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SHORT NOTE

Marine debris in the nests of tākapu (Australasian gannets, *Morus serrator*) in the inner Hauraki Gulf, New Zealand

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Marine debris, principally plastics, are a persistent pollutant in marine systems (Law 2017). The recovery of plastics from the digestive tracts of both coastal and pelagic seabirds or from around their nests has demonstrated that plastics are ubiquitous across all oceans (Wilcox *et al.* 2015; Jagielle *et al.* 2019) and has led to the use of these birds as indicators for the distribution and relative amount of marine plastic debris (Hartwig *et al.* 2007; Ryan *et al.* 2009; van Franeker *et al.* 2011; van Franeker & Law 2015; Acampora *et al.* 2016).

Seabirds are impacted by plastics through the consequences of ingestion and entanglement (e.g. Votier *et al.* 2011; Lavers *et al.* 2014; Ryan 2018). The likelihood of different types of impacts on species are related to their feeding behaviour (e.g. Provencher *et al.* 2014a). Gannets feed by a combination of plunge diving and underwater pursuit (Machovsky-Capuska *et al.* 2011). Although diving seabirds, including gannets, have been recorded with ingested plastics (Pierce *et al.* 2004; Provencher *et al.* 2010; Tavares *et al.* 2016) direct ingestion of mostly floating plastic debris is generally less likely than for surface feeding birds (Provencher *et al.* 2010, but see Tavares *et al.* 2016). However, several studies have noted that the incorporation of marine debris, particularly fibres, cord, or rope manufactured from plastics, occurs in the nests of both northern (*Morus bassanus*) and Australasian (tākapu, *Morus serrator*) gannets (Montevecchi 1991; Norman *et al.* 1995; Bond *et al.* 2012). Entanglement may occur around the mandible of gannets, when feeding or manipulating nesting material, or around the legs and feet on plastic that has been used in nest construction (Schrey & Vauk 1987; Votier *et al.* 2011; Rodriguez *et al.* 2013).

Our objective was to determine the extent and nature of plastic debris in the nests of Australasian gannets at Horuhoru Island in the inner Hauraki Gulf, New Zealand. This may provide an indication of the likely risk of entanglement and the prevalence of plastic, particularly fishing debris in the surrounding gulf (Montevecchi 1991; Bond *et al.* 2012; Provencher *et al.* 2014b). Gannets are coastal feeding seabirds that occur

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in warm or cool temperate waters characterised by seasonally productive waters that frequently support important fish populations, and hence may encounter debris arising from commercial or recreational fishing as well as terrestrial sources. Commercial fishing is focussed in the outer gulf, but does occur within the inner Hauraki Gulf and includes bottom longlining, set netting, and trawling (Whitehead *et al.* 2019). In addition, due to its proximity to the largest urban area in New Zealand, recreational boating and fishing effort in the gulf is high (Whitehead *et al.* 2019). This coupled with the semi-enclosed nature of the water body may result in plastic debris persisting in the area (Barnes *et al.* 2009; Whitehead *et al.* 2019). Gregory (1991) noted that beaches around the inner Hauraki Gulf had substantial amounts of plastic debris from land-based sources although only small amounts of debris from fishing activities. A review of the environmental state of the Hauraki Gulf did not specifically consider the issue of plastic debris in the system (Aguirre *et al.* 2016).

This study was conducted at Horuhoru (Gannet Rock) (36°43′S, 175°10′E), 1.5 km off the north east corner of Waiheke Island in the inner Hauraki Gulf, New Zealand. The gannet colony is located along the top of the main ridge of the islet and on the east-facing slopes of Horuhoru. The west-facing side of the rock falls off as a cliff and is not suitable for nesting. We conducted our nest checks on 12 January 2019 when the colony contained a total of 134 chicks. A count of occupied nests in November 2017 in the previous breeding season indicated a breeding population of approximately 1,000 pairs (Gaskin *et al.* 2019). This suggests that gannets had a poor breeding season, or that by the January count date a substantial number of chicks had fledged and departed from the island. While not necessarily mutually exclusive explanations, that most chicks on the rock were large and replacing the down with feathers or had completed this process is suggestive of departures of fledglings prior to counting. To minimise disturbance to remaining birds we examined nests at the lowest section of the colony on the east facing slope. In this part of the colony chicks had moved away from their nest sites to form small crèches. We examined all 57 nest pedestals in the area.

For each nest we recorded the number of plastic items that formed part of the nest. We did not distinguish between polypropylene, nylon, and polyester ropes or cords. These items were classified into braided plastic cord, plastic threads, knot clumps of plastic cord, and packaging straps. Tangles consisted of individual threads of plastic that had become twisted together into an inseparable bundle. Knots were short pieces of plastic cord that had been deliberately knotted. We measured the length of the plastic items and recorded their colour. In contrast to some other studies in which nests were probed for plastic waste (e.g. Montevecchi 1991; Norman *et al.* 1995; Bond *et al.* 2012), we only recorded details from plastic that was visible.

