

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



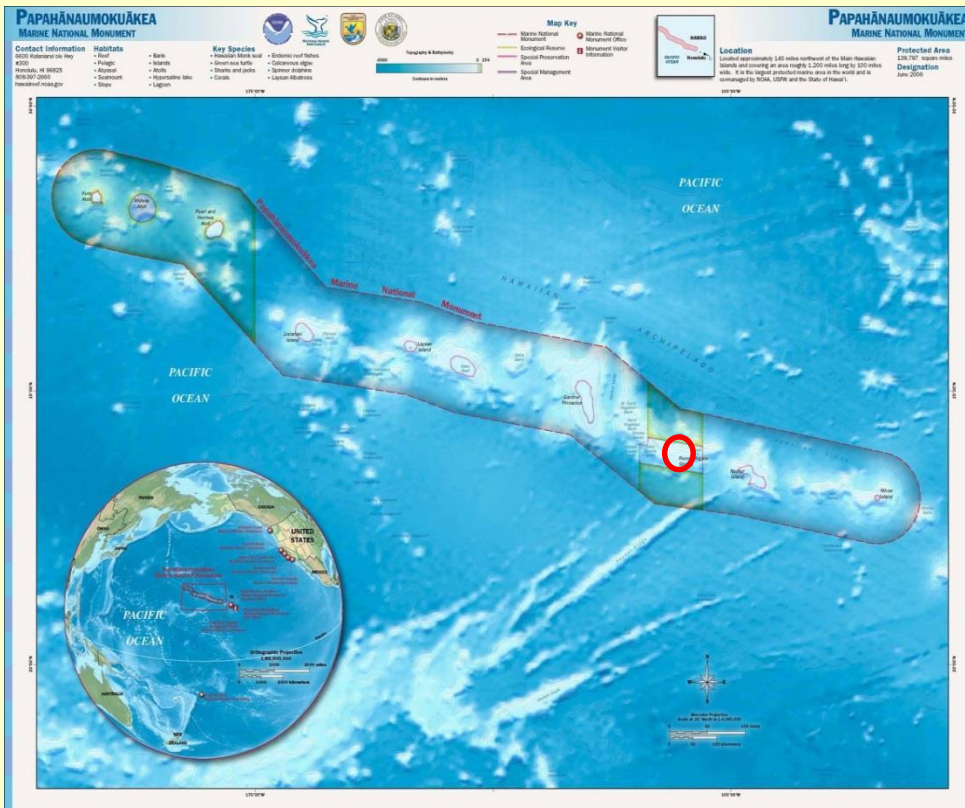
BIOPs

- 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)

