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SEA TURTLE HATCHERIES IN SRI LANKA: THEIR ACTIVITIES AND POTENTIAL CONTRIBUTION TO SEA TURTLE CONSERVATION

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ABSTRACT

Hatcheries can be used as an *ex situ* conservation tool, however their contribution to the effective management of sea turtles is highly debated. A questionnaire survey was used to assess the activities of the seven hatcheries currently in operation in Sri Lanka. All the hatcheries were operated by private owners, and the primary motive was profit from ecotourism. During the 1990's, hatcheries only operated during the tourist season, but recently remained open throughout the year. It was a common practice to buy sea turtle eggs from egg collectors at a rate of about 8-15 LKR (< 0.15 USD) each and bury them in an incubation enclosure within the hatchery. "Headstarting" occured at all hatcheries. Most of the rearing tanks were regularly cleaned, but crowded during the turtle nesting season. Juvenile and sub-adult turtles that had been kept for display were often released to the sea when feeding became costly. None of the hatcheries were involved in any collaborative research or provided visitor education contributing to sea turtle conservation; operations were an attraction for tourists and provided financial income for the local community.

INTRODUCTION

Sea turtle hatcheries exist as an *ex situ* conservation tool in many countries (Shanker, 1994; Upm & Perhilitan, 1996; Chan, 2001; Shanker, 2003), including the southeastern coast of Sri Lanka (Hewavisenthi, 1993; Tisdell and Wilson, 2005a). However, doubts have been raised about the effective contribution of hatcheries to the conservation of sea turtles (Hewavisenthi, 1993; Shanker & Pilcher, 2003). Tisdell and Wilson (2005a) modeled the role of tourism-based sea turtle hatcheries by combining economical and ecological parameters, and demonstrated that hatcheries can make a positive contribution to sea turtle conservation, but their effectiveness depends on their management.

Of the seven sea turtles species in the world, five (the green, *Chelonia mydas*; leatherback, *Dermochelys coriacea*; loggerhead, *Caretta caretta*; hawksbill, *Eretmochelys imbricata*; and, olive ridley, *Lepidochelys olivacea*) nest in Sri Lanka (Deraniyagala, 1953). Nesting occurs throughout the year, but March to May is considered as the nesting season with a peak in April (Ekanayake *et al.*, 2002; 2010). The south and southeast coastlines, encompassing suitable beaches and vast areas of seagrass beds and coral reefs, provide important nesting and foraging grounds (Deraniyagala, 1939; Amarasooriya, 2000). This area has a high human population and tourism is also largely concentrated along these coasts. A study conducted in 2007 indicated that many villagers from the nesting areas had eaten turtle eggs, but most of the consumption occurred during the 1990's or earlier (Rajakaruna *et al.*, 2009).

The first Sri Lankan sea turtle hatchery was established in 1956 at Yala National Park by the Wildlife and Nature Protection Society of Sri Lanka, a non-governmental organization for nature conservation. A second hatchery was established at Palatupana in 1969. Both hatcheries were opened with conservation, restoration and management of the sea turtles and their habitats in Sri Lanka as the main objectives. The number of hatcheries increased rapidly in the 1970's, with as many as 23 additional hatcheries opening (Fernando, 1977). The number of hatcheries has since varied: 16 hatcheries were recorded in 1994 (Richardson, 1995) and 25 hatcheries

were listed in the proposed action plan for conservation restoration and management of turtles and their habitats in Sri Lanka in 1996 (de Silva, 1996). However, a survey conducted in 1996 recorded only seven hatcheries (Amarasooriya & Dayaratne, 1997). Wickremasinghe (1982) estimated that during 1981 and 1982 three hatcheries used 48,934 turtle eggs; IUCN (2005) estimated that nine hatcheries used ~300,000 turtle eggs in 2000.

During the 1990's, only two hatcheries in operation defined conservation as their main objective, and the remainder operated primarily for commercial gain (IUCN, 2005). The long-term success of these programs cannot be evaluated, as hatcheries rarely kept records of hatching success or tracked hatchlings once they left the beach (Hewavisenthi, 1993; Hewavisenthi & Kotagama, 1990). While the contribution of turtle hatcheries to the conservation of sea turtles was highly debated, the Department of Wildlife Conservation (DWC) in Sri Lanka considered that management techniques in operation at the majority of hatcheries were not conducive to the conservation of sea turtles (IUCN, 2005). We conducted a survey to assess the activities of current hatcheries in Sri Lanka, and the potential contribution to sea turtle conservation.

