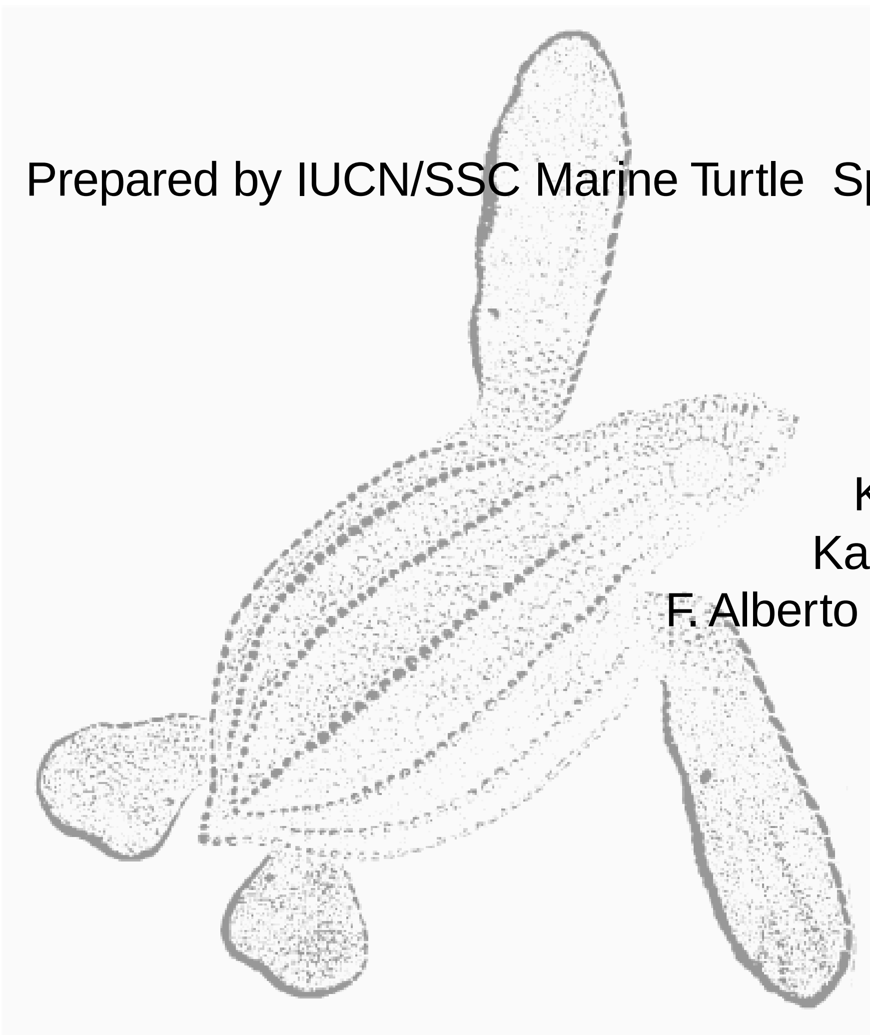
Research and Management Techniques for the Conservation of Sea Turtles



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Preface

In 1995 the IUCN/SSC Marine Turtle Specialist Group (MTSG) published *A Global Strategy for the Conservation of Marine Turtles* to provide a blueprint for efforts to conserve and recover declining and depleted sea turtle populations around the world. As unique components of complex ecosystems, sea turtles serve important roles in coastal and marine habitats by contributing to the health and maintenance of coral reefs, seagrass meadows, estuaries, and sandy beaches. The *Strategy* supports integrated and focused programs to prevent the extinction of these species and promotes the restoration and survival of healthy sea turtle populations that fulfill their ecological roles.

Sea turtles and humans have been linked for as long as people have settled the coasts and plied the oceans. Coastal communities have depended upon sea turtles and their eggs for protein and other products for countless generations and, in many areas, continue to do so today. However, increased commercialization of sea turtle products over the course of the 20th century has decimated many populations. Because sea turtles have complex life cycles during which individuals move among many habitats and travel across ocean basins, conservation requires a cooperative, international approach to management planning that recognizes inter-connections among habitats, sea turtle populations, and human populations, while applying the best available scientific knowledge.

