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Options and Limitations in the Conservation of Sea Turtles

ABSTRACT

The options for conserving sea turtles are limited by many things, but especially by the biology of the animals, themselves, and by our inadequate knowledge of them. These limiting factors include mysterious life cycles and obscure ecological relationships, long migrations across international boundaries, unknown population dynamics, unknown taxonomic relationships of different populations, nesting cycles of highly variable length, and an exceedingly long maturation time.

The combination of our incomplete knowledge about sea turtles and the numerous constraints imposed by their biology dictates a very conservative conservation strategy. Many of these limiting factors will not change markedly in the future. I conclude that the best we can do is to concentrate on the protection of existing wild populations, using the simplest and least risky techniques of conservation.

Fortunately, the techniques with the lowest risk and greatest promise are also those with the lowest cost and requiring the least elaborate technologies. (This is also true of conservation-related research.) Highest conservation priority should be given to the following items (listed in no special order): 1) protection of nesting grounds and aquatic habitats, including minimization of environmental disruption at these sites; 2) use of hatcheries and short-range transplantation of nests to protect eggs at the nesting beach; 3) conservation education; 4) control of international trade; 5) national and international coordination of conservation strategies; and 6) dissemination of improved fishing trawls (when available).

I accord lower priority to: 1) long-range transplantation of nests; 2) headstarting; 3) fisheries-type management of the turtle catch; 4) manipulation of sex ratios; 5) cottage industry turtle ranching; and 6) noncommercial captive breeding to maintain gene pools. Commercial ranching and farming cause a net drain on wild populations of sea turtles, and do not belong in

a conservation strategy.

It is no coincidence that the conservation methods that have the greatest potential for saving wild sea turtles are those not limited by the biology of these animals or by our ignorance of it.

Introduction

In the preamble to the Draft Conservation Strategy we wrote that "of the . . . factors . . . that determine the fate of sea turtles, only one, the biological factor, is nonnegotiable in a conservation strategy." This idea is of critical importance. No matter what we decide at this conference, and no matter what conservation measures are adopted later, if they are not in accord with the biological facts of life of sea turtles, they will not work. In other words, the options for conserving sea turtles are limited by the animals, themselves, and by our inadequate knowledge of them—limited to an extent rarely encountered in conservation.

The biological limiting factors include: mysterious and inaccessible life cycles for all species, with many of their ecological relationships totally obscure; long migrations that take turtles across international boundaries; unknown population dynamics; equally unknown taxonomic relationships of different populations; nesting cycles of variable length, which make yearly census data difficult to interpret, especially for green turtles; and an exceedingly long maturation time, which makes it likely that many of us will be in our graves before it is possible to know whether our conservation policies have done any good. Of course research will erase some of our ignorance, but most of these limitations are not going to change very much in the near future, and some are fixed in the genes of the turtles and will not change at all.

To see where the limitations apply, and to determine which conservation options have the greatest potential for success, it is necessary to examine critically the conservation techniques that have been suggested for sea turtles. Therefore, I will list many of them, as follows, with some of the technologically simpler and less expensive methods first.

Protection of Nesting Beaches

One of the simplest ways to conserve sea turtles is to make their nesting beaches sanctuaries, either by law or by official regulation. The effectiveness of this procedure depends mostly upon the local traditions of respect or disregard for laws and regulations, and upon the degree to which they are enforced. Another factor that can be important is the size of the reserve—whether it has enough depth to maintain the ecological integrity of the beach, itself, and whether it is wide enough to include the major turtle nesting areas. If conditions are favorable, it is sometimes possible to achieve considerable success in conserving sea turtles by using this technique, without the need to worry too much about the many subtleties of the biology of the turtles.

The simple protection of nesting beaches can be supplemented by a variety of practices designed to protect the area from destructive development, especially development related to tourism and recreation. Sella (this volume) has described how the removal of sand from Israeli beaches for construction purposes destroyed the nesting habitat there; and Witham (this volume) has listed the ways in which it is possible to lessen the human impact upon nesting beaches. This needs no further comment.

Another conservation technique that can greatly enhance the protection of nesting beaches (and sea turtles in general) is local conservation education. This technique is uncomplicated and relatively inexpensive, but it has been little used to date.