METHODS

All existing sea turtle hatcheries were included in this study. Hatcheries were visited once during the nesting off-season (02 October 2010) and again during the nesting season (28 March 2011). We interviewed the owner, or the hatchery keeper present, at the time of our visit. Verbal consent was first sought from the interviewee, after explaining the objectives of the study and presenting a permission letter issued by the DWC, Sri Lanka. Each interview lasted between 30–40 mins, and collected information about the hatchery and hatchery keeper/owner, hatchery management practices, compliance with the Fauna and Flora Protection Ordinance (FFPO, 1938 amended in 1972), and potential contribution to conservation of sea turtles.

Hatchery profile
The name, district, location, age, distance from the sea, reasons for site selection, number of current employees, number of volunteers (if any), number of incubation enclosures, number of tanks and their capacity were recorded. Information about the effect of the tsunami in December 2004 and the extent of damage to the hatchery was also collected.

Hatchery keeper/owner profile
Eight questions were asked to gather personal information about the hatchery keeper/owner to gather information about their experience as a hatchery keeper/owner and formal training in hatchery management.

Management practices of the hatchery
Twenty-seven questions were asked to assess the management practices of the hatchery: egg collection methods, number of suppliers (if relevant), site/s of egg collection, frequency of egg collection, number of eggs collected (during peak season and off-season), proportion of eggs originating from suppliers, method of transport of eggs to the hatchery, price of an egg, how the eggs are buried, number of eggs in one artificial nest, distance between nests, hatch success, turtle species currently in the hatchery (including adults and hatchlings), percentage of hatchlings that are kept in the hatchery, method of releasing the hatchlings, diet of hatchlings and adults, duration of hatchling holding time in tanks, method of hatchling release, and frequency of cleaning the tanks. Further questions were asked about visitor entry (and the entry price if applicable), souvenir sales, number of visitors

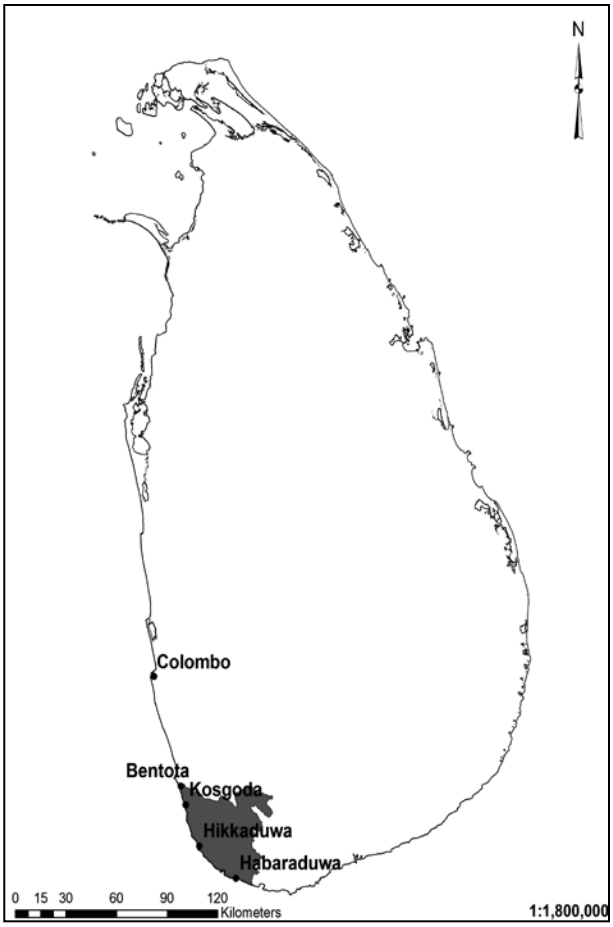

Figure 1. Hatcheries along the southwestern coast in the Galle district of Sri Lanka

a year, if visitors were allowed to touch, hold or feed hatchlings, juveniles and/or sub-adults and if visitors requested to release hatchlings for religious purposes.

