

THE USE OF SEA TURTLE HATCHERIES AS AN *EX SITU* CONSERVATION STRATEGY IN INDIA

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INTRODUCTION

India is home to regionally important nesting populations of green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and olive ridley (*Lepidochelys olivacea*) turtles. The Wildlife (Protection) Act of 1972 protects nesting sea turtles, their eggs, and hatchlings. However, there has been significant consumption of turtles and eggs, in addition to threats from predators and coastal development (as described below) over time. Hatcheries have been employed as an *ex situ* conservation strategy in India to mitigate such threats since at least 1973 and 1974 (Valliappan & Whitaker, 1974; Biswas *et al.*, 1977 in Pandav *et al.*, 2006), but details of their specific operations are sparse. Partially filling this knowledge gap are narrative accounts of sea turtle hatchery operations in India presented by Shanker & Kutty (2005) and Shanker (2015) and this paper, which compiles all available records of sea turtle hatcheries in India to infer their potential use as a conservation strategy from proportion of known nests protected and hatching success.

METHODS

We searched the databases Scopus, Google Scholar and JSTOR, the Sea Turtles of India bibliography (<https://www.seaturtlesofindia.org/library/bibliography/>), and professional newsletters *Indian Ocean Turtle Newsletter* and *Marine Turtle Newsletter* for publications and reports on sea turtle hatcheries operating in Indian states and territories at any time to late 2017. More hatcheries may have been in operation than those described in these sources, as the news media (for example, Arockiaraj, 2017) name hatcheries at locations not described in published literature or reports. However, we chose not to include hatcheries described in news stories due to questions about the reliability of location, number of nests or eggs protected, and/or number of hatchlings released.

RESULTS

Threats to sea turtle nests and eggs that contributed to the use of an *ex situ* conservation strategy and the details available for hatchery operations are summarised below (in alphabetical order by location; Tables 1-8). As many records overlap in geographic area, time, and data sets, it is not possible to quantify the number of hatcheries but the use and productivity of hatcheries as an *ex situ* conservation strategy may be inferred.

Andaman and Nicobar Islands

There is little publicly available information about hatcheries operating in the Andaman and Nicobar Islands. Andrews *et al.* (2001) describe hatcheries to which green, hawksbill, and leatherback turtle nests of unknown numbers were relocated in the decade prior to their study commencing in the 2000/01 nesting season: Ramanagar Beach (North Andaman), Smith Island (North Andaman), Cuthbert Bay (Middle Andaman Island), Rutland Island (South Andaman), and Galathea Beach (Great Nicobar Island). However, relocation of nests to hatcheries at Smith Island and Cuthbert Bay ceased in the 2000/01 nesting season due to concern about the low hatching success (30-45%) when compared with *in situ* nests (80-100%). In 2001/02, hatchery practices at Galathea Beach were modified (further information not provided) so that hatching success rose to 75-100% from that previously recorded (25-35%) (Andrews *et al.*, 2001). Nests laid below the high tide line at Galathea Beach continued to be relocated to the hatchery in 2003/04 and 2004/05 nesting seasons (Andrews *et al.*, 2006). A paper by Jadeja *et al.* (2016) indicates the ongoing operations of a hatchery at Galathea Bay after the 2004 Indian Ocean tsunami.

Threats to sea turtle eggs and hatchlings in the region include human consumption (note: indigenous peoples of the Andaman and Nicobar Islands are exempt from the

Table 1. Records of olive ridley nests relocated to sea turtle hatcheries in Andhra Pradesh. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. An.- annually. Av.- Average.

Location	Nesting Season/s	# Nests &/or # Eggs	Hatching Success (HS) &/or # Hatchlings	Source
East Godavari district, Sacramento Island	2010/11	-	-	Saravanan <i>et al.</i> , 2013
Visakhapatnam district, Srikakulam and Visakhapatnam	2010/11	54 nests; 5,832 eggs	Av. HS 84%	VSPCA, 2011
Visakhapatnam district, Bheemli, Jodugullapalem, Rushikonda & Visakhapatnam	2011/12	181 nests; 21,343 eggs	Av. HS 63%*	VSPCA, 2012
Visakhapatnam district, Jodigullapalem and Yoga Village	2012/13	74,586 eggs	Av. HS 87%	VSPCA, 2013
Visakhapatnam district, Jodigullapalem and RK Beach	2014/15 2015/16	320 nests; 38,793 eggs 343 nests; 39,604 eggs	Av. HS 86% Av. HS 83%	VSPCA, 2015; VSPCA, 2016
Visakhapatnam district, Jodigullapalem, Lumbini Park, Peddanagaya palem, RK Beach & Tanthidi	2016/17	705 nests; 78,494 eggs	Av. HS 83%	VSPCA, 2017

