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SEA TURTLE RESEARCH AND CONSERVATION—SOME PROBLEM AREAS

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ABSTRACT

In the light of recent researches on sea turtle biology, some of the problem areas which need urgent attention for developing research programmes in the country are discussed here. It is hoped that focus on these problems would help in developing more meaningful conservation and management programmes. The paper also outlines research and conservation strategies for the future.

INTRODUCTION

There are five species of sea turtles in the Indian Seas and all are considered endangered and placed in Schedule I of the Indian Wildlife (Protection) Act of 1972. These species are also listed in Appendix I of the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibit trade in turtle products by party countries. None of the five species are endemic and may undertake long migration to feeding and breeding grounds often across international boundaries. There are recent suggestions on the existence of non-migratory populations or population segments. During their life-history, sea turtles pass through various ecosystems and this diversity from the nesting beaches to their sojourn to the feeding grounds and back to the nesting beaches is a complicated one. At all stages they are vulnerable to heavy natural predation and exploitation by man. In nature, recruitment to adults is extremely low, large-scale mortality occurring even before the hatchlings enter the sea and in the inshore waters.

With considerable importance given currently to the recovery programmes aimed at the conservation and management of sea turtle resources, there is a greater national awareness on the problem. More individuals and organisations are evincing an ever increasing involvement in researches on sea turtles. During the past year, I have been receiving requests from interested workers as to what type of studies could fruitfully be under taken on the ecology, biology and behaviour of sea turtles with our limited resource facilities. The problem for many seems to be, where to start, what to look for, whether material will be available for long range studies and monitoring and how to go about it in the first instance as sea turtles are completely protected animals. Benign research has no doubt a place in the Scheme of things. Today there is a school of thought advocating that hatching and release programme is a must and that investigations connected with these may only be meaningful. We may have to critically examine whether we are over reacting in this or whether the hatchery programmes have to be considered for selected areas. There is a clear case for such a programme along the Madras Coast where human and non-human egg predation is very high. On the other hand in a place such as the mass nesting beach at Gahirmatha, Orissa, perhaps transplantation of eggs to other parts of the beach may be a solution.

We may have to fix our priorities on conservation measures to be adopted and supported by research programmes. The fact remains that the sum total of our knowledge on the biology of sea turtles from India is so meagre that one should not feel defident to take up challenging researches which may aid conservation and management programmes. The subject is more complex as all five species of sea turtles show differences in their life habits and behaviour.

It is in this context I feel that the ' World Conference on the Biology and Conservation of Sea Turtles ' held in Washington DC from 26th to 30th November, 1979 is a landmark. The published Proceedings of the Conference entitled ' Biology and Conservation of Sea Turtles ' Edited by Karen A. Bjorndal, for the first time brings together expert opinion on various facets of turtle biology, life habits, reproductive physiology, population dynamics and other aspects to help in development of constructive programmes on conservation and management of the resources. I had occasion with two other Scientists from India to attend this very

important Conference and have felt that some of the problem areas identified in the presentations and in the course of the discussions also embodied in the published Proceedings have great relevance to us today. The lack of biological information to the conservationist is often frustrating and leads to the extreme view of total protection to be accorded but, why and how this is to be done still remains a problem. This is very true for sea turtles where basic knowledge of many of the life habits are wanting. There is a rapid accumulation of literature on nesting beaches and the nesting habits of sea turtles. What was considered good and positive at one time such as the hatchery programme for incubating the eggs and releasing the hatchlings or the head-starting programmes are today considered in some quarters as highly questionable. To give one example, recent researches have pointed to the effect of temperature on sex regulation and this in hatchery incubated hatchlings could create great imbalances if not properly managed. So also the once well thought of head-starting programme is today not considered favourably in view of the disorientation that may happen in the young turtles which may find it difficult to reach the natural feeding grounds. This feeling has surfaced since activities in these directions have not resulted in visible signs of building up of the resources. In the light of the perspectives in turtle research and the need for developing a coordinated programme of research on sea turtles in India, I would like to discuss here some of the problem areas which need our special attention.