Compliance with the FFPO and contribution to conservation

Compliance with the FFPO was determined by assessing interviewee awareness that possessing and/or selling sea turtles or their products was illegal, while an observation check list noted down any turtle products displayed or available for sale in the hatchery. Interviewees were also asked if they were aware that establishing a turtle hatchery was illegal. The potential contribution of the hatchery towards conservation of sea turtles was determined by asking questions about conservation awareness programs or information available for visitors, and whether they believes that hatcheries should be required to obtain a yearly license based on proper management, records of eggs collected, hatch success etc. Information about any collaborative research, prior participation in surveys and purchase of eggs during the tourist off-season was also collected during the interview. The scale of the hatchery, overall organization, health of hatchlings, overcrowding in the tanks, water condition and cleanliness, other income generating methods, beachfront, garden or street lighting, and incubating enclosures (distance between two nests, vegetation cover, amount of sunlight and shade) were also measured/observed and noted down using a checklist.

RESULTS AND DISCUSSION

At the time of the study, seven sea turtle hatcheries were in operation along the southwestern coast in the Galle district of Sri Lanka (Table 1, Figure 1).

Hatchery profile

All the existing hatcheries were operated by private owners and categorized as small, medium or large based on the total hatchery area, number and size of egg incubation enclosures, and number and capacity of tanks (Table 1). All were more than 10 years old, and five of the hatcheries were more than 20 years old. The oldest hatchery, Sea Turtle Hatchery in Kosgoda, began operations in 1963 and the most recent, Sea Turtle Farm and Hatchery in Periliya was established in 2000. All the hatcheries were severely damaged by the tsunami in December 2004, and have been subsequently rebuilt further from the sea. The Sea Turtle Farm and Hatchery in Hikkaduawa was completely destroyed by the tsunami and still does not have a proper roof, so rain water collected into the rearing tanks.

Small scale hatcheries were managed and maintained by a single person, usually the owner or a family member, while large scale hatcheries employed a varying number of people for routine maintenance (Table 1). The highest number of employees at a single hatchery was 12 people (including the owner or manager).

All hatcheries possessed egg incubation enclosures inside the premises. Egg incubation enclosures, and sometimes the total hatchery area, were fenced to protect nests from predators and poachers (Figure 2C). A varying number (usually 6–9) of cement tanks, of different sizes (1000L-5000L), for rearing hatchlings, juveniles and sub-adults were present in a roofed area (Figure 3A; Table 1). All hatcheries had three to ten individuals of three or four species of juvenile and sub-adult turtles on display. Entry tickets cost between 50 and 250 LKR (0.40–2.00 USD), and some hatcheries also had a donation box for

Table 1. Profiles of the seven turtle hatcheries operating on the southwestern coast of Sri Lanka in 2012.

Hatchery Name	Location	Years Operating	# Staff (Including Owner)	# Species	# Egg Incubating Enclosures	# Holding/ Rearing Tanks	Distance to Sea	Scale*
Wunder Bar	Bentota	16	1	4	2	7	250m	Small
Sea Turtle Conservation Research Project	Bentota	31	12	4	2	9	50m	Large
Turtle Conservation Research Centre	Kosgoda	33	10	4	2	8	10m	Large
Sea Turtle Hatchery	Kosgoda	48	10	3	2	7	300m	Large
Kosgoda Sea Turtle Conservation Project	Kosgoda	23	1	4	3	6	15m	Medium
Sea Turtle Farm and Hatchery	Hikkaduwa	11	1	3	2	8	10m	Medium
Habaraduwa Turtle Hatchery	Habaraduwa	21	5	4	1	8	20m	Small

*Based on the number and the size of rearing tanks, incubation enclosures and total hatchery area.

visitor contributions towards sea turtle conservation. Souvenirs, clothes and other items were sold to create additional income. None of the hatcheries had volunteers, local or foreign, working during our visits, although some owners said that there had been many in the past.

