Selected causes of human-related morbidity and mortality in wild sea turtles

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The prevalence of disease and mortality of any species depends on a number of factors including geographical location, age of the animal and environment (freedom vs. captivity). As an example, fibropapillomatosis is a common condition in green turtles (*Chelonia mydas*) in Hawaii and Florida (Fig. 1), but it is rare in other parts of the world; negative interaction with fishing hooks is a very common cause of mortality of loggerhead turtles (*Caretta caretta*) in the Mediterranean Sea (Fig. 2), but other fishing techniques may negatively affect sea turtles in other geographical areas; metabolic bone disease and other growth-related problems are found in young captive sea turtles (Fig. 3), while they are hardly seen in captive adults or in wild animals. Therefore, literature about diseases and mortality of sea turtles (a large body of it coming from the USA) should be adapted in order to avoid under-representation of conditions affecting some areas of the world (e.g. those areas where less research is being done) or specific groups of animals (e.g. hatchlings).

Causes of mortality in sea turtles can be natural or anthropogenic. Natural causes include ageing, predation (both on eggs and turtles), disease, starvation, nest destruction by other turtles (affecting only eggs) and meteorological phenomena (hurricanes, cold-stunning syndrome, excess rain, etc.) (Márquez 2004). Natural causes of mortality are unlikely to produce significant changes in population abundance. However, anthropogenic causes of mortality have a greater chance to significantly and negatively impact sea turtle populations and drive them toward threat and extinction (locally or globally) (Lewison & Crowder 2007). As an example of this, a pathological study of sea turtles stranded in the Canary Islands revealed 70% anthropogenic mortality and 30% natural mortality (Orós *et al.* 2005).

Anthropogenic causes of sea turtle mortality include inappropriate manipulation by conservationists, habitat degradation (destruction of nesting beaches, introduction of predators, collision with boats), pollution (e.g.

Fig. 1. Fibropapilloma in a green turtle. This condition affects mainly green turtles in Hawaii and the south-east of the USA.

Fig. 2. Entanglement with fishing line has eventually produced the amputation of the right front flipper of this loggerhead turtle.

Fig. 3. A captive-reared two-year-old loggerhead turtle with increased size and deformed growth due to excessive feeding. Floating was so abnormal that the animal had to be euthanased.

ingestion of debris), oil spills, collection (of eggs and turtles) and interaction with fishing devices (bycatch) (Márquez 2004). This article reviews a selection of important causes of anthropogenic morbidity and mortality in wild sea turtles. When appropriate, veterinary treatment of these conditions is also explained.

Boat strike

Boat strike is one of the most common causes of trauma in sea turtles, and collision with boats is an increasing problem in some areas such as the Mediterranean Sea (Camiñas 2004). Boat strike accounted for 24% of total mortality in stranded sea turtles in the Canary Islands (Orós *et al.* 2005). Propeller injuries can include head lacerations, eye injury, injury to the limbs and carapacial lacerations and fractures (Walsh 1999) (Fig. 4). Internal damage after boat strike can be severe and surviving individuals may not be able to swim properly due to spinal damage, flotation problems, wound contamination or lung puncture with introduction of seawater into the respiratory system (Walsh 1999; Wyneken *et al.* 2006). Drowning as a result of trauma is a serious and common condition (Wyneken *et al.* 2006). Critical patients should be stabilized (with antibiotics, analgesics, fluid therapy, wound care, etc.) before attempting to repair carapacial fractures. The less

Fig. 4. Severe trauma with skull fracture and damage to the right eye in a loggerhead turtle. The brain was exposed and the wound characteristics were indicative of some chronicity. Although sea turtles have an amazing ability to heal, this animal was euthanased due to the low chances of returning it into the wild. As in Fig. 2, severe trauma to head or flippers carry a grave prognosis.

invasive method of treating wounds and carapacial fractures involves the use of the properties of salt water (Fig. 5). More intensive therapeutic options involve the use of antibiotic creams, honey and waterproof bandages. Some carapacial fractures can be stabilised with epoxy resin (water-resistant epoxy resin is easily available as it is commonly used to fix boats) (Fig. 6), while wire can be used to stabilise carapace, plastron or skull (Wyneken *et al.* 2006) (Fig. 7). Turtles with polytraumatized carapaces may need to stay out of water for several weeks, which produces no adverse effects if the principles of skin hydration are followed (Wyneken *et al.* 2006). These polytraumatized cases may need months of care and rehabilitation, with great cost and labour investments (Wyneken *et al.* 2006).

