rehabilitation of an olive ridley turtle from Mannalamkunnu beach, Thrissur, Kerala, India. *Indian Ocean Turtle Newsletter* 30: 10-11.

Sundaram, S., N.J. James & A. Saleem. 2019. Conservation activities carried out on olive ridley turtles, *Lepidochelys olivacea* (Eschscholtz, 1829) and observations on its hatching from Chavakkad beach, Kerala, India. *International Journal of Life Sciences* 7: 83-91.

WHEN IS A STRANDED TURTLE A BYCATCH TURTLE? ASSESSING POTENTIAL CAUSE OF STRANDING IN SEA TURTLES

ANDREA D. PHILLOTT[1,#] & MATTHEW H. GODFREY[2,3,4]

[1]FLAME University, Pune, Maharashtra, India

[2]North Carolina Wildlife Resources Commission, Beaufort NC, USA

[3]Duke Marine Laboratory, Nicholas School of Environment, Duke University, Beaufort NC, USA

[4]Department of Clinical Sciences, College of Veterinary Medicine, North Carolina State University, Raleigh NC, USA

[#]andrea.phillott@flame.edu.in; andrea.phillott@gmail.com

INTRODUCTION

"*While some of them were found tangled in nets, most lay bloated with their eyes popped out, indicating drowning*" (Hemalatha, 2015).

Stranding of live and dead sea turtles may occur for many reasons, such as after incidental capture in fisheries gear (including ghost gear) and shark control gear, vessel strike, ingestion of foreign materials, disease, and development activities, or after specific environmental factors such as freshwater discharge after intense rainfall or low water temperatures resulting in cold stunning (for examples see Casale *et al*., 2010; Pilcher *et al*., 2014; Poli *et al*., 2014; Flint *et al*., 2015; Flint *et al*., 2017). However, in areas where mortality of sea turtles accidentally caught in fishing gear is high, there is a tendency to hold fishers responsible for all turtles found washed ashore. In India, the observations used to justify such blame often includes that described in the above quote from Hemalatha (2015)- that bloated turtles with protruding eyes must have drowned after becoming entangled in fishing gear such as trawler or gill nets.

Certainly, entanglement in active fishing gear and ghost gear can result in injury or death. Rates of mortality are often highest in areas where fishing occurs in waters where turtles aggregate for breeding and nesting (e.g. along the Orissa coast; Pandav *et al*., 1997; Gopi *et al*., 2007) and ghost gear becomes concentrated by ocean currents (e.g. around the Maldives in the central Indian Ocean; Stelfox & Hudgins, 2015). But holding the fishing industry primarily responsible for turtle mortalities and declines can result in fishers being defensive about their livelihoods (e.g. Tucker *et al*., 1997; Santora, 2003) and resistant to using modified gear or complying with area or seasonal closures that reduce the rates of sea turtle bycatch (e.g., Tucker *et al*., 1997; Campbell & Cornwell, 2008).

Bloating in turtle carcasses is not a conclusive sign of drowning; instead, it is caused by gases accumulating during decomposition (Epperly *et al*., 1996). Evidence is needed to demonstrate that turtles stranded as a result of entanglement in fishing gear, and sea turtle biologists and conservationists wanting to collect information about possible causes of mortality can use the stages of decomposition and injuries or interactions with pathogens described below.

STAGES OF SEA TURTLE DECOMPOSITION

Sea turtles killed at sea often sink, rising to the surface again only when gases produced during decomposition cause the body to float (Epperly *et al*., 1996). The carcass may then drift with local currents and wind (Epperly *et al*., 1996; Hart *et al*., 2006) until it washes ashore as a dead, stranded turtle. The condition of turtle carcasses

has been categorised in various studies using different but overlapping criteria and descriptions (Table 1). Categorisation is based on odour, state of skin, scutes, and internal organs, presence of post-mortem abrasions, and state of soft tissue (Flint *et al*., 2009a; Santos *et al*., 2018). Santos *et al*. (2018) also provide photographs that can aid when determining condition state of carcasses that have been submerged during decomposition.