Hatchery keeper/owner profile

The hatchery owner, or a family member (wife/son), who was present at the time of visit was interviewed at all the operations except one (Wunder Bar in Bentota), where an employee (hatchery keeper) participated in the interview. Six of the interviewees were males and one was female; all were between 23 to 50 years of age. Most had completed education at least up to junior secondary level (until ~16 years of age). A hatchery owner with only primary school education had 33 years of experience and had undergone formal training in hatchery management from the programmes conducted by K.D. Amarasooriya of the National Aquatic Resources Research and Development Agency (NARA), Sri Lanka, and Prof. S. Kottama, University of Colombo, in the 1990s. Three hatchery owners claimed that they had participated in training programs on hatchery maintenance while others did not have any formal training but claimed that they learned either from the employer or from his/her father (Table 2).

Hatchery management practices

All hatcheries purchased eggs that were collected at night, from nearby nesting beaches, by fishermen or villagers; there were between four and 50 designated egg suppliers in some areas. Hatcheries paid 8 to 15 LKR (0.07 – 0.12 USD) for an egg, depending on the nesting season and area (Table 3). With the exception of one hatchery (Sea Turtle Conservation Research Project in Bentota), all claimed that they purchased all the eggs brought by a supplier, even during the tourist off-season. Sea Turtle Conservation Research Project reported they did not purchase all olive ridley turtle eggs as the hatch success was lower than other species. It was unknown whether the suppliers brought the eggs to hatcheries due to demand, or would stop doing so if there was no market, but Tisdell and Wilson (2005a) reported that purchasing eggs from suppliers established a market value. One hatchery owner reported that police had donated eggs confiscated from poachers in the area. Some hatchery managers themselves collected eggs from the beach.

Table 2. Profile of interviewees from sea turtle hatcheries in Sri Lanka.

Hatchery Name	Status	Age (Yrs)	Sex	Education	Hatchery Experience (Yrs)	Formal Training in Hatchery Management
Wunder Bar	Keeper	23	Male	O Levels	3	No
Sea Turtle Conservation Project	Owner	50	Male	A Levels	30	Yes
Turtle Conservation Research Centre	Owner	49	Male	Secondary	33	Yes
Sea Turtle Hatchery	Owner's Son	32	Male	O Levels	20	No
Kosgoda Sea Turtle Conservation Project	Owner	40	Female	A Levels	11	No
Sea Turtle Farm and Hatchery	Owner	35	Male	A Levels	5	No
Habaraduwa Turtle Hatchery	Owner	36	Male	A Levels	15	Yes

Table 3. Management practices of the seven turtle hatcheries in southwestern Sri Lanka.

Hatchery Name	Egg Price (USD)	# Egg Suppliers	Status of Incubating Enclosures*	% Hatchlings Released	Hatchling Holding Period	Rearing Conditions for Adults*	Water Quality*	Overall Hatchery Standard*
Wunder Bar	0.10-0.15	9	3	99	1 day	2	3	3
Sea Turtle Conservation Project	0.10	5	4	95	1-3 days	2	2	2
Turtle Conservation Research Centre	0.10-0.12	50	3	80	1-3 days	2	2	2
Sea Turtle Hatchery	0.10-0.20	30	5	75	>2 weeks	5	5	5
Kosgoda Sea Turtle Conservation Project	0.10	4	3	95	1 day	2	2	2
Sea Turtle Farm and Hatchery	0.10	4	3	95	1 week	3	4	4
Habaraduwa Turtle Hatchery	0.08-0.09	25	2	80	1-7 days	4	2	3

Despite the collection of turtle eggs from the wild being illegal, beaches were not declared as protected areas or reserves and were, therefore, open access resources. Tisdell and Wilson (2005a) argued that once eggs were collected and sold to hatcheries, they became private property and could be protected by the hatchery owners. Supporting this argument, some suggested that private ownership of wildlife might be an effective means for conservation (Swanson, 1994; Skonhoft, 1999) and this concept could also be applied to sea turtles if there was specific ownership and clear legal responsibilities (Eckert, 1991; Crowder, 2000; Witherington & Frazer, 2003).