Fig. 5. Green turtle under rehabilitation due to carapacial fracture caused by propeller strike. These wounds may take months to heal. Similar to the animal in Fig. 4, sea turtles rarely present with fresh trauma.

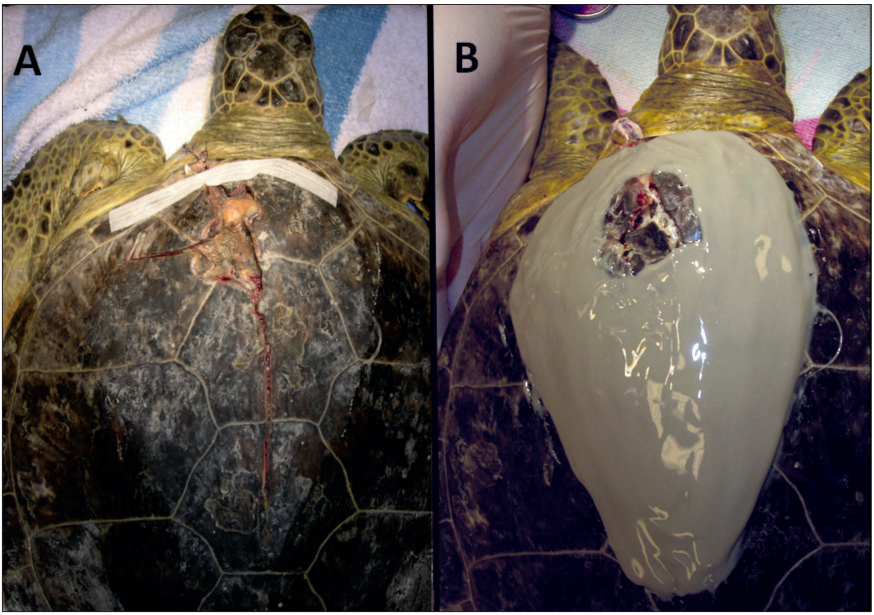

Fig. 6. A. Carapacial fracture in a green turtle caused by propeller strike. B. Stabilisation of the fracture using water-resistant epoxy resin; an area of wound has been left open to continue with wound care.

Fig. 7. Screws and wires used to stabilise a carapacial fracture in a loggerhead turtle.

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Fig. 8. Adult loggerhead turtle with a chronic buoyancy problem. If the problem is not resolved, these animals cannot be returned to the ocean.

Floating (buoyancy) problems

Sea turtles with buoyancy problems are unable to maintain proper flotation or have difficulty with diving (Jacobson 1998; Wyneken *et al.* 2006) (Fig. 8). Trauma (e.g. boat strike) can cause lung rupture and pneumocoelom (accumulation of free air in the coelomic cavity) or spinal damage, both causing buoyancy problems (Jacobson 1998; Wyneken *et al.* 2006). Pneumocoelom and buoyancy problems can also be caused by infectious coelomitis, usually secondary to gastrointestinal perforation due to ingestion of fishing hooks (Wyneken *et al.* 2006). Gastrointestinal impactions (generally from ingestion of sea debris) produce gas accumulation anterior to the impaction, with consequent flotation problems (Wyneken *et al.* 2006). Turtles that are very weak and hypothermic and those with pneumonia can also present with buoyancy problems (Jacobson 1998; Wyneken *et al.* 2006; Keller *et al*. 2012).

