OBSTRUCTION AND STARVATION ASSOCIATED WITH PLASTIC INGESTION IN A NORTHERN GANNET *MORUS BASSANUS* AND A GREATER SHEARWATER *PUFFINUS GRAVIS*

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Received 13 August 2004, accepted 19 November 2004

Plastic ingestion by seabirds is well documented (see Laist 1997 for a list of species with ingestion records). However, cases definitively attributing seabird mortality to ingestion of plastic are rare. Seabirds that die from ingestion often suffer obstruction of the gastrointestinal tract. Ultimately, the birds die of starvation and often quickly sink in the ocean's waters or are scavenged (van Pelt & Piatt 1995, Wiese 2003).

Many of the studies that attempt to determine baseline levels of plastic ingestion and associated health risks use pre-fledglings or apparently healthy birds, and therefore probably underestimate associated health risks of plastic ingestion (e.g. Connors & Smith 1982, Furness 1983, Ryan 1987a, Sileo *et al.* 1990, Moser & Lee 1992, Robards *et al.* 1995, Spear *et al.* 1995, Auman *et al.* 1997, Blight & Burger 1997). The few experimental studies that explored plastic ingestion have force-fed birds small, rounded industrial pellets that lack the fragmented nature and sharp edges of the user plastic in the world's oceans (Ryan & Jackson 1987, Ryan 1988). Furthermore, a limited number of studies have necropsied beached birds (but see Stephen & Burger 1994), including those received alive by wildlife clinics and rehabilitation centers. Often, only with a clinical history can a necropsy pinpoint a precise cause of death.

Plastic enters the ocean via waste disposal from merchant and fishing vessels, offshore dumping, accidental or deliberate discharge of the raw pellets used by the plastics industry (Joyner & Frew 1991), material left behind by beachgoers, and waste carried into the oceans by rivers and drainage systems (Pruter 1987, Williams & Simmons 1997). Plastic is found in the surface waters of all of the world's oceans and poses a potential hazard to much marine life, including seabirds through entanglement or ingestion (Laist 1987). Because many seabirds preferentially select plastic of specific colors and shapes, it is believed that plastic is often mistaken for prey (Azzarello & Van Vleet 1987, Laist 1987, Moser & Lee 1992). Seabirds that capture prey by surface seizing and piracy are particularly at risk, because most plastics float at or near the surface (Furness 1983, Ryan 1987b, Robards *et al.* 1995, Spear *et al.* 1995, Blight & Burger 1997). Although many seabirds may ingest plastic, procellariiforms suffer the most negative consequences of such ingestion (Furness 1985, Azzarello & Van Vleet 1987, Ryan 1987b, Moser & Lee 1992, Spear *et al.* 1995). Most Procellariidae have small gizzards and an anatomical constriction between the gizzard and proventriculus that make it difficult to regurgitate solid material such as plastic (Furness 1985, Azzarello & Van Vleet 1987).

Several studies have asserted that plastic does not substantially affect seabird health (Furness 1985, Ryan 1987a, Ryan & Jackson 1987, Moser & Lee 1992). On the other hand, documented consequences of plastic ingestion include blockage of the intestines and ulceration of the stomach (Pettit *et al.* 1981, Day *et al.* 1985, Zonfrillo 1985, Fry *et al.* 1987), reduction in the functional volume of the gizzard leading to a reduction of digestive capability, and distension of the gizzard leading to a reduction in hunger (Connors & Smith 1982, Ryan 1988). Body fat, a measure of energy reserves, is negatively correlated with the number of pieces of plastic in a seabird's stomach from species groups including shearwaters, petrels, storm-petrels (Ryan 1987a, Spear *et al.* 1995), albatrosses (Auman *et al.* 1997) and phalaropes (Connors & Smith 1982). Plastic accumulation in seabirds has also been shown to be correlated with the body burden of polychlorinated biphenyls [PCBs (Carpenter *et al.* 1972, Ryan *et al.* 1988)]. Associated problems with a high PCB load in birds include lowered steroid hormone levels causing delayed ovulation and other reproductive problems (Hoffman *et al.* 1996). Furthermore, plastics often contain toxic softeners, colorants, and antioxidants that may be assimilated from ingested plastic (van Franeker 1985, Azzarello & van Vleet 1987). Finally, several studies found negative correlations between body weight and plastic load (Ryan 1987a, Sievert & Sileo 1993, Spear *et al.* 1995, Auman *et al.* 1997), although, as Ryan (1987a) emphasized, many correlational studies do not take into account other factors that may influence the results. A high incidence and load of plastic has been reported in Greater Shearwaters (Furness 1983, Furness 1985, Ryan 1987a, Moser & Lee 1992).

Here, we report two cases of plastic ingestion, one by a Northern Gannet *Morus bassanus* and the other by a Greater Shearwater *Puffinus gravis.* Both seabirds were recovered in Massachusetts, USA, and died as a result of plastic ingestion, obstruction, and subsequent starvation. These seabirds were part of a larger study on seabird mortality (SEANET), in which samples of seabirds are collected from beached bird surveys along the northeastern coast of the United States, local wildlife rehabilitators and as fisheries bycatch.