A total of 49 (86%) of the 57 nests examined contained plastic. Most of the items of plastic recovered (N = 125) consisted of braided cord or individual threads most likely derived from the cord (Fig. 1 & 2). Many of the plastic items were black (56%) with other darker colour items (black combination and blue) comprising another 29.6% (Fig. 3). The average length of plastic cord or threads was 21.6 ± 1.2 cm (± 1S.E.) (Fig. 4).

Figure 1. Plastic debris in Australasian gannet nest at Horuhoru, Hauraki Gulf. The nest bowl is about 25 cm.

The prevalence of plastic debris in nests at Horuhoru was substantially higher than the 28.4% of nests of the same species at three colonies in Victoria, Australia (Norman *et al.* 1995). It was also higher than the 46% averaged across 29 northern gannet colonies that contained marine debris, including plastics (O'Hanlon *et al.* 2019) although values at some colonies was substantially higher. For example, 97% of all nests examined across two Northern gannet colonies in Newfoundland,

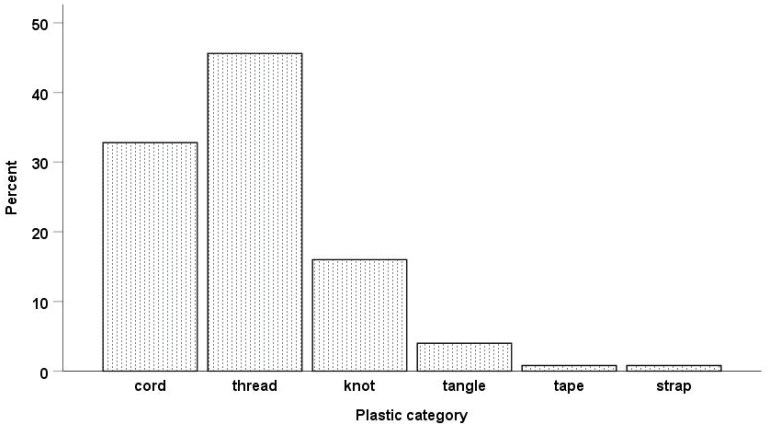

Figure 2. Proportion (%) of different categories of marine debris recovered from 57 Australasian gannet nests at Horuhrou, Hauraki Gulf, New Zealand.

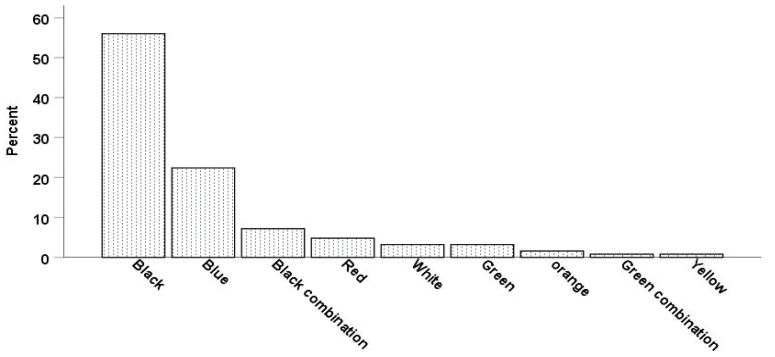

Figure 3. Proportion (%) of colours from marine debris (N = 125) recovered from Australasian gannets at Horuhoru, Hauraki Gulf, New Zealand.

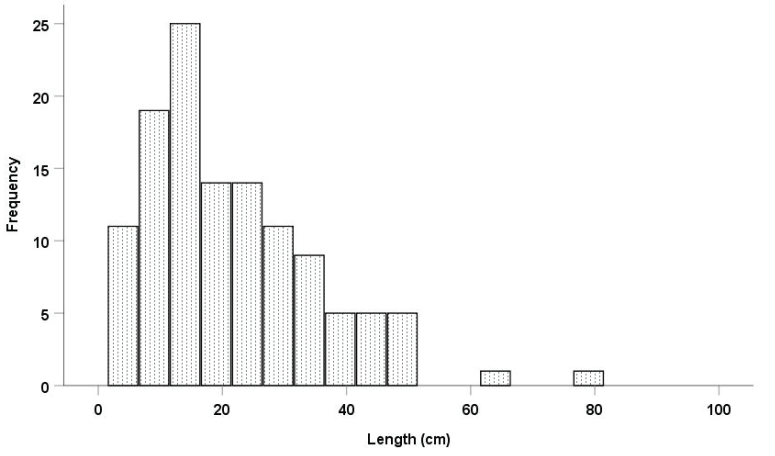

Figure 4. Size frequency distribution of long axis of marine debris (N = 125) recovered from gannet nests at Horuhoru, Hauraki Gulf, New Zealand.

