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'Head-starting' and other conservation techniques for marine turtles Cheloniidae and Dermochelyidae

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Seven species of living marine turtles are recognised. These include the worldwide Leatherback turtle *Dermochelys coriacea*; the pantropical Green turtle *Chelonia mydas* and Hawksbill *Eretmochelys imbricata*; the subtropical Loggerhead *Caretta caretta*; the Olive ridley *Lepidochelys olivacea*, absent from the north and north-west Atlantic but otherwise pantropical; Kemp's ridley *Lepidochelys kempi*, restricted to the Gulf of Mexico and the North Atlantic; and the Flatback turtle *Chelonia depressa* from Northern Australia.

Concern has been expressed for the survival prospects of all sea turtles; all except Australian *Chelonia* populations are included on Appendix I of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), and the Leatherback, Hawksbill, and Kemp's ridley, Florida and Mexican populations of the Green turtle, and Pacific Mexican and Surinam populations of the Olive ridley, are listed as 'endangered' by the United States Department of the Interior. The seven species have very different population status. Kemp's ridley is certainly the rarest; perhaps as few as 400 breeding ♀♀ survive. I have estimated world Leatherback populations at 29,000 to 40,000 breeding ♀♀ (Pritchard, 1971); subsequent discovery of some new nesting beaches, especially the important beach at Tierra Colorada, Guerrero, Mexico, might raise this estimate to perhaps 50,000. The world population of mature ♀ Loggerheads may be of the order of 100,000. The Green turtle and the Olive ridley number at least a few hundred thousand, and probably over a million. No estimates have been made for the diffuse-nesting Hawksbill, but it is known to be declining in many areas; it is most abundant in the Indonesian area, and is severely depleted throughout the Atlantic. The Flatback is relatively unstudied, but it is not subject to commerce, is not valued as food by aboriginals, and there is no evidence that populations are depleted – though loss by drowning in prawn trawls may be significant (Cogger & Lindner, 1969).

There is an almost total lack of knowledge of the population dynamics of all species of sea turtle, despite numerous tagging programmes, some of which have been in progress for one or two decades. There is still no proven method of permanently tagging hatchlings, and it is unfortunately true that most adult tagging programmes yield more information about the life span of turtle tags than of the turtles themselves.

This lack of knowledge makes the design of effective turtle conservation or restoration programmes very difficult; indeed, turtle conservationists are even divided as to whether turtle populations that must be exploited for human consumption are best harvested at the egg, immature, or adult turtle level, though the majority favours controlled egg exploitation and complete protection of the turtles themselves. Most workers proceed on the general assumption that if fewer turtles are killed and more nests protected from human or animal predation, the population as a whole will benefit. Certainly the logic behind this argument appears to be watertight; but some turtle populations have managed to persist to the present despite massive inroads into the eggs or adults for human consumption, while others have disappeared altogether or diminished to a fraction of primordial levels despite careful protection of both adults and eggs. As examples of the former category, the Leatherback population nesting in Trengganu, Malaysia, appears to have been stable for at least the last couple of decades, with about 1000 (650–2000) new (untagged) ♀♀ nesting each year, despite the collection of all but about 10% of eggs laid for human consumption. Similarly, Olive ridleys have been subject to massive slaughter of adults in Oaxaca, Mexico, for at least the last 15 years, yet enormous nesting aggregations are still seen – though perhaps for not much longer.

On the other hand, populations of Kemp's ridley in Tamaulipas, Mexico (the only known breeding site for the species) and of Olive ridleys at Eilanti, Surinam, have received total beach protection (both adults and eggs) for over a decade, yet both populations continue to decline and are now reduced to only about one-tenth of mid-1960's levels. It is possible that heavy shrimp trawling activities in the adjacent waters results in the death by drowning of so many turtles that recovery of the population is impossible. On the other hand, the populations of these group-nesting species may have been reduced below a critical recovery point – or again it may be that the maturation time is so long that the hatchlings produced since protection was instituted have not yet reached maturity.

