



Fisheries impact on breeding of olive ridley turtles (*Lepidochelys olivacea*) along the Gahirmatha coast, Bay of Bengal, Odisha, India

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In India, the Gahirmatha coast is among the most important nesting grounds of olive ridley turtles, *Lepidochelys olivacea*. The coastal waters of Odisha are also subjected to heavy commercial fishing activities, leading to turtle-fisheries conflicts. This study was carried out to quantify the effects of fishing on breeding turtles. Data on stranded, dead turtles were collected during three breeding seasons (2007–08, 2008–09 and 2009–10) between November and April along a 35 km stretch. A total of 13,443 dead olive ridleys were counted (2008–09: $n=9502$, 2007–08: $n=2754$, 2009–10: $n=1187$). Maximum mortality occurred in February. Few strandings of dead male turtles were recorded. Stranded turtles had a curved carapace length between 51.3 and 77 cm. Mortality is largely attributed to drowning in trawl nets and caused by gill nets. A decrease in size of adults may be related to their high mortality.

Key words: breeding, fishing, mortality, *Lepidochelys olivacea*, olive ridley, size class

INTRODUCTION

Out of four species of sea turtles reported to occur along the coast of Odisha in India (*Lepidochelys olivacea*, *Chelonia mydas*, *Eretmochelys imbricata* and *Dermochelys coriacea*), only the olive ridley (*L. olivacea*) has been confirmed to nest (Dash & Kar, 1990; Pandav et al., 1994; Pandav & Choudhury, 2000). Olive ridley sea turtles are listed as Vulnerable by the IUCN (Abreu-Grobois & Plotkin, 2008), and are also listed by CITES. The 480 km of Odisha coast harbours three mass nesting beaches (Gahirmatha, Devi and Rushikulya). Olive ridleys arrive during October, followed by mating in shallow coastal waters and nesting from January to April. With an estimated annual nesting of between 100,000 and 500,000 turtles during arribadas, Gahirmatha is the world's largest known nesting aggregation of olive ridleys (Dash & Kar, 1990; Patnaik & Kar, 2000; Behera, 2012).

Mortality is a crucial parameter for the population dynamics of long lived species (Crowder et al., 1994; Crouse, 1999), and mortality due to by-catch by fisheries is a major threat to sea turtles (Lewison et al., 2014; Wallace et al., 2010). Commercial fishing operations adversely impact on the survival of sea turtles and are contributing to their global decline (Spotila et al., 2000; Hays et al., 2003; Swimmer et al., 2006). There is global concern regarding the future of olive ridleys in Odisha,

particularly due to large-scale mortality of sea turtles along the coast (Kar, 1980a; Silas et al., 1983; James et al., 1989; Dash & Kar, 1990; Rajagopalan et al., 1996; Pandav et al., 1997, 1998; Shanker & Mohanty, 1999; Pandav, 2000a; Behera et al., 2014). These studies have recognised incidental capture of turtles in fishing nets as the major cause of mortality.

The present study attempts to quantify dead olive ridley turtles stranded along the beach of Gahirmatha coast between the breeding seasons of 2007–08 to 2009–10. Size class and relationship between turtle mortality and trawl fishing along the Gahirmatha coast was also examined.

MATERIALS AND METHODS

Study site

The Gahirmatha coastline extends for about 35 km from Dhamra to the Barueni river mouth including the Gahirmatha Marine Wildlife Sanctuary (between 80°45' E and 20°17' N). The sanctuary is bounded by the Bay of Bengal on the east and the coastline on the west comprises an area of 1435 km², of which 1408 km² are water bodies and the remainder constitute mangrove forests, mud flats and sand spits. The continental shelf in this region is shallow and does not exceed 20m even at an off-shore distance of 7 km.