Canada in 1988 and 1989 (Montevecchi 1991) and 80% of nests in a Welsh colony in the western Atlantic (Votier *et al.* 2011) contained plastic debris. Our nests represented a group of neighbouring nests on the periphery of the colony, and so may not be representative of the whole colony. By not probing nests for debris, we may have underestimated plastic prevalence. In the Australian study, Norman *et al.* (1995) noted that in one of three colonies the central nests, presumed to be older established nests, contained more plastic items than more peripheral nests.

Australasian gannets build nests from a combination of guano deposited by birds over time and material, such as strands of seaweed, collected at sea by male birds (Matthews *et al.* 2008). Although individuals will pilfer seaweed from nearby nests or birds, most seaweed is likely collected from the surface of surrounding waters. The elongated nature of plastics items recovered from the nests of other Australasian gannets and other sulids is consistent with the described collection of nesting material, as suggested by other studies (e.g. Bond *et al.* 2012).

While some recycling of plastic by birds is likely to occur through pilfering within the colony, our data suggest that plastic marine debris is frequently encountered by gannets in the inner Gulf and more often than that of Australasian gannets in Victoria in the early 1990s. In the absence of historical data from Horuhoru it is unclear whether this reflects an increase in plastic debris over time across the species range and/or differences in the local conditions between the two sites. Partly consistent with the largely black and red marine debris collected by the tropical sulid *Sula leucogaste*a (brown booby), recovered debris from Australasian gannets was dominated by dark colours. This may result from selection by gannets for elongated nesting materials similar in colour to the seaweeds although without data on relative abundance of different plastic debris in the surrounding water this conclusion is tentative. Despite its high prevalence in nests we noted no entanglement of gannets by plastic in January 2019. During three visits over three consecutive breeding seasons to the colonies at Horuhoru and Mahuki Island (in the outer gulf) we noted only a single case of entanglement involving a bundle of plastic threads wound around the lower bill of an adult gannet. Higher entanglement rates have been recorded for some populations of northern gannets. Votier *et al.* (2011) noted that nestlings were most at risk and that once entangled, mortality rate was high. However, the total numbers of birds affected remained relatively small and was considered to have little population level effect (Votier *et al.* 2011). At-sea surveys conducted in the non-breeding season have shown similarly, that immature northern gannets are disproportionally impacted (Roderiguez *et al.* 2013) and that, exceptionally at one sampling location entanglement rate reached 20.2 % of the observed birds.

Much of the plastic encountered by Australasian gannets in the Hauraki Gulf is likely derived from discharged fishing gear, boat gear, or possibly mariculture operations that are located nearby (Kemper *et al.* 2003). In contrast to some studies on northern gannets (e.g. Bond *et al.* 2012) we did not recover pieces of plastic fishing nets from gannet nests at Horuhoru. The link between fishing intensity or activity and prevalence of fishing related debris in gannet nests has been demonstrated in several studies on northern gannets (Bond *et al.* 2012; O'Halon *et al.* 2019). O'Halon *et al.* (2019) noted colonies located in areas of high fishing effort had a greater proportion of nests with incorporated debris. Similarly, Bond *et al.* (2012) showed that the proportion of northern gannet nests with marine debris decreased following the closure of a gill net based fishery and the occurrence of debris in gannet nests was substantially higher at colonies closer to fishing areas compared to those located further away. A similar relationship between the occurrence of marine debris in bird nests and availability in the environment has been demonstrated for brown boobies (*Sula leucogaster*) in the tropical Atlantic Ocean off Brazil (Tavares *et al.* 2016). Consequently, we conclude the high prevalence of plastic at gannet nests at Horuhoru indicates these plastics are common in the surrounding waters although incorporation of plastic into nests may also be affected by the availability of seaweed as nesting material. While plastic debris was common in gannet nests at Horuhoru the number of discrete items per nest was low (125 items from 57 nests). Internet sourced images of gannets; identified using search terms that included gannet, nest, plastic, and marine debris; as well as estimates of the average amount of plastics (470 g) at some northern gannet colonies (Votier *et al.* 2011) suggest accumulation amounts were substantially greater at some of these northern gannet colonies with an increased risk of entanglement than at Horuhoru.

In summary, plastic marine debris commonly occurs in gannet nests at a colony in the inner Hauraki Gulf consistent with its collection as nesting material and its likely commonly availability in the surrounding water. At present levels the risk of plastic entanglement of gannets breeding at Horuhoru seems low compared to other northern gannet colonies. Future surveys should indicate whether prevalence and abundance of plastic marine debris in nests increases, along with the associated risks of entanglement, and by expanding to other colonies whether the inner Gulf waters are particularly polluted with plastic marine debris.

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