*Hatching success in 2011/12 was potentially reduced due to inundation of the hatcheries after a tsunami and extreme high tides in March 2012, resulting from the 2012 earthquakes near Indonesia

Wildlife (Protection) Act) and predation by water monitors, feral dogs and pigs. Andrews *et al.* (2001) estimated that feral dogs depredated >70% of eggs and hatchlings at some locations, with pigs destroying an additional 10% of nests and consuming emerging leatherback hatchlings.

Andhra Pradesh

Andhra Pradesh (AP) supports sporadically high numbers (up to ~10,000 per season) of olive ridley turtles, but as solitary nesting events and not the mass nesting *arribadas* that occur in the adjacent state of Odisha. Described threats to sea turtle nests and hatchlings in AP include human consumption of eggs, depredation by feral dogs, pigs, foxes, hyenas, and jackals, light pollution, and aquaculture development (Rao, 1985; Tripathy, 2001; Tripathy *et al.*, 2006, Saravanan *et al.*, 2013).

Hatcheries from different areas were identified from

literature about sea turtles in AP (Table 1). There is little information available about the hatchery in East Godavari District, but reports indicate that *ex situ* conservation of turtle nests in Visakhapatnam district commenced in 2010/11, after which all possible nests were relocated to hatcheries. The number and location of hatcheries has since varied from year to year (VSPCA, 2011, 2012, 2013, 2015, 2016, 2017) and hatching success is high (usually >80%) when compared with that of hatcheries in other locations.

Goa

Nests and hatchlings in Goa may be threatened by human consumption of eggs, light pollution, construction of hotels and resorts, sand mining and non-biodegradable waste on nesting beaches (Giri & Chaturvedi, 2006; Giri *et al.*, 2006). Hatcheries in Goa (Table 2) appear to protect all nests laid on those, and some from adjacent, beaches (Giri & Chaturvedi, 2006; Giri *et al.*, 2006). The reported hatching success is high (>~75%) in comparison to other locations.

Table 2. Records of olive ridley nests relocated to sea turtle hatcheries in Goa. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. Av.- average.

Location	Nesting Season/s	# Nests &/or # Eggs	Hatching Success (HS) &/or # Hatchlings	Sources
Agonda	2000/01 2003/04	9 nests 6 nests	Av. HS 94% -	Giri & Chaturvedi, 2006; Giri <i>et al.</i> , 2006
Galgibaga	1999/2000 2000/01 2001/02 2002/03	10 nests 33 nests 19 nests 14 nests	Av. HS 80% Av. HS 75% - -	Giri & Chaturvedi, 2006; Giri <i>et al.</i> , 2006

Gujarat

Green and olive ridley turtles nest on the Gujarat coast, and nests may be relocated to hatcheries in the state to mitigate threats from human consumption of eggs, depredation by domestic dogs, wild pigs, monitor lizards, hyenas and jackals, and pollution such as oil, industrial effluent, sewage, and debris (Sunderraj *et al.*, 2006a). Many of the known nests on monitored beaches in Gujarat are protected in hatcheries (see Sunderraj *et al.*, 2006; Goswamy *et al.*, 2013) but large number of nests will also remain *in situ*. Hatching success of nests relocated to hatcheries ranges from ~20-90% (Table 3; note the record of leatherback eggs also).

Karnataka

Olive ridley turtles (and potentially greens or leatherbacks- see Sharath, 2006) nest sporadically in Karnataka. Hatcheries in the state (Table 4) may operate for short periods of time (as little as a year) and protect low numbers of nests annually (K. Shanker and M. Manohar Krishnan, pers.comm.). Threats to nests and hatchlings include human consumption of eggs, light pollution, depredation by domestic and feral dogs, and beach erosion and loss due to the construction of seawalls (see Sharath, 2006). Nest counts for Dakshina Kannada, Udupi, and Uttara Kannada districts (Sharath, 2006; Pandit & Soans, 2013) suggest that all known nests may be relocated to hatcheries, where the average hatching success varies between ~15-97% (Table 4).