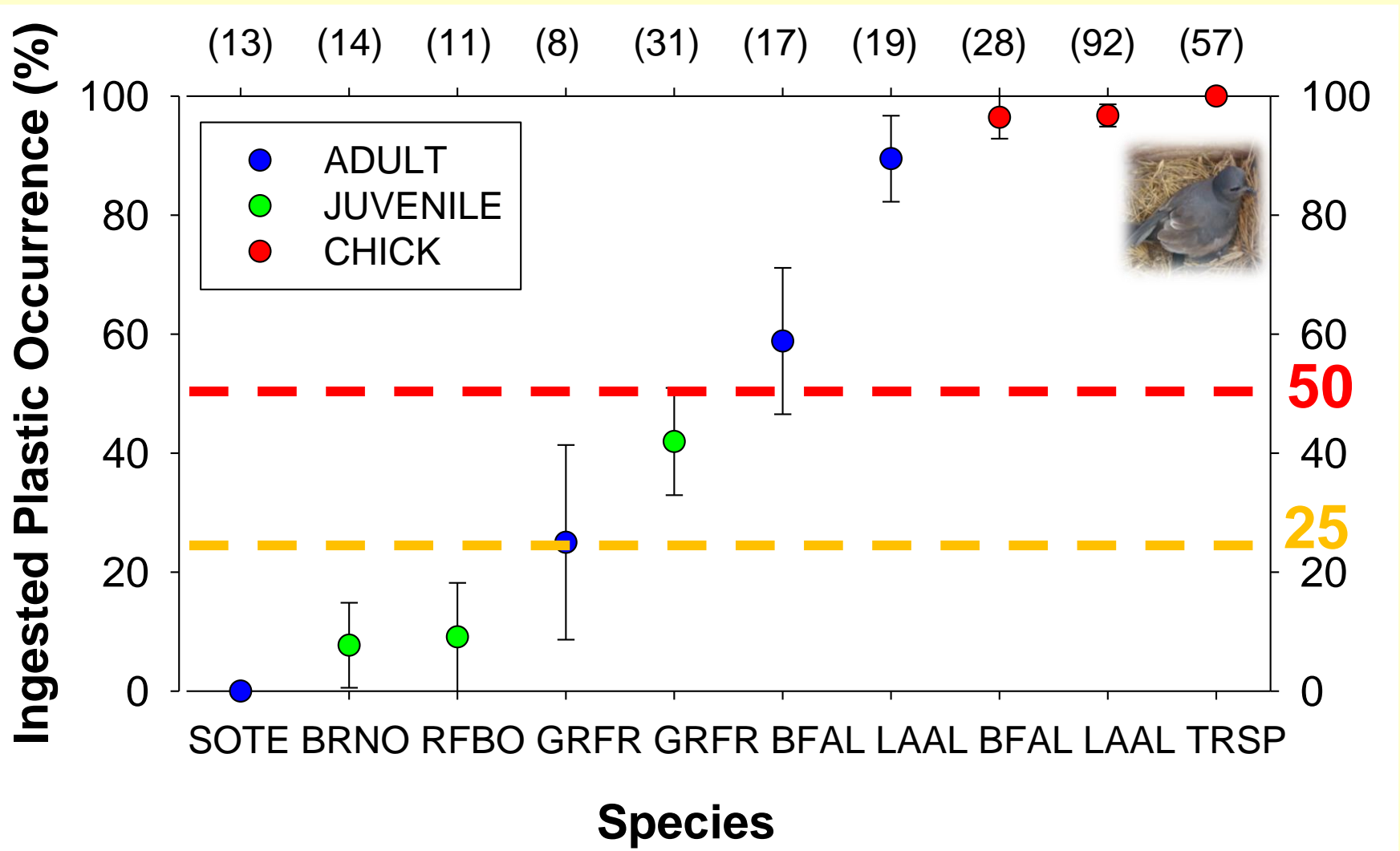


11 of 16 species (68.7%) had ingested plastic

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

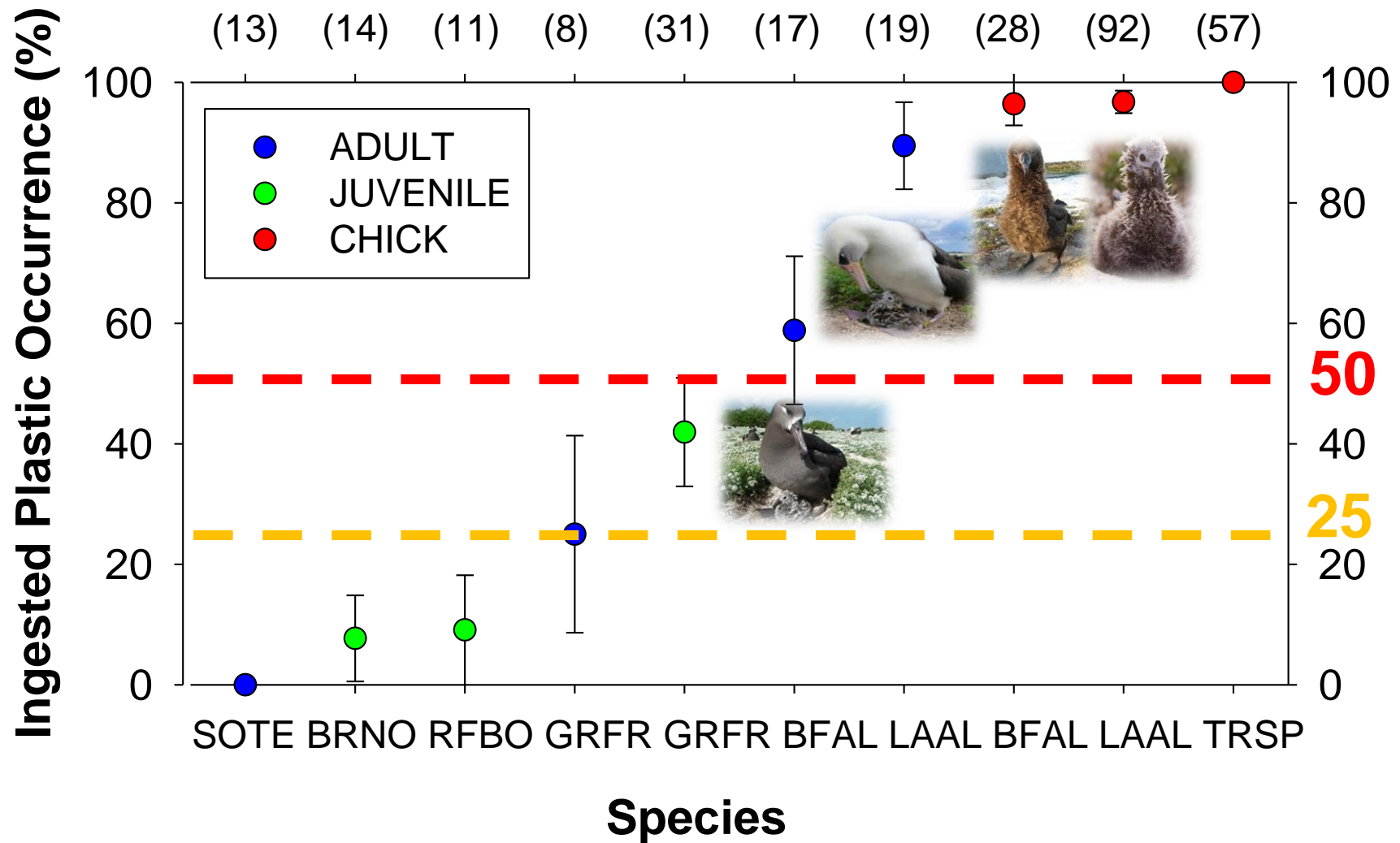
100% plastic ingestion incidence (n = 57 birds)