Sea turtles may be alive or at any stage of decomposition when stranded (washed ashore). Stranded turtles can be examined for injuries or exposure to pathogens to potentially identify factors that may have contributed to their washing ashore. However, care should be taken when attributing 'injuries' on moderately to severely decomposed and mummified carcasses to any of the causes described below as damage to soft tissues, bones and the carapace may appear as a post-mortem artefact.

ASSESSING POTENTIAL CAUSE(S) OF STRANDING IN LIVE AND DEAD SEA TURTLES

Live sea turtles and carcasses in the early stages of decomposition can be examined without necropsy, although examination of internal organs can help determine potential factors contributing to stranding in some cases. Common signs of fishing gear entanglement, boat strike, predation, cold-stunning, disease and debilitation, and plastic ingestion have been described below. Images to help identify the potential cause of injury or death in stranded turtles can be found in some studies (see Innis *et al*., 2010; Bornatowski *et al*., 2012; García-Párraga *et al*., 2014; de Quirós *et al*., 2016; Nelms *et al*., 2016; Parga *et al*., 2017; Stacy *et al*., 2017; Archibald & James, 2018). Minor abrasions, tears and notches on flipper margins or the carapace are often too difficult to assign to a cause of injury (Archibald & James, 2018).

Entanglement in line, ropes or nets results in characteristic wounds or scars that entirely or partially encircle the front flipper and/or neck. Amputation of limbs may occur if turtles have been entangled in ghost gear for extended periods. (For further information see Innis *et al*., 2010; Eckert *et al*., 2012; Barreiros & Raykov, 2014; Stelfox & Hudgins, 2015; Archibald & James, 2018.) Sea turtles that have been entangled in fishing gear may wash ashore alive or dead. Some entanglements may cause sepsis, and result in death long after the entanglement incident occurred (Stacy *et al*., 2017). Signs of capture myopathy (muscle damage after extreme exertion, struggle, stress; also known as exertional myopathy) could also be present; bruising in the shoulder muscle is indicative of capture in nets but may not always be visible, especially in carcasses that are not fresh. Clinicopathological examination by experienced veterinarians may also detect metabolic acidosis, muscle necrosis and myoglobinuria as described by Phillips *et al*. (2015).

Drowning can result when turtles have been held

Table 1. A comparison of codes and criteria used to categorise stage of decomposition in sea turtle carcasses.

Source	
Flint *et al*. (2009a)*	**Santos *et al*. (2018)#**
D1- Alive, subsequently died	0- Alive
D2- Dead, carcass fresh – suitable for pathology and fresh enough for consumption	1- Fresh Dead- Odourless; no bloating; skin and scutes intact; may still be in state of rigor
D3- Dead, carcass fair – decomposing but intact internal organs	2- Moderately Decomposed- Odour mild to strong; slight to very bloated; skin and scutes beginning to peel; internal organs distinguishable; small cuts/scratches
D4- Dead, carcass poor – advanced decomposition with internal organs falling apart	3- Severely Decomposed- Odour strong to none; carcass deflated; moderate to significant skin peeling; internal organs liquefying and hard to distinguish individually; large abrasions on body cavity
D5- Dead, mummified carcass- skin holding bones together	4- No description
D6- Dead, disarticulated bones – no soft tissue remaining	5- Skeleton, Bones Only- Carapace and plastron separated; bones predominantly clean; minimal and unidentifiable soft tissue remaining

*Based on Limpus (2007) and Rowles *et al*. (2001)

#Based on the US National Oceanographic and Atmospheric Administration's Sea Turtle Stranding Salvage Network (STSSN) stranding report forms and guidelines (http://www.sefsc.noaa.gov/species/turtles/strandings.htm)

underwater after capture in fishing gear (such as trawler nets). It is difficult to diagnose drowning as cause of death in stranded turtles, as there is often no external sign of injury. At necropsy, lungs might be expanded and contain fluid, and a thick white or pale pink foam could be expressed from the nostrils or observed in the trachea, bronchi or lungs of recently drowned turtles (Wolke & George, 1981; Stacy *et al*., 2017).

