FIRST EVIDENCE OF PLASTIC INGESTION BY WHITE-TAILED TROPICBIRDS FROM O'AHU, HAWAI'I

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Ingested plastics have been reported in necropsies of marine birds, turtles, mammals, fish, crustaceans and squid (Laist 1997, Ocean Studies Board 2008). Herein, we report the first record of plastic ingestion by a White-tailed Tropicbird *Phaethon lepturus* (hereafter WTTR) sampled on O'ahu (Hawai'i). This observation adds a second tropicbird species (order Phaethontiformes) to the one sampled thus far and found to ingest plastic, and increases to 116 the number of seabird species in which this phenomenon has been observed.

Previously, comprehensive reviews of the literature reported evidence of plastic ingestion for at least 36.9% (115 of 311) of the seabird species sampled to date (Laist 1997, Ocean Studies Board 2008). Yet, there are significant differences in the incidence of ingestion among different orders, with tubenose seabirds (Procellariiformes: albatrosses, petrels, shearwaters, storm-petrels, diving petrels) most susceptible (63.4%, 64 of 101), and penguins (Sphenisciformes) the least (12.5%, 2 of 16). These disparities have been attributed to the higher susceptibility of surface-foragers to scavenge and eat floating plastic (e.g., Ryan 1987). Yet, despite the oceanic habits of tropicbirds, plastic ingestion has been investigated in only one of the three tropicbird species to date (Table 2).

As part of a collaborative research program in which specimens are salvaged for investigation of heath, diet and plastic ingestion, we investigated seabird specimens delivered to Sea Life Park, O'ahu (Hawai'i), since 2009. Two of us (JAJ and KDH) necropsied three WTTRs following standardized necropsy protocols (van Franeker 2004). The specimens belonged to the *dorothea* subspecies and were juveniles (first- or second-year birds), on the basis of their plumage (Pyle 2008). They were in poor body condition, as evidenced by the low breast muscle (pectoralis) scores (value range: 0 to 3) and subcutaneous / intestinal fat scores (value range: 0 to 3; Table 1). The stomach of one of these specimens contained a large (14.5 cm long, 3.25 cm wide) pale blue plastic fragment (Fig. 1). We contend that this large floating item was mistaken for an epipelagic fish, because of its size, shape and coloration.

WTTR is a widely distributed species, ranging throughout the world's tropical and subtropical oceans: the southern Indian, the western and central Pacific, the south Atlantic, and the Caribbean (Lee & Walsh-McGehee 1998). Approximately 1 800 pairs breed in Hawai'i, mostly in the main Hawaiian Islands: Kauai, Moloka'i, Lāna'i, Hawai'i, and the offshore islet of Mokoli'i. Although a few pairs nest on some areas of O'ahu, their abundance is poorly known (Harrison 1990, Lee & Walsh-McGehee 1998). WTTRs forage in deep water, rarely in association with subsurface predators (Harrison 1990), and feed on epipelagic prey, largely flying fish (2–12 cm in length), supplemented with squid and crustaceans (Harrison 1990, Lee & Walsh-McGehee 1998). WTTRs forage by plunge diving from 15–20 m above the water, and can consume very large fish, up to 18% of their body mass (Harrison 1990). While WTTRs do not forage in multi-species flocks involving subsurface

TABLE 1
Summary of necropsy results of three juvenile White-tailed Tropicbirds

Collection date	Age	Sex diagnostics	Weight (g)	Wing (mm)	Tarsus (mm)	Breast score[a]	Fat score[a]	Stomach contents weight (g)	Description
17 November 2012	FY–SY	♂ largest testis: 5 x 1 mm	252	255	20.2	0	1/0	7	No plastic. 7 squid beaks
31 December 2010	SY	♀ oviduct code 1 follicle < 1 mm	191	235	22.8	1	0/0	15	1 plastic fragment. No prey
17 January 2010	FY–SY	♂ largest testis: 4 × 2 mm	205	224	21.1	1	1/0	0	Empty

FY = first year; SY = second year
[a] Van Franeker (2004).

predators around the Main Hawaiian Islands (Hebshi *et al.* 2008), they frequently (45%, or 5 of 11 foraging birds) associate with small multi-species seabird flocks over small (< 0.6 m) yellowfin tuna *Thunnus albacares* and skipjack tuna *Katsuwonus pelamis* in the Eastern Tropical Pacific (Spear & Ainley 2005).

Although the diet of WTTR in Hawai'i is poorly known, it is likely similar to that of the Red-tailed Tropicbird (*P. rubricauda*, RTTR; Schreiber & Schreiber 1993, Lee & Walsh-McGehee 1998; Spear & Ainley 2007). Colony sampling and at-sea collections have documented plastic ingestion by RTTR in the North Pacific (Table 2). Yet, because RTTRs ingest fragments considered too small for direct ingestion, plastic pollution in this species has been attributed to secondary ingestion via their prey (Harrison 1990), an indication of potential emerging pathways of pollution transfer in epipelagic food-webs. RTTRs do not forage in multi-species flocks involving subsurface predators around the Main Hawaiian Islands (Hebshi *et al*. 2008). However, they occasionally (28%, or 7 of 25 foraging birds) feed in association with surface-feeding tuna and dolphinfish *Coryphaena hippurus* in the Eastern Tropical Pacific (Spear & Ainley 2005, 2007).