Protection of Feeding Grounds and Other Aquatic Habitats

Here the principle is the same as in the protection of nesting beaches, but the application is more difficult. It is far harder to delineate and patrol several thousand hectares of open water than to do the same for a few kilometers of linear beachfront. Nevertheless it can be done, as has been shown by the United States in protecting the turtle hibernaculum sites in the waters off of Cape Canaveral, Florida. Again, once it has been determined that turtles are using a particular area intensively for some purpose, it is not necessary to know too much more about them to effect simple conservation.

Sometimes it may be necessary to protect the aquatic ecosystem from damage by various kinds of human activities: destruction of reefs or reef faunas, and pollution by chemicals, silt, and other contaminants. Petroleum and related compounds are especially significant. Research concerning the responses of turtles to pollutants is lacking and would be interesting, but we do not need research to tell us that a 20-km oil slick is going to be bad for the turtles that get in its way, or, for that matter, that a reef that is repeatedly dynamited is not going to support a large population of hawksbills. As far as habitat degradation is concerned, it is important from the standpoint of management to remember that what happens upcurrent may determine what happens inside the reserve itself.

Management of Turtle Catch for Maximum Sustained Yield

One kind of active manipulation of populations in their aquatic ecosystems is the application of modern fish-

eries management techniques to sea turtles. Here I think we come to the first serious limitation imposed by sea turtle biology on a conservation option. I am not referring to the general criticism of the maximum sustained yield concept; this has already been well-covered by Dodd (this volume), and I agree with both him and Larkin (1977) in their conclusions. What concerns me are the specific problems caused by applying the methodologies developed for fish to the catching of sea turtles. We simply do not have the kind of long-term data on population dynamics and catch per unit effort that are necessary for even rudimentary fisheries management.

In addition, the slow growth rates of sea turtles make fisheries management of them especially difficult. Pritchard (this volume) reports extremely slow maturation rates for *Lepidochelys, Caretta,* and *Chelonia.* Balazs (this volume) has data that show that green turtles probably take several decades or more to reach sexual maturity. The danger of any fisheries management models applied to turtles is that the long lag time between turtle hatching and maturity will prevent managers from seeing the effects of their miscalculations during their tenure in the job, or during their lifetimes. Sea turtles are not like most commercial fish species, which mature much more quickly. What happens "now" to a managed turtle population is largely the result of past history, not current management practices, and this is very misleading. Our knowledge is such that sea turtle populations are not yet ready for fisheries management practices aimed at regulating the catch; if they ever are, it will probably be with dynamic pool models that take such variables as age structure of the population, growth rates, and mortality into account. But this kind of information may continue to elude us.

Manipulation of Eggs and Hatchlings at the Nesting Beach

There are 3 kinds of biological management at nesting beaches, each of which involves some interference with eggs and occasionally with hatchlings. Perhaps the least intrusive of these is the local nest transplantation method described by Stancyk (this volume). If this practice does reduce nest predation significantly, it may prove to be a boon to conservation. First, however, some fairly easy questions need to be answered. Will predators learn, in the course of a few nesting seasons, to find the artificial nests? Stancyk indicates that this is a possibility. Will nest transplantation fool predators other than raccoons in other parts of the world? Will the hatching rate be reduced in some places where workers may be badly trained and supervision is lax? Are the artificial nests being dug to the proper depth so that incubation temperatures and other microenvironmental factors are as natural as possible?

The removal of eggs to hatcheries is a more manipulative technique than short-range nest transplantation, and there is evidently enough of a difference to have resulted in a lower hatching rate under experimental conditions. Nevertheless, on beaches where natural hatching is low or nonexistent because of predation, hatcheries are clearly necessary. The Suwelo method (this volume) of protected incubation under natural conditions, coupled with immediate release of hatchlings after emergence is a safe and effective conservation technique, which also has the great advantages of minimal technology requirements and low cost. The principal danger is that the effort may be wasted if too small a percentage of local eggs are used; there is no guarantee that "15 percent of the harvested eggs," a figure cited by both Suwelo and his coworkers and by Siow Kuan Tow and Moll (this volume), will be enough to keep the populations in long-term equilibrium.

The discovery, described by Mrosovsky and Yntema (this volume), that incubation temperature can affect the sex of hatchlings, shows us that it is important to keep incubation conditions as natural as possible in the hatchery. Beyond this, the development of the elegant sexing method described by Owens (this volume) may tempt hatchery managers to use incubation temperatures to alter population sex ratios in some direction that is judged likely to increase fertility rates in the wild. I would caution against this. Our physiological understanding of sea turtles, primitive as it is, is far advanced over our genetic, evolutionary, and ecological knowledge. We have no way of knowing what deliberate manipulation of sex ratios will do to a population over the course of many years, thus there is a great potential for damage from such well-intentioned management schemes.