Decompression sickness ("the bends") may develop in live turtles that are pulled aboard from water >10 m depth (García-Párraga *et al*., 2014). Gas emboli are formed as dissolved gases come out of solution in the blood and form bubbles inside the body on depressurisation. The condition may be identified only by clinico-pathological examination. For live turtles, ultrasound examination is needed for confirmation of decompression sickness/gas emboli; for dead animals, necropsies should be conducted on fresh dead animals, lest decomposition result in confounding gas bubbles in vessels. (For further information on signs and diagnosis of decompression sickness in turtles see Casale *et al*., 2010; García-Párraga *et al*., 2014; de Quirós *et al*., 2016).

Hooks usually cause puncture wounds on the shoulder and/or neck, sometimes with raised scar tissue. If the hook is ingested, fishing line may protrude from the mouth and/or cloaca. (For further information see Watson *et al*., 2005; Archibald & James, 2018.) Interaction with a hook or hooks may not have been the cause a turtle stranding, but incidental. For example, a turtle that has a hook embedded in a flipper or other soft tissue may otherwise survive.

Boat strike includes collisions with the propeller or hull. Parallel, evenly spaced lacerations (usually on the carapace) indicate the turtle has been hit with a boat propeller. Propeller strike can also cause lacerations on the flippers and head. Impact with a boat hull may result in paint being deposited on the head or carapace. Remember that collision after turtle death is also possible (particularly when decomposing carcasses are more likely to float), so damage and marks should be evaluated carefully. (For further information see Hazel & Gyuris, 2006; Work *et al*., 2010; Eckert *et al*., 2012; Archibald & James, 2018.) For dead turtles, examining the brain for signs of blunt impact may be helpful (Stacy *et al*., 2017). Also, assessing amount of blood in heart chambers may help indicate whether turtle bled to death from boat strike injury (although is not necessarily the case in all boat strike events; Stacy *et al*., 2017).

Attack by a predator such as a shark is seen as partial or complete amputation of flippers with circular, shredded or jagged edges accompanied by rake marks on the carapace, missing semi-circular sections of the carapace, and/or lacerations on the head. Note that some predation may occur after the turtle has died. These signs should not be confused with damage from entanglement in fishing gear. (For further information see Horrocks, 1989; Witzell, 2007; Bornatowski *et al*., 2012; Eckert *et al*., 2012; Archibald & James, 2018.)

Cold-stunning occurs when sea turtles are exposed to cold water temperatures (generally <11°C), and has been reported in the winter waters of the Arabian/Persian Gulf (Pilcher *et al*., 2014, 2015; Robinson *et al*., 2017). Affected sea turtles may float in an unusual position, with the rear of the carapace above the water, the head pointing down, and the front flippers extended out; floating turtles may strand ashore. If cold-stunned and floating for extended periods, turtles may accumulate barnacles but these will attach to any suitable object at the water surface and are not a characteristic sign of cold-stunning. (For further information see Mrosovsky, 1980; Flint *et al*., 2009b; Pilcher *et al*., 2014, 2015.)

Disease and debilitation can occur in sea turtles as a result of various systemic disorders or exposure to toxins that leads to lack of adequate nutrition (Flint, 2009b; Manire *et al*., 2017). These turtles generally appear thin or emaciated, and support a heavy load of epibiota including barnacles, leeches and other marine organisms (Boylan *et al*., 2017). The movement of these animals is slower than healthy turtles, and may predispose them to other factors that may cause them to strand, such as boat strikes or entanglement.

Ingestion of plastic items can debilitate and kill turtles by blocking or perforating their gastrointestinal tract or bladder, preventing feeding, or increasing buoyancy. Plastic may be observed extruding from the cloaca of live stranded turtles or in their faeces, or found in the gut of dead turtles during necropsy. (For further information see Hoarau *et al*., 2014; Nelms *et al*., 2016; Ryan *et al*., 2016). Presence of plastic in a dead turtle does not automatically indicate that death was caused by plastic (see Clukey *et al*., 2017).

