. Poaching and black markets thrive on scarcity and bans; the seller has to set a price commensurate with the risks incurred. When a commodity is available at a reasonable price the incentive to steal may be reduced. In the villages in Surinam, a green turtle egg sells for less than a hens' egg. In 1982 the equivalents in U.S. currency were respectively about 6 cents and 10 cents, and the turtle's egg is barely 20% lighter. Not surprisingly poaching there is of minor importance.

There are several other things to note and further attractions of putting more effort into developing procedures for egg harvesting. To start with, taking eggs is compatible with having tourists on the beach. Only minimal restrictions are needed: the turtles should not be molested and flashlights should only be used sparingly. What a fantastic tourist attraction the great ridley arribadas could be! Thousands and thousands of turtles crawling out of the sea and nesting all at once! And, with the actual day of the arribada being unpredictable, what money could be made in charges for accommodation and drinks while people waited! But there is more than a financial harmony between turtle watching and egg collecting. Many wildlife enthusiasts may dislike talking about turtles as egg-laying machines or swimming meat deliveries. They may prefer to think of them as bearers of ancient biological traditions and representatives of life forms as good as ours, or to dwell on their mastery of spectacular navigational skills. They may prefer to describe them as wonderful mysterious gentle creatures—and so they are, so they are. This really is one of the few cases where one can have it both ways. Collecting a quota of eggs is compatible with a

respect for another mode of existence. This is obvious in Malaysia where there are long-standing traditions against killing adult turtles. Egg collecting is institutionalized, controlled by the state. At the same time each year many Malaysians go to the Trengganu beaches simply to watch the giant leatherbacks haul out of the sea and lay their glistening eggs and put on a spectacular show of sand-flinging. The people enjoying these sights there are by no means only affluent tourists from northern countries.

Even the proponents of animal liberation allow for taking their eggs. With chickens, 'assuming you can get free-range eggs, the ethical objections to eating them are relatively minor. Hens provided with both shelter and an outdoor run to walk and scratch around in live comfortably. They do not appear to mind the removal of their eggs' (Singer, 1976). Far less objectionable still then would be the taking of eggs from turtles living their full lives in freedom and returning to the sea without ever seeing their eggs.

Killing adults when they gather to breed is very different. Butchering a turtle is a messy business. After stunning or cutting the throat, it is necessary to saw through or otherwise sever the bony junction between the plastron and the carapace; inside the tenacious heart goes on beating and blood and eggs slop around in the bowl of the upturned carapace, the contribution to the next generation unfulfilled. Even turning a turtle over and hauling it off to a discreetly located slaughter house is a sight some tourists will not appreciate.

Another point about harvesting eggs is that it is unlikely to endanger any other species. There are no known animals that eat turtle eggs exclusively. With nesting being seasonal it would be difficult for such a species to evolve. An extreme example is an arribada where laying is confined to a very short period: this satiates predators at one time but denies them food at other times. Once the season is over, crabs, coyotes and vultures have to survive on other fare.

Even in places in the tropics where laying occurs all year round, it is much more frequent in certain months (Hendrickson, 1958; Servan, 1976). It remains conceivable that removing and protecting many clutches might deprive a predator of nourishment at a time of particular need in its life cycle. Perhaps there are places where monitor lizards need turtle eggs to breed successfully. Of course when any intervention on behalf of a particular species is contemplated, as much consideration as possible must be given to possible interactions with other species.

However, at present there is nothing known to suggest harvesting turtle eggs would upset the 'balance of nature'. Some of the major egg predators like racoons and ghost crabs are hardly endangered species. If, along with harvesting, conservation measures were successful, then rivalry between increased numbers of turtles and other species might result. In the case of green turtles at least, the carrying capacity of sea-grass pastures is probably far in excess of the present day reduced turtle populations (Bjorndal, 1980a), so that competition with other grazers like dugongs is only a remote possibility.

Next, and this is essential, operating an egg harvesting and protection scheme does not preclude conservation measures aimed at other stages of the life cycle. On the contrary it should encourage them. The fewer adults killed, the more eggs will be available. And the more eggs saved from the tides, the more hatchlings can be released and the more the pressures on the adults mitigated. As an example, accidental drowning of sub-adult and adult turtles is common off the U.S.A. If the attempts to develop nets that allow turtles but not shrimp to escape prove successful, perhaps one of the few cases where a technological fix will be the solution (Anon., 1982; Seidel and McVea, in press), the benefits would not be lessened by taking eggs from racoons on the beaches and selling them to people. But to argue that eggs should not be harvested because many turtles are being killed by trawlers would be to miss the point of the present proposals: by diverting losses from predators and tides and linking harvesting to conservation, the turtles should be better off than before. By studying the number of clutches destroyed by animals or high seas, egg collection and conservation can be balanced in a rational way, and in a cautious way that allows for some of the minor uncertainties mentioned.

