MINIMAL PLASTIC IN FLESH-FOOTED SHEARWATER *ARDENNA CARNEIPES* BURROWS AT SOUTHWESTERN AUSTRALIA COLONIES

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ABSTRACT

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Flesh-footed Shearwaters *Ardenna carneipes* are declining globally, and exposure to plastic pollution may be a contributing factor. To investigate the exposure of the southwestern Australian population to plastic, under the assumption that fragments would be defecated by burrow occupants or occasionally spilled as parents regurgitate food to their young, sand samples were collected from nesting burrows from Shelter and Breaksea islands and examined for plastic fragments. One fragment was found among a total of 67 burrows inspected. The lack of plastics may be due to the feeding habits of these birds, or the availability of plastics related to local oceanography. Our study provides evidence that plastics may not yet be an issue for nesting Flesh-footed Shearwaters on the south coast of Western Australia.

Key words: *Ardenna carneipes*, southern Western Australia, plastics, burrows, Flesh-footed Shearwater

INTRODUCTION

Plastics have a negative impact on wildlife of all trophic levels, including marine birds (Cressey 2016, Lavers 2015), and have been found in many remote locations (Jamieson *et al*. 2017). The effect of plastics on wildlife includes entanglement (Cressey 2016), displacement of food in the diet (Rodríguez *et al*. 2012), and exposure to chemicals including Bisphenol A (S and C) and phthalates (Hardesty *et al*. 2015). The distribution of plastics in the ocean is uneven, with plastic accumulating in the central gyres of most ocean basins, forming "Garbage Patches". In the Indian Ocean, one patch extends from South Africa to waters off southwestern Australia (Cozar *et al*. 2014, Cressey 2016, Eriksen *et al*. 2014). The degree of exposure to plastics by marine birds is likely to depend on a combination of feeding behaviour and the concentration of plastics in foraging grounds (Young *et al*. 2009).

Procellariform seabirds, including Flesh-footed Shearwaters *Ardenna carneipes* (FFSH), are upper trophic level predators and experience a range of threats, including the ingestion of plastics (Lavers 2015). The ingestion of plastics has been estimated through opportunistic necropsies of dead birds (Acampora *et al*. 2014) and emetics (Bond & Lavers 2013) on live animals. Necropsies rely on the availability of dead birds, and emetics may cause concern for the wellbeing of birds (Carlisle & Holberton 2006, Hardesty *et al*. 2015). Emetics may also underestimate the exposure of chicks to plastics (Sileo *et al*. 1989). Non-destructive techniques that sample the relationship between seabirds and plastic debris are important tools for assessing levels of plastic ingestion. One method of estimating exposure to plastics in seabirds is to examine plastic prevalence in nests and burrows, as has been done for Satin Bowerbirds *Ptilonorhynchus violaceus* (Coleman *et al*. 2004) and Brown Boobies *Sula leucogaster* (Lavers *et al*. 2013).

Lavers & Bond (2016) necropsied adult FFSHs from fishery by-catch and beach-cast fledglings in southwest Western Australia (WA). They found that 13% of adults (2–3 fragments each) and nearly all post-fledglings (19 fragments per bird) had ingested plastic. Lavers & Bond (2016) suggested that the heavy load in post-fledglings indicated risky early foraging habits. We examined the abundance of plastics in FFSH burrows on two islands on the WA south coast to determine if plastic ingestion by post-fledglings occurred via parental feeding. We assumed that plastic particles would be deposited through sloppy feeding of chicks, defecation, and chick death. Therefore, adults undertaking burrow maintenance would be likely to kick plastic particles from burrows along with other debris. We predicted that the burrow mounds of FFSHs on Shelter and Breaksea islands act as an accumulation sink for plastic fragments transported by individuals from the sea to the burrows.

METHODS

We surveyed FFSH burrows on two islands near Albany, WA (Fig. 1). Shelter Island (10 ha, 35°4′S, 117°41′38″E) and Breaksea Island (103 ha, 35°3′44″S, 118°3′E) can be visited by the public, but this is infrequent (Mr P. Collins 2015, pers. comm.). We visited Shelter Island in May 2016 after the birds had dispersed from the area, and both islands in January 2017 during the breeding season.

On Shelter Island, 37 burrows were selected randomly from the main collection of burrows at the island's eastern end. At larger Breaksea Island, groups of burrows are distributed around the whole island. We excluded burrows near man-made structures to avoid the possibility of collecting "litter." Five burrows were sampled from six of the remaining burrow groups (30 burrows total). We maintained a high level of vigilance while traversing the island to find additional plastics and remains of birds to examine for plastic fragments.