Kerala

Olive ridley eggs and hatchlings in Kerala experience similar threats to those elsewhere in India: human consumption of eggs (Dileepkumar & Jayakumar, 2006; Bhupathy, 2007), depredation by feral dogs and jackals (Damodar, 2002), light pollution, and beach erosion and loss due to the construction of seawalls (Pareparambil & Mathew, 2013). We identified sea turtle hatcheries from publications and reports, with ~30-90% of eggs successfully hatching (Table 5). Only a fraction of the coast is monitored (e.g. only 8km of beach on the 71km of coastline in Kozhikode district is monitored (Pareparambil & Mathew, 2013) but likely represents the limited nesting habitat available due to the extensive construction of sea walls (Dileepkumar & Jayakumar, 2006).

Maharashtra

The number of nests protected over time at hatcheries in Maharashtra is relatively low (see Table 6), reflecting

the low numbers of nesting olive ridley and, sporadically, green turtles in the state (Giri & Chaturvedi, 2006). Katdare (2013) reported that all known nests on monitored beaches are transferred to hatcheries, with the average hatching success around 50% (Table 6). Conservation of sea turtle nests in hatcheries occurs to mitigate threats from human consumption of eggs, chemical pollution, and sewage (Giri & Chaturvedi, 2006).

Odisha

Olive ridley turtle *arribadas* or mass nesting events have been reported from three beaches in Odisha, Devi River mouth, Gahirmatha and Rushikulya, while much of the rest of the state's coastline supports solitary nesting turtles of the same species (see Pandav *et al.*, 2006; Kar & Peters, 2013). As the mass nesting events may exceed 1 lakh (i.e. 100,000) individual turtles annually, only a small proportion of the nests laid in Odisha each year are likely to be relocated to a hatchery. We found records of hatcheries in four districts, but only one specific location (Table 7). Limited information about hatching success is available, but suggests that a high proportion (>90%) of relocated eggs hatched in two years of study.

Tamil Nadu

Only olive ridley turtles (but possibly also leatherbacks; Arockiaraj, 2017) have been reported nesting in Tamil Nadu in recent years (see Saravanan *et al.*, 2013), and nests and hatchlings are vulnerable to human consumption of eggs (>95% of nests; Bhupathy & Saravanan, 2006) which may be collected by professional poachers, and depredation by jackals and domestic dogs (Bhupathy *et al.*, 2006). Hatcheries (Table 8) have been used during the 45 years of near continuous monitoring and protection of nests on beaches adjacent to Chennai by the Madras Snake Park Trust, Central Marine Fisheries Research Institute, Tamil Nadu Forest Department, and Students' Sea Turtle Conservation Network. Many of the known nests laid on Besant Nagar and Marina beaches are relocated to hatcheries (see Shanker, 2003; Arun, 2011; Arun, 2013), and a comparison of annual numbers of nests on monitored beaches in Nagapattinam (17 nests in 2003/04, 30 nests in 2004/05, and 37 nests in 2011/12- Saravanan *et al.*, 2013) with the number of nests relocated to hatcheries in the district (Table 8) suggests the same situation. The reported hatching success varies among hatcheries, from ~33%-93%.

West Bengal

Olive ridley turtles nest in low densities on beaches of the mainland and islands throughout the Sunderbans in West

Table 3. Records of nests relocated to sea turtle hatcheries in Gujarat. Locations have been adjusted to their current name. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. An.- annually. Av.- Average.

