Sea Turtle Conservation and Halfway Technology*

NAT B. FRAZER

Savannah River Ecology Laboratory
PO Drawer E
Aiken, S.C. 29802, U.S.A.
and
Department of Biology
Mercer University
Macon, GA 31207, U.S.A.

Abstract: *How we define a problem often determines what we are willing to consider as a solution. When we define the impending extinction of a sea turtle species solely in terms of there being too few turtles, we are tempted to think of solutions solely in terms of increasing the numbers of turtles. Hence, some of our attempts to conserve sea turtles involve "halfway technology," which does not address the causes of or provide amelioration for the actual threats turtles face. Programs such as headstarting, captive breeding, and hatcheries may serve only to release more turtles into a degraded environment in which their parents have already demonstrated that they cannot flourish. Furthermore, captive programs may keep turtles from serving important ecological functions in the natural environment, or place them at some disadvantage relative to their natural counterparts once released. Such programs can be contrasted with more appropriate technologies that directly address and correct particular problems encountered by sea turtles without removing them from their natural habitat. For example, installing turtle excluder devices in shrimp trawl nets will reduce mortality of adults and larger juvenile sea turtles, and using low pressure sodium lighting on beaches may prevent hatchlings and nesting females from becoming disoriented. In the final analysis, we need clean and productive marine and coastal environments. Without a commitment to such long term goals, efforts to protect sea turtles will be futile.*

Resumen: *La forma en que definimos un problema, usualmente determinará que es lo que estamos dispuestos a aceptar como solución. Cuando definimos la inminente extinción de la tortuga de mar, solamente en términos de que quedan muy pocas tortugas, nos vemos tentados a pensar en soluciones sólamente en términos de incrementar el número de las mismas. Por consiguiente, alguna de las cosas que hacemos en nuestros intentos para conservar tortugas de mar involucra una "tecnología a medias," que no considera las causas ni brinda medidas que tiendan a disminuir los peligros reales que las tortugas enfrentan. Programas como "headstarting" (cría de tortugas desde la etapa de huevo hasta unos 9 meses de edad, antes de liberarlas al medio ambiente), cría en cautiverio y viveros, servirán sólamente para liberar más tortugas a un medio ambiente deteriorado en el cual sus padres ya han demostrado que no pueden prosperar. Más aún, programas de animales en cautiverio, podrian impedir que las tortugas cumplan importantes funciones ecológicas en su medio ambiente natural, o las colocarían en desventaja con respecto a sus contrapartes naturales una vez liberadas. Dichos programas pueden ser comparados con tecnologías más apropiadas que dirijan y corrijan directamente problemas particulares que las tortugas de mar encuentran, sin sacarlas de su medio ambiente natural. Por ejemplo, la instalación de dispositivos que excluyan las tortugas de las redes de pezca de camarones reducirá la mortalidad de los adultos y de las tortugas juveniles de mayor tamaño; el uso de iluminación de sodio de baja presión en playas, podría prevenir que las crías y las hembras se desorientasen. En concreto, lo que se necesita son ambientes costeros y marinos limpios y productivos. Sin un compromiso a largo plazo sobre dichos objetivos, los esfuerzos por protejer las tortugas de mar serán inútiles.*

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A recent reading of Thomas Berry's (1988) *The Dream of the Earth* reminded me of how disconnected my work has become from the natural systems that first led me to be interested in ecology and conservation. As a population ecologist and conservationist, I often work with mathematical abstractions in my attempts to understand what sea turtles are doing and what we can do to help them. For example, in one of my early papers on sea turtles (Frazer 1984:284), I wrote that "the proportion of females expected to reproduce at each subsequent age, $P_L(x)$ [for all $x \geqslant \alpha$], may be calculated as:

$$P_L(x) = N_L(x) \div N(x),$$
$$\text{where } N_L(x) = \Sigma[N_L(X\text{-}i)R(i)(0.8091)^i]."$$

Now, almost ten years later, even I have trouble relating these equations to the turtles, and those of us who first constructed sea turtle population models (Crouse et al. 1987; Frazer 1989*a*) find that we must speak out against the misuse of the models by those who formulate management plans (Crouse 1989; Frazer 1989*b*).