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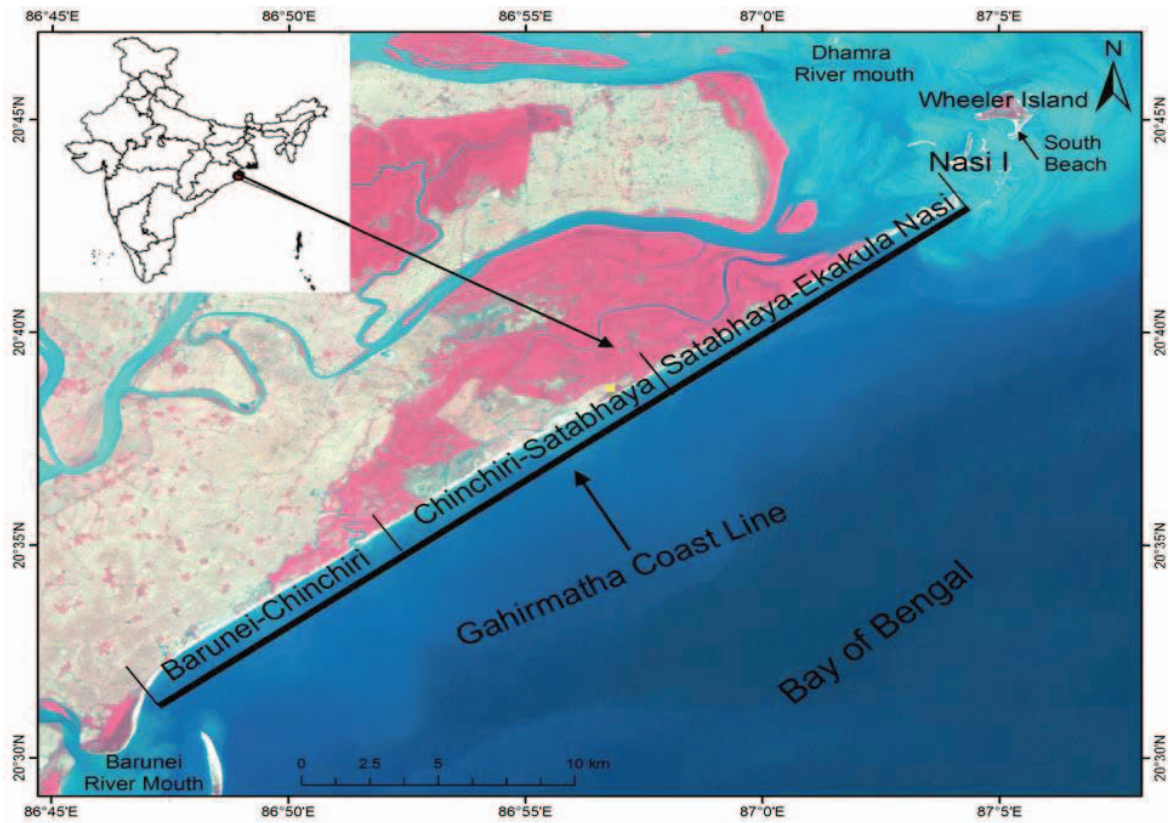


Fig. 1. Map showing the three mainland and two island sites along the Gahirmatha rookery.

Since 1994, the Government of Odisha has issued biennial orders under the OMFRA (Odisha Marine Fisheries Regulation Act, 1982) prohibiting all fishing in the coastal waters of the Gahirmatha. Nevertheless illegal fishing takes place, pre-dominated by migrating fishermen whereas marine fishing by the native Oriya fishermen is minimal. Among the different types of fishing gear, drift or gill nets are most popular (Tietze et al., 2007).

The numbers of mechanised fishing vessels were counted daily from shore throughout the study period along a predefined coastal stretch to avoid repeat counts. Numbers of vessels were related to numbers of beach strandings as an indicator of fishery-induced mortality.