A final word about hatcheries: in looking at the data reported from Malaysia (Siow and Moll, this volume), I note that the different turtle hatcheries had markedly different annual rates of hatching (20 to 53 percent, 32 to 71 percent, 70 to 90 percent). Unless there is some trivial explanation for this, it might be worthwhile to find out what caused the differences, which are likely to transcend differences related to the species of eggs that are incubated.

The third and least natural method of manipulating eggs at nesting beaches for conservation purposes is to combine the use of hatcheries with headstarting programs, in which the hatchlings are raised to a size at which they are deemed to be less vulnerable to predation before they are released. Headstarting has become a common practice, and the existence of a headstarting program is often used to justify the removal of eggs from nesting beaches for other purposes such as commercial ranching and farming, or long-range transplantation efforts. I want to emphasize, however,

that there has not been a proven return of an adult headstarted turtle to its nesting beach. This does not mean that headstarting does not work. But headstarting does involve removing a turtle from a complex and totally unknown sequence of experiences that it would have had in its natural environment, and that may play a necessary role in its development. Everything we know about development in other vertebrates indicates that the genetically programmed sequence of developmental events is distorted in an aberrant environment. The early life histories of sea turtles appear to be very elaborate and take place in a sequence of different environments; there is no reason to believe that environment is less important to them than to other vertebrates.

As Pritchard (1979) has said, the "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." There is nothing wrong with headstarting *as an experiment*, provided that it, together with all other uses of eggs and hatchlings, remains an insignificant percentage of the reproductive effort at a given beach. We often hear that survival of hatchlings in the first year of life is only 1 to 2 percent, and that therefore headstarting programs should receive high priority. Yet we should consider that the figure of 1 to 2 percent survival is pure conjecture, not based on one shred of evidence, and that the survival and reproductive success of headstarted turtles after release is also unknown.

Efforts to Establish New Nesting Beaches

There have been a number of these efforts, from the massive Operation Green Turtle, in the 1960s, to the present heroic attempt to give *Lepidochelys kempi* a new chance for survival at Padre Island. The latter program has the benefit of accumulated knowledge, and has been carefully thought out in most respects. Klima and McVey (this volume) identify 4 factors that are considered to be the minimum necessary for potential success of a long-distance transplantation program. These are: 1) natural incubation conditions and orientation exposure for hatchlings on the new beach; 2) headstarting of released turtles; 3) an adequate marking technique; and 4) biologically appropriate release conditions. Of these, only the second is questionable (although the third may be hard to achieve). Headstarting is questionable because, unlike the other "minimum" conditions, it offers the very real possibility of lowering rather than raising the chances for success of the transplantation program. By combining headstarting and long-distance transplantation in the same experiment, 2 sets of independent variables are mixed together. Should the effort to establish a new ridley nesting beach at Padre Island fail or achieve only limited success, we may never know whether it was the headstarting or the transplantation that did not work. It might be better to release the majority of transplanted hatchlings directly upon emergence from the nest, reserving the minority for headstarting. I would certainly advise that this be done in Israel, to maximize the chances for success of their transplantation effort.

In their paper, Klima and McVey give 5 reasons for headstarting *L. kempi*. I have discussed, without citing them, some of these reasons in the section on headstarting above, and in the "noncommercial captive breeding" section, below. But one of these reasons deserves comment here. Klima and McVey state, "to verify the establishment of a second nesting beach at Padre island a 'headstarting' program is required, to produce turtles which can be tagged to provide later identification." But because the tags are unlikely to last until the turtles reach maturity, this is a very weak justification for headstarting.

I want to make one more observation that concerns both headstarting and long-distance transplantation. These experiments are all designed with the idea in mind that hatchling—or even embryonic—turtles may be "imprinted" with the odor or taste of chemicals released by the sand of their natal beaches. This is certainly a possibility, and it costs very little to take it into account. But even though I am one of the originators of the beach imprinting idea, I still must agree with Hendrickson (this volume) that the hypothesis is totally unproven. It may be that other characteristics of the beach environment are more important: infrasound, magnetic field characteristics, nature of the offshore waters, and so forth. If this is so, then headstarting may produce defective animals unable to respond to the cues from their own, or any, nesting beach. Again, this reinforces my warning that headstarting should never be used as a complete substitute for natural nest emergence of hatchlings on their natal or adopted beaches.