Large loads of ingested plastic (0.1 - 2.8 g)



(Youngren et al., 2018)

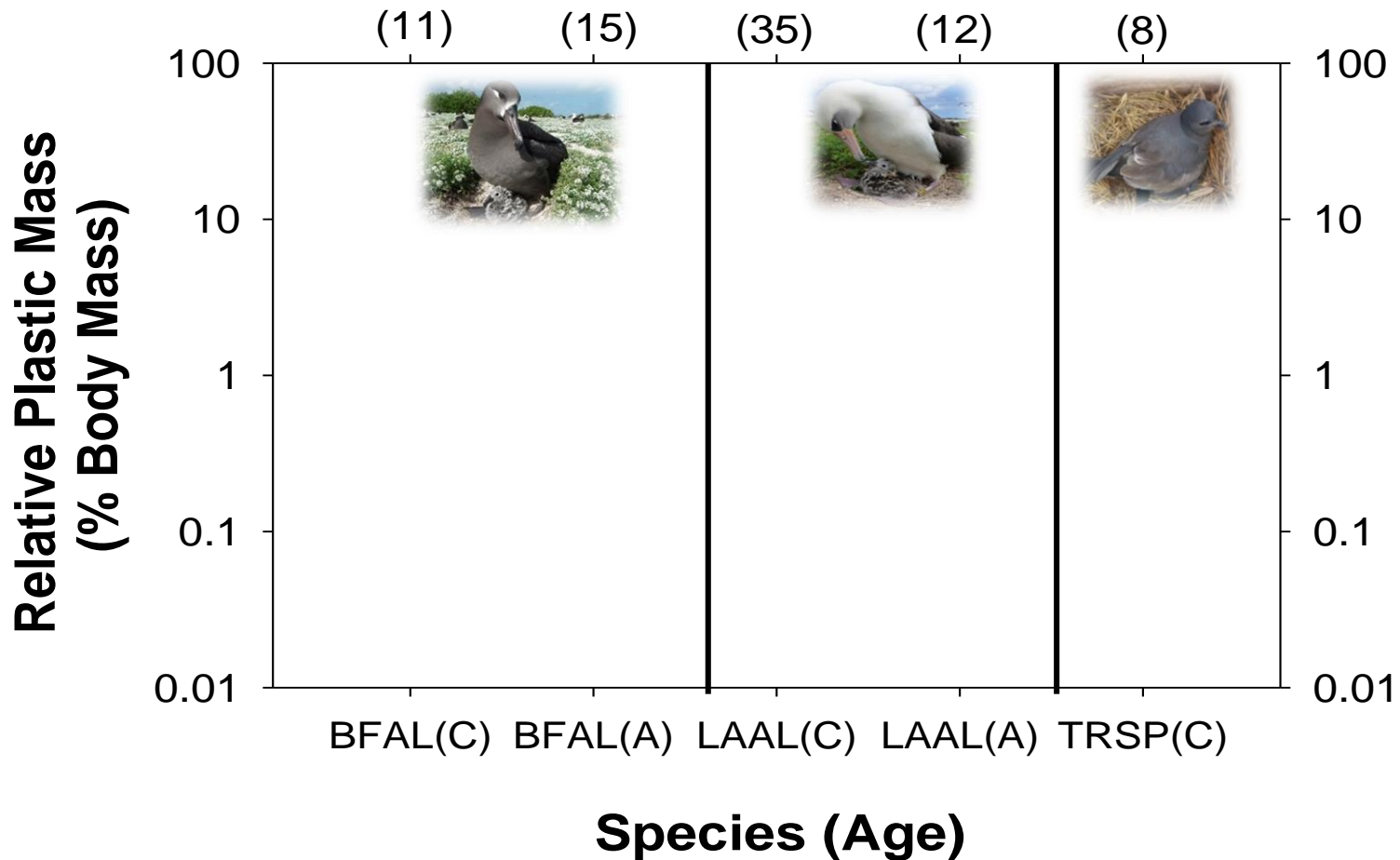
Plastic Frequency of Occurrence



- Laysans have higher incidence than Black-foots
- Chicks have higher incidence than adults

