Incidence, Mass and Variety of Plastics Ingested by Laysan and Black-footed Albatrosses Recovered as By-Catch in the North Pacific Ocean

Holly Gray [1], Gwendolyn L. Lattin [1], Charles Moore [1]

[1] Algalita Marine Research Foundation, 148 N. Marina Dr., Long Beach , CA 90803, USA www.algalita.org

Introduction

Of the 82 species of seabirds known to ingest plastic debris (Ryan 1990), albatrosses ingest the largest quantities and sizes (Fry et al. 1987; Sileo et al. 1990b). Plastic ingestion in chicks of Laysan and Black-footed Albatrosses has been documented through analysis of regurgitated non-food items in boluses (Pettit et al., 1981; Young et al. 2009), induced emesis (Harrison et al., 1983, Sileo et al., 1990b) and necropsy of deceased chicks (Auman et al., 1997; Fry et al., 1987; Kenyon and Kridler, 1969; Pettit et al., 1981; Sievert and Sileo, 1993, Sileo et al., 1990a, 1990b). Though the high quantity and frequency of ingested plastic in albatross chicks points to frequent ingestion of plastic in foraging adults, there have been few attempts to examine plastic loads in adult and subadult age classes of Laysan and Black-footed Albatrosses (Blight and Burger, 1997; Fry et al., 1987; Harrison et al., 1983; Sileo et al., 1990b). Given that albatrosses are long lived birds with slow reproductive rates, a better understanding of plastic ingestion in adult and subadults is integral to an assessment of potential population level effects. Our study quantifies and compares the incidence, mass and variety of plastic ingested by adult and subadult Laysan Albatrosses and Black-footed Albatrosses foraging in the North Pacific Ocean.

Materials and Methods

We examined 18 Laysan Albatross and 29 Black-Footed Albatross specimens. The specimens were obtained as by-catch from fisheries near the Hawaiian Islands by observers from the National Oceanographic and Atmospheric Administration (NOAA) during 2006-2008 (Figure 1).

Figure 1. The specimens used in this study were obtained as by-catch.

We removed the proventriculus and ventriculus from each specimen. The diet contents were collected and weighted to the nearest 0.001g. We sorted digestive contents manually and removed plastics using visual identification aided by the use of a dissecting microscope (Figure 2).

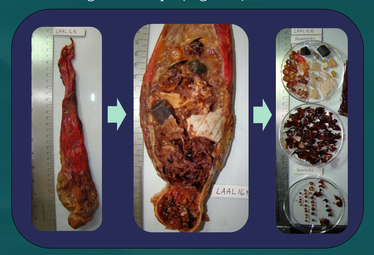

Figure 2. The proventriculus and ventriculus were opened with a single incision and the digestive contents were removed and sorted.

We rinsed all plastics in water, dried them overnight, then weighed each piece individually to the nearest 0.001g, and measured their maximum dimensions to the nearest 1mm. We categorized plastics into four visually identifiable varieties (Figure 3). Prey items were also categorized (Figure 3).

Figure 3. Categories of Plastic and Prey used during the sorting process

Results

Thirty of 47 albatross specimens (63.8%) contained ingested plastic. Laysan Albatrosses (n=18) had a higher frequency, 83.3% of ingested plastic than Black-footed Albatrosses, 51.7% (n=29) (chi-square test of independence $X^2 = 4.8$, df =1, P = 0.028; Table 1).

Table 1. Mass and frequency of occurrence (FO) of plastic and digestive contents in the proventriculus and ventriculus of Laysan Albatrosses (LAAL) and Black-footed Albatrosses (BFAL) and of both species combined (B) in the North Pacific Ocean, 2006-2008 .

	LAAL (n=18)	BFAL (n=29)	Both (n=47)
mass of plastic (g)			
total x ± SD	0.998 ± 2.244	0.130 ± 0.286	0.463 ± 1.447
median	0.127	**0**	0.004
maximum	8.124	1.085	8.124
% FO of ingested plastic	83.3	51.7	61.7
mass of digestive contents (g)			
total x ± SD	57.396 ± 93.358	53.405± 96.496	54.880 ±94.322
median	16.456	16.575	16.516

At 0.998g 2.244, Laysan Albatross specimens exhibited a higher mean mass of ingested plastic than the 0.134g 0.291 for Black-footed Albatrosses (Mann-Whitney U test, U= 174, P = 0.0575). The maximum mass of ingested plastic found in an individual was 8.124g, recovered from a Laysan Albatross (Figure 4), while the Black-footed Albatross maximum was 1.085g. Five of the 47 specimens had more than 1g of plastic, however the median of 0.004g of plastic indicates that most individuals had much less plastic than the mean value (Table 1).