Suppliers transported turtle eggs in plastic bags or cardboard boxes. Hatchery practice guidelines (IUCN, 2005) recommend a special container, such as a bucket or a box, be placed inside a larger polystyrene box during transport and there be minimum rotation of the eggs. Egg suppliers in Sri Lanka were not educated on how to collect, transport or handle eggs, and most of the hatchery keepers were unaware of the location of egg collection, when the eggs had been laid and when they were collected. Purchase of eggs transported in plastic bags, and from far locations, should be discouraged; eggs should be collected within three hours of oviposition and re-buried before white spots appear on the surface of the eggshell (IUCN, 2005).

Egg incubation enclosures

Eggs were buried in hand-dug nest chambers inside incubation enclosures (Figures 2A & 2B). The enclosures were well protected from predators (Figure 2C) and located several meters above the highest water mark of the diurnal tide. All hatcheries possessed two egg incubation enclosures, except Habaraduwa Turtle Hatchery which had only one (Table 1). IUCN (2005) hatchery guidelines recommended at least two enclosures within a hatchery, used alternately every six months. In order to prevent infection by fungi and bacteria, the same incubation site should not be used over two consecutive nesting seasons (IUCN, 2005). Interviewees claimed that the eggshell and unhatched egg debris were removed by hand, and the sand in the pen was changed completely or washed before re-use in a subsequent season.

Most hatcheries marked nest locations with a flagpole (Figures 2B & 2C), a label on which showed the species and the date the clutch was buried. Piling sand on top of the nest was a common practice at all hatcheries (Figure 2B) except Habaraduwa Turtle Hatchery. The sand pile was created when the egg chamber was not deep enough to accommodate the entire clutch. The average natural nest depth for each turtle species is: leatherback 90cm, green turtle 70cm, loggerhead 65cm, hawksbill 55-65cm, and olive ridley 31-45cm (IUCN, 2005); the average depth of the nests in the hatcheries was not determined. Hatchery nest depth influences nest temperature (Van De Merwe *et al.* 2006) and piling sand on the nest may also have an effect on nest temperature and subsequent hatchling sex ratios.

Figure 2B. Mounds of sand on hatchery nests

Photo credit: Lalith Ekanayake

Figure 2A. Structure and location of nests in hatchery

Photo credit: Lalith Ekanayake

Figure 2C. Egg incubation enclosures

Photo credit: Lalith Ekanayake

The Sea Turtle Conservation Research Project in Bentota did not purchase all available olive ridley eggs as the hatch success was lower than for other species. The egg incubation enclosures in this hatchery were located in an area surrounded by tall beach vegetation and received less sunlight than the other hatcheries. Olive ridley turtle nests are much shallower (31-45cm) than nests dug by other species, and are usually laid on open beaches (IUCN, 2005). A possible reason for lower hatching success in olive ridley nests in Sea Turtle Conservation Research Project in Bentota may be the effect of burying these eggs in deeper and shaded nests, creating nest temperatures below the lower threshold of tolerance for developing embryos. The proximity of vegetation and degree of shading in egg incubation enclosures should be an important consideration when choosing a hatchery location.

Variability in the thermal environment of nests can result in hatchling sex ratios different to those in natural nests (Standora & Spotila, 1985; Spotila *et al.*, 1987). Research should be conducted to determine the pivotal temperature at Sri Lankan nesting beaches, from which eggs were collected, then sufficient shade and light exposure provided at the hatchery to match this temperature as closely as possible.

At one hatchery, nests were located less than one foot apart (Figure 2B). The recommended distance between two nests is at least 2ft, to minimize their impact upon one another and to allow room for hatchery workers to move (IUCN, 2005). However, overcrowding of small enclosures with a large number of nests during the nesting season was common in most hatcheries. In one hatchery (Sea Turtle Hatchery in Kosgoda) some viable eggs were incubated for display in partially buried, open buckets (Figure 4A).

Hatchling emergence and migration

The emergence of hatchlings from the nests occurred unaided but "headstarting" (the captive rearing of turtles through an early part of their lifecycle) was practiced at all hatcheries. After a certain time (usually one day to two weeks depending on the hatchery and season) or size (once the yolk sac was fully absorbed), headstarted neonates were released into the sea where they were assumed to have improved survivorship (Heppell & Crowder, 1996; Pilcher & Enderby, 2001). Some hatchery owners believed headstarting raises hatchlings through their most vulnerable period, when they may be subject to intense predation. Headstarting of Kemp's ridley turtles in Galveston, Texas, has yielded no conclusive evidence of long-term success (Byles 1993).