To date our success in achieving both of these tasks has been minimal. Sea turtle species are recognized as "Critically Endangered," "Endangered" or "Vulnerable" by the World Conservation Union (IUCN). Most populations are depleted as a result of unsustainable harvest for meat, shell, oil, skins, and eggs. Tens of thousands of turtles die every year after being accidentally captured in active or abandoned fishing gear. Oil spills, chemical waste, persistent plastic and other debris, high density coastal development, and an increase in ocean-based tourism have damaged or eliminated important nesting beaches and feeding areas.

To ensure the survival of sea turtles, it is important that standard and appropriate guidelines and criteria be employed by field workers in all range states. Standardized conservation and management techniques encourage the collection of comparable data and enable the sharing of results among nations and regions. This manual seeks to address the need for standard guidelines and criteria, while at the same time acknowledging a growing constituency of field workers and policy-makers seeking guidance with regard to when and why to invoke one management option over another, how to effectively implement the chosen option, and how to evaluate success.

The IUCN Marine Turtle Specialist Group believes that proper management cannot occur in the absence of supporting and high quality research, and that scientific research should focus, whenever possible, on critical conservation issues. We intend for this manual to serve a global audience involved in the protection and management of sea turtle resources. Recognizing that the most successful sea turtle protection and management programs combine traditional census techniques with computerized databases, genetic analyses and satellite-based telemetry techniques that practitioners a generation ago could only dream about, we dedicate this manual to the resource managers of the 21st century who will be facing increasingly complex resource management challenges, and for whom we hope this manual will provide both training and counsel.

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Reducing Threats to Eggs and Hatchlings: *In Situ* Protection

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Once a clutch of sea turtle eggs has been laid, the female leaves the beach, offering no protection to eggs or emergent hatchlings. From this point forward, eggs and hatchlings are subject to a number of natural threats *(e.g.,* beach erosion, storm and tidal inundation, native predators) and other hazards *(e.g.,* poaching, non-native predators and livestock, coastal development). A variety of *in situ* methods have been developed to reduce the effects of these threats. This chapter will describe some of these techniques, and offer examples of their application and success.

It should be noted from the outset that the preferred option is always the least manipulative intervention that will yield the desired result. Collecting and reburying eggs should be considered only as a last resort (see also Mortimer, this volume). Against some threats, including depredation, beach surveillance and nest caging are likely to be more effective and result in higher rates of hatching success than could be expected from *in situ* egg reburial programs. Of all the options discussed in this chapter, aversive conditioning and predator control are least likely to produce desirable results.

The reader is referred to Witherington, this volume, for solutions to specific threats *(e.g.,* armoring, artificial lighting, and recreational activities) posed by coastal development.

Beach Patrols and Disguising Nests

The presence of researchers or surveillance personnel *(e.g.,* law enforcement officers, voluntary game wardens, community activists) on the nesting beach can reduce or even eliminate a variety of threats, including egg poaching, depredation, and, in the case of hatchlings, entrapment in beach debris or disorientation inland toward artificial light sources. Some predators, such as wild hogs (*Sus* sp.) or chronically undernourished dogs, may not be dissuaded, but most small mammals and predatory birds (and poachers) are reticent to act in the presence of humans.

To reduce the likelihood that poachers will determine the pattern of surveillance (enabling them to focus their activities during non-surveillance periods), beach patrols should either be continuous (all-night) or should occur at random intervals, often enough to act as a deterrent. In either case, nests should be disguised by effacing the physical evidence with a palm frond, rake, or by walking back and forth repeatedly over the site. The objective is to smooth out the site to match the surrounding beach, reducing the likelihood that a poacher will expend energy probing the area. This method should not be used on beaches where ongoing management efforts depend on daily or weekly crawl counts to assess the status of the turtle population.

When “disguising” a nest from predators, masking odors *(e.g.,* urine, pepper sauce) are sometimes applied to the immediate vicinity of the nest with an aim to confuse or repel non-human predators. There are no data available with which to evaluate the success of these actions. Care should be taken not to introduce noxious chemicals to the beach environment that may be harmful to the developing embryos, emergent hatchlings, gravid females, or non-target wildlife.

