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# Occurrence of Plastic Particles in Seabirds from the Eastern North Pacific

LOUISE K. BLIGHT and ALAN E. BURGER*
*Department of Biology University of Victoria, Victoria, British Columbia, Canada V8W 2Y2 and Bamfield Marine Station, Bamfield, British Columbia, Canada V0R 1B0*

**We found plastic particles in the stomachs of 8 of the 11 species of seabirds caught as bycatch in the pelagic waters of the eastern North Pacific (41–50°N, 131–134°W). Plastic was found in all surface-feeding birds (two storm-petrel, one albatross, one petrel and one fulmar species) and in 75% of shearwaters. Densities in some storm-petrels, shearwaters and the petrel were possibly sufficient to impede digestion, but were negligible in other birds. Plastic was also found in two diving species (puffins) but absent in three others (murre, auklet and murrelet). Of 353 anthropogenic items examined, 29% were industrial pellets and 71% were fragments of discarded products ('user' plastic), with user plastic making up 60% of total mass. Our study is evidence of widespread plastic pollution affecting birds in a previously unsampled sector of the North Pacific. © 1997 Elsevier Science Ltd**

Plastic particles floating on the sea surface are ingested by seabirds in many parts of the world (Furness, 1983, 1985; van Franeker, 1985; Fry *et al.*, 1987; van Franeker & Bell, 1988; Robards *et al.*, 1995). Voluntary ingestion likely occurs in surface-feeding birds due to floating particles of plastic being confused with prey items (Azzarello & van Vleet, 1987; Fry *et al.*, 1987; Boersma & Groom, 1993) or may enter birds within the bodies of prey species, as is suspected for some alcids (Robards *et al.*, 1995). Plastic is often passed from parents to chicks in regurgitated food (Fry *et al.*, 1987; Ryan, 1988; van Franeker & Bell, 1988; Sievert & Sileo, 1993).

Two types of plastic debris are commonly consumed by seabirds: manufactured plastic products ('user' plastic) such as bags, bottles, containers and packaging that are discarded at sea and slowly broken down into smaller fragments; and raw industrial plastic pellets which may occur at sea at densities as high as 8000 per $km^2$ (Pruter, 1987). We report the occurrence of plastic particles in 11 species of seabirds collected from the mid-latitude eastern North Pacific, in an area previously unsampled.

*Corresponding author.

## Study Area and Methods

We examined a sample of 58 seabirds drowned in an experimental drift-net fishery for squid, 13 June–24 August 1987, in oceanic water 250–500 km off British Columbia, Washington and Oregon (area bounded by 41–50°N, 131–134°W; Jamieson & Heritage, 1988). The nets were green 8-gauge monofilament with mesh size of 115–121 mm (Jamieson & Heritage, 1988). Birds were frozen when collected and the stomachs (gizzards and proventriculi) later removed and contents examined.

Particles from each stomach were separated into user plastic and industrial pellets. These were counted, classified by colour, air-dried, and weighed (to 0.001 g). Very small particles were identified using a microscope. The presence of other anthropogenic material, pumice and pebbles was noted.

## Results

Eight of the eleven species (73%) had ingested plastic particles (Table 1). Plastic was found in all surface-feeding procellariiforms examined (albatross, petrel, fulmar and storm-petrels), in 75% of the shearwaters, and in 39% of the pursuit-diving alcids. The number of pieces of plastic in each bird was highest among the two species of storm-petrels and in the single Stejneger's Petrel *Pterodroma longirostris* (Table 1). One Sooty Shearwater *Puffinus griseus* contained 23 particles.

Most (95%) birds containing plastic carried less than 0.3 g each, and only one Sooty Shearwater (carrying 1.1 g) and one Black-footed Albatross *Diomedea nigripes* (6.6 g) had loads exceeding 1 g. A second Sooty Shearwater had ingested a wad of fibrous material, possibly surgical dressing, with a mass of 4.8 g, or 32% of the total mass of anthropogenic material examined. This was excluded from further analyses.