There is very little sociality among sea turtles, except during courtship and mating and when large reproductive aggregations known as arribadas occur. Group activity is also seen at the time of emergence of the hatchlings from the nest where they trash about and emerge in quick succession and thenceon have to fend for themselves.

The mechanism that enables the hatchlings to take an accurate seaward heading is not still fully understood, although a good amount of literature has accumulated on this subject (Ehrenfeld, 1968 ; Schone, 1975, Mrosovsky, 1978 ; Van Rhijin, 1979, Carr, 1981).

Carr (1963, 1981) has focused on the spectacular response of the hatchling to the surf within minutes of its emergence. The ability of the hatchling to circumvent the forces of the breaking waves and get beyond the surf with ease needs study under different surf conditions.

The 'lost year' has been a puzzle for a long time since hardly anything is known about the hatchlings once they reach beyond the surf. Frick (1976) and Carr (1981) talk about the seaward drive of the hatchlings which head towards the open sea. Little is known about the pelagic existence of the hatchlings. Silas *et al* (1984) have discussed the utilization of the reserve yolk in the hatchlings in captivity for several days after their emergence. Their movements in relation to surface currents and other oceanographic parameter needs study.

The migration of the turtles to the feeding grounds and thence for reproduction to the nesting beaches needs study through tagging or marking experiments as well as work on their sensory physiology to understand the mechanisms helping in such guidance system. Better methods of tracking the migrating turtles including the use of internal tags and satellite telemetry should be explored. The turtles which are tagged on the nesting beaches will be females and as such more information will be needed on non-breeding stages of both sexes. Little is known about the male segment of the population except from incidental catches in fishing gear. We have no information from our waters of sea turtles basking on the beaches close to feeding grounds nor of their hibernating at the sea bottom.

Reproduction

The ethology of mating is today better known for the green turtle *Chelonia mydas* (Bustard, 1972 ; Booth and Peters. 1972, Hendrickson, 1958). Information is very scanty on courtship and mating in other species.

According to Ehrhart (1982) the temporal relationship of copulation, fertilization and egg laying has puzzled marine turtle biologists for over 25 years. The need of repeated matings or the long term storage of sperms from one mating yet awaits elucidation. Carr and Hirth (1962) and Carr (1965) opine that pre or post nesting mating may fertilize eggs to be laid 2 or 3 years later, and not eggs laid during the season. This concept of delayed fertilization has been questioned by Frazier (1971) on the following grounds :

'*a*. There is no evidence that nesting females without claw mark on the carapace have not mated and the eggs laid by such females are fertile.

b. It appears non-adaptive for virgin females to migrate long distance to mate, but not nest for the next two or three years.

c. The need for the males to migrate to the breeding grounds to mate in order to deposit spermatozoa about 3 years in advance instead of mating at the feeding grounds a few months before nesting.

d. The mechanism by which females could maintain viable sperms in the reproductive tract which has been doubted has now shown to be possible by Solomon and Bain (1979) in the case of *C. mydas*.'

In short, delayed fertilization or otherwise, needs verification in the different species. The frequency of mating prior to or during the nesting season, and whether this happens once or more during a season needs further elucidation.

As regards nesting. Carr and Ogren (1960), Hirth (1971) and others have identified and categorised eleven stages of activity. Ehrhart (1982) has discussed selected traits among different species such as gait, oviposition, character of body pit,and time of day when nesting takes place. More quantified information on these and other habits are wanting. Reproductive potential has been discussed for the different species by many authors based on clutch size. Here we find a good amount of variability between clutch size of the same species in the same nesting ground, clutch in relation to body size and so on. Egg size also differs in the same clutch. At the same time, it is not known whether the same animal returns to nest a second or a third time during the nesting season and whether the variability in clutch size has anything to do with such behaviour.

Reproductive Physiology

Owen (1982) has delinated three areas where reproductive Physiologists could fruitfully interact with turtle conservationists. These are the identifications of critical reproductive processes ; improving conservation and research techniques for instance through determination of sex in hatchlings and immature sea turtles ; and continuing basic research in sea turtles adopting also technique such as radioimmunoassay of hormones, x-ray photography, laparotomy, hormone manipulation and electroejaculation, without harming the animals. A dependable sex determination method has been the estimation of circulating levels of androgens which is higher in male turtles.