Thus, I've recently come to understand that although mathematical models are extremely useful, treating turtles simply as inputs and outputs has its perils. How we define a problem often will determine what we are willing to consider as solutions. If we define the impending extinction of a sea turtle species solely in terms of there being too few turtles, then we are tempted to think of solutions solely in terms of increasing the numbers of turtles.

Such thinking can lead us to conservation solutions analogous to what Lewis Thomas (1974:33) called "halfway technology" in his essay on the technology of medicine in *The Lives of a Cell.* Thomas defined halfway technology as "the kinds of things that must be done after the fact, in efforts to compensate for the incapacitating effects of certain diseases whose course one is unable to do very much about. It is a technology designed to make up for disease, or to postpone death." In short, halfway technology does little or nothing to address the cause or the cure of disease. It's what we use to treat a disease when we don't really understand it. Among the examples that Thomas gives of halfway technology is that of cardiac replacement with donor or artificial hearts. Our society has defined the problem as a bad heart, so we replace it with a new heart in expensive, labor-intensive operations that are dependent upon large corporate health care systems, undergirded by an enormous insurance infrastructure. As Thomas points out, the halfway technology of replacing hearts doesn't involve understanding why the old tissues went bad. It's not a cure for the disease nor does it constitute disease prevention for those not yet stricken. It's only a makeshift technique that allows us some feeling of security in our present state of ignorance.

I believe that we can fall into the same bad habits in conservation. When we define the impending problem of sea turtle extinction as there being too few turtles, we risk falling for perceived solutions to this problem that are likely to rest on halfway technology. Increasing numbers of turtles certainly is important, but equally important is some measure of their prospects for flourishing in their natural environment. With this in mind, I will address an example of halfway technology presently being used in sea turtle conservation and compare it with examples of more appropriate technology.

Sea turtles, like many other turtles, have evolved a suite of life history traits over the past hundred million years that includes high adult survivorship, iteroparity (repeated reproduction), and high mortality rates for juveniles and eggs (for reviews, see Wilbur & Morin 1988; Congdon & Gibbons 1990; Iverson 1991). Mortality of turtle eggs or destruction of their nests may approach 100% in some years due to a combination of biotic and abiotic factors (Hopkins et al. 1978; Kraemer & Bell 1980; Congdon et al. 1987). The survival rate from egg to adulthood has been estimated to be less than one per thousand for the loggerhead sea turtle, *Caretta caretta* (Frazer 1986). Of those green turtle (*Chelonia mydas*) hatchlings that make it safely out of the nest, as few as 2.5 per thousand may survive to adulthood (Hirth & Schaffer 1974). The generally low but variable survival rates of juveniles and eggs are thought to have been important selective forces leading to the evolution of high adult survival rates and the consequent ability for iteroparity in turtles (Wilbur 1975; Congdon & Gibbons 1990).

In recent history, sea turtles along the U.S. Atlantic and Gulf of Mexico coasts have been subjected to new sources of mortality for which they are not prepared by adaptation. Adults and larger juveniles are captured in fishing gear such as shrimp trawl nets (Hillestad et al. 1982; Murphy & Murphy 1989), resulting in an estimated 10,000 to 12,000 deaths annually (Henwood & Stuntz 1987). Nesting adults and hatchlings emerging from their nests face increasing levels of artificial lighting on developed beaches (Raymond 1984), which may disorient them in their attempts to find the sea (Mrosovsky & Kingsmill 1985; Witherington & Bjorndal 1991). These problems exacerbate the difficulties in aiding sea turtle populations to recover from the low levels presumably brought about by directed fisheries in earlier decades (Rebel 1974).