Data on washed ashore turtles were collected for three breeding seasons (November–April 2007–08 to 2009–10, Dash & Kar, 1990; Pandav et al., 1994). In October 2008, one of the islands where mass nesting takes place (Nasi-II) was submerged and a sand bar formed on the southwestern side of Wheeler Island. For counting washed ashore carcasses, the entire stretch of Gahirmatha coast was divided into five zones: Nasi-I, south beach (formerly Nasi-II), Ekakula-Satabhaya, Satabhaya-Chinchiri and Chinchiri-Barunei (Fig. 1). Washed-ashore carcasses were counted every 2–3 days, marked on their carapaces with white paint, and dragged to the upper part of the beach.

Morphometric measurements of carcasses were taken following Bolten (1999). Curved carapace length

Table 1. Summary of size measurements of male and female olive ridley turtles stranded along the Gahirmatha coast from 2007 to 2010, tagged olive ridley turtles in 1996 to 1999 and 1978 to 1985 (Size measurements data taken from Shanker et al., 2004; Pandav, 2000a; Dash & Kar, 1990).

Location	Sex (n)	Curved carapace length Mean (SE)	Range	Curved carapace width Mean (SE)	Range
Dead on beach (2007–2010)	Males (266)	69.2 (0.3)	51.4–75.1	68.6 (0.3)	50.2–74.2
	Females (947)	70.3 (0.2)	53.6–77.5	69.8 (0.2)	51.3–77
	Unknown (71)	69.9 (0.3)	61.2–75.1	69.2 (0.2)	60.3–74.4
Tagging turtles (1996–1999)	Males (292)	70.9 (0.2)	57.8–77.2	68.6 (0.2)	56.7–76
	Females (894)	71.1 (0.1)	62.3–79.7	68.9 (0.2)	61.5–77.5
Tagging turtles (1978–1985)	Males (176)	72.9 (0.3)	64.7–79.3	72.1 (0.2)	62.2–78.4
	Females (277)	72.6 (0.2)	64.9–78.5	71.6 (0.2)	61.9–78.7

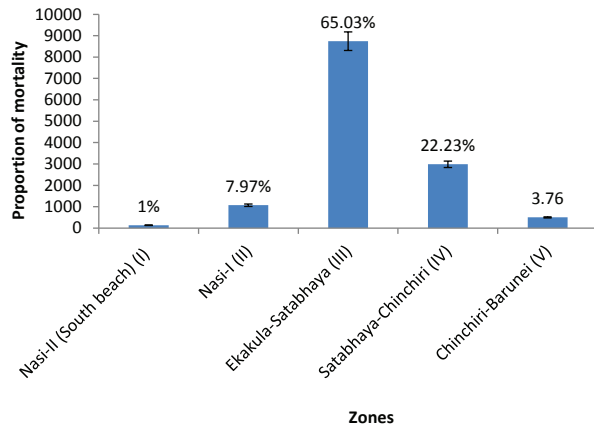


Fig. 2. Annual mortality rates of olive ridleys (*Lepidochelys olivacea*) in different zones over the period of three years.

(CCL) and curved carapace width (CCW) was measured in centimetres using a flexible tape. Apparent causes of death (physical injury, torn net entanglement) were recorded whenever possible. Males were characterised by the presence of a long tail which extends beyond the posterior end of the carapace, and strongly curved claws on the fore-flipper, whereas females had shorter tails and a small and straight claw (Bolten, 1999). Highly decomposed carcasses with no visible external characteristics were classified as turtles of unknown sex. The data of the present study were also compared with the size of nesting females recorded between 1978 and 1985 (Dash & Kar, 1990) and between 1996 and 1999 (Pandav & Choudhury, 2000), as well as with dead turtles recorded earlier (Pandav et al., 1997).

RESULTS

A total of 13,443 dead olive ridley turtles were counted, peaking for the 2008–09 breeding season followed by 2007–08 and 2009–10 (Fig. 2). The highest numbers of dead turtles were counted in February ($n=7929$), and the lowest numbers were recorded for November ($n=230$, Fig. 3). Spatially, the lowest numbers of dead turtles were counted in Nasi-II (1%; $n=135$), whereas and the highest number of dead turtles were recorded between Ekakula and Satabhaya (65.03%; $n=8,742$, see Fig. 2).