It is known that the Green turtle, at least, may mature under captive conditions in eight to nine years; the Cayman Turtle Farm has now demonstrated that ♀♀ hatched on the premises in 1967 produced viable eggs in 1975 and 1976 (Wood & Wood, in press), and Witham (1970) has demonstrated captive mating between nine- and ten-year-old Green turtles in Florida. Nevertheless, maturing time in the wild remains unknown; fragmentary data suggest that growth under natural conditions (when the turtles feed primarily upon marine vegetation instead of the high-protein fish-derived diet of the farm animals) may be erratic and amazingly slow. Several half-grown Green turtles caught in the Galapagos Islands (where the growing season is presumably year-round) showed no increase in length whatsoever when re-caught approximately a year later (D. Green, pers. comm.). Preliminary observations by George Balazs in Hawaii suggest that maturing time of local Green turtles in the wild is much longer than in captivity, and C. Limpus (pers. comm.) has found that immature Green turtles near Heron Island, on the Great Barrier Reef, grew on average only 1·31 cm per year, irrespective of whether they were nearer the lower or upper end of the size range studied (60–90 cm). This would suggest that a 5 cm hatchling might take well over 50 years to reach maturity at 105 cm! Witham (1976) in his mark and recapture studies of captive-raised and released Green turtles similarly concluded that captive growth rates do not provide a useful model for the much slower rate in the wild.

Few data are available for maturation time of other species, but it appears possible that the carnivorous species mature much more rapidly than the herbivorous Green turtle. George Hughes, working in Tongaland, South Africa, experimentally marked a large number of hatchling *Caretta* by excision of a certain marginal scute in each. Four seasons later – about three years nine months after the hatchlings were marked – two adult ♀ turtles were found on the nesting beach with similarly excised marginals. Nevertheless, Hughes has been cautious about interpreting this as definite evidence of a four-year maturation time, since the mutilations of the adult turtles could have been inflicted by some other cause. Similarly, studies in Malaysia (Siow, 1978) on Leatherbacks demonstrated that, of 100 hatchlings marked in 1967 by clipping off the pointed posterior tip of the carapace, two adults with similar mutilations were seen nesting several years later, in 1974 – but again, the mutilation may have been inflicted by some other cause. A total of 11,502 hatchlings were similarly clipped in 1976 to provide a more useful statistical sample.

In nature, loss of eggs and hatchlings is often very high. Mammalian predators (for example, raccoons in Florida and Georgia, or coyotes in Tamaulipas, Mexico) may raid almost all nests on certain beaches – often before the ♀ has even finished laying. Ghost crabs, monitor lizards, ants, and many other predators are also able to penetrate a nest and destroy some or all of the eggs therein. On some beaches erosion may be so severe that eggs may be washed into the sea, or exposed to non-burrowing predators such as Black vultures *Coragyps* long before they hatch. Hatchling turtles are also eaten by vultures and ghost crabs, as well as by night herons, feral pigs, frigate birds, and many other predators. Once at sea, their ranks are rapidly decimated by predatory fish, and the need for a ♀ turtle to lay many hundreds of eggs in order simply to replace herself becomes evident. An obvious strategy for restoring a depleted turtle population is therefore to supervise egg incubation under protected conditions, and to raise the hatchlings in captivity until they have outgrown most of their predators – though a more conservative strategy is simply to release the hatchlings on their natal beach, and protect them from predation as they move down to the sea.

Since the mechanism by which a turtle relocates its nesting beach once it reaches maturity is unknown, it is prudent to assume that some form of 'beach imprinting' takes place, and that a well designed recruitment enhancement programme will not neglect the necessity of providing hatchlings with the opportunity to become thus imprinted. Another critical consideration that should not be ignored is that the sex of Green turtles, and probably other marine turtles (as well as certain freshwater and terrestrial forms), does not appear to be irrevocably determined when the ovum is fertilised, but rather remains labile, and is apparently controlled in part by the temperature of incubation. Much further research must be done to amplify this observation, but if eggs are incubated artificially it is important that the temperature regimen of the eggs so treated closely follows that of natural clutches. Failure to ensure this may result in producing a nearly unisexual batch of hatchlings.

Relatively few studies have been done on the percentage fertility (or rather, percentage emergence) of absolutely natural nests. However, series of undisturbed nests of the East Pacific green turtle *Chelonia mydas agassizi* in the Galapagos Islands gave an average yield of 39·15% for January nests, 32·21% for February nests, 39·18% for March nests, and 38·26% for April nests. The average figure was severely depressed by complete failure of several nests in each sample, and in each month at least one nest yielded 95–100% hatch. It appears that transfer of eggs from natural nests to artificial nests of similar depth in a beach hatchery depresses the percentage of successfully emerging young; moreover, eggs transferred more than about 24 hours and less than three or four weeks after deposition are liable to fail completely. On the other hand, some workers have found that percentage hatch may be enhanced by incubation in styrofoam boxes, these providing protection from extreme temperature fluctuations, dehydration, flooding, and predators. In such boxes, even eggs taken from the oviducts of slaughtered ♀♀ may produce a 37–40% hatch.

