40. The chemical signature analysis of plastic ingested by Laysan Albatross breeding at Kure Atoll

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BACKGROUND
The widespread presence of plastic particles in the marine environment has profound effects on the birds inhabiting the world's oceans (Azzarello and Van Vleet 1987). Seabirds that utilize large areas of the North Pacific are known to ingest this material along with their natural prey (Nevins et al. 2005; Ryan 2008; Hyrenbach et al. 2009). A concern for the breeding seabirds ingesting plastic debris at sea is that the debris is regurgitated and fed to the developing chicks at the colony (Fry et al. 1987; Ryan 1990). The ingested plastic can cause potential mechanical problems such as obstruction, lesions, and may be linked to dehydration (Sievert and Sileo 1993). The surface-feeding procellariiformes have been shown to be the group of seabirds that ingest plastic most consistently, with an incidence of ingestion of up to 100% (Blight and Burger 1997; Colabuono et al. 2009). The Laysan albatross is a surface-feeding procellariiform known to ingest plastic debris (Pettit et al. 1981; Fry et al. 1987; Auman et al. 1997a; Young et al. 2009). The 2 million Laysan albatross that breed in the Hawaiian Islands (both the main and northwestern islands) each year are susceptible to plastic ingestion since they range over vast areas in search of dispersed prey and are known to forage in the same frontal systems that aggregate marine debris at sea (Hyrenbach et al. 2002; Pichel et al. 2007; Kappes et al. 2010). Each piece of plastic debris that is ingested by the albatross chicks contains the plasticizers added during manufacturing (Oehlmann et al. 2009), and has the potential to contain numerous other noxious hydrophobic chemicals that can be collected while floating freely in the ocean (Endo et al. 2005; Rios et al. 2007; Teuten et al. 2007; Colabuono et al. 2010). The ingested plastic debris found in seabirds is currently classified based on the physical characteristics of each piece. The larger plastic pieces show a very high resistance to aging and minimal biological degradation because of the complex polymers used in their creation (Klemchuk 1990; Rios et al. 2007). Laysan albatross generally ingest larger pieces of plastic debris, and have been found to ingest items such as a cigarette lighters, toothbrushes, golf balls, children’s toys and even tampon applicators (Edwards 2005). These items may be identifiable due to their size and remarkable shape, but there is also a percentage of the ingested debris that is unidentifiable and referred to as “fragments” (Vlietstra and Parga 2002; Nevins et al. 2005). These small, broken, post-consumer shards of plastic may come from a number of sources and have the potential to be any of the various types of plastic.

METHODOLOGY
The plastic from the Laysan albatrosses was collected on Kure Atoll, from the boluses casted within a known Laysan albatross breeding area by Cynthia Vanderlip (DLNR – DOFAW), under her manager's permit in the spring – summer (April – June) of 2005. The samples were transported back to Hawaii Pacific University where they were sub-sampled for 200 items. Since the Laysan albatross ingest mostly fragments, all suitable pieces of foam, sheet, line and nurdles were selected for analysis (all found for the entire colony; 71 samples total). The remaining 129 samples were randomly selected from the fragments.

Samples of approximately 0.05 grams and larger were preferentially chosen for this study. All plastic samples were ground into particles of less than 2mm in diameter using stainless steel food grinders (washed with soap and water, rinsed with acetone, wrapped in aluminum foil, and combusted at 500C for at least 12 hours). Samples were extracted for at least 24 hours in a hexane: dichloromethane (1:1) mixture. Sample clean up entailed passing sample through a combusted (500C for 12 hours) glass 9-inch Pasteur pipette filled with approximately 0.25g of silica (pore size 100-200) and eluted with hexane and dichloromethane. Samples were concentrated to approximately 0.05ml and injected into a 7890A GC System and 5975C inert MSD with triple axis detector (Agilent Technologies) equipped with a methyl silicone-coated fused-silica capillary column HP-5MS (0.25mm i.d. X 30m, 0.25um film thickness, J&W Scientific). Samples were analyzed by comparing the mass spectra of the developed “tracer chemicals” in the reference chromatograms to the chromatograms of the plastic samples for assurance that the compounds are of the same structure/components.

OUTCOMES
A total of 200 items were analyzed by this novel approach: 129 fragments, 44 pieces of foam, 10 pieces of line, 6 pieces of sheet and 11 nurdles. Of the total ingested plastic debris analyzed the largest proportion was comprised of polypropylene (Type 5) at 48% of samples. Polypropylene was the most common resin type in both nurdles and fragments (66.7% and 62.7% respectively). Polystyrene (Type 6) was the second most common type of plastic found at 27% of total samples identified. Polystyrene was also the most common resin type in foam samples (84%). The most common resin type for the line samples was polyvinyl chloride (Type 3). Finally, the most common resin type in the sheet samples was low density polyethylene (Type 1) (Figure 1). The most abundant type of plastic found cannot currently be recycled (PP, Type 5).

Plastic fragments are the most commonly ingested artificial item by the Laysan albatross. Since stomach content analyses for plastics began, some items have become iconic, and used as common examples for the discussion of ingested plastics. A few of these items are bottle caps, fishing floats and lighters. A total of thirty-five identifiable bottle caps were processed and analyzed from the plastic samples taken from Kure Atoll. They were identified to be PP, PVC or PETE. The highest proportion of bottle caps analyzed was found to be PP followed by PVC and then PETE (Figure 2). A total of eight fishing floats were processed and analyzed from the plastic samples taken from Kure Atoll in 2005. They were analyzed to be PP, PS and a combination of PETE and PS (Figure 2). There were a total of five lighters processed in the samples that were taken from the Laysan albatross at Kure Atoll in 2005. The samples were found to be a higher proportion of PVC than PETE (Figure 2). The remaining plastic fragment samples that were analyzed were sixty-four unidentified pieces. The unidentifiable fragments
were determined to be PP (twenty-three samples), PVC (nine samples), PETE (six samples) and there were also three samples that were identified as mixtures of various resin types.

**PRIORITY ACTIONS**
Using this method to further identify the ingested plastic debris can be useful in determining the type of plastic that is most frequently ingested by various species of marine organisms, as well as the plastic that is the most common contributor to marine debris. Identification of these plastics, in this case polypropylene (Type 5) and polystyrene (Type 6) can be the basis for redirected point source reduction efforts to limit the amount of plastic debris entering the ocean environment.

**FIGURES AND TABLES**

<table>
<thead>
<tr>
<th>Ingested Plastic Category</th>
<th>Sheet</th>
<th>Line</th>
<th>Nurdles</th>
<th>Foam</th>
<th>Fragments</th>
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<td>PETE (1)</td>
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<td>HDPE (2)</td>
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<td>PP (5)</td>
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<td>PS (6)</td>
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**Figure 1. Percent composition of each of the ingested plastic categories.** The percent composition of the ingested plastic categories, separated by the SPI resin types. Percentages equal more than 100% since the plastic samples that were found to consist of more than one resin type are included in this comparison.
Figure 2. Number of ingested pieces of the various fragment items. The number of ingested plastic pieces of each of the fragment item categories, separated by the SPI resin type each was identified to be. Mixture corresponds to samples that were identified as more than one SPI resin type. N/A corresponds to samples that were not identifiable.

REFERENCES


Ryan P. The effects of ingested plastic and other marine debris on seabirds; 1990. p 623-634.