Location (District, Beach/Village)	Turtle/s	Nesting Season/s	# Nests &/or # Eggs Collected	Hatching Success (HS) &/or # Hatchlings	Sources
Bhavnagar district, Hathab	Green, olive ridley	1987/88-1989/90	10,689 eggs	Av. HS 65%	Sunderraj <i>et al.</i> , 2002
Bhavnagar district, Piram Is.	Green, olive ridley	1987/88-1989/90	40,195 eggs	Av. HS 69%	Sunderraj <i>et al.</i> , 2002
Junagadh coast	Green, olive ridley	2004/05-2010/11	371 nests, 31,507 eggs	Av. HS 84%	Sunderraj <i>et al.</i> , 2013
Junagadh district, Kodinar	Green	2004/05	4,170 eggs	Av. HS 80%	Goswamy <i>et al.</i> , 2013
		2006/07	2,982 eggs	Av. HS 76%	
		2008/09-2010/11	20,847 eggs	Av. HS 21%	
Junagadh district, Mangrol (inland)	-	Visited in 1987	-	-	Frazier, 1987
Junagadh district, Sapur Beach (inland)	-	Visited in 1987	-	-	Frazier, 1987
Junagadh district, Madhavpur	Green, olive ridley	1993/94-1996/97	-	49,161 hatchlings	Frazier, 1987; Sunderraj <i>et al.</i> , 2001, 2002, 2013
		1998/99-1999/2000	-	98,005 hatchlings	
		2005/06-2011/12	34,915 eggs	Av. HS 81%	
Kachchh district	Olive ridley	2000 (?)	37 nests	-	Sunderraj <i>et al.</i> , 2001
Kachchh district, Mandvi	Olive ridley	1990/91-1992/93	6,700 eggs	Av. HS 64%	Sunderraj <i>et al.</i> , 2002, 2006b, 2013; Meena <i>et al.</i> , 2007, 2009
	Olive ridley	1999/2000	37 nests, 4,395 eggs	-	
	Green, olive ridley	2000/01	4,399 eggs	Av. HS 41%	
	Olive ridley	2001/02	1,273 eggs	Av. HS 32%	
	Olive ridley	2004/05-2005/06	2,002 eggs	Av. HS 59%	
	-	2006/07-2007/08	1,491 eggs	Av. HS 68%	
Kachchh district, Nalia	Green	2007/8-2011/12	69 nests, 7,752 eggs	Av. HS 79%	Meena <i>et al.</i> , 2007
	Olive ridley	1985/86-1986/87	199 eggs	Av. HS 72%	
	Olive ridley, leatherback	2000/01	321 eggs	Av. HS 48%	
	Olive ridley	2001/02	210 eggs	Av. HS 66%	
	Olive ridley	2004/05	533 eggs	Av. HS 69%	
	Green	2005/06	135 eggs	Av. HS 53%	
Kachchh district, Nana-Layja	-	2005/06	108 eggs	Av. HS 60%	Meena <i>et al.</i> , 2007
Porbander district, Positra	Green	2010/11	13 nests	-	Goswamy <i>et al.</i> , 2013
Porbander district, Rangbai	Green	2004/05	82 nests, 8,188 eggs	Av. HS 73%	Sunderraj <i>et al.</i> , 2006b, 2013
	Olive ridley	2004/05	23 nests, 2,514 eggs	Av. HS 767%	
	Green, olive ridley	2007/08-2011/12	96 nests, 9,080 eggs	Av. HS 86%	
Porbander district, Tukda Miyani	Green	2004/05	45 nests, 4,545 eggs	Av. HS 71%	Sunderraj <i>et al.</i> , 2006b
	Olive ridley	2004/05	24 nests, 2,425 eggs	Av. HS 69%	

Table 4. Records of olive ridley turtle nests relocated to hatcheries in Karnataka. Locations have been adjusted to their current name. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. Av.- average.