An adult male Northern Gannet was found on a beach on Cape Cod, Massachusetts, USA, in April 2004. It was brought to a nearby wildlife rehabilitation center with signs of extreme emaciation. It was too weak to stand, was dehydrated and lethargic, and was breathing shallowly. A tube-feeding regimen was begun,

but the bird did not appear to digest the food. It regurgitated much of it, and the small amount of feces produced was discolored and of an abnormal consistency. The bird died within three days. A necropsy at Tufts Cummings School of Veterinary Medicine (TCSVM) revealed a 4.1-cm diameter red plastic bottle cap in the thoracic esophagus (Fig. 1). On further dissection, the gizzard was found to contain four 1-cm × 1-cm ulcerations, three of which were situated near the pylorus. Each lesion had a sunken center and an irregular, black-tinged margin. It was determined that the bottle cap had been lodged in the gizzard and had most likely been dislodged into the esophagus after death. When the bottle cap was placed back into the gizzard, the edges fit perfectly with the ulcerations, obstructing passage of food into the small intestine. Unable to obtain sufficient calories and becoming increasingly weak, the gannet died from starvation.

An adult female Greater Shearwater was presented to a different rehabilitation clinic on Cape Cod, Massachusetts, USA, in July 2003, after being found on a local beach. It appeared weak, lethargic, and debilitated, with no signs of trauma. After an initial tube feeding, the bird was force-fed Capelin *Mallotus villosus.* No feces were observed. Five days after admission to the clinic, the shearwater died. The seabird was necropsied at TUSVM, and the force-fed capelin were found packed in the esophagus and proventriculus, clearly unable to pass into the lower digestive track. On dissection of the gizzard, a 1.4-cm × 0.8 cm fragment of red user plastic with a slight lip, possibly once part of a cap, was found blocking the pylorus (Fig. 2). The plastic had obstructed the passage of food, and the bird had died from starvation.

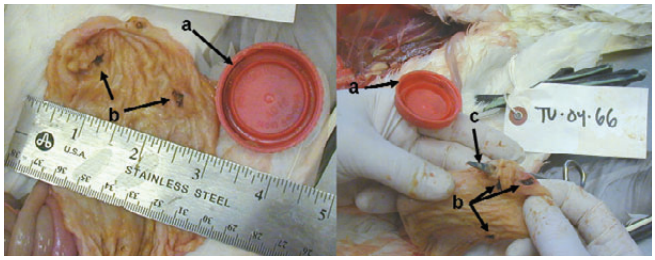

Fig. 1. Left: Gizzard of a Northern Gannet and (a) a 4.1-cm diameter red plastic bottle cap that obstructed the pylorus. (b) Two of four 1-cm × 1-cm ulcerations caused by the bottle cap. Right: Scissors (c) demonstrate the location of the pylorus relative to nearby ulcerations (b) from the bottle cap (a).

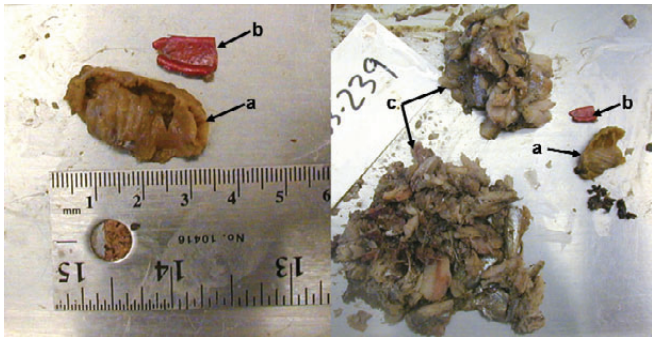

Fig. 2. Left: (a) Gizzard of a Greater Shearwater and (b) a 1.4-cm × 0.8-cm fragment of red user plastic that obstructed the pylorus. Right: (c) Capelin from the upper digestive track was unable to pass through the pylorus because of obstruction by plastic.

Obstruction by plastic is probably a more frequent cause of seabird death than has been documented. Most birds that die from ingestion of plastic sink quickly in the ocean (Wiese 2003) or are eaten by scavengers (van Pelt & Piatt 1995). The frequency of plastic obstruction is unknown even for those birds that are found moribund, because plastic is not visible by radiograph or physical examination, and few veterinary and wildlife rehabilitation clinics perform regular necropsies. Determining cause of death without necropsy is often unreliable (Stephen & Burger 1994). (We are investigating the potential use of ultrasound in detecting ingested plastic.)

Although only two case reports are presented here, those cases emphasize the negative consequences of plastic ingestion in North Atlantic seabirds. For a species such as the Greater Shearwater, which circumnavigates most of the Atlantic Ocean, the issue is of international concern (Rowan 1952, Voous & Wattel 1963, Brown *et al.* 1981). Furthermore, plastic may stay in the digestive system from six months (Day *et al.* 1985) to two years (Ryan & Jackson 1987), and it is therefore often unclear where the birds pick it up, even though plastic debris is common in the North Atlantic (Carpenter & Smith 1972, Carpenter *et al.* 1972, Colton *et al.* 1974, Wilber 1987, Galgani *et al.* 1995, Ribic *et al.* 1997). Studies examining matched samples of adult seabirds from beached bird surveys and from bycatch should be conducted to fully assess the impact of plastic ingestion in the western North Atlantic.

ACKNOWLEDGEMENTS

This publication is a contribution of the SEANET project of the Tufts University School of Veterinary Medicine Center for Conservation Medicine. Many thanks to Dr. Catherine Brown and to Judy Ellal at the Cape Wildlife Center for participating in this project and providing numerous specimens. KEP was funded through Wellesley College by the Lumpkin Family Internship for the Environment, with thanks to SEANET funders, the Geraldine R. Dodge Foundation, Massachusetts Environmental Trust, and the Lynn Trayser Mitchell Memorial Bird Fund.

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