Technology to Reduce Incidental Take

The development of this technology may prove indispensable for the conservation of many populations of sea turtles, and it should be pursued energetically. The existence of this research program, however, should not prevent us from recommending that certain critical sea turtle habitats be closed to shrimp and other fishing until trawls that exclude sea turtles are commercially available.

"Cottage Industry" Programs to Raise Sea Turtles for Subsistence, Cash Income, and Release

After the spectacular failure of the Torres Straits Islands turtle farming scheme, it is unlikely that this type of technique will receive widespread support from either conservationists or government officials. But ideas of this sort never seem to die, as we have seen at this conference, so some remarks are appropriate. First, as Nietschmann has repeatedly and lucidly explained, the introduction of cash payments for resources into a subsistence culture, the act of coupling such a culture to the world or regional economy, destroys both the resource and the culture. Cottage industry headstarting or ranching programs turn a subsistence resource into a market commodity. (They also emphasize the value of luxury goods, such as tortoise shell and turtle leather, which rightly have little worth in a subsistence culture.) Even the much simpler policy of buying eggs from native peoples for resale and for conservation purposes is fraught with some of the same risks, although the damage can be intangible and may not appear for a number of years. I accept Dr. Siow's statement (conference discussion) that egg purchase is sometimes necessary. But there is a danger in teaching people that conservation is always accompanied by a cash profit, and a certain danger in running conservation programs on the proceeds from the sale of a resource. We have discovered this in the United States, where state fish and game departments are supported by hunting fees—often with most unsatisfactory results. I think it is very wrong also to assume the superior attitude that peoples in poor countries are incapable of having or acquiring moral feelings of conservation.

Second, it is worth noting that both headstarting and farming are techniques that require sophisticated technology and a high level of scientific control. These features are not available to peoples emerging from subsistence cultures.

Insofar as cottage industry farming or the sale of a part of the egg harvest are based on the assumption that headstarting works, then they are even more risky as conservation ventures.

Control of International Trade

The control of international trade in turtles and turtle products cannot be faulted as a conservation tool from a biological point of view. More will be said about it in conjunction with the discussion of commercial farming, below.

Commercial Ranching, Plus Headstarting to Augment Wild Populations

Apart from any benefits associated with headstarting and the release of a small percentage of their captive turtles, turtle ranches are entirely detrimental to conservtion. The value of headstarting is sufficiently unproven so that it is not enough to justify any commercial ranching operation. In many other respects, ranching is similar to farming, discussed below.

Commercial Farming

I have written about commercial farming elsewhere (Ehrenfeld 1974, 1980) and have concluded that it is detrimental to the conservation of sea turtles for a number of reasons. I see no need either to repeat or to modify my argument now. We have heard some people reject the conservation premises upon which turtle farming is based, and we have heard others defend them. How does one decide between them? Remembering my purpose here to describe the nonnegotiable constraints that sea turtle biology places on various conservation techniques, I will limit my discussion of this controversy to a single table. I have based this table on a paper by Webber and Riordan (1976). The paper was entitled, "Criteria for candidate species for aquaculture," and in my table I have simply evaluated sea turtles according to the criteria of suitability that they list (see Table 1).

What this table says to me is that because of intractable, unchangeable limitations imposed by the biology of the sea turtles, ranching and farming will remain practicable only while international demand for all turtle products, especially the luxury ones of shell, leather, and stuffed animals, remains high, and while the prices of these products also remain very high. It will therefore be necessary for the industry to seek ever wider markets and higher prices if they wish to survive in an inflationary world. According to Mack, Duplaix, and Wells (this volume), the sea turtle is now "the most profitable wild animal in large scale international trade." This explains the survival, even expansion, of the biologically absurd turtle farming industry. We are told that Cayman Turtle Farm and other farms will saturate the markets for turtle products, while continuing to expand these markets. If turtles were gold, and someone found a complex, capital-intensive way to farm gold and make a modest profit, is it likely that the wild gold mines would be abandoned?