Scaled Plastic Mass

Only FFF Specimens

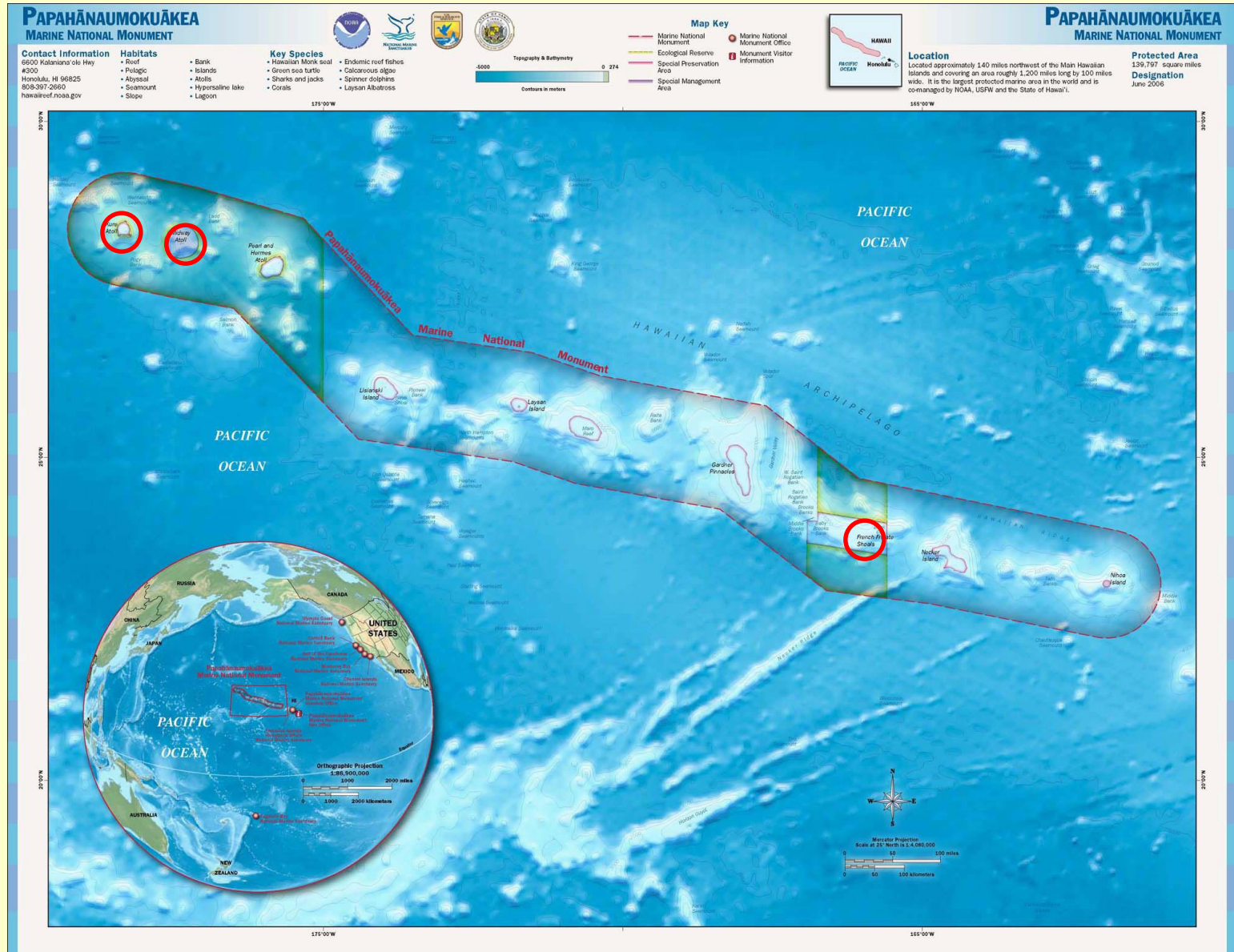


- Ingested plastic mass higher in chicks than adults



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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