Buried Mesh and Caging

Depredation of turtle eggs generally involves digging into a freshly laid or newly hatched nest. The placement of treated *(e.g.,* galvanized or plastic coated) wire or rigid plastic mesh just below (and parallel to) the sand surface or, alternatively, formed as a cage over the nest can deter nest excavation. It is important to use mesh small enough to prevent access by the predator, yet large enough to allow the passage of hatchlings to the surface.

For medium-sized mammals *(e.g.,* dogs; raccoons, *Procyon lotor;* hogs; coati mundis, *Nasua nasua, N. narica),* a 1 m square section of 5 x 10 cm mesh galvanized welded wire, anchored with corner stakes, should be placed over the nest as soon as possible (see Jordan, 1994). In Jordan's study, the stakes were fashioned from 60-90 cm steel reinforcing bar, bent to form a hook at the top which secured the corners of the screen. For smaller mammals, such as mongoose *(Herpestes auropunctatus),* a smaller mesh can be used but must be removed prior to hatching. In any case, the mesh should be buried 8-10 cm below the surface to conceal it from predators and curious pedestrians on the one hand, while precluding any interference with the incubating eggs on the other hand.

Galvanized wire mesh cages can be formed in a ring or in a square. The square shape is often advocated because it allows the wire constituting the four faces to be bent outward at the bottom, discouraging digging by small mammals. Addison (1997) illustrated the construction of a 90 x 90 x 75 cm cage from 5 x 10 cm mesh screening, with the bottom 15 cm bent horizontally outwards. Optimally, cages are buried to a depth of 30 cm over the nest. This is accomplished by centering the cage over the nest, setting it aside, and then excavating a 90 x 90 cm trench 30 cm deep around the nest. Dry, surface sand should be swept aside prior to digging. Once the trench is in place, the cage is placed in the trench and backfilled, leaving approximately 45 cm of the cage above the sand, thus preventing predators from digging into the nest. Addison and Henricy (1994) determined that cages were more effective than just using flat mesh, although they are more visible than the buried mesh.

Ratnaswamy (1995) used predator removal, nest screening and conditioned taste aversion at Canaveral National Seashore, Florida USA. She found nest screening to be the most effective, though the most costly, method in reducing nest depredation. In addition, this method reduces any direct impact to local raccoon populations, and therefore presumably reduces potentially adverse ecological effects of predator removal.

Translocating Eggs

While the first and best management choice should always be to protect eggs *in situ*, there are circumstances under which the movement of eggs is a viable conservation option. The removal of eggs from a natural nest (typically at the time of deposition) and their reburial elsewhere on the beach can be effective in mitigating for a variety of threats that reduce hatching success or result in high levels of nest loss. The technique is most useful under the following circumstances:

Severe and Predictable Erosion

Many sandy beaches are subject to seasonal or storm-related erosion and deposition (accretion) cycles which can lead to nest loss when portions of the beach succumb to changes in current direction or velocity. By carefully relocating nests laid in known high risk areas (areas with serious and predictable erosion) to more stable beach zones, seasonal reproductive output can be significantly enhanced.

Inundation

Low profile areas where the subterranean water table comes within 50 cm of the beach surface can result in standing water in the nest cavity; the usual result is high embryo mortality. Relocation of these nests to higher profile areas can significantly increase hatch success. Similarly, nests laid very near the sea may be lost prior to term. Relocation of these eggs can result in at least moderately good hatch success.

Poaching

Field signs, including beach crawls and nesting pits, can be rendered ineffective by removing eggs from their natural nest and relocating them to another site, even one very close to the original nest but outside of the crawl and body pit area. Excavation of the original site may ensue, but to no avail, making it less likely that the egg collector will return.