"Head-starting" is among the techniques that have been advocated and instituted in an attempt to rebuild populations of sea turtles (Klima & McVey 1982; Mrosovsky 1983). The technique consists of hatching eggs and rearing turtles in captivity for nine months to a year, until they reach a size at which they are no longer subject to predation from many of their natural predators such as fish, birds, and invertebrates (see Stancyk 1982, for a review of sea turtle predators). Thus, conservationists attempt to mitigate the effects of human-induced mortality by reducing natural mortality due to predation (Woody 1990). I argue that headstarting is halfway technology, and that there are more appropriate technologies available to us at present.

Although headstarting undoubtedly has some value as a public relations activity in bringing sea turtle conservation into the news (Huff 1989), it has come under criticism as a conservation technique (Mrosovsky 1983; Woody 1990). Like transplanting hearts, headstarting does nothing to address the causes of the problems. Whether turtle populations are being decimated by directed turtle fisheries, incidental take in shrimp trawl nets, or beach development, headstarting serves only to put more turtles into the environment to face those same problems. Although it may help to ensure that turtles survive in the short term, it cannot ensure their long term survival. In any case, it is an "experimental" technique (Klima & McVey 1982), and no headstarted turtle has ever been demonstrated to have survived to adulthood (Woody 1990).

As an ecologist, I have an additional concern about headstarting programs that I have rarely heard voiced by other sea turtle scientists. I first realized this concern when I read William Conway's article on technology and species preservation (Conway 1988:265). In it, he makes the point that "sustaining species . . . in a captive population or in small fragmented refuges provides little to the Earth in the way of basic ecological services."

As a population biologist, my own evaluation of headstarting programs has always centered on my concern for the turtles—that is, on trying to decide whether they can survive and prosper once we release them. We do know that headstarted turtles are capable of surviving for several years after their release (Witham 1980), but no comparative studies have been done to assess their survival rate relative to that of their wild counterparts. Thus, I have worried whether this form of halfway technology might somehow place the released turtles at a disadvantage relative to their wild counterparts. Other sea turtle conservationists also have voiced this concern (Ehrenfeld 1982; Woody 1990), but I have never heard anyone express the thought that the marine environment might be at some disadvantage while the turtles are being held in captivity. Until I read Conway's article, I had never stopped to consider that while headstarted turtles are held in captivity for nine months to a year, we are depriving the other denizens of the marine environment of the benefits of whatever functional role young sea turtles have played in their natural habitat over the past hundred million years or so. Of course, the same point could be made concerning captive breeding programs or the establishment of small, isolated refuges for feeding or nesting. Such areas may help to ensure the temporary survival of a species by isolating and protecting local demes of much-reduced size, but they do not allow turtles to perform functional roles in the ecosystem, except in those isolated, small areas.

In our rush to increase the numbers of large juvenile and adult turtles inhabiting our nearshore waters, do we assume that the millions of little turtles that used to come off our beaches play no important role simply because we rarely see them playing it? We like to see big turtles nesting, and we like to see eggs being laid and little turtles hatching and entering the ocean, and we like to see large juveniles feeding in our seagrass beds and reefs and coastal waters. But we almost never see little turtles doing whatever little turtles do in their natural environment (Carr 1986).

Thus, my two main objections to the halfway technology of headstarting are that it does not address in any way the causes of sea turtle mortality and that it prevents the turtles, while they are being held in captivity, from performing whatever ecological function they normally serve in the natural environment. On an ethical basis, I have a third objection. Just like halfway technology in medicine, I believe that headstarting serves as an attempt to relieve humans of the consequences of our actions. We may feel a little more free to degrade the habitat and overharvest turtles either intentionally or incidentally if we have headstarting programs in place. Instead of controlling human-induced turtle mortality directly, we attempt to mitigate it by forcing nonhuman predators to make up for our actions by withholding turtles from them. We keep turtles in captivity, deprive nonhuman predators of their take, and justify or excuse our continued take of turtles and habitat degradation. But in the long run, such behavior cannot relieve us of the consequences of our actions as they affect either the turtles or their habitat.