Location (District, Beach/Village)	Nesting Season/s	# Nests &/or # Eggs Collected	Hatching Success (HS) &/or # Hatchlings	Sources
Karnataka coast, 40 unnamed locations	1984	-	-	Appayya, 1985 (in Sharath, 2006); Anonymous, 2011
Karnataka coast, 3 unnamed locations	1985?	-	15,000 hatchlings	
Dakshina Kannada district, Baidur	1985/86	-	-	Frazier, 1989
Dakshina Kannada district, Thrasi	1984/85-1986/87	89 nests	Range HS 20-94%	Frazier, 1989
Udupi district, Unnamed location	2004-2006	2,348 eggs	Av. HS 76%	McCann, 2007
Udupi district, Bengre Beach	1984/85	-	2,560 hatchlings	Madhyastha <i>et al.</i> , 1986 (in Sharath, 2006); Frazier, 1989
	1986/87	1,612 eggs	Av. HS 90%	
Uttara Kannada district, 3 locations	2005/06	-	>5,000 hatchlings	Pandit & Soans, 2013
	2007/08-2010/11	186 nests	-	
Uttara Kannada district, Apsarakonda	2006/07	9 nests, 846 eggs	-	Pandit, 2008; Chandran <i>et al.</i> , 2012
	2007/08-2008/09	1,617 eggs	Av. HS 53%	
Uttara Kannada district, Devbag	2001/02	616 eggs	Av. HS 16%	Kurian & Nayak, 2003
Uttara Kannada district, Dharehwara	2006/07	6 nests, 704 eggs	-	Pandit, 2008; Anonymous, 2011; Chandran <i>et al.</i> , 2012
	2007/08-2008/09	4,739 eggs	Av. HS 41%	
Uttara Kannada district, Gangavali	1985/86	-	-	Frazier, 1989; Pandit, 2008; Anonymous, 2011; Chandran <i>et al.</i> , 2012
	2006/07	8 nests, 677 eggs	-	
	2007/08-2008/09	1,959 eggs	Av. HS 48%	
Uttara Kannada district, Haldipur	1985/86	-	-	Frazier, 1989; Anonymous, 2011; Chandran <i>et al.</i> , 2012
	2006/07	-	-	
	2007/08-2008/09	28 nests, 2,845 eggs	Av. HS 43%	
Uttara Kannada district, Heeregutti	2004-2006	-	Total 2,500 hatchlings	Pandit & Soans, 2013
Uttara Kannada district, Holadgadde Beach	1985/86	-	-	Frazier, 1989
Uttara Kannada district, Hosahittu (Manki)	2007/08-2008/09	10 nests, 897 eggs	Av. HS 60%	Chandran <i>et al.</i> , 2012
Uttara Kannada district, Jali Village	1985/86-1986/87	69 nests	-	Frazier, 1989
Uttara Kannada district, Kade Beach	1985/86	-	-	Frazier, 1989
Uttara Kannada district, Kadle (Holangadde)	2006/07	7 nests, 712 eggs	-	Pandit, 2008; Anonymous, 2011; Chandran <i>et al.</i> , 2012
	2007/08	1,802 eggs	Av. HS 50%	
Uttara Kannada district, Kagal	2006/07	-	-	Anonymous, 2011a; Chandran <i>et al.</i> , 2012
	2007/08-2008/09	3 nests, 278 eggs	Av. HS 97%	
Uttara Kannada district, Kasarkod Beach	1985/86	-	-	Frazier, 1989
Uttara Kannada district, Kodibag Beach	Est. 2003	-	-	Pandit & Soanes, 2013
Uttara Kannada district, Manki	2006/07	-	-	Anonymous, 2011
Uttara Kannada district, Ramanagindi	2007/08	163 eggs	Av. HS 30%	Chandran <i>et al.</i> , 2012

Table 5. Records of olive ridley nests relocated to sea turtle hatcheries in Kerala. Locations have been adjusted to their current name. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. An.- annually. Av.- Average.

Location	Nesting Season/s	# Nests &/or # Eggs Collected	Hatching Success (HS) &/or # Hatchlings	Sources
Calicut district, Kolavi & Kasaragod district, Thaikadappuram	2002/03-2006/07	104 nests, 13,314 eggs	Av. HS 75%	Kumar, 2007
Kozhikode district, Kolavipalam	2002/03-2013/14	>151 nests	Av. HS 74%	Laladhas <i>et al.</i> , 2017
Kasaragod district, Thaikadappuram	1996 onwards	An. 40-60 nests	-	Kutty, 2001; Bhupathy <i>et al.</i> , 2006; Bhupathy, 2007; Laladhas <i>et al.</i> , 2017
Kozhikode district, Kolavipalam	1998-2012/13	450 nests, 44,006 eggs	Av. HS 80%	
	1998/99-2015/16	Range 322-6,264 eggs	Range HS 33-89%	
Thrissur district, Palapetty beach	2015/16	-	-	Sreeram <i>et al.</i> , 2016

Table 6. Records of olive ridley nests relocated to sea turtle hatcheries in Maharashtra. Locations have been adjusted to their current name. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. Av.- Average.