In situ

(non-hatchery) relocation is best accomplished using regular beach patrols, enabling the collection of eggs at deposition. Eggs are gently gathered as they drop and placed immediately in a clean bag, bucket or basket. Alternatively, a plastic bag can be positioned in the hole to receive the eggs. In either case, the bag or other container must be strong enough to reliably carry up to 12 kg of eggs. If a bag is placed in the hole, the opening should be clasped shut (to exclude falling sand) and the bag swiftly dug out from behind as soon as egg-laying is complete. Assistance may be needed during this process to hold flippers out of the way, provide light or to receive eggs. Efforts should be made to minimize the amount of sand gathered with the eggs. Sand will score (abrade) the egg shells and can reduce hatch success. If the eggs are to be transported a long distance, they should be covered to reduce moisture loss.

Care must be taken to record nest depth so the original dimensions can be replicated. Suspend a stiff tape measure or weighted string (scored in metric units) in the hole until it reaches the bottom and read the depth at the sand surface. Since the original sand surface is often effaced by the nesting process, it is suitably accurate for most species to record the depth at the bottom edge of the carapace just behind a rear flipper. It is important not only that the measurement be as accurate as possible, but that the technique be consistent. A measurement should also be taken of the diameter of the neck of the nest.

Eggs should be transported immediately to the relocation site (if transport occurs by vehicle, the egg bag/bucket should be secured and cushioned). Reburial should occur within 1-6 hr to minimize movement-induced injury to embryos, and the negative effects of changes in the temperature and moisture content of the eggs. To simplify project logistics, minimize transport trauma, and promote the perpetuation of the population at its chosen nesting beach, every effort should be made to translocate eggs elsewhere on the same nesting beach. The new nest site should be sufficiently above the high tide line and conform with species-specific parameters; *e.g.,* leatherback nests on the open beach, hawksbill nests in the beach forest (if appropriate to the site). Care should be taken not to locate the nest too near (< 1.0 m) other translocated clutches, or natural nests.

To begin the reburial process, dry surface sand is swept aside (to a depth of 5-10 cm, depending on local conditions) to prevent it from sifting into the excavation. Once the damp subsurface is exposed, a narrow shaft to the desired depth is excavated using one hand. The weight of the person excavating the nest should rest heavily on the other hand, and as far from the rim of the hole as possible. When proper nest depth has been confirmed using a tape measure or weighted line, the neck of the nest is widened, again using one hand, to the desired diameter. Finally, the egg chamber is widened at the bottom so the finished nest resembles a flask or inverted light bulb.

The eggs should be placed carefully, not dropped, in groups of 2-5 (a comfortable handful) and counted. In the case of leatherback turtles, the yolkless eggs should be placed last *(i.e.,* on top). Burying a short length of colorful surveyor's tape with the eggs (see Miller, this volume) is useful if nest contents will ultimately be examined. Using a permanent marker, record the tag number of the female (if tagged), the date the nest was laid, and, if different, the date the nest was reburied. Cover the nest by replacing the damp subsurface sand removed from the hole (do not place hot surface sand on the eggs), firmly tamping it in place in layers of 8-12 cm.

Once the hole is completely filled, it is difficult to locate the nest with accuracy. Therefore, if the nest will be monitored through time or excavated at hatching, coordinates should be recorded (measurements to the nest from numbered stakes or natural landmarks on either side of the nest) or the nest otherwise marked at this time. Once the hole is filled, disguise the nest by smoothing over the disturbed sand surface, sweeping dry surface sand evenly all about.

In assessing this technique it should be noted that average hatch success will likely be measurably lower than that of undisturbed natural nests. But, when the process is undertaken with care, the technique is effective at reducing nest loss to threatening agents listed at the beginning of this section. More than a decade of experience with the leatherback population nesting at Sandy Point National Wildlife Refuge, U. S. Virgin Islands, clearly shows that annual reproductive success can be doubled or better using this technique in the context of regular all-night patrols of the nesting beach, collection of eggs at deposition (if laid in documented high risk zones), and immediate reburial (Boulon *et al.*, 1996).