Temperature Dependence of Sexual Differentiation

The pivotal temperatures at which more females or more males could result during incubation is an important new area of research in sea turtle biology having far reaching consequences. Mrosovsky and Yntema (1982) have critically reviewed this in the light of implications in conservation practices. In principle it has been found that females predominate when incubation temperatures are high and more males are obtained at lower temperature and females at still lower temperatures in the freshwater snapping turtle *Chelydra serpentina*. As mentioned earlier, one of the major lacunae is information on male population of sea turtles which is not accessible as the females in the nesting grounds. Thus the fact that embryonic sex differentiation depends on temperature, makes this an important tool to help manipulate sex ratio. The need here is to develop a rapid technique for sex identification which will not involve sacrificing the animal. In *C. mydas* it may take 4 to 6 years before any visible external signs are available for differentiating male turtles. Armed with this knowledge, we may now try to find out :

— The implication of temperature variabilities in hatcheries where eggs are incubated or in alternate nesting sites where clutches are transplanted.

— Whether in a single clutch sex differentiation happens on temperatures as follows : the eggs dropped in the latter half of oviposition and closer to the surface and subjected to marginally higher temperature turning out to be females and those dropped first lying at the bottom of the nest males ? It is imperative that data be obtained on sex ratio in eggs developing in natural nests as compared to those incubated artificially.

— The reason for protracted incubation period — specifically whether this can be correlated with temperature. According to Mrosovsky and Yntema (1982) a 1°C lowering of temperature will be reflected in a 5-day increase in incubation time. Hence, what would be the effect of a decrease of 2 or 3°C on masculinization or the increase of 2°C on producing predominantly females and the relative increase or decrease in the number of days of incubation ?

— There are suggestions that eggs from a clutch may be kept apart in 2 or three lots to ensure better hatching success. Since metabolic heat is produced by eggs, would smaller clutches be cooler and produce all males ? In short, would the size of the clutch affect sex ratio ?

— The crucial question is at what stage of embryonic development does the pivotal temperature play its role in sex differentiation.

I feel that temperature dependence of sex differentiation is basically one of the most important aspect in sea turtle research which calls for immediate indepth research. The well intentioned hatchery programmes without utmost consideration to this may for all lead to negative results.

Reproductive Endocrinology

Licht (1977) was the first to show that two distinct gonadotropins *viz.*, Follicle Stimulating Hormone (FSH) and Leutinising Hormone (LH) were present in the pituitary of *C. mydas*. In captive rearing populations it has been found that the FSH peaks during the nesting and LH and the steroid progesterone about a day later when ovulation of the clutch occurs. Verification of this in the wild population and in other species has still to be carried out. Further, in captive fresh water turtles the use of oxytocic hormones has been found to induce the turtle to deposit a clutch of eggs (Ewert and Legler, 1978). Such work should be attempted in sea turtles.

Behavioural Ecology

A whole range of problems can be posed in behavioural ecology of sea turtles of which we are totally ignorant of. To mention a few :

- — We have very little knowledge of the internesting intervals and travels of sea turtles.
- — Experiments elsewhere have shown the ability of migrating adult turtles to hold courses independent of the prevailing ocean current (Meylan, 1982). Turtles (*Lepidochelys kempi*) after nesting and returning to sea are known to initially travel against the current and later return with it.
- — The distances to which turtles travel during the internesting period is still a question mark.
- — Day time and night time activity of the post-nesting turtles is still blank. Diurnal acticity could differ from species to species and intraspecifically.
- — On what cues do turtles orient themselves at night ? What is the mechanism involved ?
- — What are the swimming speeds of turtles ? Here tag recoveries may give clues. For *Chelonia mydas* Carr, Ross and Carr (1974) have recorded as much as 7·2 km/hr.

Beach Selection by Nesting Turtles

Heaviest nesting have been observed along unlit beaches with no obstacles in the offshore approaches. Mortimer (1982) found a decreasing density of nesting with different types of beaches from those with no offshore obstacles to rocky approaches to lighted beaches in the Ascension Island. Bustard (1972) has reported the green turtle nesting when a good amount of beach front vegetation including large bushes and trees are present. Hawksbill is known to nest beyond the sandy beaches amongst vegetation (Frazier 1975; Mortimer 1982).