By contrast, there are egg collecting schemes where this balance is more arbitrary. In Trengganu, Malaysia, most of the eggs laid by leatherback turtles are taken, as they have been for decades. The state authorities there sell the rights to collect eggs on particular stretches of beach. The fees received from the licensed egg collectors go toward running a hatchery and looking after part of the beach set aside for conservation and tourists. People making a living collecting eggs obviously do not want the turtles disturbed while nesting and have an interest in the success of the conservation project and biologists from the Fisheries Department are able to influence events at the rookery. The whole social machinery is excellent: the problem is that nobody knows at what

level to set the controls. The aim (not usually achieved) is to incubate about 15% of the leatherback eggs in a central fenced-off plot and release the hatchlings. But without knowing how many eggs are doomed naturally on the beach, many assumptions enter into setting the quota. It might be that losses of hatchlings in the first few days at sea outweigh losses to predators on the beach; high tides destroy very few nests on this beach (Mrosovsky, in press b). Allowing only 15% of the eggs to incubate, with a hatch rate of around 50%, might result in fewer baby turtles reaching the water than would occur if people left the rookery alone altogether. Or it might be that 15% was more than enough to sustain the population. There is no way of telling at present because there are no reference areas here to assess natural losses. In the long run the health of the rookery might provide some sort of answer, though with the longevity of the adults unknown, when that will be is anyone's guess.

Guesswork, arbitrary quotas, gambling on the future—these are far too frequent in turtle conservation already. They must be replaced by cautious management procedures that link use and protection in a logical way. Countries with a combination of funds for wildlife, scientific expertise and large sea turtle populations could take the lead. Australia is even better placed than the U.S.A. Several species of turtle nest in considerable numbers on its shores and some 40% of their eggs are inundated by high seas (Parmenter, 1980b). To what extent this results from erratic storms or from turtles laying below clearly visible high tide lines needs documenting. Unpredictability of egg loss, in place or time, would influence harvesting methods. There would probably also be difficulties in transporting eggs from remote islands. Development of new ways of handling and preserving eggs may be required. Perhaps pickling or freeze-drying would enable them to be kept near the beaches and collected en masse later in a single trip. It would be foolish to attempt precise suggestions without having a detailed knowledge of the situation. But it can confidently be asserted that with 40% of the eggs gobbled up by the seas there must be some room for organized egg harvesting in a way undetrimental to the turtles. If the Australian authorities worked out procedures, then they would not only obtain extra food for their own people but could also provide less fortunate countries with a helpful example of cautious sound use of this renewable resource.

An added advantage of exploiting eggs is that in some places it could be instituted rapidly. Giving people a stake in conservation while there is still something left to conserve may well be a more robust form of protection than protracted surveys and attempts to cut down on exploitation. For instance, in French Guiana it is already known that laying below the high tide line is responsible for many doomed eggs, probably more than 30% of the total for leatherbacks (Mrosovsky, in press b). Also stray dogs from nearby Indian villages create havoc digging up nests and devouring hatchlings (Fretey and Frenay, 1980). Nearly 15 years after the discovery of the French Guiana turtle rookeries, there are still no reserves, no regular beach patrols. The World Wildlife Fund and a few dedicated individuals cannot fill this gap adequately. Some government-sponsored protection is needed. Starting immediately personnel could be paid to rebury some of the eggs in fenced-off areas above the high water mark and take the rest, at the same time recording data on the frequency of misplaced nests on different stretches of the beach and in different months of the season. The same could be done in Oman on Masirah Island where about 40% of the loggerhead nests are destroyed by high seas (Ross and Barwani, in press).

Where eggs are to be taken mainly from predators rather than the seas, it may take longer for baseline studies to be completed. More than one year would be best in case numbers of predators fluctuated. Also there may be interactions between different factors affecting the chances of successful hatching (Hopkins and Murphy, 1981). When storms are few, there will be more eggs available for racoons. When racoons are few, after extermination programmes for instance, there will be more eggs for high seas to wash away. If a complete reserve area of comparable habitat to the harvested area was set aside for continuing studies this could be helpful. But it should not be necessary to wait a decade before exploitation began. On some beaches predation rates have already been investigated, for instance at Tortuguero, Costa Rica. Collecting eggs at Tortuguero? In a national park? How shocking! Again it must be repeated that what is advocated is more use of eggs that are lost anyway. At Tortuguero more than 40% of the eggs are lost to predators and high tides (Fowler, 1979). Feral dogs do most of the damage. A programme to control them has begun but it is not effective yet. Keeping dogs away and routine protection of eggs costs extra money. Selling some of the eggs could assist such endeavours

and still leave more hatchlings entering the sea. After all the park at Tortuguero was created largely for turtles, not for dogs, coatis and vultures. But it is not worth debating here whether this is a place where more use should be made of doomed eggs or whether it should be kept as natural as possible as a reserve.

