Marine Pollution Bulletin 135 (2018) 159–164

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Entanglement of birds in plastics and other synthetic materials

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ARTICLE INFO

Keywords:
Google
Bycatch
Fishing line
Kite strings
Netting
Mitigation

ABSTRACT

Entanglement of animals is one of the main environmental impacts of waste plastic. A 2015 review of entanglement records found that the proportion of affected seabirds increased from 16% of species to 25% over the last two decades. However, this was restricted to published records; Google Images and other web-based sources indicate that at least 147 seabird species (36%), as well as 69 freshwater birds (10%) and 49 landbirds (0.5%) from 53 families have been entangled in plastic or other synthetic materials. Fishing gear is responsible for entangling most species (83%), although it is often difficult to differentiate entanglement from bycatch on active gear. Mitigation measures include banning high-risk applications where there are alternatives (e.g. six-pack rings), discouraging the use of high-risk items (e.g. balloons on strings, 'manja' kites), and encouraging fishers to not discard waste fishing gear by providing specific receptacles and associated educational signage in fishing areas.

1. Introduction

Plastics are a complex set of synthetic polymers that are largely immune to biological degradation. Their relatively low cost, light weight, long lifespan and excellent barrier properties makes them the first choice of material for a wide range of applications (Andrady and Neal, 2009). Unfortunately, the characteristics that make plastics such versatile materials also make them excellent pollutants that persist in the environment for many years, and that can disperse far from source areas (GESAMP, 2015). Global production of plastics has increased rapidly over the last 70 years to > 300 million tonnes per year (~400 million tonnes if you include synthetic fibre production), and continues to grow at around 8% per year (Geyer et al., 2017). Most waste plastics (79%) are either disposed of in landfills, or released into the environment (Geyer et al., 2017). As a result, waste plastic items are now ubiquitous marine pollutants that have significant economic and environmental impacts (Gregory, 2009; Kühn et al., 2015). More recently there has been concern about waste plastics in freshwater systems (e.g. Wagner and Lambert, 2018), partly because most marine plastics derive from land-based sources. Rivers, in particular, are major vectors of waste plastics into the sea (Lebreton et al., 2017). However, there also is concern about the impacts of plastics on freshwater biota.

The main impacts of waste plastics on birds arise from ingestion of small plastic items, and entanglement in larger items (Ryan, 1990a; Laist, 1997; Kühn et al., 2015). The most recent reviews suggest that at least 40% of all seabird species contain ingested plastic, and 25% have been recorded entangled in plastic (Gall and Thompson, 2015; Kühn et al., 2015; Ryan, 2016). Entanglement of birds is more obvious than ingestion, as are its impacts, which include injury, impeded mobility (with consequences for the ability to obtain sufficient food or avoid predators) and drowning (Laist, 1997; Kühn et al., 2015). However, entanglement tends to be relatively infrequent in most species, and many entangled birds are not detected because they die far from land (Laist, 1997). It is thus likely that more bird species are entangled than is readily perceived (Laist, 1997; Kühn et al., 2015).

Laist (1997) produced the first review of entanglement records for marine animals, and reported that 16% of seabirds (51 species, although he listed Rockhopper Penguin *Eudyptes chrysocome* in error, see Supplemental Table 1) had been reported entangled in marine debris, as well as five other bird species (two geese, a shorebird, a raptor and a passerine, although the latter was drowned in a stranded box that filled with water, and thus not really entangled). Kühn et al. (2015) updated this list to the end of 2014, and found that 25% of seabird species had been reported as entangled (103 species; the proportion of species affected increased less than the total number of species because of taxonomic changes and the inclusion of sea ducks and loons by Kühn et al. that increased the total number of seabirds from 312 in Laist's, 1997 review to 406 in Kühn et al., 2015). Kühn et al. (2015) concluded that all species of seabirds were at risk of entanglement, and that the list of affected species was bound to increase.

Little is known about the impacts of plastics on freshwater birds (Wagner and Lambert, 2018). Several ducks and other waterbirds have been recorded to become entangled in waste plastics (e.g. Laist, 1997; Thiel et al., 2011; Hong et al., 2013; Sazima and D'Angelo, 2016), but

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https://doi.org/10.1016/j.marpolbul.2018.06.057
Received 6 June 2018; Received in revised form 21 June 2018; Accepted 23 June 2018

Fig. 1. Three Cape Gannets *Morus capensis* entangled in monofilament fishing line at Bird Island, Algoa Bay, in November 2006 (Leshia Upfold). The central bird was foul hooked by the red and white lure on its breast, and thus probably caught on active fishing gear (=bycatch), but the other two birds were presumably entangled subsequently. Camphuysen (1990) reported how four Northern Gannets *M. bassanus* struggling to free themselves from a net fragment attracted other gannets that also became entangled.

most studies on the impacts of plastics on freshwater birds to date have focused on ingestion (e.g. English et al., 2015; Faure et al., 2015; Holland et al., 2016; Gil-Delgado et al., 2017; Reynolds and Ryan, 2018). Landbirds also are occasionally entangled in synthetic debris (e.g. Thiel et al., 2011; Townsend and Barker, 2014). There has been no review of entanglement records among freshwater or terrestrial bird species.