The technique enjoys several advantages over moving eggs to an enclosed hatchery. Maintenance and personnel (surveillance) costs are high in properly maintained hatcheries; in addition, losses due to depredation, storms, and various other factors can be severe because eggs (and hatchlings) are artificially concentrated. Other factors also favor *in situ* reburial, including the fact that nest sites are unmarked, temperature and moisture profiles are likely to be closer to the norm since nests can be individually placed in appropriate habitat, and hatchlings emerge naturally.

Notwithstanding, it cannot be overemphasized that eggs should never be collected and reburied unless there is compelling evidence that significant losses will accrue which cannot be countered using non-manipulative strategies. Moreover, in choosing this technique, managers must be willing to commit the resources requisite to ensure that eggs are properly collected either at deposition or at first light the following morning (before the heat of the day). Under no circumstances (barring the emergency rescue of eggs found washing out to sea) should eggs be collected more than 12 hr after deposition. Once the embryo has settled on the wall of the egg shell, movement can be fatal. Indeed, some investigators have recommended that eggs not be moved at all between 3 hr and 21 days after oviposition (Harry and Limpus, 1989).

Aversive Conditioning

With this technique, predators are conditioned to avoid prey items by the selective use of chemicals which cause an unpleasant (sometimes very unpleasant) reaction when consumed. Researchers have used lithium chloride and various hormones in and on eggs in hopes that predators, especially small mammals, will lose their desire to consume turtle eggs. The author has been unable to find any researchers who can report the successful accomplishment of this technique for turtle eggs. Hopkins and Murphy (1982) found that lithium chloride did not work with raccoons in the lab or in the field. They determined that it might work on individuals who had never before eaten sea turtle eggs, but individuals characterized by a prior positive experience with eggs would not become aversively conditioned using this technique.

Ratnaswamy (1995) used oral estrogen (17-alpha-ethinyl-estradiol) to treat chicken eggs in an attempt to produce conditioned taste aversion (CTA) in raccoons. The hope was that any CTA developed towards chicken eggs would be transferred to turtle eggs. She found no significant difference in turtle egg depredation before and after treatment. She concluded, given the relatively large size of the raccoon population, that it may be impossible to develop a level of CTA adequate to protect turtle nests at the study site. It is not known whether raccoons can detect taste differences between chicken and turtle eggs which may complicate effective application of the CTA treatment.

One study in the U. S. Virgin Islands successfully conditioned mongooses to avoid chicken eggs using the hormone estradiol (D. W. Nellis, USVI, Div. Fish Wildl., pers. comm.). The process involved familiarizing mongooses with several sources of eggs over a period of time. The eggs were then injected with estradiol for two days, before returning to untreated eggs. After their experience with the treated eggs, the mongooses refused subsequent offers of chicken eggs. The test was never performed on sea turtle eggs, as the sacrifice of eggs from Endangered sea turtles did not seem prudent, but the technique shows promise.

Predator Control

While some nest depredation is certainly opportunistic, the habit of raiding turtle nests is, for at least some predator species, clearly a learned behavior. Predator control, broadly speaking, encompasses a variety of techniques, all of which are time consuming, some of which are very expensive, and few of which have shown consistently favorable results. Nevertheless, some methodologies may be worth pursuing if depredation constitutes a serious threat; that is, a threat well beyond the natural cycles of the food web.

Perhaps the least complicated method is to shoot the offending animals. This method has been used to cull feral dogs at some Central American nesting beaches, raccoons and hogs in the southeastern U.S., and a variety of "pest" species elsewhere in the world. Public hunts work moderately well, depending on the circumstances; relatively unpopulated areas are most conducive. If planning such a course of action, bear in mind the possibility of outcry from animal-rights groups or individuals. Some success may also be achieved with inexpensive poisoning campaigns, but such initiatives are almost certain to bring unwanted consequences in the form of death to non-target (and often beneficial) coastal species, as well as to children and/or domesticated animals.