The more general point being urged here is that it is time to examine some of the currently cherished notions about sea turtles. Are they really endangered? Is there more room for using them? What is conservation for? In the early 1960s having the answers to these questions was not so pressing. Far fewer turtle rookeries were known then, and some that were seemed in a precarious state. A hands-off conservation ethic, or restricting use to very local levels, seemed most appropriate then for turtles. But now the situation is different. The numbers of turtles nesting at various well-studied beaches have not plunged (e.g., Figures 4, 5, 13 & 15). Huge new rookeries have been discovered, in Australia, India, Mexico, the Guianas, Costa Rica, Oman, Indonesia and on Europa Island, besides many minor ones elsewhere. And not all these countries appear to be intent on wiping out these resources in the way the Americans did in the time of Audubon.

Some of the bitterest arguments within conservation circles arise when protective measures are successful, when endangered species become numerous. National parks in Africa allow elephants to build up to such densities locally, that they destroy their own habitat, trample it down. Many elephants have been shot. This arouses passionate protests (Graham, 1973). The vicuna saga, already discussed in Chapter 8, is another case. This is not the place to debate whether the vicuna has yet reached numbers where culling is appropriate, or whether more animals should be transported from the Pampa Galeras to other areas. Better agreement between population estimates would certainly help in making such decisions. But sooner or later, if the vicuna conservation programme continues to show results, then use of the animal, and not just its wool, is almost inevitable. This will require the emotionally difficult transition from protecting individual animals to killing them. Whatever the reasons, it seems that success creates more dissension among conservationists than failure.

With turtles, perhaps partly because of some success in arresting declines in various areas, and increased public participation and new laws, and surely partly because of revised estimates of the numbers of turtles and their breeding places, we are now entering this controversial

phase. So it is unlikely that some of the suggestions in this book will be universally acclaimed. But the sea turtle situation today is so completely different from that in the 1960s that it is time to re-examine every assumption, both about the biology and the use of these animals.

It is often thought a grave handicap that sea turtles are tied to their ancient habit of coming ashore to nest. Both the adults and the eggs and hatchlings are so vulnerable there. But in a humanized world this is their best hope for survival. If turtles laid their eggs in the sea, or carried their young within their bodies, protection of their reproductive efforts would be much harder. As it is, turtles adopt the strategy of laying vast numbers of eggs to overcome the odds against survival of any individual egg on land. This creates an opportunity for greatly boosting turtle populations. It is almost as easy for people to prevent eggs being taken by animals as to take them themselves. By ensuring that many more turtles survive at the early stages in their life cycle, populations can be raised to the limits imposed by nesting space, feeding habitats and other drains on the adults. And at the same time people can put food on their own plates.

Another assumption: it is often deplored that turtle eggs are mistakenly thought to be aphrodisiacs. In the short run this belief does increase pressure on the turtles, but in the long run perhaps this delusion might even be an advantage. Perhaps after a meal of turtle eggs the anticipation of extra sensations is enough to create them. If people are prepared to pay more for turtle eggs than warranted on a strictly caloric basis, then it would assist the operation of management schemes based on use of the eggs.

More generally, if the eggs are highly valued, for whatever reason, it simplifies setting the balance between protection and utilization because the main doubts about harvesting sea turtle eggs along the lines suggested above are these: maybe a turtle is worth more as meat than as an egg-laying machine and maybe its shell and leather are worth far more. If so, this would entail an altogether different approach to utilization because it would be much harder to forge a rational link between culling and conservation. In the proposal to set aside twice as many eggs for conservation as one takes for human consumption, there is at least some element of logic in the link. If many eggs are destroyed naturally, it is not especially risky, with the provisos mentioned and perhaps others also, to take some eggs and save others. But if it is a matter of culling adults, how many can be taken? What should be

done to compensate for each turtle taken?

By far the easiest way of reimbursing the population would be to augment the numbers of young starting out by protecting eggs and hatchlings on the beach. But how many extra eggs have to be added for each adult turtle that was taken for its meat or shell? An empirical answer, even assuming there was a method of putting a mark on hatchlings that lasted till adulthood, would take decades to obtain because of the long maturation period. There are 2 ways, theoretically, of answering the question but at present both are dubious in practice. The first is to start with rates of predation at each stage of the life cycle, for the eggs in the nest, for the hatchlings on land, for the hatchlings when they enter the water and so on, and then calculate, given these rates, how many eggs are needed to produce an adult. This has been tried by Hendrickson (1958) for the Sarawak green turtles but he considered his figures to be only 'within the range of possibility.' The trouble is that predation rates, especially in the water, are little more than guesses. The second approach is to start with the number of eggs that an average female lays in her lifetime. To replace herself in a stable population she must produce one adult female and one adult male. So by dividing the lifetime output of eggs by 2, one arrives at the number needed to give one adult. This assumes a 1:1 sex ratio, but worse than that it requires knowledge of how many eggs an average turtle lays—just the kind of data that tag loss prevents one obtaining. Instead, from information about how many eggs can be laid by certain frequently seen tag-retaining turtles, one has to guess what the average turtle does, and that is an unsatisfactory procedure. So if adults are to be exploited, it is difficult to balance this with appropriate intervention on behalf of the turtles, and therefore it becomes all the more important, in thinking about resource utilization, to know whether it really is better to harvest the eggs or the adults.