The sex of 517 (3.8%) of the dead turtles could not be ascertained. Strandings of males and females differed significantly across months (ANOVA: $F=1.9$,

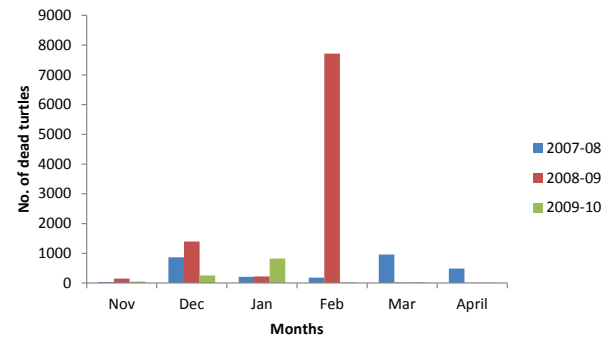


Fig. 3. Monthly annual mortality of olive ridleys at Gahirmatha rookery, Odisha during 2007–08, 2008–09 and 2009–10 (when an arribada took place).

$df=11$, $p<0.001$). Mean CCL±SD for were 69.2±3.5 cm for males (range=51.4–75.1 cm; $n=266$) and 70.3±2.8 cm for females (range=53.6–77.5 cm; $n=947$). CCW±SD for males and females were 68.6±3.5 cm (range=50.2–74.2 cm; $n=266$) and 69.8±3.4 cm (range=51.3–77 cm; $n=947$), respectively. For turtles of unknown sex, CCL and CCW varied between 61.2 and 75.1 cm and 60.3 and 74.4 cm, respectively. Of the 1,284 dead turtles that were measured, 113 (8.8%) were subadult. The body size of dead turtles was significantly smaller than the turtles measured during earlier studies (Table 1, Kruskal-Wallis test $p<0.001$).

A total of 13,439 fishing vessels (including mechanised and non-mechanised) were counted in 2008–09 and 2009–10; 11,354 and 2,085 vessels were observed during 2008–09 and 2009–10, respectively (Fig. 4). These numbers are correlated with the observed mortality rates linear regression, $r^2=0.520$).

DISCUSSION

In Gahirmatha coastal waters, male olive ridleys arrive and leave the breeding grounds before females (Plotkin, 1996; Pandav, 2000a; Tripathy, 2010). Since females spend more time in the coastal waters of the nesting ground, they are subjected to longer interaction with coastal fisheries. This could possibly be behind the large number of dead females turtles documented during our study. Data from other studies suggest that olive ridleys mate far from the breeding beaches (NMFS & USFWS, 1998).

Table 2. Detail records of stranding dead olive ridley turtles along the Gahirmatha coast since 1978 to 2010.

Year of stranding	No. of turtles stranded	Reference
1978–1985	4,682	Dash & Kar, 1990
1983	7,500	James et al., 1989
1993	5,400	Pandav et al., 1994
1994–1998	12,376	Pandav & Choudhury, 1999 Pandav, 2000a
1999	1,524	Pandav, 2000b
2008–2009	1,667	Tripathy, 2010
2007–2010	13,443	Present study

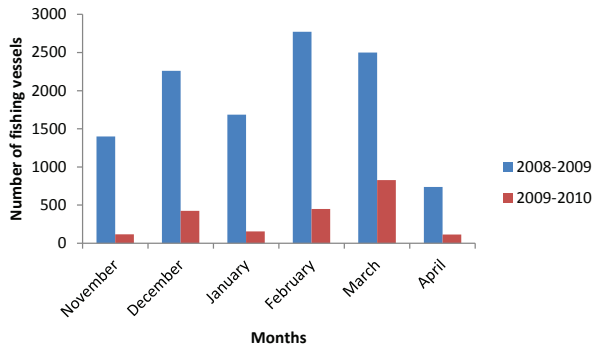


Fig. 4. Estimated number of fishing vessels for two breeding seasons (2008–2009 and 2009–2010) along the Gahirmatha coast.