Location (District, Beach/Village)	Nesting Season/s	# Nests &/or # Eggs Collected	Hatching Success &/or Total # Hatchlings	Sources
Raigad district, Akshi	To 2008	1 nest	-	Sanaye & Katdare, 2009
Raigad district, Diveagar	2004/05	4 nests	237 hatchlings	Giri <i>et al.</i> , 2006; Sanaye & Katdare, 2009; Katdare, 2012
	To 2008	22 nests	-	
	2011/12	6 nests	-	
Raigad district, Harihareshwar	2004/05	4 nests, 455 eggs	Av. HS 56%	Giri <i>et al.</i> , 2006; Sanaye & Katdare, 2009; Katdare, 2012
	2005/06	4 nests	-	
	2011/12	6 nests	-	
Raigad district, Maral	To 2008	8 nests	-	Sanaye & Katdare, 2009; Katdare, 2012
	2011/12	8 nests	-	
Raigad district, Murud Harnai	To 2008	3 nests	-	Sanaye & Katdare, 2009
Raigad district, Murud Janjira	2005/06	1 nest	-	Sanaye & Katdare, 2009
Ratnagiri district, 5 unnamed locations	2002/02-2006/07	214 nests	>9,000 hatchlings	Katdare, 2008
Ratnagiri district, Anjarle	To 2008	10 nests	-	Sanaye & Katdare, 2009; Katdare, 2012
	2011/12	1 nest	-	
Ratnagiri district, Dabhol	2004/05	4 nests, 410 eggs	Av. HS 57%	Giri <i>et al.</i> , 2006; Sanaye & Katdare, 2009; Katdare, 2012
	To 2008	23 nests	-	
	2011/12	2 nests	-	
Ratnagiri district, Guhagar	2011/12	4 nests	-	Katdare, 2012
Ratnagiri district, Kelshi	2004/05	1 nest, 51 eggs	Av. HS 28%	Giri <i>et al.</i> , 2006; Sanaye & Katdare, 2009; Katdare, 2012
	To 2008	9 nests	-	
	2011/12	1 nest	-	
Ratnagiri district, Kolthare	2004/05	322 eggs	Av. HS 26%	Giri <i>et al.</i> , 2006; Sanaye & Katdare, 2009; Katdare, 2012
	To 2008	21 nests	-	
	2011/12	5 nests	-	
Ratnagiri district, Sandkhol	2005/06	1 nest	-	Sanaye & Katdare, 2009
Ratnagiri district, Tavsai	2011/12	2 nests	-	Katdare, 2012
Ratnagiri district, Velas	2002/03-2004/05	94 nests, 9,868 eggs	Av. HS 50%	Katdare & Mone, 2003; Giri <i>et al.</i> , 2006; Katdare, 2012
	2011/12	15 nests	-	
Sindhudurg district, 5-11 unnamed locations	2007/08-2013/14	7,343 eggs	Av. HS 54%	Andhare & Hatkar, 2015
Sindhudurg district, Bhogave, Katvan, Mochemad, Shiroda, Tambaldeg, Tarkarli, Vayangani	To 2008	10 nests	-	Sanaye & Katdare, 2009; Sanaye & Pawar, 2009

Table 7. Records of olive ridley nests relocated to sea turtle hatcheries in Odisha. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting seasons indicated. '-' indicates no information reported. An.- annually. Av.- Average.

Location	Nesting Season/s	# Nests &/or # Eggs Collected	Hatching Success (HS) &/or # Hatchlings	Source
Ganjam district, Ramayapatana	2012/13	195 nests	Av. HS 95%	Behera & Kar, 2013
Ganjam district, Rushikulya hatchery'	2009-16	~30 nests	Av. HS 63%	Chandarana <i>et al.</i> , 2017
Jagatsinghpur district	-	-	-	Kar & Peters, 2013
Kendrapara district	-	-	-	Kar & Peters, 2013
Puri district	-	-	-	Kar & Peters, 2013

nests collected from Purunabandha, Gokharkuda and Podampetta beaches

Table 8. Records of olive ridley nests relocated to sea turtle hatcheries in Tamil Nadu. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting season/s indicated. '-' indicates no information reported. An.- annually. Av.- Average.

