The Impact of Plastic Pollution on Marine Life – The Case of Sea Turtles

Introduction

It is estimated that 4-12 million tons of plastic enter the world's ocean each year, which makes it the predominant component of marine and costal debris (Pham et al. 2017). Microplastics (<5 mm in diameter; Cole et al. 2011), mesoplastics (5-10 mm in diameter; Isobe et al. 2014) and macroplastics (>20 mm in diameter; Cole et al. 2011), can be distinguished among marine plastic pollution.

Sea turtles are vulnerable to marine plastic pollution, as the result of their migratory behaviour and variable habitats. Six of the seven species are classified as threatened with extinction by the IUCN Red List of Threatened Species (International Union for Conservation of Nature and Natural Resources). Sea turtles are threatened by the presence of plastic debris in marine and coastal habitats, the biggest threats being ingestion of and entanglement in plastics. Turtles can ingest plastic in two possible ways: directly and indirectly, when debris is physically connected with normal dietary items (Nelms et al. 2016). Plastic debris ingestion can result in death by perforation or impaction of the gastrointestinal system and toxic compounds in plastics may have sublethal effects on development and population dynamics (Nelms et al. 2016). When it comes to entanglement many objects can cause it, such as abandoned or lost gear, used recreationally and commercially fishing gear, and other types of ropes and trash, for instance plastic bags (Fisheries, N. 2021). From a welfare perspective, entanglement may cause long-term suffering and a slow deterioration (Nelms et al. 2016). The threats caused by plastic pollution differ significantly between species, populations, and life stages (Schuyler et al. 2014a).

Nesting habitats

Plastic pollution can affect sea turtles already at the earliest life stages. Sandy beaches have great importance as nesting habitats. At the same time, they are known to be accumulation areas for macro- and microplastics. Pollution can reach high densities, especially on remote and inaccessible beaches where no clearing is conducted resulting in threats for nesting females as well as their eggs and hatchlings (Nelms et al. 2016).

Gündoğdu et al. (2019) have differentiated various effects different types of plastic litter can have on reproduction success of sea turtles. The most frequent effect of almost every type of plastic is a general reduction of nesting success. In more detail, this is a result of macroplastics becoming obstacles and microplastics changing the physical beach properties. Larger items like fishing gear, wrappers and bags can cause entanglement of both females and hatchlings. Although the study could not identify plastic litter as the decisive cause, the authors do suggest that impediment during nest selection might lead to the abortion of the nesting attempt. For hatchlings, disposable items like bottles, cups and sacks, textiles and plastic fragments can become barriers on their way to the sea while almost all larger items have the potential of an entrapping effect, preventing the hatchlings from even reaching the surface. This observation is also described by Nelms et al. (2016). As it is crucial for the offspring to reach the sea as quickly as possible to avoid desiccation and predation, consequences of obstacles are increased vulnerability, death or in the better case an increase in spent energy (Nelms et al. 2016).

Another shared property by almost all types of plastic is the path of eventually breaking down into microplastic particles. These can change physical properties of the beaches. Microplastics decrease thermal diffusivity of sand and thus temperatures. Hatchling sex-ratios depend on temperatures: Lower temperatures favour the development of male individuals, so this has direct consequences on populations. Another aspect is an increased permeability of the sand leading to decreased humidity and an increased risk of desiccation of the eggs. Finally, sediment contamination can occur through plasticizers and persistent organic pollutants, again potentially affecting sex-ratios (Nelms et al. 2016).

Ingestion

Macroplastics can be very harmful for marine animals. Ingestion of macroplastics can cause intestinal blockage and internal injury, dietary dilution, malnutrition, and increased buoyancy which in turn can result in poor

health, reduced growth rates and reproductive output, or death (Caron et al. 2018; Nelms et al. 2016). Ingestion of fishing lines made of plastic is a serious threat to sea turtles where studies have shown several sea turtles found dead due to the intestinal blockage from these fishing gears. The fishing line causes death when it becomes lodged in the gut as a tangled ball, often at valves leading from one gut segment to another and this obstructs the digestion flow. Studies have shown that turtles have died by the cause of a blockage in the junction between the small and large intestines. The fishing line made of plastic can also stop normal gut function and result in death when a strand that extends along a portion of the gut becomes lodged at the anterior end of the animal (Nelms et al. 2016; Oliveira et al. 2020; Ryan et al. 2016).