Trapping programs are more expensive, but can yield satisfactory results. In the Caribbean region, where the mongoose is a significant predator on both eggs and hatchlings, conventional live traps (15 x 15 x 45 cm) baited with chicken or fish are sometimes set at 30 m intervals in shaded areas on the upper beach. Traps are checked at least daily. Captured individuals are either relocated to distant locales or euthanized. Five days of trapping can remove over 80% of the mongooses in a localized area (Coblentz and Coblentz, 1985). In the Coblentz and Coblentz study, hawksbill turtle nests suffered no depredation during or immediately following the trapping interval at the nesting beach. By trapping just prior to the nesting season, nest depredation may be significantly lowered during the season, depending on the number of immigrants and young-of-the-year, both of which may be less apt to depredate turtle nests until they have learned this behavior.

Similar success is reported by George *et al.* (1994) in the trapping and relocation of raccoons from the nesting beaches of the southeastern U.S. They concluded that the removal of large numbers of individuals from the predator population at the nesting beach clearly reduces the incidence of nest depredation. The real success of relocation programs ultimately depends on the propensity of the offending animal(s) to return to the territory from which they were removed. When possible, traps should be set along game trails leading to the beach. Again, the highest degree of effectiveness is obtained by campaigns just prior to the nesting season. If the problem persists into the nesting season, traps can be set near known nests. For humane reasons, live traps are preferred. Barring government restrictions, trapped animals may be transported inland and released; alternatively, humane disposition *(e.g.,* lethal injection, shooting) should be considered.

In New Zealand, Hawaii (U.S.), the Philippines, and the Galapagos Islands (Ecuador), trained "pig dogs" have been used to control feral hogs which threaten turtle nests. The use of these dogs was originally to harvest pigs, but their use has recently been considered for both sea turtle and tortoise protection (Clarke and Brisbin, 1994). This technique may be beyond the undertaking of most sea turtle management authorities, but is worth considering if feral (unclaimed) hogs are a serious problem.

Among insect predators, fire ants, which have been known to burrow into nests and attack hatchlings as they emerge from their eggs, may present the most serious threat. The use of chemicals around nests to deter ants is unacceptable, due to the potential for secondary toxicity and harm to hatchlings. On Ocean Isle Beach, North Carolina, U.S., dry grits (coarse ground corn) are sprinkled around nests twice a week and after any rain. Fire ants eat the grits, which supposedly swell and kill the ants; none of the treated nests were infested with fire ants (J. Simmons, pers. comm.).

Before contemplating any eradication program, the following caveats must be kept uppermost in mind. The systematic control of non-native species *(e.g.,* hogs, rats, dogs, mongooses), or widespread species of small mammals or birds whose population sizes are clearly exaggerated due to the presence of human settlements, is unlikely to have a detrimental effect on the larger coastal ecology. However, the removal of native predators *(e.g.,* vultures and other birds of prey, crabs, shore birds, snakes) from a nesting beach and its environs may be ecologically devastating. Poisons and indiscriminate traps may extract a heavy toll on non-target species, as well as on children. Their use should be carefully controlled.

Public Education

While not generally considered an *in situ* protection measure, education can play a significant role in protecting sea turtle nests and hatchlings. For example, in lieu of undertaking a predator control program, managers should consider whether changing the behavior of people might achieve a similar result. Establishing public dump sites well away from nesting beaches and controlling beach litter may reduce the number of scavengers *(e.g.,* dogs, rats, mongoose, vultures) visiting the area. Promoting license and leash laws for dogs and reasonable controls on the ranging of livestock *(e.g.,* hogs) may also curb rates of depredation. Where nests are exhumed (after hatchling emergence) for study purposes, nest contents should be completely reburied in the nest cavity. Indiscriminate disposal attracts the attention of predators.

Public education campaigns can enhance the success of virtually any nest protection program. The public should be made aware of the importance of stakes and other research landmarks, as well as nest cages and other equipment left on the beach. Residents should be encouraged to support nest protection efforts by volunteering to participate in beach surveillance programs, disguising nest crawls (unless this compromises ongoing research and monitoring programs), and reporting illegal activities. Education programs should be designed for a variety of audiences, including fishermen, school children, and coastal landowners (or land controllers), both residential and commercial. By involving all parties in a conservation program, it is possible to create an attitude of stewardship that will foster compliance with conservation and management strategies.

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