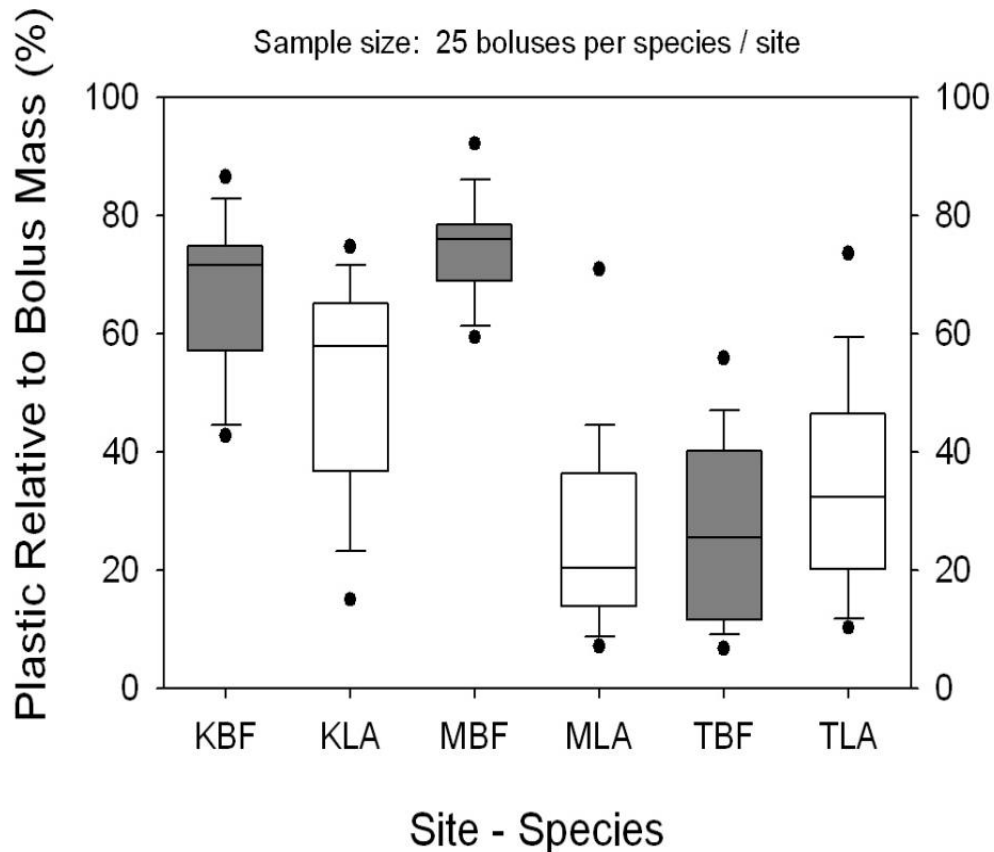
➤ 4 Types

- 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 ($p = 0.001$)

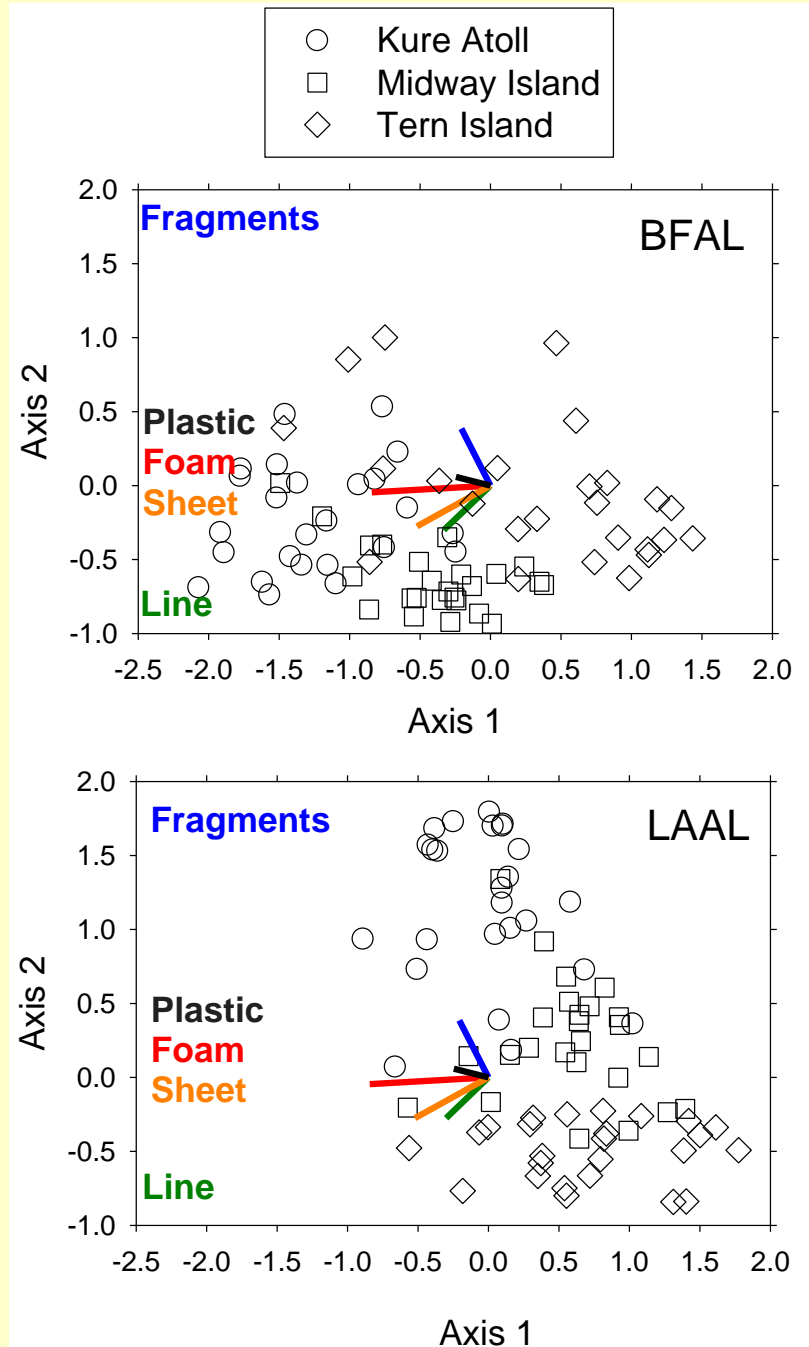
PermANOVA revealed 3 significant patterns ($p < 0.001$)