The coastal waters of Gahirmatha and adjacent areas are relatively shallow, and are mating grounds for olive ridleys (Dash & Kar, 1990; Pandav, 2000a; Pandav & Choudhury, 2000). The coexistence of large numbers of turtles with intense near-shore bottom trawling from fishing bases are likely to result in high turtle mortality. The Gahirmatha coastal waters are largely predominated by mechanised fishing practices and rampant fishing takes place during the turtle breeding season. The fishing season coincides with the breeding of turtles at Gahirmatha resulted in large scale mortality of turtles due to incidental catch during fishing operations. Further long term studies are required to investigate the correlation between trawling and mortality of turtles along Odisha coast (see also Behera et al., 2013).

Large-scale mortality of olive ridleys along the Gahirmatha coast was reported earlier (Kar, 1980a; Silas et al., 1983; James et al., 1989; Dash & Kar, 1990; Pandav et al., 1994; Pandav & Choudhury, 1999). Mortality due to illegal near shore trawling and gill netting has now reached a maximum (Table 2). The number of dead turtles along the Odisha coast was found to be increased from the last week of December, reaching a peak during February. The frequent observations of large scale entanglement of olive ridleys in fishing gear supports the argument that mechanised fishing is indeed the major reason behind this large scale mortality. Once entangled, turtles die from suffocation or are beaten to death by boat crew men for easy removal from the net (personal observation). The injuries on heads and carapaces of turtles washed ashore are also ample evidence of this fact.

All recorded dead turtles were adults and subadults. During 1979, only three dead subadult olive ridley turtles from Gahirmatha were reported (Kar 1980b, Dash & Kar, 1990), and Pandav et al. (1995) reported two dead subadults olive ridley turtles from in 1995. However, all subadult turtles have previously been observed in the breeding season. During December 2009, a carapace of a juvenile olive ridley (21 cm CCL, 19.5 cm in CCW) was found to be washed ashore on the beach of Babubali Island (Satyaranjan, personal observation), and more recently a live subadult olive ridley was recorded from the Gahirmatha Marine Sanctuary in their non-breeding season (44.1 cm CCL, 45.4 cm in CCW, John et al., 2011).

Subadult green turtles (*Chelonia mydas*) are known to migrate along with the adults (Meylan, 1982), which could also apply to olive ridleys.

The present study documents a sharp decrease in size of adult turtles compared to earlier observations. Turtles stranded along the Gahirmatha coast during 2007–08 to 2009–10 have a mean CCL which is >1 cm below the turtles tagged between 1978 and 1985, and between 1996 and 1999 (see Table 1). Shanker et al. (2004) and Pandav (2000a) similarly reported CCL decreases of female turtles in Odisha between 1996 and 2002, and the average CCL of females at Gahirmatha between 1978 and 1985 were larger than those measured by Pandav (2000a; see also Dash & Kar, 1990). The present study found that the female turtles recorded by Pandav (2000a) were larger than turtles stranded during 2007–08 to 2009–10 suggesting a decreasing size since 1978 (see also Silas et al., 1983; Pandav et al., 1994; Kalb, 1999; Bhupathy & Karunakaran, 2003; Kannan & Rajagopalan, 2007; Tripathy, 2008). However, Pritchard (1969) found the average size of olive ridley is slightly larger in the Indian Ocean (sampled from the Sri Lankan population) than elsewhere.

The failure of arribadas at Gahirmatha in 1997 and 1998 accompanied by the sharp decrease in size of adults suggest an imminent population decline (Pandav, 2000a; Shanker et al., 2004), essentially following a global trend (Myers et al., 1996; Myers & Cadigan, 1995; see Jackson, 1997 for the Caribbean).