Eggs in boxes should rest on a few cm of sand, and have a sand layer of similar depth on top of the topmost eggs; lids should be placed loosely, and the sand dampened slightly if it appears to dry out. However, too much moisture may cause the hatchlings at the bottom to drown. Boxes containing incubating eggs may be moved around if necessary, but should always be kept upright. Average incubation temperature should be around 27°C, although some diurnal fluctuation is acceptable. Incubation of eggs of all sea turtle species takes approximately 60 days, with extremes of between 43 and 72 days; ridleys are somewhat more rapid than others, and Leatherbacks somewhat slower.

Hatchlings usually emerge after dark, and should be released promptly; after 24 hours or if they become too warm or too cold, they are liable to lose their infantile 'swimming frenzy' which carries them beyond the breakers, and may be thrown back on shore or otherwise disadvantaged. The hatchlings should be released high on the beach, and escorted down to the sea so as to prevent loss by beach predators. In this way it may be assumed that natural 'imprinting', if it takes place, has been successfully duplicated.

Many turtle conservationists have attempted to eliminate the high at-sea mortality of hatchling sea turtles by raising them in captivity for the first months of life. This is a legitimate experimental technique, although since it is still not known for sure if the young will be correctly programmed to nest in an appropriate place when they reach maturity, it should not be attempted with more than a small proportion of the production of a given beach. In any case, if the operation is successful and captive mortality is low, the logistics of housing and feeding many hundreds or thousands of growing young turtles soon become daunting indeed. However, studies by Ross Witham in Florida have shown that captive-raised Green turtles may survive and grow in the wild, and the technique appears to have promise. Hawksbill turtles have been successfully head-started and released in the Palau Islands by James McVey. Palau may be considered a well selected site for such a programme, since eggs left in natural nests are liable to be raided by local people; and the Hawksbill appears to be the most sedentery of the sea turtles, so when released in the nearly enclosed Palau Lagoon, it is likely to remain there. Head-starting is also being conducted at the present time with several thousand hatchling Kemp's ridleys, out of the approximately 90,000 eggs laid by this species in 1978, as part of an integrated intensive effort to save this highly endangered species.

Hatchling sea turtles are very liable to fungoid and other diseases, and it is essential that they be housed in the cleanest possible sea water. A rapid once-through irrigation system is ideal, although where this is impossible a recirculating system, with high-volume pumps and cleansing of the water by filtration and through activated carbon and exposure to ultraviolet light, may be used. A land area should not be provided, since hatchlings are liable to crawl ashore and become dehydrated. For the first week or more, the turtles have positive buoyancy from their yolk sac, and cannot dive. Food during this period should therefore be of a type that will float, unless the turtles are kept in water only a few cm in depth. Hatchling turtles require animal food; in order to facilitate adjustment to the wild this should be varied – chopped non-oily fish, chopped shrimp, proprietary fish chow, etc. – since turtles accustomed to a single type of food may fail to recognise other types as edible.

Ideally, young turtles should be raised in separate tanks, though this is seldom feasible. When crowded, they are liable to take bites out of each other's flippers, and the resultant injuries become infected very easily. To some extent, this aggressive behaviour can be forestalled by frequent feeding (several times daily) *ad libitum*. Leatherbacks cannot be raised on a diet of fish or muscle meat; their digestive system cannot process such food, and they will die from diseases resulting from gut impaction and stagnation. In the wild the nearly exclusive diet of Leatherbacks is jellyfish, of which they eat phenomenal quantities to reach their adult weight of about 500 kg; and this also provides the best diet for young Leatherbacks in captivity. Where this is not feasible, some success may be achieved with substitute soft foods such as chicken liver. The soft-skinned Leatherbacks are also liable to injure themselves on a hard-walled (glass or concrete) tank, and containers should therefore be lined with sponge rubber or plastic 'curtains' to prevent this.

Once turtles have been raised to a suitable size for release (20–30 cm), the location of the release requires careful consideration. In the majority of cases, the habitat adjacent to the nesting beach is unoccupied by and unsuitable for turtles in this size range, and it would be a mistake to release them there. For some species (e.g. *Chelonia mydas, Eretmochelys imbricata, Lepidochelys kempi, Caretta caretta*), natural habitat for at least some of the immature individuals can be identified, and this should be utilised as a receiving point for released yearlings. However, it is not known where the young of *Dermochelys coriacea* or *Lepidochelys olivacea* may be found, and until this lack of knowledge is rectified it is probably better to refrain from 'head-starting' these two species.

Above all, it should be emphasised that captive rearing of hatchling sea turtles for release is an experimental procedure, and should never be used as a justification for higher levels of harvest of wild turtle populations, or conducted to the exclusion of direct release of hatchling turtles.

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