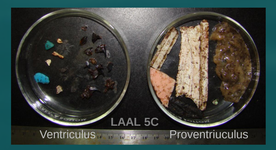

Figure 4. Digestive contents of a LAAL containing 8.124g of plastic, the greatest mass of ingested plastic recovered from a specimen during this study

Of the four varieties of plastic, fragments contributed the greatest mean mass in both species and the highest incidence in Laysan Albatrosses (Table 2). Between the species, Laysan Albatross specimens contained a higher mean mass of fragments, and Black-footed Albatross specimens contained a higher mean mass of line (Table 2). Line was often found entwined in masses of fish eggs, and of the 9 Black-footed Albatrosses that contained line, 8 also contained fish eggs (compared to the average 62% with fish eggs overall; Table 1). Only 11.1% of the Laysan Albatrosses (n=18) contained fish eggs (Table 1) and plastic line was also far less prevalent in this species (Table 2). The maximum number of plastic pieces recovered from a single specimen was 139, found in a Black-footed Albatross; 135 of these were line.

Table 2. Mass, count, and frequency of occurrence (FO) of different varieties of plastic recovered from the digestive contents of Laysan Albatrosses and Black-footed Albatrosses found to contain ingested plastic.

	Mass (g) x ± SD	count (#) x ± SD	%FO
Laysan Albatross (n=15)			
fragments	1.162 ± 2.436	4.8 ± 5.23	80.0
line	0.002 ± 0.005	1.0± 2.00	33.3
pellets	0.010 ± 0.024	0.4 ± 1.06	20.0
foam	0.001± 0.003	0.3 ± 1.03	6.7
Black-footed Albatross (n=15)			
fragments	0.186 ± 0.293	3.8 ± 5.95	53.3
line	0.070 ± 0.209	16a.7 ± 36.17	53.3
pellets	0.002 ± 0.007	0.1 ± 0.26	6.7
foam	0.001± 0.004	0.1 ± 0.13	6.7

We noted signs of regurgitation e.g. diet contents in the esophagus and mouth, in several specimens during necropsy (Figure 5a). We also found the diet contents of several specimens to be primarily composed of cut pieces of bait fish (Figure 5b).

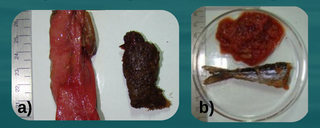

Figure 5. a) Diet contents removed from the upper esophagus. b) Cut bait fish recovered from diet contents

Discussion

The high incidence of ingested plastic we observed in both Laysan (FO =83.3% n = 18 and Black-footed (FO = 51.7 n=29) subadult and adult specimens indicates both species of albatrosses are exposed and that any detrimental effects from plastic ingestion may be far reaching.

Figure 6. Examples of plastic diet contents recovered. The majority of both LAAL and BFAL specimens examined contained plastic.

Of the two species, the higher incidence and mean mass of plastic in Laysan Albatrosses suggests this species may be at greater risk from any harmful effects. However, further research would be required to exclude bias introduced by seasonal and annual foraging trends and the use of by-catch specimens to confirm the variations we noted between species.

Of the four varieties of plastics recovered in this study, the dominance (by mean mass) of fragments indicates that both Laysan and Black-footed Albatrosses are primarily ingesting plastics composed of a variety of degraded post-consumer products. The mass of foam and industrial pellets recovered in this study was minimal. Between the two species, Laysan Albatrosses had a higher mean mass of fragments and Black-footed Albatrosses had a higher mean mass of line. The higher average mass of line we found in Black-footed Albatrosses is consistent with the findings of Sileo et al. (1990b). This suggests that Black-footed Albatrosses ingest more fishing industry by-products than Laysan Albatrosses. The greater mass and incidence of line in the digestive contents of Black-footed Albatrosses appears to be due to the higher incidence of fish eggs (Table 1), which we often found attached to plastic line, in their diet. This association was previously reported by Harrison et al. (1987).

The high incidence of ingested plastic we found in Laysan Albatrosses (83.3% n=18) was lower than values previously reported for Laysan Albatross chicks (Auman et al., 1997; Young et al. 2009). A trend of greater incidence of ingested plastics in Laysan Albatross chicks than in adults was also observed by Sileo et al. (1990b). If the mass of ingested plastic we recorded represents that carried by foraging albatrosses in the North Pacific Ocean, load dependent effects of plastic ingestion, such as impaction or displacement of prey items, would more likely occur in their chicks. However, the low median mass of digestive contents (Table 1) raises questions about use of by-catch specimens to quantify plastic ingestion. Potential sources of bias in our sample include; loss of ingested items due to regurgitation upon entanglement with fishing gear, and altered foraging behavior caused by interaction with fishing vessels. Further research is required to determine if specimens obtained through fisheries by-catch result in underestimates of plastic burdens in these species.

To better understand long-term effects of plastic ingestion on albatross populations, ongoing monitoring efforts will be required. Unfortunately, disparate research methodology provides little comparable data to analyze ongoing trends within populations of Black-footed Albatrosses and Laysan Albatrosses. A unified approach for assessing long-term impacts of plastic ingestion is needed.

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Acknowledgments

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