The case for harvesting eggs has been developed by Hendrickson in 1958 in a paper that for its insights and range of information still remains essential reading today. He supported taking eggs rather than adults in 3 ways: with historical arguments, on general biological grounds and with specific calculations. First he claimed that in parts of Asia where the Muslim tradition of leaving the adults alone prevails, the numbers of turtles had declined far less than in parts of the world where mature turtles are slaughtered. This is hard to substantiate though. Not only is there a scarcity of quantitative data about the

abundance of turtles in former times but any method of exploitation can be overdone. Even if there are more green turtles remaining in the South China Sea than the Caribbean, that does not in itself prove that egg collection is inherently superior. Nevertheless, proved or not, Hendrickson may well be right because there are general biological reasons for supposing that it is far safer to exploit the eggs.

> The individual *Chelonia mydas* female has a high reproductive potential and the species is adapted to sustain enormous losses at the very early stages of its life history. The small proportion of individuals which survive the early period of high mortality mature rather slowly and presumably remain reproductively active for a considerable number of years. In maintenance of the population, each adult female is of equal value to several thousands of eggs. The harvesting of eggs constitutes exploitation at that stage of the life cycle where the species is adapted to sustain high losses in the natural course of events. A very large portion of the eggs collected represent, not new losses to the population, but diversion of losses which would have occurred even if there had been no intervention by man. The slaughter of grown turtles, on the other hand, is a direct threat to the dynamic equilibrium of the population, and it would appear that the species is ill-adapted to sustain such losses. It is obvious that flesh and fat are the biologically more expensive food form to be obtained from Green Turtles, while eggs are biologically cheap. Given nutritional equivalence between eggs and flesh in terms of kilograms of edible protein per year, exploitation for eggs is the logical choice.
>
> (Hendrickson, 1958)

This last point was supported quantitatively. Green turtles in Sarawak 'usually lay' 6 or 7 times a season. With more than a 100 eggs per clutch, it is not unreasonable to suppose that production of 600 eggs per season is common. Assuming the turtle breeds in 3 separate seasons, it provides a total of 1,800 eggs weighing about 60 kg in all. An adult turtle in Sarawak weighs about 120 kg. If half of this is edible, it yields 60 kg of flesh and fat for consumption. This means that in terms of weight of food provided a turtle has only to breed for 3 seasons for the eggs to be worth as much as the turtle itself. And there always remains the possibility that it will come back in subsequent years to breed yet again.

If that was all there was to it, the case for leaving the adults alone and taking some of the eggs would be strong. But, as Hendrickson realized, the situation is complicated by the fact that a small strip of gelatinous tissue in the green turtle, the calipee, used for soup, is worth a sum out of all proportion to its weight or nutritional value. He believed, however, that even if the cash obtained by killing the turtles and selling the calipee was converted back into food by the vendor there would still be a net nutritional loss. In 1958, however, turtle leather was not fashionable and the shells were worth much less as souvenirs than they are now. Today these items fetch huge prices and it is unrealistic to ignore this. A further complication is that the value of different parts of the turtle varies widely between the different species. It may be best though to begin with a simple case.

The leatherback turtle, despite its name, is useless for leather. The flippers lack a cornified skin; their oily rubbery covering is difficult to preserve even for museum specimens. Nor does the carapace make a good souvenir. Instead of the usual turtle scutes there are only tiny bones embedded in a thick blubbery fibrous layer. Oil from leatherbacks is used in some parts of the world for varnishing boats, medicinal purposes and in lamps, but as there are other sources of oil in most of these societies and as it is hard to find a cash value for leatherback oil, for the sake of simplicity it is ignored here as of minor importance. That leaves only the eggs and the meat. So it is likely that arguments Hendrickson gave for harvesting the eggs of green turtles, based on comparisons of the weight of their eggs and meat, would today apply better to the leatherback. When similar calculations are made, based on the cash value of eggs versus meat, it turns out that a leatherback has only to lay for about 2 seasons for the value of the eggs to equal that of the meat (Table 3).

Of course, these calculations involve assumptions and should be refined as better data become available; they should be reworked for caloric and protein values as well as cash values. It might be that this would decrease the relative value of the eggs. But, on the other hand, it is improbable that an average leatherback only lays for 2 seasons. It would be odd for an animal after a long maturation period to breed once or twice only, especially when it is as swift and strong as a leatherback and has so few natural enemies. Killer whales take them sometimes, sharks inflict wounds, and jaguars occasionally kill them when they nest but at weights approaching 400 kg they are impervious to

most predators (Mrosovsky, in press a). And indeed there are data showing that some individuals return to lay as many as 15 years after first being seen nesting (Hughes, in press a). Probably many leatherbacks produce thousands of eggs over a number of seasons. So killing the adults is neither good biology nor good economics. They are more valuable as egg-laying machines.