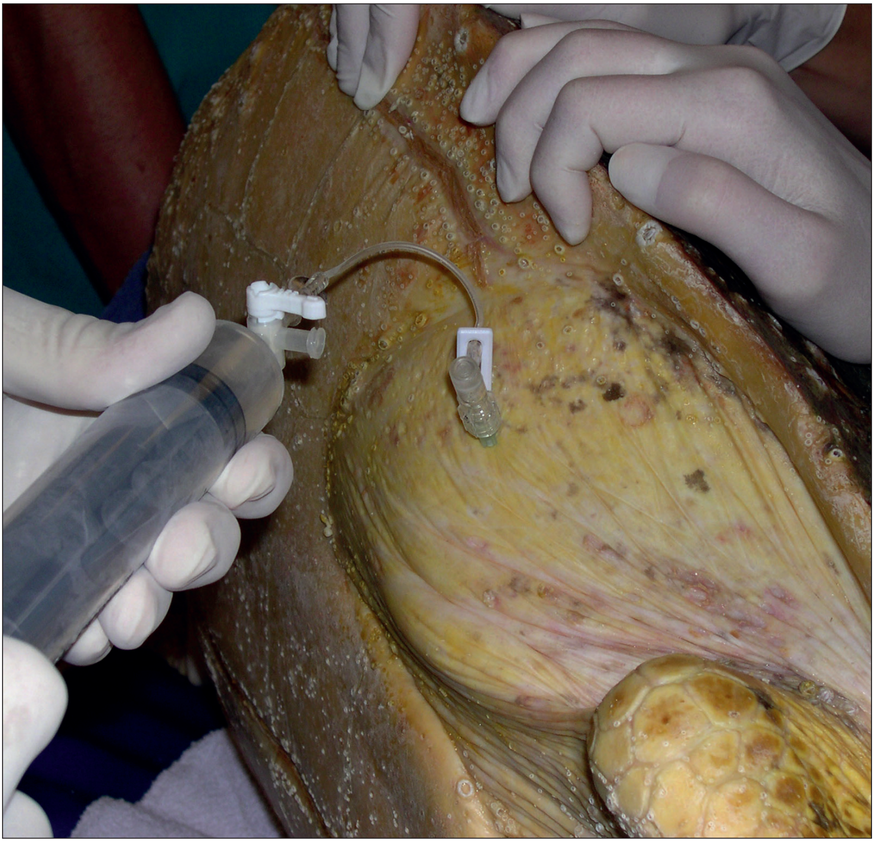

Fig. 9. Removal of air from the coelomic cavity of a loggerhead turtle with buoyancy problems. In some cases, the removal of that air (as a single procedure or repeated periodically) can resolve the problem.

Sea turtles that are unable to dive cannot feed, have increased chances of boat strike, are likely to be attacked by predators (sharks, gulls, etc.) and are commonly presented stranded. Rehabilitation can be achieved if the cause of the problem is found and corrected. In some cases, lung fissures can be found using endoscopy, but resolution is not easy. Removal of air from the coelomic cavity (as a single procedure or repeated periodically) can resolve the problem in some cases (Wyneken *et al.* 2006) (Fig. 9). Unresolved cases should be euthanased or kept in captivity for life. Captive animals with chronic floating problems may develop pressure points on the skin of the dorsal neck due to friction with the carapace. Some unreleasable animals may be kept in captivity with weights attached to those areas of the carapace where increased buoyancy is noted.

Fig. 10. This loggerhead turtle has ingested fishing line and part of it can be seen exiting through the mouth.

Fig. 11. Same animal as in Fig. 10 showing fishing line exiting through the cloaca. In this case, the fishing line affects the whole gastrointestinal tract and surgery is needed to remove it.

Ingestion of foreign bodies

The presence of anthropogenic debris in the oceans is a growing concern for a number of species including sea turtles. Approximately 6.4 million tons of debris, most of it plastic, enters the marine environment every year (Schuyler *et al.* 2013). Debris ingestion by sea turtles occurs worldwide, but debris tends to accumulate far from shore and therefore animals feeding in open waters (pelagic) are more likely to ingest debris than coastal foragers (benthic). Due to the extensive migratory movements of sea turtles, there is little correlation between level of debris ingested and proximity to areas of highest human density or proximity to stranding areas (Schuyler *et al.* 2013). Most debris ingested by sea turtles is plastic, but also rope, styrofoam, fishing line, balloons, cigarette butts, crude oil and others (Orós *et al.* 2005; Schuyler *et al.* 2013). Hawksbill (*Eretmochelys imbricata*), green and leatherback (*Dermochelys coriacea*) turtles seem to be more likely to ingest/retain debris than carnivorous species such as loggerhead and Kemp's ridley (*Lepidochelys kempii*) turtles (Schuyler *et al.* 2013). Debris ingestion by sea turtles is an increasing phenomenon and can affect 0-100% of populations depending on the study (Schuyler *et al.* 2013). The presence of debris in the gastrointestinal tract of sea turtles can be asymptomatic or can produce problems such as ulcerations, perforations and obstructions (Fig. 10). Overall, it is estimated that ingestion of debris accounts for 4% of the total sea turtle mortality, and 9% of those that have ingested debris die as a consequence of it (Schuyler *et al.* 2013). Fibroendoscopy (flexible endoscopy) can be used to retrieve foreign bodies from the stomach with the turtle under sedation or anaesthesia (Wyneken *et al.* 2006), although surgery will be necessary to remove lineal foreign bodies such as fishing line (Fig. 11).