Of 353 ingested items, 29.2% were industrial pellets and 70.5% were user plastic (7.9% and 60.1% by mass, respectively). The proportions of each plastic type varied among species (Table 1). Pieces of monofilament line found in two albatrosses were included as user plastic. The majority of plastic particles were beige or

TABLE 1
Occurrence and composition of plastic particles in seabirds from the eastern North Pacific.

| Species | | No. of birds sampled | % Containing plastic | No. of particles per bird | | | Industrial pellets (% of total particles) |
|---|---|---|---|---|---|---|---|
| *Surface-feeding procellariiforms* | | | | | | | |
| Black-footed Albatross | *Diomedea nigripes* | 3 | 100 | 5.3 | 2.9 | 2–11 | 50 |
| Fork-tailed Storm-petrel | *Oceanodroma furcata* | 7 | 100 | 20.1 | 6.6 | 1–51 | 16 |
| Leach's Storm-petrel | *O. leucorhoa* | 1 | 100 | 47 | — | 47 | 6 |
| Northern Fulmar | *Fulmarus glacialis* | 3 | 100 | 7.7 | 5.2 | 1–18 | 48 |
| Stejneger's Petrel | *Pterodroma longirostris* | 1 | 100 | 24 | — | 24 | 71 |
| *Surface-feeders/pursuit divers* | | | | | | | |
| Sooty Shearwater | *Puffinus griseus* | 20 | 75 | 3.4 | 1.3 | 0–23 | 38 |
| *Pursuit divers (alcids)* | | | | | | | |
| Tufted Puffin | *Fratercula cirrhata* | 9 | 89 | 3.3 | 0.9 | 0–9 | 43 |
| Horned Puffin | *F. corniculata* | 2 | 50 | 1.5 | 1.5 | 0–3 | 100 |
| Common Murre | *Uria aalge* | 1 | 0 | 0 | 0 | 0 | 0 |
| Xantus' Murrelet | *Synthliboramphus hypoleucus* | 5 | 0 | 0 | 0 | 0 | 0 |
| Rhinoceros Auklet | *Cerorhinca monocerata* | 6 | 0 | 0 | 0 | 0 | 0 |

brown (68%), while 15% were white or grey, 5% blue, 4% black, and the remaining 8% were light shades of various colours. Most blue particles (16 of 19) were found in storm-petrels. Small stones and pumice (specific gravity $>1.0$ and $<1.0$, respectively) were found in five birds.

## Discussion

A high proportion of seabirds examined by us, including every one of the surface-feeding procellariiforms, contained plastic particles in the proventriculus or gizzard. In most birds the quantities found were considered unlikely to impede digestion but in small storm-petrels, the Stejneger's Petrel, and one Sooty Shearwater the quantities might have been sufficient to reduce the volume of food in the gizzard, or to affect its assimilation. Although shearwaters dive below the surface to take prey in addition to feeding at the surface, 75% of the 20 shearwaters in our sample contained plastic.

The alcids are pursuit-divers and unlikely to feed on surface-floating objects. In this group we found no plastic in three species: the Common Murre *Uria aalge*; Xantus' Murrelet *Sythliboramphus hypoleucus*; and Rhinoceros Auklet *Cerorhinca monocerata*. By contrast, plastic particles were found in a high proportion of both puffin species (Tufted Puffin *Fratercula cirrhata* and Horned Puffin *F. corniculata*) in our sample. The absence of plastic in some alcids and presence in others may be related to dietary differences and a variable tendency among prey species to ingest plastic pellets.

The majority of birds examined by us had ingested more user plastic than industrial pellets, although the opposite pattern was observed in Alaska where industrial plastics made up 75% and 76% of the plastic particles found by Day (1980) and Robards *et al.* (1995), respectively. The differences in our results likely reflects differing composition of floating plastic rather than regional differences in feeding preferences of the birds. The predominance of beige or brown coloured plastic in our sample is probably due to the similarity of these particles to prey items, but we cannot rule out the possibility that these colours were more common among the floating particles.

Increasing plastic production since the 1960s and a corresponding rise in the amount of plastic debris in the oceans correlate with an increase in the consumption of plastic in seabirds (Sievert & Sileo, 1993; Robards *et al.*, 1995). The uncertainty over the long-term, cumulative effects of this pollution on seabirds makes it important to monitor plastic ingestion worldwide. Our results confirm the high frequency of plastic particles in surface-feeding birds, as well as in some pursuit-divers, from the eastern North Pacific. This provides further evidence of widespread pollution of the pelagic ocean by both user and industrial plastic.

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