At the other end of the spectrum is the hawksbill turtle. Although its flesh is sometimes toxic and rarely eaten, its hide makes good leather and its shell is especially sought after; a single hawksbill may bring a fisherman as much as $60 U.S. (Nietschmann, 1981) or even $200 U.S. (Carr and Meylan, 1980b). It has displaced the green turtle as the world's most valuable reptile. With these kinds of prices there is little incentive to leave these turtles to lay eggs. Even a decline in numbers, which normally protects species by making it less worthwhile to go searching for them, may not save them. In the Caribbean divers hunting on reefs for lobsters or snappers will spear an animal worth $200, even if they did not set out specially to look for it (Carr and Meylan, 1980b). And with the hawksbill habit of nesting here and there in small numbers over large areas, it is difficult to protect its breeding and augment the numbers of hatchlings reaching the sea. Certainly it is hard to argue, as with the leatherbacks, that it is better as a matter of self-interest for a society to leave adult hawksbills alone.

Some conservationists believe that the only hope for the hawksbill is clamping down on all international trade in its products—by banning it, by fining violators, by discouraging consumers from wearing hawksbill jewellery, by Greenpeace-type gestures, by any means possible. Would that work? It might help but it is significant that Japan is the major importer of hawksbill shell. Making ornaments for officers' uniforms out of tortoise-shell and combs and pins for ladies goes back many centuries there. Formerly, these decorations were confined to the aristocracy and officials; exquisitely worked pieces were much prized. Now use of tortoise-shell products is more widespread but they still have auspicious and ceremonial connotations. It is significant also that Japan has recently joined CITES but has entered an exception for hawksbills. This means that while supporting the general aims of CITES, it is not prepared to renounce commerce in this species. France also has a reservation on this species. With such nations insisting on the right to trade, it would be optimistic to think that an international ban is going to be effective. Continued outcry over many years

Table 3. *Value of eggs and meat of leatherback turtles in Mexico* (adapted from Mrosovsky, 1981).

Data	Basis for assumptions and comments
Value of meat	
Carapace length = 147 cm	Mean over-the-curve measure for Tierra Colorada (n=13, Mrosovsky and Marquez, unpublished)
Weight = 295 kg	Pritchard (1971a) reported that a leatherback with a 149 cm carapace weighed 295 kg. Since his measure was straight line, it is not likely a 147 cm over-the-curve leatherback would weigh more.
Weight of meat = 103.2 kg	Rebel (1974) states that the flesh of a green turtle, including the muscles, constitutes about 40% of the body weight. At the Cayman Turtle Farm a 100-150 kg green turtle yields about 20% steak (Wood, J.R., personal communication). The latter figure may be more accurate but a leatherback with a less bony carapace and plastron and on a less rich diet probably has more of its weight as meat—at a guess 35%. If the flippers and fat are eaten, perhaps an even higher figure should be taken.
Price of meat = 60 pesos/kg	As reported by people at Tlacoyunque, 1978. Cliffton et al. (in press) state that the value of the meat is negligible. Nesting leatherbacks are sometimes killed for their oil and sometimes by egg poachers who do not want to wait for the turtles to lay. So often the potential value of a slaughtered leatherback is not realized.
Value of meat = 6192 pesos	

Value of Eggs

Clutch size = 70	Mean for Tierra Colorada (n=11, Mrosovsky, unpublished).
Cost per egg = 8 pesos	As reported by people at Tlacoyunque, 1978. Cliffton et al. (in press) give a value of 10-12 pesos per egg for 1978.
Value for 1 clutch = 560 pesos	
Number of times a leatherback has to lay for the value of the eggs to exceed the value of the meat	Assuming 1 clutch is collected when turtle is killed for meat.
$= \frac{6192 + 560}{560} = 12.06$	
Number of breeding seasons a leatherback has to stay alive for the value of the eggs to exceed that of the meat	Assuming the average leatherback lays 6 times in a season. Even if it lays only 5 clutches per season, the figure is still close to 2.
= 2	

has not yet stopped the Japanese from whaling, although the International Whaling Commission recently voted to phase out commercial operations by 1985. Turtles are not likely to arouse the public as much as whales.