This paper attempts to list all bird species recorded to be entangled in discarded plastics or other synthetic materials. The graphic nature of entanglements lends them to being recorded by members of the public and reported in the popular media. Accordingly, I used Google searches (initially focusing on Google Images, but then more broadly) to locate entanglement records that had not been published or captured in reviews to date. Google Images can be a useful resource for collecting biologically relevant data (Leighton et al., 2016). These searches not only identified entangled freshwater and terrestrial bird species but also additional seabirds. My review confirms that virtually all marine and freshwater birds are at risk of entanglement in waste plastics and other synthetic materials, and that a wide diversity of terrestrial species also are impacted at least occasionally.

2. Methods

The entanglement records listed in the Online Supplement 1 in Kühn et al. (2015) were used as the starting point for this review; only references to additional records are given here or in Supplemental Table 1. Searches of the literature and the internet were made using various combinations of search terms including 'entangle' and 'entanglement', and different bird groups (mainly waterbirds) as well as other terms such as 'plastic', 'balloon', 'six-pack ring', etc. To limit a language bias, searches also were conducted in Spanish, Portuguese, French, German, Italian, Dutch, Swedish, Norwegian, Finnish, Polish, Russian, Arabic, Hindi, Malay, Thai and Japanese using the term 'entangled bird' as translated by Google translate, which added four additional species records (two from Italy, one from Chile and one from Sweden). However, some searches yielded a high proportion of irrelevant images, which suggests that the translated search term might not always have been appropriate. The literature search focused mainly on sources published since 2014, but older sources listed by Kühn et al. (2015) were checked to identify the type of entangling material (listed by Laist, 1997, but not Kühn et al., 2015). These searches located some additional records overlooked in previous reviews.

Only birds caught in discarded materials were included. Birds are entangled by a diverse array of items ranging from Christmas decorations and fake halloween spiderwebs to football goal nets (e.g. Chicago Bird Collision Monitors, birdmonitors.net), but these records were ignored as they were not discarded debris. However, it is often impossible to differentiate between captures in active or 'ghost' fishing gear. Birds found entangled in fishing line could have been caught by discarded line, or in active gear (cf. Taylor, 2004; Abraham et al., 2010). Records involving the ingestion of fishing hooks probably are best treated as bycatch rather than entanglement or ingestion. However, some birds that swallow hooks either break free or are cut from the line and fly off, only to become entangled by the trailing line in trees or other vegetation (e.g. frigatebirds; Gauger Metz and Schreiber, 2002; Tirtaningtyas and Hennicke, 2015). And in some instances, bycatch can result in the subsequent entanglement of other individuals (Fig. 1). Similar problems of interpretation occur with fragments of gill nets that wash ashore containing birds (e.g. Camphuysen, 2000; Good et al., 2009; Moore et al., 2009). Given the difficulty in teasing apart these various causes of entanglement, all cases involving fishing hooks/lines and fishing nets of indeterminate provenance have been included in this report as entanglement, which is consistent with previous reviews (e.g. most of the records of albatrosses and many of those for loons, grebes and cormorants in Kühn et al., 2015 involve birds that swallowed hooks). However, I excluded birds definitely caught in active fishing gear as well as in netting designed to keep birds off crops or out of fish ponds (cf. Nemtzov and Olsvig-Whittaker, 2003).

Most internet sources included images of the entangled birds, and some included descriptions of the entangling material, which was used to record the type of material responsible for each entanglement. However, it is not easy to identify all thread-like items (e.g. differentiating fishing line from kite string or other strings). Translucent monofilament fishing line was fairly easy to recognise in good quality images, but braided fishing line was harder to identify. Even in the hand it can be hard to determine the source of entangling threads (cf. Weston et al., 2009). When there was uncertainty as to the nature of the thread-like material it was listed as 'fishing line' as this is the most common source of these materials. However, netting used for other purposes (e.g. baling hay or landscape netting, cf. Husak and Landoll, 2012) was listed under 'other rope/string' rather than fishing gear.

Not all species were correctly identified. Some misidentifications were easy to detect (e.g. a Ruddy Turnstone *Arenaria interpres* labelled as a Least Sandpiper *Calidris minutilla*, https://previews.123rf.com/images/cpaulfell/cpaulfell1206/cpaulfell120600023/14175652-a-least-sandpiper-with-monofilament-fishing-line-tied-around-foot-.jpg), but others were more subtle (a Lesser Scaup *Aythya affinis* incorrectly identified as a Greater Scaup *A. marila*, http://moosetique.com/wp-content/uploads/2015/03/Scaup_16-March-GLB-7807_ME.jpg). There thus needed to be some expert input to confirm species identifications.