The imminent decrease in sizes may be related to the mortality of breeding adult ridleys, as over 100,000 dead turtles have been documented on the Odisha coast since 1994 (Pandav, 2000a). Most of the turtle carcasses do not get stranded along the coast (Epperly et al., 1996). Stranding has previously been used as an index of sea turtle mortality from shrimp trawling activities (Caillouet et al., 1991) but is subject to other factors including wind and currents (Hart et al., 2006). Murphy & Hopkins-Murphy (1989) reported that only 6 of 22 tagged loggerhead carcasses at sea were recorded on the shore, and the actual mortality of breeding turtles along the Gahirmatha coast is likely higher than the reported one. In recent years, the Wildlife Wing of the Odisha Forest Department has adopted the practice of burying dead turtles immediately upon being washed ashore (Tripathy, 2010), additionally causing real mortality rates to be possibly underestimated.

The turtle congregations off the Gahirmatha rookery are found within 5 km from the seashore, and effective protection of the congregation area will be necessary to protect the breeding turtles. Instead of guarding large spatial entities that may or may not be active turtle habitats, the reproductive patches should be identified and protected in a targeted manner.

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REFERENCES

- Abreu-Grobois, A & Plotkin, P.T. (2008). *Lepidochelys olivacea*. In *IUCN Red List of Threatened Species, Version 2012.1*. IUCN (2012). Available from: <www.iucnredlist.org>. Accessed: 13 August 2013.
- Behera, S., Tripathy, B., Sivakumar, K. & Choudhury, B.C. (2014). Stomach contents of olive ridley turtles (*Lepidochelys olivacea*) occurring in Gahirmatha, Odisha coast of India. *Proceedings of the Zoological Society*, DOI 10.1007/s12595-014-0100-0
- Behera, S.K., Kar, C.S., Behera, S., John, S., et al. (2013). Abundance of olive ridleys along Odisha coast: sources of mortality and relative importance of fisheries impacts. In *Ecology and Conservation of Tropical Marine Faunal Communities*, 311–321. Venkataraman, K et al. (eds.). Berlin Heidelberg: Springer-Verlag.
- Behera, S. (2012). Ecology and distribution pattern of olive ridley sea turtles *Lepidochelys olivacea* at Gahirmatha rookery of Orissa coast, India. *PhD thesis*. Odisha, India: North Orissa University.
- Bhupathy, S., & Karunakaran, R. (2003). Conservation of olive ridley *Lepidochelys olivacea* (Reptilia/Chelonia) along the Nagapattinam coast, Southeast coast of India. *Indian Journal of Marine Science* 32, 168–171.
- Bolten, A.B. (1999). Techniques for measuring sea turtles. In *Research and management techniques for the conservation of sea turtles*, 110–114. Eckert, K.L., Bjorndal, K.A., Abreu-Grobois, F.A. & Donnelly, M. (eds.). IUCN/SSC Marine Turtle Specialist Group Publication.
- Caillouet, C.W., Duronslet, J.R., Landry, M.J., A.M., J.R., Revera, D.B., et al. (1991). Sea turtle strandings and shrimp fishing effort in the north western Gulf of Mexico. *Fishery Bulletin* 89, 712–718.
- Crouse, D.T. (1999). The consequences of delayed maturity in a human-dominated world. In *Life in the Slow Lane: Ecology and Conservation of Long-lived Marine Animals*, 195–202. Musick, J.A. (ed.). Bethesda, MD: American Fisheries Society Symposium.
- Crowder, L.B., Crouse, D.T., Heppell, S.S. & Martin, T.H. (1994). Predicting the impact of turtle excluder devices on loggerhead sea turtles. *Ecological Applications* 4, 437–445.
- Cushing, D.H. (1988). *The Provident Sea*. Cambridge, UK: Cambridge University Press.