Studies on beach sands have been carried out, some positive and some inconclusive. However. Mortimer (1981) has found an optimum range of grain size for hatching success. He opines that nests could fail if sand is too fine or too coarse. Biotic factors such as beaches between estuaries and sand banks off open beaches may also have a role to play in nest site selection by the turtle.

Human intererfence such as lighted beaches, physical structures on beaches and antierosion works, beach mining and so on are known to have adverse effects on the nesting habits of sea turtles as well as also affect emerging hatchlings. Henridkson (1982) has rightly pointed out that besides interspecific and intraspecific differences in details of nesting behaviour among sea turtles, little is known about the effect of perturbations on nesting successes, particularly those of human origin. Effects of high amplitude low frequency sound vibrations which could mask surf sounds which could be a beach 'signature' for homing sea turtles is not known.

Nesting Cycles of Sea Turtles

It is well recognised that nesting cycles do exist but according to Hughes (1982) what needs to be known is whether the nesting cycle embraces the majority of the population or only a small segment of each population.

With the exception of the olive ridley in Surinam the tagged turtles returning as remigrants are fewer. However, information is available that the green turtle nests twice or even upto five times in consequtive years or at intervals of two, three or four years. We know that the remigration rates have been extremely low in the olive ridley tagged in Gahirmatha rookery in Orissa during the last four to five years.

Tagging has not led to any better understanding of feeding migrations. However, it has given information on average distances covered by turtles per day, approximate distances travelled, migration against prevailing currents and so on. Little is known of group migration of turtles. Use of long-term internal tags for hatchlings has been suggeted (Schwartz, 1981). While this may be an useful tool, I am a little defident when I think about the detection part of tag returns where an x-ray machine will have to be used. The

problem looks at present formidable as a working proposition in inaccessable beaches. To be meaningful, tagging (Monal tags) has to be taken as a long term project and on an intensive scale to yield any useful results. Still its greatest focus will be on the breeding migrations, and regular and irregular nesting behaviour.

Feeding Ecology

Feeding ecology is an emerging area of interest for sea turtle biologists in view of the fragmentary information available. A wide variety of items have been reported as the food of sea turtles and the findings are mostly qualitative in nature. Since they are protected species and cannot be sacrificed, the method of pumping stomachs of freshly captured sea turtles in the field as developed by Balazs (1979) should be of interest. The foraging patterns of turtle in feeding grounds especially where algal and sea grass beds exist warrants study. The Gulf of Mannar along the Tuticorin Coast is known to be the foraging ground of the green turtle through earlier capture of sub-adults in the fishing operations ; but no detailed work on the feeding ecology has been carried out. It is pertinent to mention here that the flesh of *C. mydas* and *E. imbricata* are known to be poisonous during certain periods and the consumption of poisonous algae/seaweeds are said to be one of the reasons for tainting the meat, the others being the animals feeding on the Portuguese man-of-war or jelly fishes. This needs a special study since during the last two decades there have been a number of fatalities as a result of consuming turtle flesh along the South Tamil Nadu — South Kerala Coast (Silas and Fernando 1984).

Food could affect growth rate, sexual maturity and the reproductive potential as has been reported for the Caribbean green turtle by Bjornal 1982).

Growth and Maturity

Growth rates in the wild population will not agree with what is seen in captive rearing. Tagging gives some clues as to growth since annuli in bones have not given good results.

Maturation age of turtles may differ. According to Balazs (1982) in green turtles it is known to range from 4 to 13 years based on growth rates in captivity. They are also said to mature at different sizes, some maturing at a small size while others attain a larger size before maturing. Information on other species is wanting. There are no answers to questions such as the influence of sea surface temperature on growth in sea turtles.