Is there any way to take the pressure off the hawksbill other than a confrontation between conservationists and the Japanese tortoise-shell industry? One possibility that merits consideration is farming, or ranching. Indeed the Japanese are already looking into this (Uchida, 1980). Perhaps a co-operative attitude that seeks to influence how mariculture operations are established would be more productive than a frontal attack. Suggestions about ways of compensating for the take of animals from the wild might then be better received. With farms and ranches there are feasible and rational ways this can be done, the very same ways that have been proposed for egg harvesting. The number of eggs taken for starting up a farm or maintaining a ranch should be balanced by twice that number being protected from predators and tides on the beaches. For instance, if the Australians were selling the Japanese hawksbill eggs, the price should be set so that it could cover beach patrols and staff sufficient to relocate and guard twice that number of doomed eggs. The attraction of linking commerce to conservation in this way is that commerce pays nature in the same currency as it receives, and it pays right away. Payment in other currency is more arbitrary, more controversial. When Mariculture Ltd. started up in the Cayman Islands, it intended to compensate for the eggs it took by head-starting some of the yearlings later. It may well be that protection at the juvenile stage is a better way of exerting upward leverage on a turtle population than increasing the output of hatchlings on the beach (cf. Richardson and Richardson, in press). Some of the extra hatchlings will only go to feed the fishes anyhow. But at present far too little is known about predation in the sea and about head-starting to make this anything but a gamble. How much is a head-started turtle worth? Is it worth anything at all? Nobody knows.

Another option is for commerce to take adult or sub-adult hawksbills for their shell and compensate by protecting eggs on the beach. But without data on how many eggs the average turtle lays it is difficult to know how many eggs should be saved. And in any case those eggs will only create adults in the future. But if the hawksbill trade begins with eggs and pays in protected eggs, then it is the other way round. Commerce pays nature at once but receives its profits later,

when the shell is marketable.

There are additional potential advantages in farming or ranching for hawksbill shells. By varying the diet or genetic background it may be possible to produce animals with especially prized markings. Perhaps these would be readily distinguishable from most shells from the wild. Perhaps, if a more positive approach toward mariculture prevailed, the entrepreneurs would be willing to co-operate with scientists and wildlife departments in introducing some biological marker into the diet that lodged in the shell and could be used by customs officials to distinguish captive-raised from wild stock. Analysing the amino-acid composition of the shell is one approach to this problem (Hendrickson et al., 1977). Perhaps even better would be to introduce a synthetic fatty acid into the diet (Ackman, R.G., personal communication). The structure could be altered every few years, like changing a code number. This could be invaluable because however many farms or ranches there are, the incentive to take hawksbills from the wild will remain. Someone spearing a hawksbill on a reef has paid nothing for feeding the animal or keeping its water clean. To propose farming or ranching is not to deny that restrictions on trade in wild hawksbills are still needed. It is based on the hope that, even if farms do not remove all the incentive to take wild hawksbills, they will reduce the pressure on them by supplying a sizeable slice of the market with a dependable and perhaps superior product.

Here we come to the stale and unanswerable conundrum: will mariculture operations for turtles saturate the market or will they stimulate it? If ranching is linked to conservation in a logical careful way with a well-marked product, it is unlikely that hawksbills will be worse off, except to the extent that new markets for shell are developed and advertising stimulates consumers into a buying frenzy. If that happens, then supplies from maricultured turtles might be unable to meet the demand and the incentive to take hawksbills from the wild might become even greater. This is a legitimate fear; it cannot be dismissed. Even with better figures on the total world use of hawksbill shell, and estimates of how much farms might provide, there would be the intangibles of fashion and of how well any plans actually work in practice. Yet it is equally impossible to dismiss the hope that maricultured products would reduce the pressure on wild hawksbills.

Despite these acknowledged uncertainties, much can be said for establishing at least one fairly large scale hawksbill farm or ranch, to

investigate mariculture methods for this species and to see if the products could cut into the market. Whether the hawksbill is endangered or only vulnerable, its situation is serious, there is agreement on that. Creating more reserves and more local protection for hawksbills would be helpful, but with their widespread nesting enforcement is difficult. Moreover, the main threat stems from the demand for their shell. Any solution getting at the root of the problem has to tackle this. An international ban on trade is unlikely to be effective. By taking out a reservation under the CITES convention, the Japanese have made it clear that they are not about to renounce this trade. The outcome of a world-wide campaign against hunting and consumption of hawksbills, on a scale similar to that on behalf of whales, is just as uncertain as is the effect of mariculture on demand. The Japanese Tortoise Shell Association already seems to be moving in the direction of farms or ranches. It realizes that ransacking the oceans for hawksbills cannot go on indefinitely. The conservation community will soon be forced to adopt some attitude to these initiatives. Perhaps attempts to influence them, to inject balancing conservation contributions, would be more productive than a repeat of the drawn-out battle with the Cayman Turtle Farm. That did not demonstrably increase populations of turtles in the wild and it may have diverted attention and energy from more productive activities (Chapter 8). Finally, there is at least a hint that mariculture operations might be able to supply a sizeable portion of the market. According to compilations of government statistics (Mack et al., in press), exports from the Cayman Islands accounted for about 1/10th of the imports of raw tortoise-shell to Japan from January 1977 to October 1979. There are, of course, numerous problems with such trade figures. Imports and exports do not always match up. From the figures alone it is not certain that the exports from the Cayman Islands all or mostly came from the Cayman Turtle Farm. Some estimates coming from the Cayman Farm itself (Wood, J.R., personal communication) give lower figures for sales to Japan than the official customs statistics. Possibly some turtle shell is re-exported from the Cayman Islands by other entrepreneurs. But lacking anything better to go on, it does appear possible that the Cayman Turtle Farm may be supplying a significant part of the Japanese market. Another way of assessing the capability of farms to supply this market is to compare the total imports of shell to Japan with the production potential on the Farm. From 1976-1978 an average of 44,265 kg a year of raw tortoise-shell was