Under natural conditions, hatchlings crawl rapidly from the nest to the sea following emergence (usually at night) and immediately enter a swimming frenzy that may last up to 24 hrs, during which they distance themselves from shore and shore-based predators (Wyneken & Salmon, 1992; Wyneken & Salmon, 1994). None of the hatchery enclosures allowed free migration of the hatchlings to the sea after emergence from the nest; hatchlings were trapped within the enclosures overnight. Staff recovered hatchlings the following morning and placed them in tanks. A varying proportion (75%-95%, depending on the hatchery) were released to the sea the following night, and the remainder were kept in tanks for display (Table 3). This practice does not follow hatchery guidelines (IUCN, 2005) which specify that only 5% of the total clutch of hawksbill turtles, and less than 10% of other species, should be retained in hatcheries.

All the hatcheries held their hatchlings in tanks for 24hrs or more (Figure 3B & 3C). One owner kept all hatchlings for many days, until the yolk sac was fully absorbed, as he believed the hatchlings were easy prey if they entered the sea with the yolk sac in its natural state at emergence. During this time, hatchlings swam continuously and missed valuable hours of darkness during which they would normally distance themselves from shore (Pilcher & Enderby, 2001). The disturbance to normal post-emergence behavior likely affected their chances of survival, by depleting limited energy supplies and altering their programmed swimming behavior and timing. Although newly emerged turtles displayed vigorous swimming behaviour, those held for more than 24 hrs appeared less active (personal observations). Pilcher *et al.* (2000) found that up to 50% of hatchlings from hatcheries may be lost in the first hour at sea in Sabah, Malaysia. Hatchlings demonstrated a 12% decrease in swimming speed after just six hours of retention in a hatchery. Swimming style is also known to vary with prolonged retention; hatchlings frequently used a dog-paddle swimming style with alternate flipper movements rather than the more efficient power stroke with simultaneous flipper movements after several hours of retention (Pilcher *et al.*, 2000). This deviation from usual swimming style, combined with decreased swimming speed, likely hindered hatchling offshore migration and reduces survival rates.

Turtles show a high degree of nest site fidelity, although the level of site fidelity varied between species (Miller, 1997). Nesting female turtles usually return to their natal area to nest. This indicates that some form of magnetic imprinting may occur (Pritchard, 1980) which could be impeded if hatchlings were held in tanks (Pilcher *et al.,* 2000; Tisdel & Wilson, 2002). Therefore, the free migration of hatchlings from the nest to the sea soon after

Figure 3A. Hatchling rearing tanks

Photo credit: Lalith Ekanayake

Figure 3C. Feeding tank

Photo credit: Lalith Ekanayake

emergence is important. According to the best practice guidelines (IUCN, 2005), at least 90% of hatchlings from each nest should be allowed to immediately crawl to the sea, to promote natural imprinting. Moreover, hatchlings should not be held in tanks prior to release, and should be released within 24hrs of emerging between 7pm to 5am. Holding hatchlings for more than 24hrs should be avoided for any reason during the peak-nesting season. However, they may be kept for a maximum of seven days during the off-season (IUCN, 2005). None of the existing hatcheries followed these best practices.

Rearing of hatchlings

Hatchling should be provided with a minimum area of one square foot surface area, with a maximum stocking density of 50 hatchlings per tank; the maximum number of hatchling tanks recommended for a hatchery is five (IUCN, 2005). Most of the rearing tanks observed during our study were clean and the tank size was sufficient for the hatchlings (Table 3). However, crowded hatchling tanks were common during the nesting season (Figure 3B). Hatchlings were transferred to a separate tank for feeding (Figure 3C) at all the hatcheries. Green, loggerhead, hawksbill and olive ridley hatchlings were held in tanks, but not leatherback turtle hatchlings. The DWC does not permit rearing of leatherback turtles in a hatchery, as the species feeds on jellyfish, which are not easily accessible (DWC pers.comm.). Although the hatcheries displayed sign boards that prohibitied touching and feeding, eggs, hatchlings, juveniles and sub-adults were touched and photographed by visitors to most hatcheries. None of the hatcheries allowed visitors to feed the hatchlings, but some hatcheries allowed visitors into the incubation enclosures.