A total of 36 loggerhead sea turtles, *C. caretta*, were analysed and necropsied between November 2017 and May 2019 in the Greek archipelago. Out of these, 72% were detected with plastics in one or more of the gastrointestinal sections (Digka et al. 2020). Early juvenile sea turtles are also seen to ingest more plastics than late juvenile and adult turtles. This was seen to be 3x higher than the average plastic ingestion for adult sea turtles (Digka et al. 2020). It is uncertain to why this occurs, but this could have an enormous effect to the demography. There was also found more microplastics such as PET in adult sea turtles which sinks to the bottom and ends up in the ocean´s sediments (Digka et al. 2020). This raises a great concern over the microplastics distribution and how it really affects sea turtles in all its life stages. A study from the North Atlantic by Pham et al. (2017) reveals the same indication that plastics are ingested by sea turtles additional to the study from Greece by Digka et al. (2020). Juvenile Loggerheads are also in this area found to be especially vulnerable to microplastics and macroplastics such as plastic debris.

Microplastics

The effects of microplastics on sea turtles can be harmful at cellular or subcellular level (Duncan et al. 2019). Microplastic can also act as a carrier for toxic substances such as heavy metals, persistent organic pollutant, and polychlorinated biphenyls. Several studies on human cells have shown that microplastics can cause cytotoxicity, oxidative stress, intracellular uptake, produce immune response, induce changes in the membrane, alter gene expression, cause weak embryotoxicity and haemolysis (Meaza et al. 2021). However, most of these studies treated the cells only for acute (24 h) exposure, and data on more prolonged exposure is needed as the ingesta passage time is approximately 23 days in turtles, depending on the diet.

It is a large limitation on the research part since the term microplastic is practically new as it was first used by Thompson et al. (2004). For a better understanding on how microplastics affect sea turtles and other marine species, as well as humans, it is necessary for new data development.

Entanglement

Entanglement, or the entrapment of species by debris, is an unfortunate effect of plastics in the ocean. The main culprits of entanglements are plastic films, such as bags, and fishing gear, both active and lost (ghost gear). In fact, 5.5% of sea turtles encountered in the study got entangled, where 90% of the entangled turtles die (Duncan et al. 2017). It is important to consider the distribution of these numbers, as a 5.5% of turtles is a relatively small number. However, some areas are more affected than others resulting in population wide effects in local areas (Duncan et al. 2017). Additionally, there is the consideration of animal welfare, even if a turtle survives there is a chance of long-term suffering and slow deterioration. Injuries sustained from entanglement have caused the need for amputations to several turtles (Barreiros and Raykov 2014).

Fighting the plastic problem

There are several ways to combat entanglement, entrapment, and consumption of plastics by turtles. A possible way could be the combination of collection efforts and preventative legislation. Collection efforts can be categorized into collection of plastics that is already in the wild, as well as incentives to dispose plastics properly by recycling. An example of an incentive would be a system where some plastic goods, for example bottles, have an additional fee, that is reimbursed when you deposit the bottles at a collection point. Such systems already exist in several countries, including Norway and helps prevent unnecessary plastic pollution that could find its way to beaches or into the ocean. The United Nation General Assembly adopted the 2030 *Agenda for Sustainable Development* in September 2015 with its 17 Sustainable Development Goals (SDGs) and 169 targets. SDG14, Life below water, with the focus on targets 14.1 and 14.4 that can contribute to the protection of sea turtles. Target 14.1 concerns the prevention and reduction of marine pollution of all kinds including plastics, while 14.4 demands ending destructive fishing practices. In the context of sea turtles this is

e.g., relevant regarding entanglement in ghost nets. The need for international legislation is also addressed by SDG14 in 14.c.

Other SDGs that are related to prevention of pollution are SDG11 (Sustainable cities) and SDG12 (Responsible consumption and production). Target 11.6 aims at the reduction of negative environmental impact of cities with specific focus on municipal waste management. Target 12.4 relates to reducing the release of plastics and other waste to water, minimizing its inauspicious influence on the environment. These targets may decrease the impact of plastic pollution on sea turtles through ingestion of plastic particles or items as well as at nesting beaches.

Conclusion

Sea turtles are threatened by plastic pollution in many ways. They belong to the few organisms that can be affected in both marine and terrestrial habitats (Gündoğdu et al. 2019), starting with the earliest life stage on the nesting beaches. Negative impact in the marine habitats can be caused by entanglement and ingestion. Ingestion of macroplastics is shown to cause harmful effects on sea turtles by internal injuries as well as malnutrition which affect sea turtles in all its life stages. The effects of microplastics on sea turtles remain uncertain, but some studies indicate that it might be harmful at a cellular level due to its ability to carry toxic substances. Plastic debris in the ocean can be reduced by collection efforts, and legislation can be put in place to reduce future pollution. However, there is currently not an effective way to collect microplastic, and more research is required in both the effects and the eventual removal process.

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