imported by Japan (Mack et al., in press). On the Cayman Turtle Farm the usable carapace shell from a green turtle is .9% of its body weight and production on the Farm has exceeded 500,000 kg of turtle in the past (Wood, J.R., personal communication). The Farm therefore is capable of producing 4,500 kg of shell a year, close to 1/10th of the 44,265 kg annually imported by Japan.

The Farm does not deal in hawksbills but in substitute shell from green turtles. It is too early to know how important this development will be. But even if green turtle shell did not become widely accepted in Japan, it is still notable that a single farm seems to supply or is capable of supplying 1/10th of this market. If that really is the case it only needs 10 hawksbill farms of equivalent scale to satisfy the whole industry there. If conservationists and industry could work together toward a situation where the Japanese Tortoise Shell Association bought only from farms or ranches that had been established from eggs in ways not detrimental and even helpful to the wild stock, as suggested above, then—maybe, maybe—the prospects for the hawksbill would brighten. It is at least worth serious consideration, as an alternative to the present impasse.

Turning to the other species of sea turtles, the green, the flatback, the loggerhead and the olive ridley, in terms of the value of their eggs relative to their other parts, they lie somewhere between the leatherback at one extreme and the hawksbill at the other. In a few cases, perhaps, collecting the eggs may be the most attractive way of exploitation but probably more often, especially if the vogue for turtle leather continues, there are considerable temptations for individuals to get rich quickly by killing as many animals as they can and banking the profits. What happens when these temptations go virtually unchecked by the government is evident in Mexico. Already 3 major arribadas of olive ridleys on the west coast have been reduced to a remnant. These occurred at Tlacoyunque (Guerrero), Mismaloya (Jalisco) and Chacahua (Oaxaca). It is difficult to find details and documentation about these arribadas, presumably because they were drastically exploited before biologists had a chance to study them. But people who have visited the area attest these arribadas once existed and this has not been disputed (Marquez et al., 1976; Pritchard, 1979a; Ross, 1980, Frazier, 1981; Pritchard and Cliffton, 1981). The largest remaining arribada at Escobilla (Oaxaca) is under great pressure (Cahill, 1978; Frazier, 1981). In a single week thousands of turtles are killed as they assemble

offshore for breeding. The operation is run by co-operatives who have permission from the Instituto Nacional de Pesca to take a certain quota each year. There is also some protection on the beaches for those females that make it to the shore to lay. From those that do not, when they are slaughtered, the eggs are removed from the oviducts and put into styrofoam boxes. However, these measures bear no rational relationship to the number of adults taken. How possibly could they? With no reliable information on longevity, reproductive output, survivorship of the young and years to maturity for ridleys, there is no rational way a quota could be set. Moreover, hatch rates from oviductal eggs are poor; figures of 37% and 7-22% have been quoted (Pritchard, 1978, 1979b; Cliffton et al., in press). Also artificial incubation probably biases sex ratio. That the resulting hatchlings compensate for the adults taken is no more than a guess. The huge quotas and harvesting arrangements at Escobilla are not grounded on biological considerations but on something else:

> Coastal Oaxaca is a long way from Mexico City, and there is no real possibility of fielding a large crew of federal enforcement men in this remote area. Consequently, if PIOSA had not been allowed to have a quota as high as, or nearly as high as, it requested, such a harvest would simply have taken place anyway, with no real possibility of control. By granting one company a monopoly to purchase all turtles caught by the local cooperatives, it was hoped that the legitimate cooperatives and the PIOSA field men would act as unofficial enforcement agents, ensuring that no one else would dare get in on the act. This interpretation may reflect pragmatic reality, but also makes it clear that the quotas are set by commercial pressure rather than by any biological insight into what the populations can stand.
>
> (Pritchard, 1978)

On top of all this there is a major problem with incidental catch of turtles off the west coast of Mexico. In some areas the average catch per boat each working day is thought to be 20 turtles, green turtles as well as ridleys. More than 35 green turtles have been caught in a single trawl (Pritchard and Cliffton, 1981).