Stocking and rearing of juveniles and sub-adults

Although it is recommended that only one adult turtle be held in a single tank (IUCN, 2005), two or more juveniles or sub-adults were frequently housed in one tank at all the hatcheries surveyed (Figures 4B). Since feeding bigger individuals was costly, some hatcheries released turtles at about 3-4 years old (about a foot long). These turtles probably lacked the behavioural adaptations to avoid predators and the foraging abilities

Figure 3B. Crowding in hatchling rearing tanks

Photo credit: Lalith Ekanayake

Figure 3D. Hatchery educational material

Photo credit: Lalith Ekanayake

Figure 4A. Eggs on display
Photo credit: Lalith Ekanayake

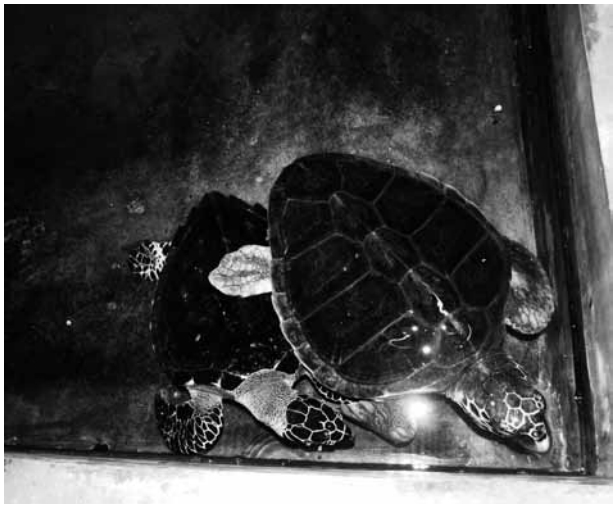

Figure 4B. Crowded juvenile turtles
Photo credit: Lalith Ekanayake

Figure 4C. Removing hatchlings from nest
Photo credit: Lalith Ekanayake

which would allow them to survive in the wild (Pilcher & Enderby, 2001). Sea turtles can return to their wild after long periods of captivity, and many long-term captive animals have successfully re-entered their natural habitat, chosen traditional migration routes, and survived (Bell *et al.*, 2005). Satellite telemetry suggests that rehabilitated turtles were able to adapt quickly and returned to "normal" foraging areas and behavior following extended periods in captivity. However, there was significant interference in the life cycle of the turtles born and raised in hatcheries and their survival in the wild is highly unlikely (Pilcher & Enderby, 2001).

At all the Sri Lankan hatcheries, turtles were fed with easily available fish, including the herbivorous, adult green turtles. Some hatchery owners claimed they provided a mixed diet of sea grass and fish to green turtles and keep sea grass in tanks to feed the turtles.

Compliance with ordinance and contribution to conservation

During the 1990's, some hatcheries operated only during the tourist season, indicating the prime motive of the hatcheries was profit rather than conservation (Hewavisenthi, 1993). Current hatcheries operated year-round, although the number of visitors was less during the tourist off-season. Some hatcheries recently changed their name from "turtle hatchery" to "turtle conservation and research project", suggesting the primary goal of the name change was for commercial gain but with an understanding about the need for hatcheries to contribute to sea turtle conservation. Some displayed educational material for visitors (Figure 3D).

All Sri Lankan hatcheries should be licensed annually, based on the recommendations of a National Steering Committee on Marine Turtle Conservation (IUCN, 2005). During the current study, all hatcheries agreed to obtain a license, if required. Records of species, date and number of eggs buried, the date hatched and the date released to sea were previously kept by some hatcheries. However, this practice was not continued after the tsunami in December 2004 when all records were lost. Interviewees acknowledged that the lack of monitoring of hatchery practices did not motivate them to keep the records.