Two examples of appropriate technology that can be used to help restore sea turtle populations to their former levels of abundance are the deployment of turtle excluder devices (trawling efficiency devices, or TEDs) on shrimp trawls (Seidel & McVea 1982) and the control of lighting on beaches (Raymond 1984; Witherington & Bjorndal 1991). Both of these techniques directly address the problems affecting sea turtles at the source, and neither should interfere with the turtles' functional role in the ecosystem.

The TED is a device that can be inserted into a commercial shrimp trawl net, allowing shrimp and small organisms to enter, but excluding larger items such as sea turtles (Seidel & McVea 1982; Oravetz & Seidel 1984). This is appropriate technology: it reduces human-induced sea turtle mortality (in this case, drowning) by directly ameliorating one of the causes. The most complete management model developed for sea turtles to date (Crouse et al. 1987) indicates that protecting large juvenile and adult sea turtles with TEDs is one of the most effective and rapid means of reversing their decline. Unfortunately, despite state and federal regulations requiring use of TEDs, they have yet to be fully accepted by the shrimping industry (Rudloe & Rudloe 1989; Williams 1990).

Even those who have called attention to the need for protecting large juveniles and adults at sea stress that our conservation efforts must address protection of other life stages as well (Crouse et al. 1987; Frazer 1989*a*). Where artificial beach lighting adversely affects nesting and hatching sea turtles, there are a number of things that can be done to address the problem at its source. Lights can be designed with deflector panels or placed low to the ground, behind dunes, vegetation, or other obstructions to avoid their shining directly onto the beach (Raymond 1984). Where this is impractical, it still may be possible to use lights of particular wavelengths to which adult or hatchling turtles are less sensitive. For example, Witherington (in press) has recently shown that nesting females may be less affected by low pressure sodium (LPS) vapor lights than by mercury vapor lights. Changes in the placement or type of lighting used on nesting beaches may therefore reduce the human impact on turtle rookeries while allowing turtles to occupy their natural habitat.

In short, my point is simple. If the cause of the problem is lighting on the beaches, the solution should address lighting on the beaches. If the cause of mortality is incidental capture in shrimp trawl nets, the solution should address the capture of turtles in nets. Unfortunately, at present, the problem is too often defined simply as there being too few turtles, and the solution is likely to be viewed as anything that increases the numbers of turtles. This is short-sighted and cannot serve to ensure the cohabitation of the planet by humans and sea turtles in the long run. We would do well to concentrate our efforts on reducing our own negative effects on sea turtle populations instead of attempting to tip the balance between the turtles and their nonhuman predators.

This is not to say that technology such as headstarting, which may lead to an immediate (though perhaps temporary) increase in numbers of turtles, should necessarily be avoided altogether. As Conway (1988:267) stated during the National Forum on Biodiversity, "The profoundly immediate problem is to save as many species as possible through the next 150 years." Even though we know that some of our efforts constitute halfway technology, we still must ensure that species survive while and until we make the environment habitable for them again. However, given that this may take quite a long time and that humans have extraordinarily short attention spans, there is a grave danger inherent in many of our current approaches. It's easy for the public to become dazzled by our halfway technology as an end in itself—by captive breeding programs, by headstarting facilities, by hatcheries with thousands of eggs and baby turtles. The public relations value of headstarting is great (Huff 1989), and a televised release of turtles, such as one I attended several years ago in Florida, is attractive filler for evening news programs. But the high visibility and attractiveness of such programs should not blind us to the fact that they do nothing to alter the processes that threaten sea turtle populations.