Estimation of Population Size

Except in the nesting beach, it is difficult, time consuming and expensive to conduct census of sea turtles. In short it is impracticable. Estimating total population is not possible at present on acount of large gaps in our knowledge of the biology of the species ; even natural sex ratio ; leave alone the age structure. In the light of these, it will be evident that it will not be possible to estimate total population size only on nesting estimates. Hence a considerable amount of basic research has to go in before we could ensure that population estimates could be done without bias. Meylan (1982) enumerates three steps towards population estimation as follows :

> ' (1) Determining the total number of female turtles nesting in a season ; (2) relating the yearly number of nesting females to the total number of reproductive females in the population ; and (3) relating the total number of reproductive females in the population to the number of turtles of both sexes and all age classes. '

The importance of aerial surveys for crawl track counts combined with ' ground truth ' data for estimating nesting population during the season needs no emphasis. Again tagging helps in estimating the female reproductive population.

Long range tagging programmes may help in developing population models for hatchlings and nesting female sea turtles. According to Richardson and Richardson (1982) ' Marine turtles may prove to be unique among wildlife species, in that a management decision by one man may not become apparent in the turtle population until an entire human generation has passed..... Predictive simulation models are one way to suggest management and research approaches to population with unusually long time lags. ' They further opine that quantitative studies of juvenile sea turtle population should receive the highest priority if realistic population models are to be developed.

Non-Human Predators

Turtle rookeries have a wide variety of non-human predators which have been very exhaustively classified by Stancyk (1982). These are predators on eggs, hatchlings, juveniles and adults. Predator control on natural nesting grounds is a major problem and cannot be done by chemical poisons (they affect also secondary consumers) and by trapping or shooting. Aquatic predation by a wide variety of bony fishes and sharks is a formidable hazard which cannot be controlled.

Transplanting of eggs to safer sites and releasing the hatchlings further out at sea may be a partial solution, but these are also fraught with dangers of induced imbalances in sex ratio of hatchlings or the wanting of natural imprinting of beach conditions in hatchlings.

There is need for studying the non-human predators in the nesting grounds and make quantitative esitimates of the damage they do to the eggs, developing embryos and emerging hatchlings. In the inshore waters the gut contents of fishes may be examined to identify the species preying on hatchlings and even juveniels.

Hybridization

Carr (1952, 1967) suggested the possibility of hybridization among sea turtle species. However, the first report of hybridization among the species, is in the case *C. mydas* and *E. imbricata* reported by Wood *et al.*, (1983). Recently Carr and Dodd (1983) have discussed the problems of hybridization in sea turtle at intraspecific levels among discrete sub-populations as well as among species. The former could happen by stocking turtles from different breeding populations in farms for breeding and the transplantation of eggs or hatchlings to other beaches as conservation measure. Hence, before translocation of eggs in different distant beaches, basic genetic studies on turtle species may have to be carried out to deliniate the spatial distribution of discrete sub-populations and avoid any imbalances. Intraspecific hybridization could become a potential problem in mariculture operations.

Conservation Options

Ehrenfield (1982) indicates the following as deserving highest priority considerations in any sea turtle conservation programmes :

—' Protection of nesting grounds and aquatic habitats, including minimization of environmental disruption at these sites.

—Use of hatcheries and short-range transplantation of nests to protect eggs at the nesting beaches ;

—Conservation education ;

—Control of international trade;

—National and international coordination of conservation strategies ; and

—Dissemination of improved fishing trawls,'

He has indicated lower priorities for

—' long range transplantation of nests ;

—headstarting ;

—fisheries-type management of turtle catch ;

—manipulation of sex ratios ;

—cottage industry turtle ranching ; and

—non-commercial captive breeding to maintain gene pools. '

Research and Conservation Strategies for the Future

I have highlighted here some of the important problems that need urgent consideration in developing research inputs to help conservation and management. However, this does not mean that there are no other equally important subject areas which will be needing our attention. In the light of our meagre experience on sea turtles biology and their life habits, I would like to suggest the following strategy for consideration :