Location	Nesting Season/s	# Nests &/or # Eggs Collected	Hatching Success &/or Total # Hatchlings	Sources
Chennai district, Adyar River to 30km south	1988/89-1991/92	504 nests, 59, 472 eggs	Av. HS 66%	Shanker, 1994
Chennai district, Besant Nagar & Marina Beaches	1989-2011 2013	134 nests 285 nests	43,106 hatchlings 22,000 hatchlings	Shanker, 2003; Arun, 2011; Arun, 2013
Chennai district, Injambakkam	- 2007	44 nests 1 nest, 100 eggs	- Av. HS 93%	Anonymous, 1982; Dharini, 2007
Chennai district, Kovalam	1978-1983	1,014 nests	Av. HS 33%	Silas & Rajagopalan, 1984
Chennai district, Madras Snake Park Trust	1974-77	197 nests	-	Bhupathy <i>et al.</i> , 2006
Chennai district, Nainar Kuppam	2006, 2007	20 nests, 2,037 eggs	Av. HS 64%	Dharini, 2007
Chennai district, Nilankarai	1998-99	69 nests	~6,000 hatchlings	Gopal <i>et al.</i> , 2000
Chennai district, Panaiyur Kuppam	2006, 2007	10 nests, 1,137 eggs	Av. HS 21%	Dharini, 2007
Chennai district, Periya Neelankarai	2006, 2007	6 nests, 718 eggs	Av. HS 72%	Dharini, 2007
Chennai district, Thiruvanmiyur	1973/74 1974/75-78/79	10 nests, 1,152 eggs 197 nests, 21,760 eggs	Av. HS 73% Av. HS 60%	Valliappan & Whitaker, 1974; Whitaker, 1979
Nagapattinam district, Point Calimere	2000	14 nests, 1,586 eggs	Av. HS 76%	Baruah, 2001
Nagapattinam district, Point Calimere, Arcotthurai & Vanavan mahadevi	1982/83	30,046 eggs	Av. HS 81%	Rahaman <i>et al.</i> , 1985
Nagapattinam district, Point Calimere, Vanavan mahadevi & Vizhundamavadii	1983/84	30,771 eggs	Av. HS 84%	Rahaman <i>et al.</i> , 1985
Nagapattinam district, Koolaiyar, Madavamedu, Point Calimere, Tharangambadi & Vanagiri	2005/06-2008/09	14,366 eggs	Av. HS 49%	Velusamy & Sundararaju, 2009
Union Territory of Puducherry, Puducherry	-	-	-	Sivakumar <i>et al.</i> , 2016

Bengal (see Bhadury *et al.*, 2013). Threats to sea turtle nests and hatchlings include human consumption of eggs (Raut & Nandi, 1988), and depredation of ~50% of nests by animals such as water monitors and wild boar (Gani, 2000; Chowdhury *et al.*, 2006; Bhadury *et al.*, 2013). Some of the early studies in India on sea turtle egg, hatchling, and incubation parameters were conducted on nests relocated to three hatcheries in West Bengal (Table 9). The most recent estimates of nest numbers in the state were 1,564 nests in the 2000/01 nesting season and 87 nests in 2001/02 (Chowdhury *et al.*, 2006) while no nests were found during a survey late in the 2010/11 season (Bhadury *et al.*, 2013). Therefore, it appears that a relatively low proportion of nests in West Bengal may have been relocated to hatcheries in the past. The reported hatching success is low (~10-50%), potentially due to the long-distance transport of eggs from islands (Kalash, Kanak, Mechua and Sainmari- Raut & Nandi, 1985; Chowdhury *et al.*, 2006) to hatcheries days after oviposition. For example, Sanyal (1984) describes the transport of clutches that were 24hr and “slightly older” by boat from an unnamed island to Sajnekhali; the transport time is not described but the distance given is >100km so the time for relocating nests is likely to exceed that recommended as a best practice (see Limpus *et al.*, 1979; Parmenter, 1980; Mortimer, 1999; SToI, 2011).

