An Overview of Sea Turtle Conservation and Management: A Nesting Beach Perspective.

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Introdution:

There are eight species of marine chelonians; loggerheads (*Caretta caretta*), hawksbill turtles (*Eretmochelys imbricata*), leatherbacks (*Dermochelys coriacea*), kemps ridley turtles (*Lepidochelys kempii*), olive ridley turtles (*Lepidochelys olivacea*), flat-back turtles (*Natator depresses*), green sea turtles (*Chelonia mydas*), and the black sea turtles (*Chelonia agassizii*), all of which are endangered, threatened, or vulnerable (Eckert, et al., 1999). As a group there are many aspects of their biology and life history that makes them particularly vulnerable to human interference. Generally, most migrate between feeding and nesting grounds (Bowen, et al., 2007), are long-lived, nest on semi-tropical and tropical beaches, breed seasonally, have large clutch sizes, and have high mortality before adulthood (Heppell, et al., 2003). It is not just one anthropogenic cause that influences sea turtle population size and dynamics, but it is a combination of many threats in-shore and out at sea that cause population declines across all species (Kornaraki, et al., 2006), where most attention is usually given to in-shore and beach conservation. This review will assess the current stressors on sea turtle populations from the perspective of nesting beach related conservation including disturbances to nesting females and disturbances to clutches and hatchlings. This report will also include an examination of the management techniques to deal with declining populations in nesting areas, including management commonly used in developed countries, management with community education and involvement in third-world countries, and management of pre-nesting off-shore females, who are often caught by fishermen as bicatch.

Disturbance to nesting females:

Humans can have the largest positive and negative impacts on sea turtle populations during breeding and nesting periods where turtles are accessible on the beaches and aggregate off-shore. Disturbance to nesting females is the first obstacle in nesting beach conservation projects. Pedestrian interference and under education about the appropriate ways to interact with nesting females is usually the primary threat, and in extreme cases such as in developing nations, poaching is highly pervasive and hard to manage (Koch, et al., 2006), but is usually rare in developed countries. Human interactions can cause females to disorientate inland and become entangled in bushes and die from dehydration and stress, be hit by cars, and potentially run into hazardous materials and sustain life threatening injuries (Koch and Guinea, 2006; Personal observation). The same can result from lighting induced disorientation, as females and hatchlings instinctively orientate to the brightest horizon, which is supposed to be the sea, but can easily be confused for buildings or car lights, and the animals will relentlessly crawl in that direction (Salmon et al., 1995b; Adamany et al., 1997; Personal observation, 2005; Antworth, et al., 2006). Human interactions can also cause aborted nesting attempts, as the females may find the beach unsuitable and unsafe, possibly interpreting humans as predators that may eat her clutch or cause her injury (Antworth, et al., 2006). Nesting abortion can also be caused by beach furniture, cement escarpments, roads, and remodelled sand, where the female will run into obstacles and become disturbed and stressed or find beach characteristics unsuitable, and abort the nesting attempt (Hays and Speakman, 1993; Salmon et al., 1995a; Bouchard et al., 1998; Wood and Bjorndal, 2000; Personal observation, 2005). Beach furniture and like objects have also been known to trap and kill females on rare occasions. It is natural, and has been documented, that females usually "false crawl", or land on their perspective nesting beach and make a U-shaped crawl up and back, once or twice before depositing her clutch, which is thought to allow her to test for beach suitability before the final deposit (Hays and Speakman, 1993; Eckert, et al., 1999). On the less disturbed beaches there are usually equal numbers of nesting and non-nesting emergences, where on highly disturbed beaches non-nesting emergences can be many times higher than nesting emergences (Eckert, et al., 1999). The aftermath of high aborted nesting attempts is not known, it has been suggested that these females usually find a nearby beach which is more suitable, or possibly reabsorb the eggs (Bouchard et al., 1998).