- Dash, M.C. & Kar, C.S. (1990). *The Turtle Paradise Gahirmatha (An Ecological Analysis and Conservation Strategy)*. New Delhi: Interpret Press.
- Epperly, S.P., Braun, J., Chester, A.J., Cross, F.A., et al. (1996). Beach strandings as an indicator of at-sea mortality of sea turtles. *Bulletin of Marine Science* 59, 289–297.
- Hart, M.K., Mooreside, P. & Crowder, L.B. (2006). Interpreting the spatio-temporal patterns of sea turtle stranding: Going with the flow. *Biological Conservation* 129, 283–290.
- Hays, G.C., Broderick, A.C., Godley, B.J., Luschi, P. & Nichols, W.J. (2003). Satellite telemetry suggests high levels of fishing induced mortality in marine turtles. *Marine Ecological Progress Series* 262, 305–309.
- Jackson, J.B.C. (1997). Reefs since Columbus. *Coral Reefs* 16, 523–532.
- James, P.S.R.B., Rajagopalan, M., Dani, S.S., Bastian, F.A. & Selvaraj, V. (1989). The mortality and stranding of marine mammals and turtles at Gahirmatha, Orissa. *Journal of Marine Biological Association* 31, 28–35.
- John, S., Behera, S., Sivakumar, K., Choudhury, B.C. & Behera, S.K. (2011). Observation of a subadult olive ridley turtle *Lepidochelys olivacea* from Gahirmatha marine sanctuary, Orissa, India. *Herpetological Bulletin* 116, 1–3.
- Kalb, H.J. (1999). Behavior and physiology of solitary and arribada olive ridley sea turtle (*Lepidochelys olivacea*) during the internesting period. *PhD thesis*: Texas A & M University.
- Kannan, P. & Rajagopalan, M. (2007). Size Composition and morphometry of incidentally captured sea turtles at Vizhinjam, South-West coast of India. *Journal of Bombay Natural History Society* 104, 288–297.
- Kar, C.S. (1980a). The Gahirmatha turtle rookery along the coast of Orissa, India. *Marine turtle Newsletter* 15, 2–3.
- Kar, C.S. (1980b). Another notched Ridley found, India. *Marine Turtle Newsletter* 14, 5.
- Lewis, R.L., Crowder, L.B., Wallace, B.P., Moore, J.E., et al. (2014). Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. *Proceedings of National Academy of Sciences* 111, 5271–5276.
- Meylan, A.B. (1982). Sea turtle migration-evidence from tag returns. In: *Biology and Conservation of Sea Turtles*. Bjorndal, K.A. (Ed.). Washington: Smithsonian Institution Press.
- Myers, R.A. & Cadigan, N.G. (1995). The Statistical analysis of catch-at-age data with correlated errors. *Canadian Journal of Fisheries and Aquatic Sciences* 52, 1265–1273.
- Myers, R.A., Barrowman, N.J., Hoenig, J.M. & Qu, Z. (1996). The collapse of cod in Eastern Canada: the evidence from tagging data. *ICES Journal of Marine Science* 53, 629–640.
- Murphy, T.M. & Hopkins-Murphy, S.R. (1989). *Sea turtle and shrimp fishing interactions: A summary and critique of relevant information*. Washington DC: Centre for Marine Conservation.
- National Marine Fisheries Service & US Fish and Wildlife Service. (1998). Recovery Plan for u.s. pacific populations of the olive ridley turtle (*Lepidochelys olivacea*). Silver Spring, MD: National Marine Fisheries Service.
- Pandav, B., Choudhury, B.C. & Kar, C.S. (1994). *A status survey of olive ridley sea turtle (Lepidochelys olivacea) and their nesting beaches along the Orissa coast, India*. Final report. Dehradun: Wildlife Institute of India.
- Pandav, B., Choudhury, B.C. & Kar, C.S. (1995). A note on the occurrence of sub-adult olive ridley turtles along the Gahirmatha coast. *Marine Turtle Newsletter* 71, 15–17.
- Pandav, B., Choudhury, B.C. & Kar, C.S. (1997). Mortality of olive ridley turtles *Lepidochelys olivacea* due to incidental capture in fishing nets along the Orissa coast, India. *Oryx* 31, 32–36.
- Pandav, B., Choudhury, B.C. & Shanker, K. (1998). The Olive Ridley sea turtle (*Lepidochelys olivacea*) in Orissa: An