1. An intensified effort be expended on basic research to understand the biology of sea turtles, their reproductive and nesting cycles, nesting grounds and seasons, pathways of migration to feeding and breeding grounds and the ecological relationships.
2. It will be necessary to identify genetically the populations and discrete sub-populations so that their behaviour biology and above mentioned aspects could be studied for the segments of the population, if genetic differences are established.
3. In view of the global decline in the population sizes of all sea turtles, except probably the leatherback, recovery programmes should be encouraged but with caution exercised on hatcheries and transplantation of clutches, bearing in mind, the possibility of incubation temperature having pronounced effects on sex ratio as well as on chance intra-specific hybridization. Nevertheless, under situations where there is heavy non-human predation on eggs and emerging hatchlings on the beaches and where man also resorts to collection of eggs for utilization, and where regulations are difficult to implement or take time, well planned hatchery programmes become imperative.
4. The hatchlings entering sea are subject to heavy predation by a wide variety of bony fishes, sharks as wall as sea birds and data on inshore

predation as well as predation on beaches will be necessary for quantifying recruitment estimates at this point of their life. Differential growth and the wide range in the number of years taken to attain maturity, and uncertainty of remigrations may be impediments in developing a forecasting system on recruitment to adult population.

5. Incidental catch of hatchlings, juveniles and adults in fishing gear, their monitoring and ways and means by which this could be avoided or minimised need our serious consideration. Regulatory measures on fishing during the seasons of courtship, mating and mass nesting of sea turtles in inshore waters as well as at the time of emergence of hatchlings from nesting beaches may be a way to circumvent the problem. However, the social implications and obligations to the artisanal fisheries sector will have to be studied before promulgating any restrictive regulations or introducing modified fishing gears.

6. Education, training and extension assume great importance. Building up a greater awareness to develop public policy should also be the goal of the scientist and conservationist.

7. There are diametrically opposing views on the question of mariculture of turtles, one school strongly advocating the impracticability and undesirability of such schemes and the other being optimistic. I have made an indepth study of the problem based on available data and am of the opinion that we shall not be in a position to consider mariculture an economically viable proposition whether on large scale or in the artisanal sector due to the complicated life habits of the sea turtles and our utter ignorance of vital aspects of their biology. Husbandry may be a possibility of the distant future, when we are in a position to manipulate and control the environment, the nutritional requirements, growth, reproduction and nesting cycles.

8. Under the circumstances, I feel that the option open to us is for stepping up recovery programmes to sea-ranching programmes once methodologies and experiences are gained in the proper incubation and release of the hatchlings. Conservation measures of protecting the nesting beaches from human interference and non-human predators, and managing the inshore ecosystem aimed at higher survival and better recruitment to juveniles and adults should greatly enhance such programmes. Thus in the near future, I would say that sea-ranching has a greater potential than mariculture of sea turtles.

9. This brings us to the question of candidate species for major sea ranching programmes. Amongst the five species undoubtedly the olive ridley stands out as far as numbers are concerned, although commercial products from it may not be of the quality that could be obtained from the green turtle *Chelonia mydas* or hawksbill turtle *Eretmochelys imbricata*. When we consider that about 3 lakhs olive ridley annually nest at Gahirmatha beach, some rough calculations could be made as to the total impact this would have on recruitment to the population. Theoretical estimates of the magnitude could be as follows :

   Assuming that on an average each clutch consists of 100 eggs nearly 30 million eggs are annually laid on this stretch of beach. Allowing for predation by non-human predators, destruction of earlier nests by subsequent nesting turtles, unfertilised eggs, arrested development due to imbalances, and hatchling predation on beaches, this may allow for only 25 per cent survival to the point of the hatchlings entry into the sea. This itself would amount to about 7.5 million hatchlings. Could we assume a 10 per cent survival of this number to adult size at first maturity? This would amount to about 75,000 turtles. If the annual estimates of recruitment is of this order with females around 70 per cent, wiih good annual remaigrations it is likely that saturations point would be reached at Gahirmatha if it is not already so.

10. Hence the need is also towards developing a future strategy of the rational utilisation of the resource by finding out whether culling of adults would be necessary in order to remove any imbalance of saturation nesting and heavy destruction to eggs in limited areas or whether this could be countered by transplantation of eggs on a continuing basis. We may objectively consider the options open. At present we have no information whether culling operations will be beneficial to the population, but the conservationist may have to address himself to answer such a question in the future. Thus, as I see it, there is need for a concerted co-ordinated effort for accelerating research on various facets of sea turtle biology, behaviour and ecology to help develop the rational management of this resource.

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