This new record highlights the susceptibility of tropicbirds to plastic ingestion and underscores the need for additional information on the other RTTR (4 subspecies) and WTTR (6 subspecies) populations (ITIS 2013). Additionally, three disjunct Red-billed Tropicbird *Phaethon aethereus* (RBTR) subspecies, which inhabit tropical waters of the Atlantic Ocean, the northwest Indian Ocean and the eastern Pacific, have never been assessed for plastic ingestion. In the Eastern Tropical Pacific, RBTR breed on the Galapagos Islands, Ecuador, and off the coast of Mexico (del Hoyo *et al.* 1992). RBTR frequently (46%, or 5 of 13 foraging birds) feed over dolphins and small scombrids in the Eastern Tropical Pacific (Spear & Ainley 2005).

Together, these observations of plastic ingestion reinforce the value of marine birds as bio-indicators of ocean plastic pollution (Ryan 1987, Ryan *et al.* 2009). Thus, we advocate the establishment of longitudinal sampling programs to quantify plastic ingestion incidence and loads in epipelagic tropical ecosystems, targeting seabirds and associated predatory fishes. Such monitoring could rely on opportunistic sampling by long-term monitoring programs (e.g., Robards *et al.* 1993, Nevins *et al.* 2005), augmented by periodic multi-species studies (e.g., Sileo *et al.* 1990, Spear *et*

TABLE 2
Summary of tropicbird plastic ingestion records by species

Species	Study type (site)	Age	Source	Method	Sample size (incidence, %)	Reference
RTTR	At sea (E.T.P.)	After hatch-year	Collection	Necropsy	6 (0)	Spear *et al.* 1995
RTTR	At sea (N.P.T.Z.)	After hatch-year	Bycatch	Necropsy	1 (100)	Robards *et al.* 1993
RTTR	Colony (Midway)	After hatch-year [a]	Sampling	Lavage	47 (4)	Sileo *et al.* 1990
RTTR	Colony (Johnston)	Hatch-year [b]	Sampling	Lavage	50 (4)	Sileo *et al.* 1990
RTTR	Colony (Midway)	Hatch-year [b]	Sampling	Lavage	64 (12)	Sileo *et al.* 1990
RTTR	Colony (Tern Island)	Hatch-year [b]	Sampling	Lavage	50 (14)	Sileo *et al.* 1990
WTTR	Beach-cast (O'ahu)	FY–SY	Salvage	Necropsy	3 (33)	This study

Species: RTTR = red-tailed tropicbird; WTTR = white-tailed tropicbird;
Study sites: E.T.P. = Eastern Tropical Pacific. N.P.T.Z. = North Pacific Transition Zone;
Age classes: FY = first year; SY = second year.
[a] Breeding birds
[b] Chicks sampled on a nesting colony

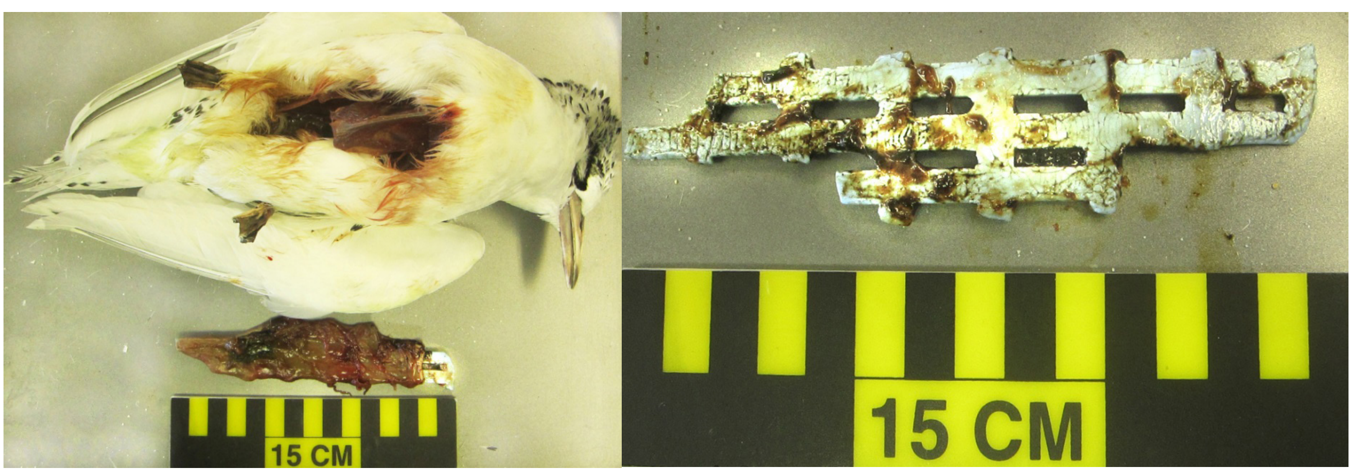

Fig. 1. Left panel: White-tailed Tropicbird specimen, with ingested plastic fragment still inside of the stomach lining. Right panel: close-up of the ingested plastic fragment (14.5 cm long, 3.25 cm wide).

al. 1995). Together, this monitoring could provide the time series required for tracking emerging pollution trends in new locations and species (e.g., Auman 2004, Ryan *et al.* 2009).

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