CONCLUSION

Collecting information about stranded sea turtles, including the date, location, species, sex, carapace length, stage of decomposition, and potential cause and condition of each injury, can contribute to a broader assessment of the threats to sea turtles in local and national waters. Assessment of local and national in-water threats can be improved by sharing of information about stranded turtles, through submissions to national

stranding databases or publication of observations (e.g. Arun, 2019; James *et al*., 2019; Ramah *et al*., 2019; Saleem *et al*., 2019). More accurate documentation of factors that contribute to sea turtle strandings, such as entanglement in fishing gear, disease, and ingestion of plastic, may help researchers and conservationists in the Indian Ocean and South East Asia to influence policy and work with local communities and fishers to mitigate threats.

Literature cited:

Archibald, D.W. & M.C. James. 2018. Prevalence of visible injuries to leatherback sea turtles *Dermochelys coriacea* in the Northwest Atlantic. *Endangered Species Research* 37: 149-163.

Arun, V. 2019. Turtle diary, 2018 - Students Sea Turtle Conservation Network. Thirty years of sea turtle conservation on the Chennai coast. *Indian Ocean Turtle Newsletter* 30: 2-5.

Barreiros, J.P. & V.S. Raykov. 2014. Lethal lesions and amputation caused by plastic debris and fishing gear on the loggerhead turtle *Caretta caretta* (Linnaeus, 1758). Three case reports from Terceira Island, Azores (NE Atlantic). *Marine Pollution Bulletin* 86: 518-522.

Bornatowski, H., M.R. Heithaus, C.M.P. Batista & R. Mascarenhas. 2012. Shark scavenging and predation on sea turtles in northeastern Brazil. *Amphibia-Reptilia* 33: 495-502.

Boylan, S.M, B.A. Stacy & J. Wyneken. 2017. Integumentary system. In: *Sea Turtle Health and Rehabilitation* (eds. Manire, C.A., T.M. Norton, B.A. Stacy, C.J. Innis & C.A. Harms. Pp. 243-263. J Ross Publishing: Plantation, FL, USA.

Campbell, L.M. & M.L. Cornwell. 2008. Human dimensions of bycatch reduction technology: Current assumptions and directions for future research. *Endangered Species Research* 5: 325-334.

Casale, P., M. Affronte, G. Insacco, D. Freggi, C. Vallini, P. D'Astore, R. Basso, G. Paolillo, G. Abbate & R. Argano. 2010. Sea turtle strandings reveal high anthropogenic mortality in Italian waters. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20: 611-620.

Clukey, K.E., C.A. Lepczyk, G.H. Balazs, T.M. Work & J.M. Lynch. 2017. Investigation of plastic debris ingestion by four species of sea turtles collected as bycatch in pelagic Pacific longline fisheries. *Marine Pollution Bulletin* 120: 117-125.

de Quirós, Y.B., P. Saavedra, A. Møllerløkken, A.O. Brubakk, A. Jørgensen, O. González-Díaz, J.L. Martín-Barrasa & A. Fernández. 2016. Differentiation at necropsy between *in vivo* gas embolism and putrefaction using a gas score. *Research in Veterinary Science* 106: 48-55.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert & P.C.H. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). USFWS Biological Technical Publication. BTP-R4015-2012. https://digitalmedia.fws.gov/digital/collection/document/id/1519/.

Epperly, S.P., J. Braun, A.J. Chester, F.A Cross, J.V. Merriner, P.A. Tester & J.H. Churchill. 1996. Beach strandings as an indicator of at sea mortality of sea turtles. *Bulletin of Marine Science* 59: 289-297.

Flint, J., M. Flint, C.J. Limpus & P.C. Mills. 2015. Trends in marine turtle strandings along the east Queensland, Australia Coast, between 1996 and 2013. *Journal of Marine Biology* 2015: ID 848923.

Flint, J., M. Flint, C.J. Limpus & P.C. Mills. 2017. The impact of environmental factors on marine turtle stranding rates. *PLoS ONE* 12: e0182548.

Flint, M.F., J. Patterson-Kane, P. Mills & C. Limpus. 2009a. A veterinarian's guide for sea turtle post mortem examination and histological investigation. University of Queensland, Brisbane QLD, Australia. https://veterinary-science.uq.edu.au/filething/get/4226/pm-guide-msf.pdf.