Soil samples were collected from each burrow mound to include the most recently excavated soil. One litre of soil was collected from a 15 × 15 cm quadrant. Large items of organic matter were removed. Each sample was then passed through two sieves (2 mm, 1 mm mesh). The material retained was emptied onto a sorting tray and examined for plastic fragments.

RESULTS AND DISCUSSION

Despite a concerted effort to find plastics in the nesting habitat of FFSH on Breaksea and Shelter islands, only one plastic pellet was found. During the survey, only two adult carcasses and no boluses were found. Neither carcass contained plastics.

The plastic dynamics on the south coast of Western Australia, therefore, are in stark contrast to Lord Howe Island in the Tasman Sea, where Hutton (2004) observed plastic fragments scattered on the ground and within FFSH carcasses. Hutton *et al*. (2008), finding that nearly all birds as well as boluses examined contained plastic fragments, speculated that ingestion was so pervasive that chicks died indirectly from their plastics load. Thus, the lack of plastics in burrows or dead chicks in our study area indicates that plastics availability within the foraging areas of FFSH breeding in southern WA is comparatively less, and is not yet a threat to these populations during chick rearing.

A number of factors may have affected our results. Several studies indicate that adult FFSH have a smaller plastics load than fledglings or chicks (Acampora *et al*. 2014, Hutton *et al*. 2008, Priddel *et al*. 2006, Roman *et al*. 2016). Roman *et al.* (2016) pointed out that individuals among several procellariform species regurgitate boluses that may contain indigestible material—including plastics—and this may account for the smaller quantities of plastics found in adults. Lavers & Bond (2016) suggest, however, that FFSH chicks are unable to regurgitate boluses prior to fledging. It is possible, therefore, that chicks fledged from southern WA who are exposed to sub-lethal quantities of plastic may regurgitate boluses after fledging, effectively exporting plastic off the island. Indeed, those authors found that almost all post-fledging FFSH examined from their south coast study area did contain plastic fragments, perhaps due to accumulation from parental feedings in addition to their own initial feeding activities. This finding would be in accord with FFSH fledglings being naïve consumers, ingesting more plastic fragments than adults (Carey 2011, Rodríguez *et al*. 2012). Given that no boluses were found on the WA islands, this raises the possibility that increased plastic ingestion may eventually lead to more frequent regurgitation.

The mechanisms driving the differences in plastic abundance between Lord Howe Island, and Shelter and Breaksea islands, may be due to the availability of plastics in respective foraging areas (Hutton *et al*. 2008, Roman *et al*. 2016, Tavares *et al*. 2016, Young *et al*. 2009). However, data are insufficient to make a proper comparison. Measurements of plastics density in the waters off southwestern WA made in August 2011 indicate the presence of 500–1500 pieces km^{-2} (Reisser *et al*. 2013), and Cozar *et al.* (2014) estimated the plastic mass in the same area at <50 g/km^{2}. Reisser *et al*. (2013) estimated the concentration of plastics in the Tasman Sea, and found that it ranged from <500 km^{-2} in the ocean to >15500 km^{-2} near Sydney. However, this study did not measure plastic density in waters in the vicinity of Lord Howe Island, precluding direct comparisons between the two regions.

Burrow density may also affect the likelihood of finding plastics on the ground between burrows in FFSH colonies. Buxton *et al*. (2013) found no plastics on Mauitaha Island, where burrow density (0.034 burrows m^{-2}) is similar to Breaksea Island (~0.033 burrows m^{-2}; Lavers 2015), but they did find plastics on Ohinau Island, where burrow density was 0.058 m^{-2} and the plastic density was 0.031 m^{-2}. On Lord Howe Island, burrow density was estimated to be 0.123 m^{-2} (Priddel *et al*. 2006) and plastic is easily seen on the ground (Hutton 2004).

While burrow density and plastics abundance appear to be related, it is likely that oceanographic features that increase productivity, and therefore burrow density, may also concentrate plastics. The productive Tasman Front that surrounds Lord Howe Island may be an example of this. In contrast, the ocean off southwestern WA has low productivity. Moreover, the oceanographic processes may move plastics offshore during the FFSH chick-feeding period. At that time, the prevailing winds in southwestern WA cause offshore Ekman transport (Ridgway & Condie 2004), potentially moving fragments out of foraging range of breeding FFSH (Powell 2009) and reducing the likelihood that plastics are fed to chicks. In summary, we suggest that plastics are not yet accumulating on Shelter and Breaksea islands due to several factors, and are therefore not a direct cause of FFSH chick death on these islands.

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Fig. 1. Location of the study sites in Western Australia.

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