Disturbances to clutches and emerging hatchlings:

The clutch and hatchlings are usually very susceptible to harm from human activities, in addition to natural predation, mortality and environmental factors, and even a well meaning researcher can inadvertently decrease a nest's success if they are not aware of the risks and needs of clutches and hatchlings (Eckert, et al., 1999; Antworth, et al., 2006; Engeman, et al., 2006; Almeida and Mendes, 2007). Many of the threats on disturbed beaches include beach equipment breaking or uncovering eggs, human pests like dogs, cats, raccoons and rats digging up eggs (Antworth, et al.,2006; Engeman, et al., 2006), inundation (and drowning) of embryos and hatchlings caused by man-made barriers and beach construction (Bouchard et al., 1998; Pilcher and Al-Merghani, 2000), fire ant attacks on emerging hatchlings (Personal observation, 2005), relocation of the clutch outside the safe 6-hour post-deposition window, rotating eggs during relocation (Almeida and Mendes, 2007), and entrapment in holes and ruts or escarpments created by people digging or moving sand (Personal observation). These threats are in addition to natural pressures such as predation from scavenging animals particularly from beach birds, raccoons, armadillos, and wild dogs and cats (Antworth, et al., 2006; Engeman, et al., 2006), and the environmental down falls of bad nest placement resulting in less than optimum moisture (McGehee, 1990), vegetation (roots may dry out clutch, entangle hatchlings, increase land mammal predation, but provide cover and shelter for females), sand firmness, ventilation, temperature, and susceptibility to seasonal disturbances such as hurricane storm surge (Hendrickson, 1982; Hays and Speakman, 1993; Karavas, et al., 2005).

Management strategies to increase sea turtle recruitment, and survival.

Management of nesting beaches is the most practical method to improve marine turtle recruitment, as it is accessible to researchers and a source of high mortality for hatchlings and adults. Nest management programs are one of the most common and effective methods of increasing survival, especially in accompaniment with legislation and community cooperation. There are some programs that are wholly community based, where marine turtles are apart of the local economy, tradition and food source, and the sustainable management of the animals benefits the community and marine turtle conservation (Almeida and Mendes, 2007). Most programs in the developed world are concerned with the protection of nests and their beaches from invasion and disturbance by humans (Antworth, et al., 2006; Almeida and Mendes, 2007). Other management strategies address the accumulation of females off-shore during the nesting period, where recreational and fishing vessels cause the mortality of females from collisions, entanglement in fishing lines, and drowning in trawl nests (Koch, et al., 2006).

An example of a typical developed or western country nesting beach program occurs in Sarasota, Florida. Here, all nesting beaches are patrolled during the nesting season (May 1st to October 31st), every morning at sunrise to record nesting and non-nesting emergences, and to mark off nests with wooden stakes and flagging tape so the program can keep track of nests and to alert the public to the nest's presence. In areas with high predation, pest, or disorientation risk nests are fitted with a cage that is buried deeply around the edges to protect eggs and emerging hatchlings from predation and disorientation (Antworth et al., 2006; Engeman, et al., 2006). The stakes are labelled with information about when the nest was laid, what location it was laid in, nest number, and if the location has been identified with a GPS unit and by triangulation in case the original stakes are lost. Records are kept regarding any unusual tracks or nests made by females, as they are usually a sign of disturbance or disorientation from human sources (Antworth, et al., 2006). The nests are monitored throughout the season for damage caused by vandals, inundation, ant invasion, predator damage, and damage caused by storm surge. About 24-48 hours after a clutch has hatched the contents are sorted and the remaining live hatchlings are brought back to the aquarium for treatment until release at the end of the season, while the number of hatched, dead, and piped (partially out of egg) hatchlings are calculated from the shell remains. Nest success is calculated for each nest as the proportion of hatchlings that successfully hatch and leave the nest; unfortunately post-hatch predation can usually not be determined and included in the measure. The 'nest success' is used to assess the relative success of the conservation methods, and to identify key risk locations where nest success is low, and may initiate the possible relocation of nests in future years (Antworth, et al., 2006). The ratio of nests to non-nesting emergences is also important to consider across the management region, as areas that deviate from the expected 1:1 ratio may be highly disturbed as females abort most nesting attempts, or a very successful beach with a high proportion of nesting emergences (Antworth, et al., 2006). These beaches can then be prioritised into beaches which need particular attention and regulation due to excessive disturbance, or need to be conserved so that highly successful beaches are not lost to development (Antworth, et al., 2006). These management programs and their enforcement power is often backed by federal and state legislation that imposes heavy fines and jail time to people who directly or indirectly contribute to the disturbance of a sea turtle, its nest, or hatchlings Details of this program were taken from personal experience at Mote Marine Laboratory, Sarasota, Florida, 2005, while similarly described programs include one in Brazil (Almeida and Mendes, 2007), in different areas of Florida (Johnson and Eckhart, 1996; Antworth, et al., 2006), and in Greece (Kornaraki, et al., 2006).