DISCUSSION

There has been widespread use of hatcheries over time in India to protect sea turtle nests against predators and poachers and other human activities. The number and longevity of hatcheries in each state or district varies and should not be the sole indicator of conservation effort. Local factors such as nesting numbers and density, availability of resources, and involvement of volunteers may determine whether a large number of hatcheries operate for short periods at different times (e.g. hatcheries in Karnataka) or fewer hatcheries operate for decades (e.g. as seen in the Andaman and Nicobar Islands and Chennai, Tamil Nadu). This review reveals varied rates of hatching success for

nests relocated to hatcheries in India, albeit within the ranges described for hatcheries elsewhere in the region (see Phillott, 2018; Phillott *et al.*, 2018 a, b). As the majority of nests in some states (e.g. Gujarat, Maharashtra and Karnataka) and the majority of nests on important beaches in other states (e.g. Besant Nagar in Tamil Nadu) are relocated to hatcheries, it is important to understand how the hatchling production of this *ex situ* conservation strategy can be optimised. The lack of detailed information about hatchery practices in the available literature does not allow us to identify specific practices (e.g. egg collection, handling, and transport techniques (see Limpus *et al.*, 1979; Parmenter, 1980; Mortimer, 1999; SToI, 2011) that could be modified to improve hatching success. Further research will now be conducted to acquire relevant details through face to face interviews with hatchery personnel.

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Table 9. Records of olive ridley nests relocated to sea turtle hatcheries in the South 24 Parganas district of West Bengal. Numbers of nests, eggs, hatchlings, and hatching success may not be representative of the entire nesting season/indicated. ‘-’ indicates no information reported. Av.- Average.

Location	Nesting Season/s	# Nests &/or # Eggs Relocated	Hatching Success (HS) &/or # Hatchlings	Sources
Bhagabatpur	1983	4 nests, 600 eggs	Av. HS 20%	Banerjee, 1985a, b
Bhagabatpur & Sajnekhali	pre. 1983	-	~2,000 hatchlings	Raut & Nandi, 1985; Chowdhury <i>et al.</i> , 2006
	1984-1999	-	~1,000 hatchlings	
	2000/01	1,928 eggs	Av. HS 10%	
Sajnekhali	1983	3 nests, 485 eggs	Av. HS 51%	Sanyal, 1984

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A REVIEW OF SEA TURTLE HATCHERIES IN BANGLADESH

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Two species of sea turtle have been recorded to nest regularly in Bangladesh, olive ridley turtles in greater numbers than green turtles, with additional reports of rare nesting events by hawksbill turtles and a single nesting event by a leatherback turtle (Islam, 2002a). Nesting occurs on the mainland of Cox's Bazar district, including Bordal, Inani, Kochopia and Monkhal beach of Teknaf Peninsula, and coastal islands in Cox's Bazar and Chittagong districts, including Hatiya, Kutubdia, Moheskhal, Sandweep, Sonadia and St. Martin's Islands (Islam 2002a, 2002b; Hossain *et al.* 2013a, 2013b). Nesting also occurs on additional areas of the Bangladesh coastline and islands in the Sundarbans mangrove forest (Islam, pers.comm.), but has not yet been published.

Sea turtles that nest in Bangladesh are included in Schedule-I of the Bangladesh Wildlife Act (Preservation and Protection) of 2012. Historically, nests and hatchlings on island and mainland beaches have been threatened by poaching of eggs for consumption by communities in the Chittagong Hill Tracts, predation of nests by wild

dogs (Islam, 2002a) and monitor lizards (Islam, 2002b), disorientation caused by beachside lighting, and man-made obstructions on nesting beaches, and alteration of the nesting beach by stands of *Casuarina* sp. (Islam *et al.*, 2011). In contrast to other locations (cf. India, Pakistan and Sri Lanka; this issue of IOTN) both governmental (GO) and non-governmental (NGO) organisations, including Centre for Advanced Research in Natural Resources & Management (CARINAM) (Rashid & Islam, 1999), Center for National Resource Studies (CNRS), Coastal and Wetlands Biodiversity Management Practices (CWBMP), MarineLife Alliance (MLA) and Sundarbans Management Project (SMP), have previously operated hatcheries in Bangladesh to reduce the loss of turtle nests to poaching and predation (Hossain *et al.* 2013a, 2013b). The NGO MarineLife Alliance has been the sole operator of sea turtle hatcheries in Bangladesh since 2013, with up to 33 hatcheries in five areas on the southwestern coast (Figure 1; Islam, pers.comm.) in any given year.

MarineLife Alliance has either relocated turtle nests to