Noncommercial Captive Breeding: Preservation of Sea Turtles in Zoos and Aquaria

It has been suggested that we preserve the gene pools of *L. kempi* and possibly other endangered sea turtles by maintaining them in captivity in selected zoos, aquaria, or special breeding ponds. Insofar as this involves the use of a few (perhaps 50) captive-raised individuals, I can see little harm to the idea. But any significant use

Table 1. Suitability of sea turtles as candidates for aquaculture (closed-system farming): evaluation of biological and economic characteristics

Characteristics	*Suitable*	*Marginal or questionable*	*Unsuitable*
Growth rate			X
Ability to take advantage of natural food production in captivity			X
Ability to feed with inexpensive processed foods or waste products			X
Suitability for polyculture			X
Tolerance to crowding		X	
Easy access to unlimited supply of wild juveniles, or complete control of reproductive cycle (including economic control)			X
Short reproductive cycling time			X
Potential for genetic improvement		X	
Hardiness		X	
Initial capital requirements			X
Water purification and waste management costs		X	
Market demand	X		
Price of products	X		

of wild-caught *L. kempi* for captive propagation seems to me to be totally unwarranted, for at least 4 reasons. First, captive breeding programs to save endangered species have been notoriously unsuccessful in the case of species whose biology is complex and badly understood. The biology of sea turtles is complex and badly understood.

Second, in the absence of natural selection pressures, the gene pools of captive animals often undergo rapid and destructive change. The great zookeeper, Hediger (1955), vividly describes how wild animals in zoos or under domestication lose, after a number of generations, both their special sensory abilities and many of their special behaviors associated with reproduction. The difficulty of reintroducing captive-reared Hawaiian geese into their native habitat is but one of many examples.

Third, if we start preserving "gene pools" in captivity, where do we draw the line? Do we keep *L. kempi,* because it is a named species, but discard the Aves Island green turtles because they are considered just a subspecies? There are not enough facilities to save every endangered gene pool.

And fourth, there is always the possibility that showy and popular efforts to create captive breeding populations of sea turtles will drain away efforts and funds from conservation activities that deserve a much higher priority.

This ends my survey of options and limitations in the conservation of sea turtles. In looking over the list, I believe some principles emerge. Most important is that a combination of our incomplete knowledge about sea turtles and the numerous constraints imposed by their biology dictates a very conservative conservation strategy. I conclude that the best we can do is to concentrate on the protection of existing wild populations, using the simplest and least risky techniques of conservation. Fortunately, the techniques with the lowest risk and greatest promise are also those with the lowest cost and requiring the least elaborate technologies. This is also true of much of the research related to sea turtle conservation. And fortunately, most of the conservation techniques are not mutually exclusive and can be applied simultaneously. Finally, conservationists must remember that the results of their efforts, good or bad, are most likely to be seen by their children.

In Table 2, I have given my personal list of priorities for research and techniques of conservation. I have not included commercial ranching and farming in the list, because I believe that they have only a negative impact on conservation. While reading this table, I urge the reader to remember that, as Hendrickson (this volume) has clearly shown, the options and limitations for conservation of sea turtles vary markedly from species to species (see Table 2).

I do not mean to imply that the items in this table with medium or low priority should not be done, rather that they should be done only when we are sure that the effort will not divert needed workers or funds from more important kinds of conservation activity.

It is no coincidence that the conservation methods that have the greatest potential for saving wild sea turtles are those not limited by the biology of these animals or by our ignorance of it—namely, control of international trade, widespread conservation education, coordination of conservation efforts, and the simpler kinds of habitat protection. The greatest irony of this convention may well be that some of the most

Table 2. Priorities in the conservation of sea turtles

Priority	*Research*	*Conservation methods*
High	Life histories, especially migrations and the non-nesting portions; population dynamics; critical habitats; effects of egg manipulation (including temperature) and other hatchery-related research; taxonomy and related population genetics; simple, inexpensive, effective tagging methods; improved fishing trawls; effects of nesting beach alterations; turtle product species identification methods	Protection of nesting grounds and aquatic habitats, including minimization of environmental disruption at these sites and designation of critical habitats; short-range transplantation of nests, use of egg hatcheries; conservation education; control of international trade; intergovernmental and interorganizational coordination of conservation strategies; dissemination of improved trawls (when available)
Medium	Control of infectious diseases and parasites in captive animals, especially juveniles; study of biological effects of pollutants; nutritional research; fisheries management research; effects of headstarting and long-distance transplantation	Long range transplantation of nests; headstarting
Low	Effects of manipulations in closed-cycle breeding systems; some high-technology research (endocrinology, sensory physiology, etc.)	Fisheries management of turtle catch; manipulation of sex ratios away from the population norm; cottage industry ranching; noncommercial captive breeding to maintain gene pools

effective conservation actions we can take are not strongly dependent on any further increase in our knowledge of sea turtles.

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