BIOPs: Towards Seabird Bioindicators of North Pacific Plastic Pollution

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Bioindicators of Plastic Pollution

- Sample plastic debris (> 0.5 mm) using North Pacific seabirds
  - Develop standardized methods (occurrence & mass)
  - Establish metrics for pollution monitoring

- Geographic Scope: GOA, BS, CCS, HI

- Approach:
  - Legacy species (time series)
  - Sentinel species (emerging issues)
  - Sampler species (regional / local)
Case 1 - Sentinels (Community Perspective)

- Tern Island, FFS
- 362 birds, 16 species
- 4 Foraging Guilds
  (Harrison et al. 1983)

- 2 albatrosses
  Black-footed & Laysan

- 3 nocturnal petrels
  Bonin & Bulwer’s Petrel
  Tristram’s Storm-petrel

- 4 plunge-divers
  Brown & Red-footed Booby
  Red-tailed Tropicbird
  Greater Frigatebird

- 5 tuna-birds
  Brown & Black Noddies
  Sooty & White Terns
  Wedge-tailed Shearwater
  (Rapp et al., 2017)
11 of 16 species (68.7%) had ingested plastic

Incidence not different across foraging guilds (p = 0.408)

Higher frequency of occurrence in chicks (p = 0.038)
Plastic Frequency of Occurrence

NOTE: Only “common” Species - Age groups (> 8 birds sampled) are considered
Tristram’s Storm Petrel

Poorly-studied: small / nocturnal / burrowing

100% plastic ingestion incidence (n = 57 birds)

Large loads of ingested plastic (0.1 - 2.8 g)

(Youngren et al., 2018)
Laysans have higher incidence than Black-foots

Chicks have higher incidence than adults
Ingested plastic mass higher in chicks than adults

Scaled Plastic Mass

Only FFF Specimens

Species (Age)
BFAL(C) BFAL(A) LAAL(C) LAAL(A) TRSP(C)
Relative Plastic Mass (% Body Mass)
0.01 (11) (15) (35) (12) (8)
Case 2 - Regional Metrics
Sampling - Chick Boluses

Field Personnel:
USFWS & State HI
DOFAW field staff
collected fresh boluses

Air dried in the field

Sample Size:
\( n = 25 \) (site / species)
All samples from 2009

Plastic Occurrence:
100% boluses had plastic
Lab Methods - Characterizing Plastic

- 4 Types
  - Sheet
  - Line
  - Foam
  - Fragment
Results - Plastic Mass

Black-footed (BF) & Laysan (LA) Albatross plastic mass at 3 sites: Kure (K), Midway (M), Tern (T).

Plastic mass differed by species \((p < 0.001)\) (BFAL > LAAL)

Plastic mass differed by site \((p < 0.001)\) (Kure > Midway > Tern)

Significant \((p < 0.001)\) species * colony interaction
Results - Plastic Types

PCA of 10 variables (mass and volume of overall plastic, and 4 plastic types) yielded 2 significant axes ($p = 0.001$)

PermANOVA revealed 3 significant patterns ($p < 0.001$)

Explained 58.88% of variance:

- species (18.88%)
- colony (15.29%)
- their interaction (14.71%)
Differences in bolus composition of BFAL / LAAL (by mass) 

(n = 150 boluses) 

<table>
<thead>
<tr>
<th>Category</th>
<th>BFAL (mean ± SD)</th>
<th>LAAL (mean ± SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>% ALL PLASTIC</td>
<td>65.5 (± 12.9)</td>
<td>51.5 (± 1.86)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% line</td>
<td>28.3 (± 12.9)</td>
<td>2.2 (± 4.3)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% foam</td>
<td>22.9 (± 12.6)</td>
<td>3.7 (± 4.0)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% sheet</td>
<td>2.2 (± 0.9)</td>
<td>0.3 (± 0.9)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>% fragment</td>
<td>12.1 (± 9.4)</td>
<td>45.3 (± 20.5)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Case 3 - Local Metrics (Midway Atoll)

- High Plastic Ingestion, Frequency of Occurrence > 90% (Sileo et al., 1990; Lavers & Bond, 2016, Rapp et al., 2017)

- Winter Breeders, Large Population (> 350,000 pairs) (Seto & O’Daniel, 1999; Seto, 1995)

Feb 2000-07 (Howell et al., 2012)
Sampling - Chick Necropsies

- Bonin petrels from Midway Atoll: 40 chicks
- Assess plastic incidence (F.O.) and loads (mass)
- Document plastic type, size, polymer composition
Results - Plastic Occurrence

- 98% (39 / 40) birds contained plastic
- Pro (68%) < Giz (90%) ($p < 0.001$)
- Fragment & Line common (> 50%)

2 chambers
Results - Plastic Loads

- **Overall Mass**: Pro = Giz (p = 0.872)
- **% Type by Stomach Chamber**: (p < 0.01)
  - Fragments (More in Gizzard)
  - Line (More in Proventriculus)
By mass, **PE** and **PP** are dominant:

- **67%** polyethylene
- **25%** polypropylene
- **91%** polyethylene
- **6%** polypropylene
Scope of Seabird Plastic Ingestion - Hawai‘i

100% Albatross boluses contain plastic (On average 66% of BFAL bolus mass)

FFS: 11 of 16 species ingested plastic
  o Four of five guilds
  o F.O. higher for chicks

New plastic ingestion records:
  o Brown booby - Tern Island  
    (Rapp et al. 2017)
  o White-tailed Tropicbird - O‘ahu  
    (Hyrenbach et al. 2013)
Implications - Focal Species

Tristram's Storm-petrel: 100%

Bonin Petrel: 98%

Laysan Albatross: 93.1%

Black-footed Albatross: 77.6%
**Implications - Focal Species**

- Greater Frigatebird: 33.4%
- Brown Booby: 25.0%
- Red-tailed Tropicbird: 16.7%
- Red-footed Booby: 4.5%
- Wedge-tailed Shearwater: 75.0%
- Brown Noddy: 7.7%
- Sooty Tern: 0.0%
- White Tern: 0.0%
Seabird Bioindicators of Plastic Pollution

- **Opportunity:** Time Series
- **Challenge:** Interpretation

- Plastic Distribution
- Foraging Ecology
It Takes a Big Flock

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