Explained 58.88% of variance:

species (18.88%)

colony (15.29%)

their interaction (14.71%)



Results - Plastic Types

Differences in bolus composition of BFAL / LAAL (by mass)

(n = 150 boluses)

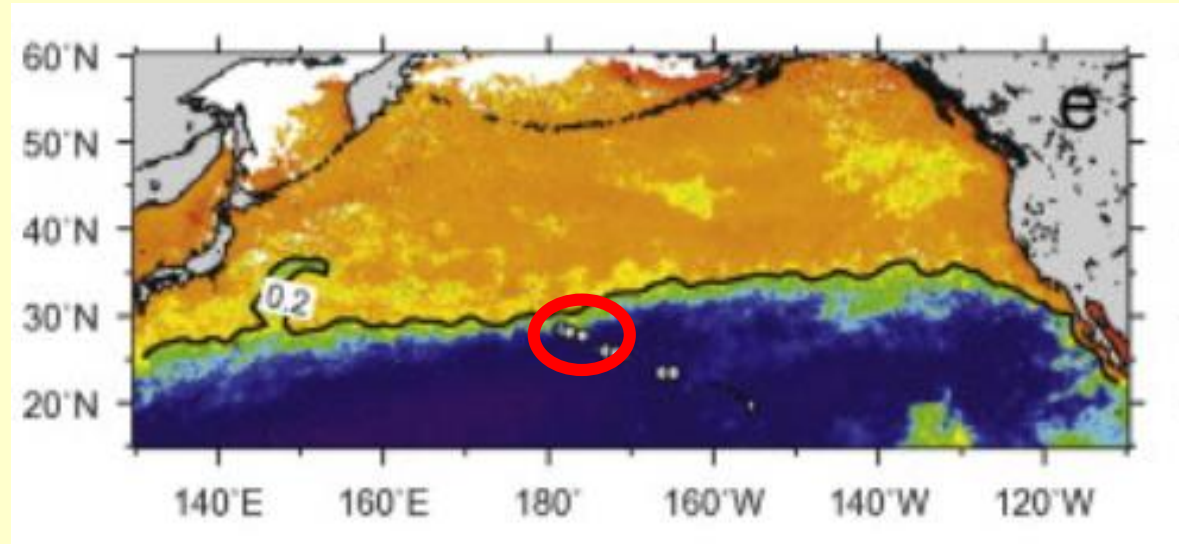


Category	BFAL (mean \pm SD)	LAAL (mean \pm SD)	p
% ALL PLASTIC	65.5 (\pm 12.9)	51.5 (\pm 1.86)	< 0.001
% line	28.3 (\pm 12.9)	2.2 (\pm 4.3)	< 0.001
% foam	22.9 (\pm 12.6)	3.7 (\pm 4.0)	< 0.001
% sheet	2.2 (\pm 0.9)	0.3 (\pm 0.9)	< 0.001
% fragment	12.1 (\pm 9.4)	45.3 (\pm 20.5)	< 0.001



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Case 3 - Local Metrics (Midway Atoll)