Interaction with fishing devices

Sea turtles can ingest fish hooks and fishing line, or can become entangled by fishing line or nets. Fishing hooks can cause severe injury, particularly in mouth and oesophagus (Walsh 1999) (Fig. 12). Commonly, damage is exacerbated by the fishing line attached to the hook, and there is a positive correlation between mortality and the length of the fishing line left with the hook (Casale *et al.* 2008; Valente *et al.* 2007). Mortality can occur by perforation of heart, blood vessels or digestive tract (often the stomach) (Casale *et al.* 2008). Some turtles that have ingested a fishing hook may survive in the wild, either by passing the hook and expelling it through the cloaca or by retaining the hook/hooks encapsulated in the gastrointestinal tract (Aguilar *et al.* 2005; Valente *et al.* 2007). Hooks can be retrieved manually or using surgery or endoscopy (Wyneken *et al.* 2006).

Ingested fishing line acts as a typical linear foreign body (Figs 10 & 11) and can cause perforations and strangulations of the intestines. Furthermore, if the ingested fishing line is pulled, both hook and fishing line can produce additional damage by perforating the gastrointestinal system and producing life-threatening coelomitis (Wyneken *et al.* 2006). While lesions by hooks usually cause death within a short period of time, fishing lines cause death after a relatively long period of time (Casale *et al.* 2008). Turtles with a long line within the digestive tract (usually longer than 50cm) and, particularly, those which additionally have an anchored hook have low possibilities of survival (Casale *et al.* 2008). Flipper strangulation with fishing line or nets is also common (Wyneken *et al.* 2006), leading to amputations, loss of flipper functionality or significant wounds (Figs 2 & 13). Additional problems with hooks and fishing lines include erosions of the lateral commissures of the mouth caused by the line and lead intoxication when sinkers are ingested (Wyneken *et al.* 2006).

Overall, more than 200,000 loggerhead turtles and 50,000 leatherback turtles are caught yearly by longline fisheries (Lewison *et al.* 2004). In the Mediterranean Sea, more than 60,000 turtles (mostly loggerheads) are caught annually as a result of fishing practices (Camiñas 2004). The yearly capture numbers by the Mediterranean fleet of just one country (Spain) is about 20,000 loggerhead turtles (Aguilar *et al.* 1995). The effect of incidental capture and mortality in the Indian Ocean is more difficult to estimate but is also deemed to be very high. As an example, the number of olive ridley turtles (*Lepidochelys olivacea*) captured incidentally by the fishery fleet annually in the waters of Orissa (India) is estimated at 10,000 to 15,000. In this region of India, about 100,000 dead turtles (mostly olive ridley) due to fishing interaction have been counted on the coast in a decade (between 1994 and 2004) (Shanker 2004). Another example occurred in Northern Australia, where 2km of shark gillnet produced the drowning of 300 sea turtles in a period of two weeks (Shanker 2004). These examples and estimations may actually be an underestimation of what it is really happening around the world, as most research has been done for longline fisheries, but other fishing techniques such as gillnets and trawling may also produce very high capture and mortality rates (Lewison & Crowder 2007).

Mortality rates for sea turtles caught incidentally by fisheries have been estimated at 10 to 50% (Camiñas 2004). About 20-30% of turtles caught by longline gear may die, with the remaining turtles released alive with the hook inside their mouth, pharynx or oesophagus (Aguilar *et al.* 1995; Camiñas 2004). Casale *et al.* (2008) indicated that mortality of captured turtles is well above 30%. Mitigation measures (e.g. turtle excluding devices) have been tested and proved to be effective across fleets and ocean regions, but their implementation and enforcement has been problematic (Lewison & Crowder 2007).

Fig. 12. Fishing hooks can produce severe damage to the gastrointestinal tract of sea turtles. In the picture, a hook has perforated the lower mandibular area of a loggerhead turtle. Photo courtesy of Pascual Medina and Fundació CRAM.

Fig. 13. Wound in the flipper of a loggerhead turtle caused by entanglement with fishing line.

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