[1]Study on the lethality of sea turtles by ingested plastics is hard to swallow

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A study published in *Nature Scientific Reports* on September 13, 2018 reported that sea turtles die from eating small amounts of plastic marine debris.[1] Based on their analysis of dead turtles, the authors concluded that sea turtles ingesting only 14 pieces of plastic have a 50% chance of dying from it and a 22% chance of dying from eating a single piece of plastic. We disagree for three fundamental reasons: 1) the authors attempted to answer the wrong question with an inappropriate approach, 2) the necropsy case definitions are not clear, and 3) the reported thresholds for mortality are unrealistically low.

Wrong question, wrong approach

The paramount problem is that this study addresses "the probability of plastic ingestion given death," whereas the question of interest is "what is the probability of death given plastic ingestion?" The latter question cannot be answered by retrospective necropsy surveys alone, but rather requires prospective controlled exposure studies addressing dose response. We understand the legal constraints of undertaking an exposure study, but the "next best" approach taken by the authors (assessing turtles through necropsy alone) is full of pitfalls and limitations. Assessing stranded turtles (except for four pelagic, bycatch turtles) imposes a certain bias towards sick and injured turtles overlooking all turtles that ingest and excrete the same or larger amounts of plastics without harm. Even if it was possible to determine the probability of death from eating plastics from dead turtles (an impossibility), assessing mostly stranded turtles will lead to a dose response threshold that is biased low.

Unclear case definitions

We also found fault in the definitions of turtle groups. The crux of their conclusion lies in the finding that quantities of ingested plastic (0.01-10 g) sequentially increased through the following four groups of turtles: a) unknown cause of death (unknown), b) known cause of death not from plastic ingestion (Known-not plastic), c) cause of death was indeterminate (Indeterminate), and d) those that

died from plastic ingestion (Known-plastic). The only distinction made between a) unknown cause of death and c) indeterminate was the relative quantity of plastic found in the guts. This biased approach nearly guaranteed statistically significant differences. Since the authors provided no evidence that the indeterminate turtles died from ingested plastic they could have been combined into the unknown group. Doing so would raise the quantities of ingested plastic in the unknown group above known-not plastic and defy their conceptual model.

Two possible mistakes made during necropsies of all sea turtle debris ingestion studies warrant discussion here: inappropriate generalization of debris types and unclear case definition of cause of death due to plastic. One generalization to avoid is the inclusion of ingested debris that can be directly attributable to active fishing. When this type of debris (e.g., actively fished hook and line) is associated with the cause of death, it should be excluded from debris quantities,[2] and the case should be categorized as a fisheries interaction rather than debris ingestion. It is unclear if this distinction was made in Wilcox et al., especially since previously published descriptions of debris in a portion of the turtles they used included non-plastic debris and "fishing items".[3] Another generalization is the lumping together of different types of plastic debris with different physical characteristics. Debris with physical features that risk lethal complications (e.g., plication, perforation, obstruction) are more acutely harmful than debris without these features that can create obstruction if ingested in sufficient quantity but otherwise likely will be defecated uneventfully. For example, a long fishing line can cause plication (increase tortuosity) and erosion of intestinal mucosa [4], a large sheet of plastic can obstruct [5], and a sharp plastic fragment can perforate the gut [1]. It does not make sense to treat such items the same as other debris that lack such features. Doing so leads to gross oversimplification and implausible predictions, such as high mortality risk associated with small quantities of debris with benign features.

Multiple researchers performed the necropsies used in Wilcox et al and inconsistencies in methods and opinions on cause of death are possible. Some researchers might be more inclined to classify the cause of death from plastics if they simply observed large amounts of plastic in the gut in absence of an obvious pathology or assumed causality based on non-specific metrics like nutritional condition.[6] Without knowledge of the post-mortem state of the specimens or details on gut pathology, it is unclear whether plastics actually caused gut perforation or whether perforation was a post-mortem event (e.g. decomposition).

Unrealistically low threshold

Fifty percent mortality from only 14 pieces of ingested plastic[1] is an unrealistically low threshold. Postmortem examination of thousands of sea turtles from Florida,[7, 8] Hawaii, [4, 9-14] and Australia[15-17] including animals contributed to StrandNet used by Wilcox et al.[1], show that ingested plastic in sea turtles is most often incidental rather than the cause of death. Sea turtles can certainly excrete plastic items with negligible harm.[2, 18-21] Furthermore, green sea turtles (*Chelonia mydas*) actively foraging and in good body condition in the Central Pacific that died from forced submergence on longline fishing gear had an average of 94 pieces or 20 grams of plastic debris in their guts.[14] These multiple lines of evidence directly contravene the authors' finding of a 50% probability of mortality associated with ingesting only 14 pieces plastic.

Wilcox et al.[1] argues that size of ingested debris may explain the discrepancy between lethality caused by few debris pieces in the Australian coastal turtles and lack of harm caused by many more pieces ingested by the Central Pacific pelagic turtles.[14] The dimensional sizes of the debris items ingested by coastal Australian turtles are not reported in Wilcox et al [1] or preceding publications.[3, 22, 23] In fact the absence of raw data (i.e. sample sizes, species, turtle sizes, debris sizes) prevents full transparency of key aspects of the analyses and makes it difficult to compare their results to those of other regions. For

future comparison, the average size ingested by Central Pacific pelagic turtles is 2 ± 3 cm in the longest dimension, and the largest piece was a plastic snack bag measuring 20.5 cm x 10.4 cm x 0.5 mm [24]. It remains to be determined if coastal Australian turtles eat larger items than pelagic turtles. However, sea turtles take crushing bites of their prey, and we have evidence that they commonly bite plastic debris items into smaller, more manageable pieces before swallowing.[24] On a final note, standardized reporting of mass of ingested debris and normalizing to turtle size or weight would allow for more accurate regional comparisons.[25]

Conclusion

We suspect a more conservative threshold is closer to the truth, which can only be estimated from a more rigorous, less biased strategy that accounts for reports of higher ingestion without harm. Without clear pathology evidence that plastic is causing antemortem harm to sea turtles, it is inappropriate to implicate plastics as a cause of death based on mere presence in the gut. Plastic pollution is certainly concerning, and human behaviors must change to fix this environmental problem. However, better methods, units, and a broader perspective are needed to accurately estimate the effects of plastics and other marine debris on sea turtles.

The use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the US Government.

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