- urgent call for an intensive and integrated conservation programme. *Current Science* 75, 1323–1328.
- Pandav, B. & Choudhury, B.C. (1999). An update on mortality of olive ridley sea turtle in Orissa, India. *Marine Turtle Newsletter* 83, 10–12.
- Pandav, B. & Choudhury, B.C. (2000). Conservation and management of olive ridley sea turtle (*Lepidochelys olivacea*) in Orissa. Final report. Dehradun: Wildlife Institute of India.
- Pandav, B. (2000a). Conservation and management of olive ridley sea turtle (*Lepidochelys olivacea*) along the Orissa coast. *PhD thesis*. Orissa, India: Utkal University.
- Patnaik, S.K. & Kar, C.S. (2000). Status and conservation of sea turtles in Orissa, India. In *Sea turtles of the Indo-Pacific: Research, conservation and management*, 13–24. Pilcher, N. & Ismail, G. (eds.). London: ASEAN Academic Press.
- Plotkin, P.T., Owens, D.W., Byles, R.A. & Patterson, R. (1996). Departure of male olive ridley turtles, *Lepidochelys olivacea* from a near shore breeding ground. *Herpetologica* 52, 1–7.
- Pritchard, P.C.H. (1969). Studies of the systematic and reproductive cycles of the genus *Lepidochelys*. *PhD thesis*. Gainesville, FL: University of Florida.
- Rajagopalan, M., Vivekanandan, E., Pillai, S.K., Srinath, M. & Bastian Fernando, A. (1996). Incidental catch of sea turtles in India. *Marine Fisheries Information Service Technical and Extension Series* 143, 8–16.
- Shanker, K. & Mohanty, B. (1999). Guest editorial: Operation Kachhapa: In search of a solution for the olive ridleys of Orissa. *Marine Turtle Newsletter* 86, 1–3.
- Shanker, K., Pandav, B. & Choudhury, B.C. (2004). An assessment of the olive ridley turtle (*Lepidochelys olivacea*) nesting population in Orissa, India. *Biological Conservation* 115, 149–160.
- Silas, E.G., Rajagopalan, M., Bastian Fernando, A. & Dani, S.S. (1983). Marine turtle conservation and management. A survey of the situation in Orissa during 1981–82 and 1982–83. *Marine Fisheries Research Institute Information Service Technical and Extension Series* 50, 13–23.
- Spotila, J.R., Reina, R.D., Steyermark, A.C., Plotkin, P.T. & Paladino, F.V. (2000). Pacific leatherback turtles face extinction. *Nature* 405, 529–530.
- Swimmer, Y., Arauz, R., McCracken, M., McNaughton, L., et al. (2006). Diving behaviour and delayed mortality of olive ridley sea turtles *Lepidochelys olivacea* after their release from longline fishing gear. *Marine Ecological Progress Series* 323, 253–261.
- Tietze, U., Siar, S., Upare, S.M. & Upare, M.A. (2007). Livelihood and micro-enterprise development opportunities for women in coastal fishing communities in India – Case studies of Orissa and Maharashtra. Rome, FAO: FAO Fisheries Circular.
- Tripathy, B. (2008). An assessment of solitary and arribada nesting of olive ridley sea turtles (*Lepidochelys olivacea*) at the Rushikulya rookery of Orissa, India. *Asiatic Herpetological Research* 11, 136–142.
- Tripathy, B. (2010). An investigation into olive ridley sea turtle (*Lepidochelys olivacea*) mortality along the Orissa coast of India. *Testudo* 7, 64–75.
- Wallace B.W., Lewison, R.L., McDonald, S.L., McDonald, R.K., et al. (2010). Global patterns of fisheries bycatch of marine turtles: Implications for research and conservation. *Conservation Letters* 3, 1–12.

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