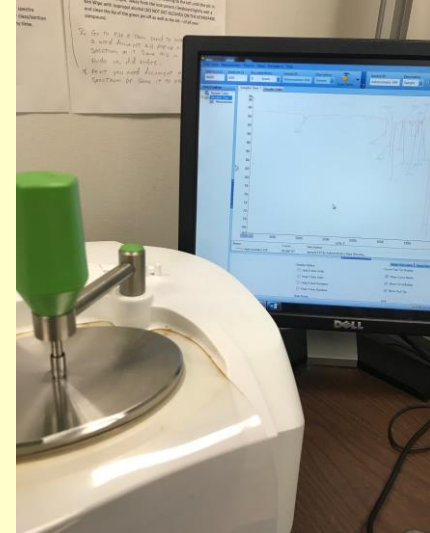
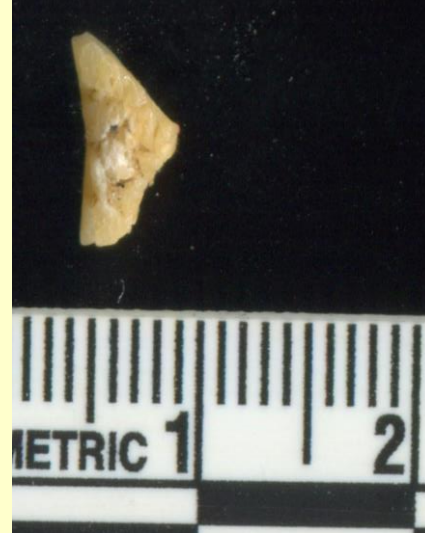
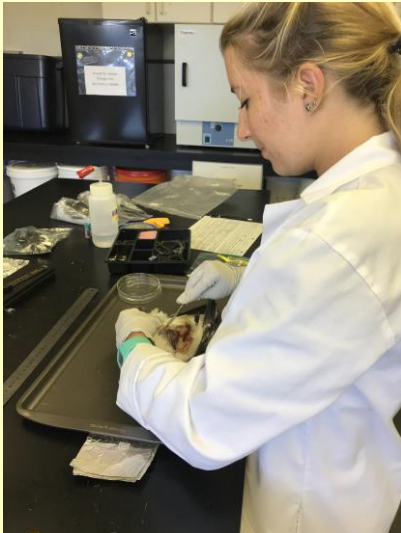









Feb 2000-07 (Howell et al., 2012)

- 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)

Sampling - Chick Necropsies

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

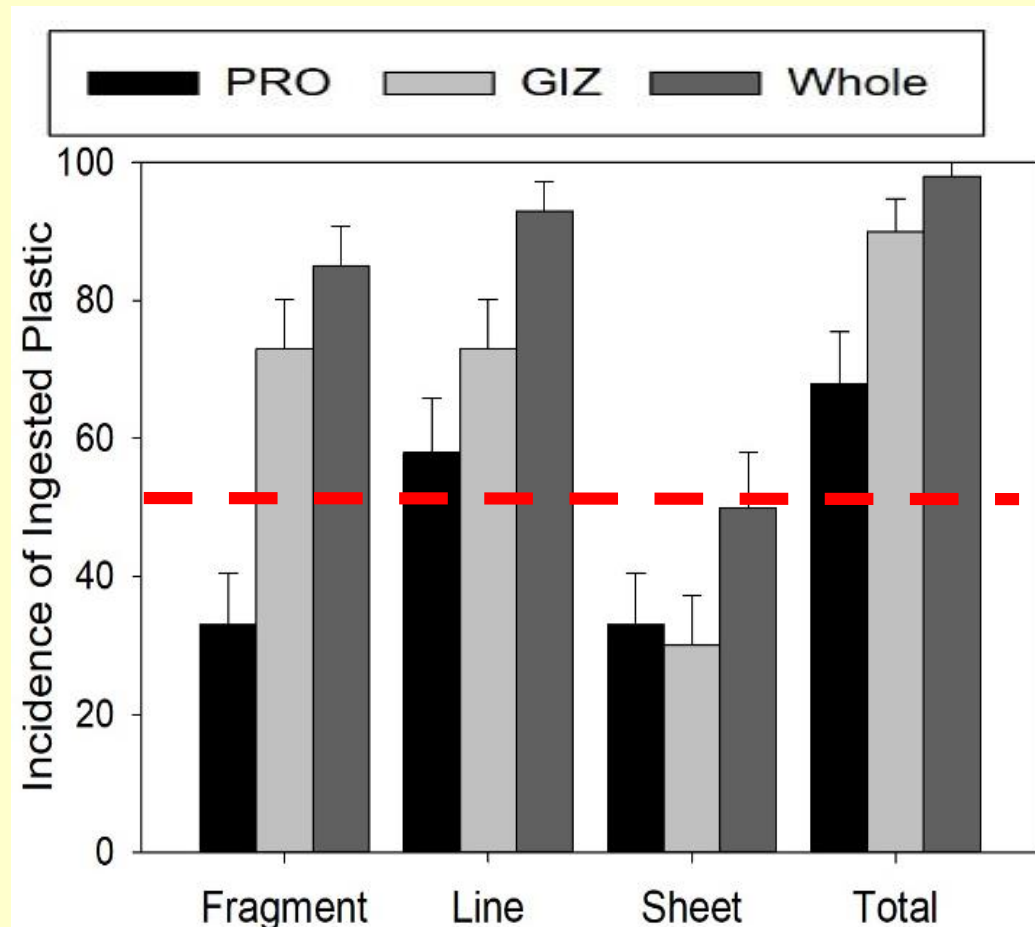


 PETE	 HDPE	 PVC	 LDPE	 PP	 PS	 OTHER
Polyethylene Terephthalate	High-Density Polyethylene	Polyvinyl Chloride	Low-Density Polyethylene	Polypropylene	Polystyrene	Other