All interviewees were aware that possessing sea turtles or turtle products was illegal, but they were unaware that hatcheries were illegal to operate without a permit. The DWC can authorize establishment of hatcheries under section 55 of the FFPO, with special emphasis on conservation and scientific studies. A national steering committee on marine turtle conservation, with members from DWC, NARA, and CCD, should

be formed to evaluate and approve the hatchery performance and give permission to issue/renew a license. However, the practices of existing hatcheries might not qualify to grant permission to operate. The primary aim in maintaining a sea turtle hatchery in Sri Lanka was as a profit oriented venture, and may not provide positive conservation benefits. Poor practices were employed at most hatcheries. However, hatchery owners and/or managers were aware of the need for sea turtle conservation. Hatcheries were often expensive to establish and maintain, and were usually located in or adjacent to villages with low socio-economic standing. They provided financial income for the community involved. Closure of existing hatcheries would be impractical, but hatchery operations should be conducted by well trained personnel under constant guidance by conservation biologists and closely monitoring by DWC. Hatchery practices should follow those of the IUCN (2005). Permission to start new hatcheries should not be granted by the DWC under any circumstances. Although establishment and operation of hatcheries was prohibited under section 30 of the FFPO, the Director of the DWC can, under section 55 of the Ordinance, authorize such activities for the purpose of protection, preservation and for scientific studies and investigations. However, sea turtle hatcheries were recommended as a last resort where in situ conservation is not possible or impractical (IUCN, 2005).

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GREEN TURTLE NESTING ACTIVITY AT JUANI ISLAND, TANZANIA, DURING THE 2012 PEAK NESTING SEASON

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INTRODUCTION

Juani Island (Figure 1) is a small island (9km long and 3.5km wide) located in the south eastern corner of Mafia Island Marine Park (MIMP) off the coast of Tanzania. Gazetted in 1995, MIMP covers 822km^2 and more than 75% of the park is below the high water mark. The marine park supports a diverse range of tropical habitats including coral reefs, seagrass beds, mangroves, intertidal flats and a strip of lowland coastal forest. The area is recognised internationally as a critical site for biodiversity (MIMP General Management Plan, 2000). There are eight turtle nesting beaches on the eastern side of Juani Island that support the largest green turtle (*Chelonia mydas*) rookery in Tanzania (Sea Sense, unpublished data). More than half (60%) of all green turtle nests in MIMP are laid on Juani Island (West, 2010a) with an average of 124 ± 45 nests per year. The beaches range from 109m to 330m in length. There are also a number of small sandy inlets, but most are submerged at high tide. Nesting activity is concentrated on four beaches (West, 2011) and occurs year round with a noticeable peak in April and May (Muir, 2005). Hawksbill turtles (*Eretmochelys imbricata*) also nest in small numbers on the southern tip of the island (L. West, pers.obs).

METHODS

In 2001, a community based nest monitoring programme was established at Juani Island. The eight nesting beaches are monitored by a Community Conservation Officer, who received training in sea turtle biology and conservation from Sea Sense, a Tanzanian registered NGO. Early morning foot patrols are conducted on a daily basis throughout the year, and the number and species of nesting turtles are recorded based on track counts (West, 2010b).

Opportunistic flipper tagging has occurred since 2004, most often when a nesting turtle was encountered during early morning patrols. In 2012, the first saturation flipper tagging programme was undertaken during the peak nesting months of April and May. Four teams of two surveyors conducted night time foot patrols between 19:00 and 06:00 hours every night, from 3rd April to 3rd June 2012 (62 nights), on the four beaches where most nesting is concentrated. Each female turtle encountered was measured (curved carapace length and width) and examined for the presence of existing tags. If not already tagged, individually numbered titanium tags (TZ series) were applied between the first and second scale along the posterior edges of the front flippers. Tags were applied after oviposition was complete, to minimise disturbance. Any nest under threat from poaching, predation or tidal inundation was relocated to a safer area above the spring high water mark (Boulon, 1999). All other nests were left to incubate *in situ*. All nests are monitored until hatching and then excavated to determine clutch size and hatching success (Miller, 1999).

RESULTS

Sixty nesting attempts were recorded, 50 (83%) of which were successful. For the purposes of comparison, Table 1 shows the number of nesting events recorded through