Flint, M., J.C. Patterson-Kane, C.J. Limpus, T.M. Work, D. Blair & P.C. Mills. 2009b. Postmortem diagnostic investigation of disease in free-ranging marine turtle populations: A review of common pathologic findings and protocols. *Journal of Veterinary Diagnostic Investigation* 21: 733-759.

García-Párraga, D., J.L. Crespo-Picazo, Y. Bernaldo de Quirós, V. Cervera, L. Martí-Bonmati, J. Díaz-Delgado, M. Arbelo, M.J. Moore, P.D. Jepson & A. Fernández. 2014. Decompression sickness ('the bends') in sea turtles. *Diseases of Aquatic Organisms* 111: 191-205.

Gopi, G.V., B. Pandav & B.C. Choudhury. 2007. Estimated annual incidental captures of *Lepidochelys olivacea* (Eschscholtz, 1829) in trawl nets along the Orissa coast, India. *Hamadryad* 31: 212-215.

Hazel, J. & E. Gyuris. 2006. Vessel-related mortality of sea turtles in Queensland, Australia. *Wildlife Research* 33: 149-154.

Heithaus, M.R., A.J. Wirsing, J.A. Thomson & D.A. Burkholder. 2008. A review of lethal and non-lethal effects of predators on adult marine turtles. *Journal of Experimental Marine Biology and Ecology* 356: 43-51.

Hemalatha, K. 2015. Murder most foul: 35 turtles washed ashore. *The Times of India (Chennai)*: 20th January 2015.http://epaperbeta.timesofindia.com/Article.aspx?eid=31807&articlexml=MURDER-MOST-FOUL-35-turtles-washed-ashore-20012015005029.

Hoarau, L., L. Ainley, C. Jean & S. Ciccione. 2014. Ingestion and defecation of marine debris by loggerhead sea turtles, *Caretta caretta*, from by-catches in the South-West Indian Ocean. *Marine Pollution Bulletin* 84: 90-96.

Horrocks, J. 1989. Leatherback injured off Barbados, West

Indies. *Marine Turtle Newsletter* 46: 9-10.

James, N.J., A. Saleem & S. Sundaram. 2019. Stranded olive ridley turtle on Edakkazhiyur beach, Chavakkad, Kerala, India. *Indian Ocean Turtle Newsletter* 30: 11-13.

Limpus, C.J. 2007. Database manual- Turtle conservation monitoring project and monitoring of marine wildlife mortality and stranding. QPWS/EPA, Brisbane.

Manire, C.A., S.I. Stacy & T.M. Norton. 2017. Chronic debilitation. In: *Sea Turtle Health and Rehabilitation* (eds. Manire, C.A., T.M. Norton, B.A. Stacy, C.J. Innis & C.A. Harms. Pp. 707-724. J Ross Publishing: Plantation, FL, USA.

Mrosovsky, N. 1980. Thermal biology of sea turtles. *American Zoologist* 20: 531-547.

Nelms, S.E., E.M. Duncan, A.C. Broderick, T.S. Galloway, M.H. Godfrey, M. Hamann, P.K. Lindeque & B.J. Godley. 2016. Plastic and marine turtles: A review and call for research. *ICES Journal of Marine Science* 73: 165-181.

Pandav, B., B.C. Choudhury & C.S. Kar. 1997. An assessment of the olive ridley turtle (*Lepidochelys olivacea*) nesting population in Orissa, India. *Oryx* 31: 32-36.

Parga, M., J.L. Crespo-Picazo, D. Garcia-Parraga, B.A. Stacy & C.A. Harms. 2017. Fisheries and sea turtles. In: *Sea Turtle Health and Rehabilitation* (eds. Manire, C.A., T.M. Norton, B.A. Stacy, C.J. Innis & C.A. Harms. Pp. 859-897. J Ross Publishing: Plantation, FL, USA.

Pilcher, N.J., I. Al-Maslamani, J. Williams, R. Gasang & A. Chikhi. 2015. Population structure of marine turtles in coastal waters of Qatar. *Endangered Species Research* 28: 163-174.