There are, nevertheless, those who go along with the quota system in Mexico for pragmatic reasons. At least it provides the co-operatives with an incentive to stop poachers and they have in fact intercepted illegal traffic on a number of occasions. The former owner of the turtle

processing plant in Oaxaca, Sr. Antonio Suarez, is quoted as saying 'the surest way to drive a species to extinction [in Latin America] is to give it total protection' (Cliffton et al., in press). Some quotas are better than none and if the authorities set too small quotas the system would collapse and there would be a free for all. Even minimally effective conservation measures, such as trying to keep a 750 m stretch of beach as a reserve for green turtles in the State of Michoacan, might be seeds that one day will grow into broad protective shields (Pritchard and Cliffton, 1981). One cannot but admire people who work for wildlife in such an unpropitious environment and hope not to say anything that will upset their efforts.

But at the same time it is necessary to denounce the mad destructiveness of killing thousands of adults when they assemble for breeding, bearing ready-formed eggs. If Escobilla is not to go the way of Rancho Nuevo and Mismaloya and Tlacoyunque, as yet another example of how to destroy a resource rapidly, even before its potential is fully assessed, then biological considerations will have to replace political ones.

Fortunately, a number of countries are taking a saner and firmer approach to their newly-found turtle rookeries. But that should not prevent them from benefiting from these resources, and rapidly too. Without endangering and even perhaps augmenting their endowment, they can use the wasted eggs, either directly, or indirectly, by converting them into adults on farms or ranches. An interesting new example in the latter category is the Saint Leu turtle ranch (CORAIL) on Réunion Island in the Indian Ocean (Lebrun, 1975; Anon., 1980a). According to a 1977 prospectus, 30,000 green turtle hatchlings a year would be taken from Europa and Tromelin. That may sound like a large number but it is only 2% of the estimated total for those islands. Moreover there is a high natural wastage. When hatchlings emerge by day, as they do sometimes, most are carried off by frigate birds. Many of the hatchlings collected for the new ranch have been from such daylight emergences (Hughes, in press b). Also at the height of the nesting season on Tromelin around 40% of the nests (107,000 eggs) are dug up by the turtles themselves (Anon., ca. 1977). This leaves plenty of scope for augmenting the number of hatchlings reaching the sea, and the proposal was to compensate for the turtles taken by protecting some of the other clutches. Among the measures suggested were putting nets over the beaches to stop frigate birds swooping down on hatchlings

emerging by day, and carrying hatchlings out beyond the coral reefs to avoid inshore fish predation. Whether these particular measures are the best is debatable. Maybe frigate birds just take an equal number of hatchlings from the surf instead of from the beach. Maybe the experience of swimming out to sea is important for orientation (Chapter 4). Also it would be rash to endorse the Réunion ranch without having more information on how the average numbers of nests each year are estimated, on the welfare of the animals in captivity (Fretey, 1978), on how many clutches are protected and by what means and on many other details. Even then in such remote places as Europa there need to be safeguards that conservation and collection procedures are adhered to. But whatever the actual practices may be—and there is little firm to go on at present—the principle is sound: linking the quantity of turtles taken to compensatory and even overcompensatory conservation, measured *in the same units* of hatchlings or eggs.

Whether ranching of this kind is sound economically is much less certain. Raising turtles in tanks for a few years is elaborate, costly and long-term. Until turtle mariculture becomes less experimental, it will often be more desirable to concentrate on using eggs as food and to turn away from the possibly more lucrative but riskier markets of luxury items made from leather and shell (see also Diamond, 1976). Ultimately, and this would take many years even with sounder tagging methods, when population dynamics of turtles are better understood, it should be feasible to offset a specified cull of adults from the wild by protecting an appropriate number of eggs. When ways of determining age are discovered, turtles could be taken at or toward the end of their reproductive lives (Hendrickson, 1958).

Meanwhile, it is wiser to exploit them as egg-laying machines. The idea of permitting and regulating egg harvesting is not new (see, for example, Hendrickson, 1958; Harrisson, 1962; Schulz, 1975, 1980; Diamond, 1976; Cornelius, in press), but too little has been done toward actually instituting such schemes or improving the few that exist. For the next few decades at least, conserving turtles needs re-orienting from sanctuaries, bans, alarmism and wailing about the past, to the benefits of managing and maximizing the eggs delivered so freely to our shores. What a wonderful opportunity sea turtles provide for us to pay with protection for what we take. If we cannot work out ways of living alongside the turtles, with such propitious circumstances, then what hope is there when it comes to the wildlife of Africa and the vicuna?

The biology of turtles, with their gentle demeanour, terrestrial breeding and huge output of eggs, many of them naturally doomed, has all the ingredients for an exemplary balance between profiting from and preserving wildlife, between taking and leaving, between use and admiration, between commerce and conservation.

ABBREVIATIONS

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CORAIL	Compagnie Réunionnaise d'Aquaculture et d'Industries Littorales
FAO	Food and Agriculture Organization of the United Nations
IUCN	International Union for Conservation of Nature and Natural Resources
NMFS	National Marine Fisheries Service (U.S.A.)
PIOSA	Pesquería Industrial de Oaxaca (Mexico), Sociedad Anónima
UNEP	United National Environmental Programme
WWF	World Wildlife Fund

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