Community conservation is often a very successful type of conservation program in third world countries, as sea turtles are often important to local economy, tradition and as a food source. Locals are often very willing to participate and run their own programs as these programs greatly benefit the community (Almeida and Mendes, 2007). An example of a very successful program is in Ostional, Costa Rica, which is the sight of one of the world's largest arribada (mass nesting) of the Olive Ridley sea turtle. When the females waiting off shore are cued to begin nesting – locals speculate the cue is related to the lunar cycle (Personal communication, 2004) – the local group of turtle watchers and visiting researchers take tourists to view nesting for a fee, which is a valuable source of income for the small village. Due to the high density of nesting females and nests on the beach, some turtles begin to dig up the nests of other turtles to deposit their own. The local people are allowed to collect a portion of the dug up eggs, as the survival of the dislodged and rotated eggs drastically decreases about 6 hours after deposit (Almeida and Mendes, 2007), and sell them at the price of chicken eggs to prevent a black market demand or increased poaching. Some of the locals also assist researchers and take part in caging clutches at risk from predation, and educate tourists about the anthropogenic and natural risks to sea turtles (Personal observation/communication, Ostional, Costa Rica, 2004).

The offshore gathering of females, such as in the pervious example at Ostional, can also pose a threat to nesting females, as they are at greater risk of drowning from longlining and trawling, and from recreational motorboats (Koch, et al., 2006; Lewison and Crowder, 2007; Read, 2007). Although the traffic off-shore from nesting beaches is hard to regulate, the invention of the 'turtle excluder device' for fishing vessels has deceased the drowning deaths of sea turtles in nets. In Bahia Magdalena, Mexico, many turtle carcasses for several species of marine turtle are found rotting along beaches within the town, which are usually the result of dumped bi-catch from off-shore trawling, if not from poaching (Koch, et al., 2006). The "turtle excluder device" is an attachment to trawl nets that allows turtles to escape through a large trap door in the back of the net, and has saved many nesting and foraging turtles from drowning. Unfortunately in some parts of the world, such as in Mexico and India, there are massive deaths caused by trawling around the nesting period, and the local fishermen refuse to use the excluder devices, provided at no cost to them, because they think they will loose fish when the turtles exit the net, though in reality few fish are lost and device saves fishermen money as they don't have to replace nets damaged by tangled turtles (Lewison and Crowder, 2007). Longline fishing is also a source of near-shore mortality, as the sea turtles may take bait or become tangled in longlines, but inventions to reduce hooking such as circle hooks have had limited success reducing mortality (Read, 2007). Recently, many nesting beach programs around the word have been satellite tagging nesting females from the beaches, and collecting data about where females wait offshore before nesting attempts and their migratory paths and destinations, which makes refining the areas of ocean to regulate in regards to fishing and human activity (oil rigs or dredging sand) much easier to define (Whiting, et al., 2006).

Conclusion:

Marine turtle conservation through management of nesting beaches to increase recruitment is a very practical and inexpensive way of monitoring turtle populations through nesting activity. Though most of a turtle's life is spent migrating and foraging, the only time when turtles are easily and predictably assessable to researchers is during nesting and gathering off-shore for breeding between nesting emergences. Most programs are relatively successful in improving nesting success hindered by human activity merely through presence and protection of nests (Antworth, et al., 2006; Almeida and Mendes, 2007). Success is usually limited by the cooperation of the community, as a lot of extra stress is placed on the populations from communities in addition to the natural level of predation and mortality. In many developed nations the maintenance of nesting beaches with legislation and patrol programs involving community education have led to an increase in population growth rates (Antworth, et al., 2006; Almeida and Mendes, 2007). While there are more management problems in third-world nations, due to lack of funding and lax legislation and enforcement, instilling a feeling of responsibility for the sea turtles in the local people can go a long way in increasing the nesting success of the beach (Almeida and Mendes, 2007).

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