It is not just the layman that succumbs to the lure of halfway technology. We scientists, too, are subject to the myopia that results from the allure of our own participation in the halfway technology game. A recent review of general patterns of survivorship in turtles (Iverson 1991) noted the ubiquity of high rates of egg and juvenile mortality and low adult mortality across several genera and families. Based on these patterns, Iverson (1991) recommended that turtle conservation programs focus their attention on early life stages and that the headstart programs common in sea turtle conservation also be aggressively applied to terrestrial and freshwater turtle populations. In direct contrast to his recommendations, however, recent demographic models of sea turtle populations indicate that increasing survival rates of adults and larger juveniles would result in a greater response towards recovery of their populations than does protecting eggs, hatchlings, or younger juveniles (Crouse et al. 1987; Frazer 1989*a*).

Furthermore, each scientist and conservationist has his or her own favorite conservation technique, and each of us falls prey to the parochialism that results from the compartmentalization of both our formal and informal educational processes. Thus, physiologists are apt to seek solutions in physiological studies, population biologists in mathematical models, aquaculturists in captive-breeding programs. But as ecologists rather than engineers, we must understand that any real and effective program for conservation of sea turtles or other endangered species must be holistic rather than piecemeal in its approach. If habitat quality is low, the chances of successful translocation or reintroduction of extirpated species are also low (Griffith et al. 1989). Recall that successful avian reintroduction programs such as reestablishing birds of prey in New England could not have been accomplished without ceasing the use of the pesticides that had been responsible for the local extinctions in the first place (Cade 1988). Similarly, we should not forget Carr's (1984:230) wise words: "Protection of sea turtles is not a parochial problem They cannot be saved in any one place, or by controlling any one phase of the life cycle." Yet time and time again, I catch myself and my colleagues acting as if Carr's simple message were not true.

I now find myself agreeing with Conway (1988:263) that "In the preservation of biological diversity, the use of technology is a last resort." In facing the acute problems inherent in avoiding the human-induced extinction of a particular species, we may have arrived at a point at which we presently must rely on the last resort of various halfway technologies. But we should not make the mistake of assuming that the technological solutions we apply today to increase the numbers of sea turtles are an acceptable solution to the chronic problems faced by the turtles or any other species. Otherwise we reduce the issue to a situation exemplified by the question posed by a Costa Rican fisherman from Puerto Limon, when he wondered how many green turtles he would have to headstart before we would stop objecting to his taking the adult females. There is no numerical answer to this question if we limit our conservation programs to halfway technology. As the seas and beaches inevitably become more and more dangerous for sea turtles, we will have to release more and more young turtles each year to ensure any sustainable harvestable excess surviving to adulthood. Instead of using technology to breed more turtles, our technological advances should be directed more appropriately toward our own activities.

As we strive to increase our knowledge of sea turtles for the purpose of doing a better job of helping them to survive, each of us must become aware and remain aware of how our individual research efforts fit into the overall task at hand. A workshop sponsored by the Minerals Management Service in New Orleans in August 1989 resulted in recommendations to prioritize future sea turtle research. More important than any of the individual recommendations was the suggestion that we approach future sea turtle research with "... a program that can be broken into a series of modules within an overall research framework. This approach would allow sections of the research program—the individual modules—to be undertaken separately. These modules would fit into the defined framework and build an overall synthesis" (Mangan et al. 1990). The document written at the workshop also will enable those who review grant proposals to assess how scarce funds might best be spent in a coordinated effort to increase our knowledge of sea turtles.

We must also consider the prediction made by Ehrenfeld (1982:462–463) at the World Conference on Sea Turtle Conservation that "some of the most effective conservation actions we can take are not strongly dependent on any further increase in our knowledge of sea turtles." We already know that there is no one problem faced by sea turtles, and that they need a clean and productive marine environment as well as peace on the beaches to ensure their survival (Carr 1984). As each of us works on his or her own research and conservation efforts, we also must take some time to work toward larger goals such as the protection of the marine and coastal environment, for it is here that the battle for sea turtle survival eventually will be won or lost. The ultimate solution for protecting organisms from overexploitation or habitat destruction is not to take the organisms out of their habitats, but to minimize the impact of human activities on that environment. We must not lose sight of this long-range ecological and evolutionary goal as we establish research and conservation priorities over the next 150 years.

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