Pilcher N.J., M. Antonopoulou, L. Perry, M.A. Abdel-Moati MA, T.Z. Al Abdessalaam, M. Albeldawi, M. Al Ansi, S.F. Al-Mohannadi, N. Al Zahlawi, R. Baldwin, A. Chikhi, H.S. Das, S. Hamza, O.J. Kerr, A. Al Kiyumi, A. Mobaraki, H.S, Al Suwaidi, A.S. Al Suweidi, M. Sawaf, C. Tourenq, J. Williams & A. Willson. 2014. Identification of Important Turtle Areas (ITAs) for hawksbill turtles in the Arabian Region. *Journal of Experimental Marine Biology and Ecology* 460: 89-99.

Poli, C., L.C.S. Lopez, D.O. Mesquita, C. Saska & R. Mascarenhas. 2014. Patterns and inferred processes associated with sea turtle strandings in Paraíba State, Northeast Brazil. *Brazilian Journal of Biology* 74: 283-289.

Ramah, S., A.T.C. Voon & K. Beetul. 2019. First encounter of a stranded loggerhead marine turtle entangled in a ghost net on the southeast coast of Mauritius Island. *Indian Ocean Turtle Newsletter* 30: 8-9.

Robinson, D.P., R.W. Jabado, C.A. Rohner, S.J. Pierce, K.P. Hyland & W.R. Baverstock. 2017. Satellite tagging of rehabilitated green sea turtles *Chelonia mydas* from the United Arab Emirates, including the longest tracked journey for the species. *PLoS ONE* 12: e0184286.

Rowles, T.K., F.M. Van Dolah & A.A. Hohn, 2001. Gross necropsy and specimen collection protocols. In: *CRC Handbook of Marine Mammal Medicine 2nd edition* (eds. Dierauf, L.A. & F.M.D. Gulland). Pp. 449-470. CRC Press: Boca Raton FL, USA.

Ryan, P.G., G. Cole, K. Spiby, R. Nel, A. Osborne & V. Perold. 2016. Impacts of plastic ingestion on post-hatchling loggerhead turtles off South Africa. *Marine Pollution Bulletin* 107: 155-160.

Santos, B.S., D.M. Kaplan, M.A.M. Friedrichs, S.G. Barco, K.L. Mansfield & J.P. Manning. 2018. Consequences of drift and carcass decomposition for estimating sea turtle mortality hotspots. *Ecological Indicators* 84: 319-336.

Saleem, A., N.J. James & S. Sundaram. 2019. On the rescue and rehabilitation of an olive ridley turtle from Mannalamkunnu beach, Thrissur, Kerala, India. *Indian Ocean Turtle Newsletter* 30: 10-11.

Santora, C. 2003. Management of turtle bycatch: Can endangered species be protected while minimizing socioeconomic impacts? *Coastal Management* 31: 423-434.

Stacy, B.A., T.M. Work & M. Flint. 2017. Necropsy. In: Sea Turtle Health and Rehabilitation. (eds. Manire, C.A., T.M. Norton, B.A. Stacy, C.J. Innis & C.A. Harms. Pp. 209-239. J Ross Publishing: Plantation, FL, USA.

Stelfox, M.R. & J.A. Hudgins. 2015. A two year summary of turtle entanglements in ghost gear in the Maldives. *Indian Ocean Turtle Newsletter* 22: 14-20.

Tucker, A.D., J.B. Robins & D.P. McPhee. 1997. Adopting turtle excluder devices in Australia and the United States: What are the differences in technology transfer, promotion, and acceptance? *Coastal Management* 25: 405-421.

Watson, J.W., S.P. Epperly, A.K. Shah & D.G. Foster. 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. *Canadian Journal of Fisheries and Aquatic Sciences* 62: 965-981.

Witzell, W.N. 2007. Kemp's ridley (*Lepidochelys kempi*) shell damage. *Marine Turtle Newsletter* 115: 16-17.

Wolke, R.E. & A. George 1981. Sea Turtle Necropsy Manual. Department of Commerce/National Oceanic & Atmospheric Administration/National Marine Fisheries Service. NOAA Technical Memorandum NMFS-SEFC-24. https://repository.library.noaa.gov/view/noaa/5456.

Work, P.A., A.L. Sapp, D.W. Scott & M.G. Dodd. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology* 393: 168-175.