Results - Plastic Occurrence

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

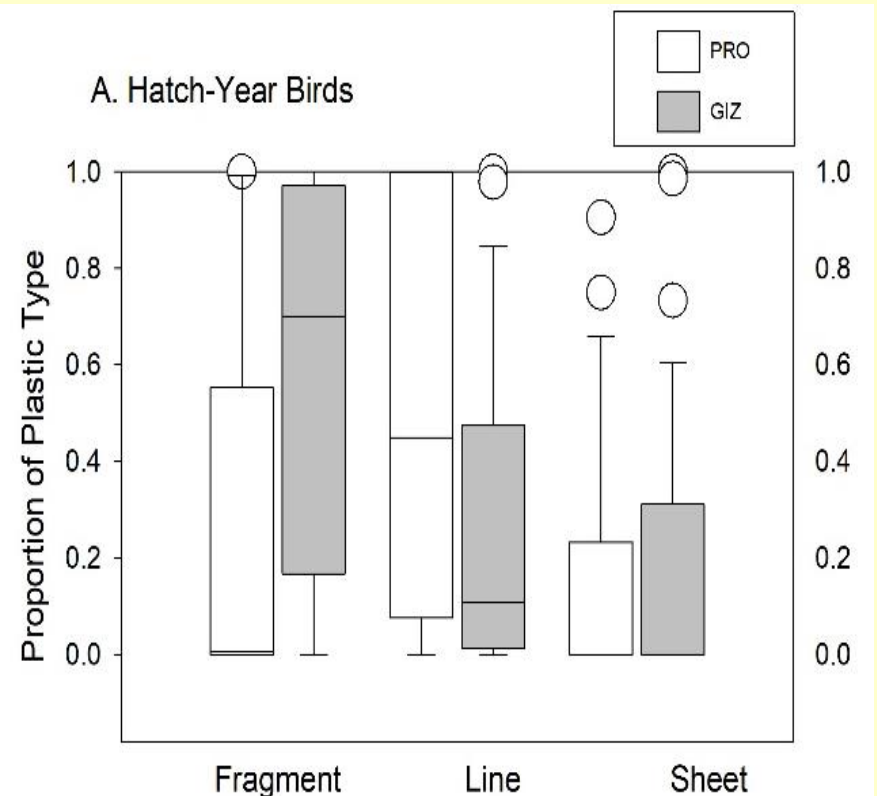
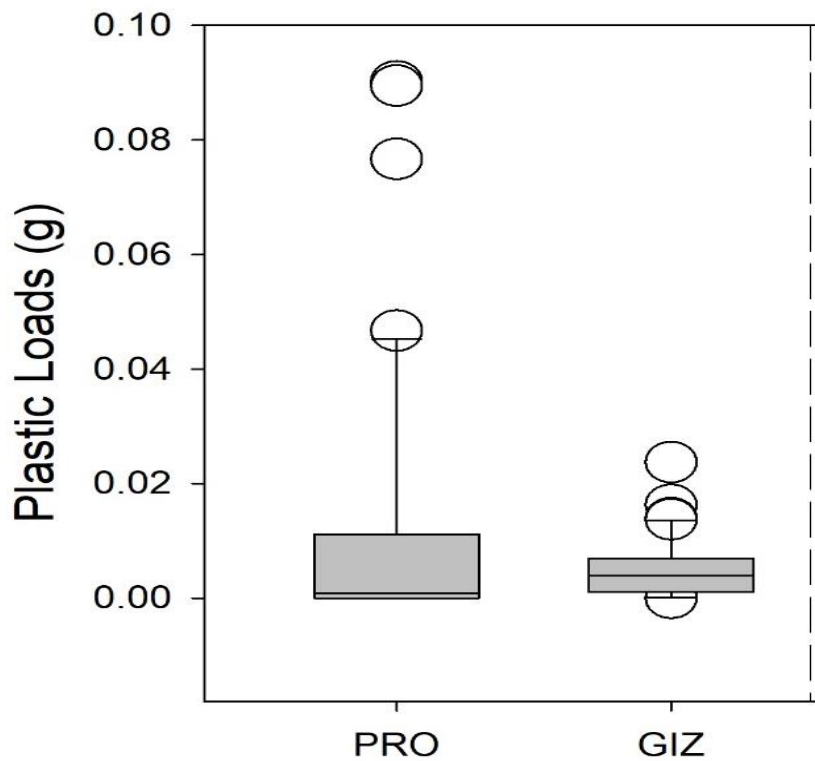
2 chambers



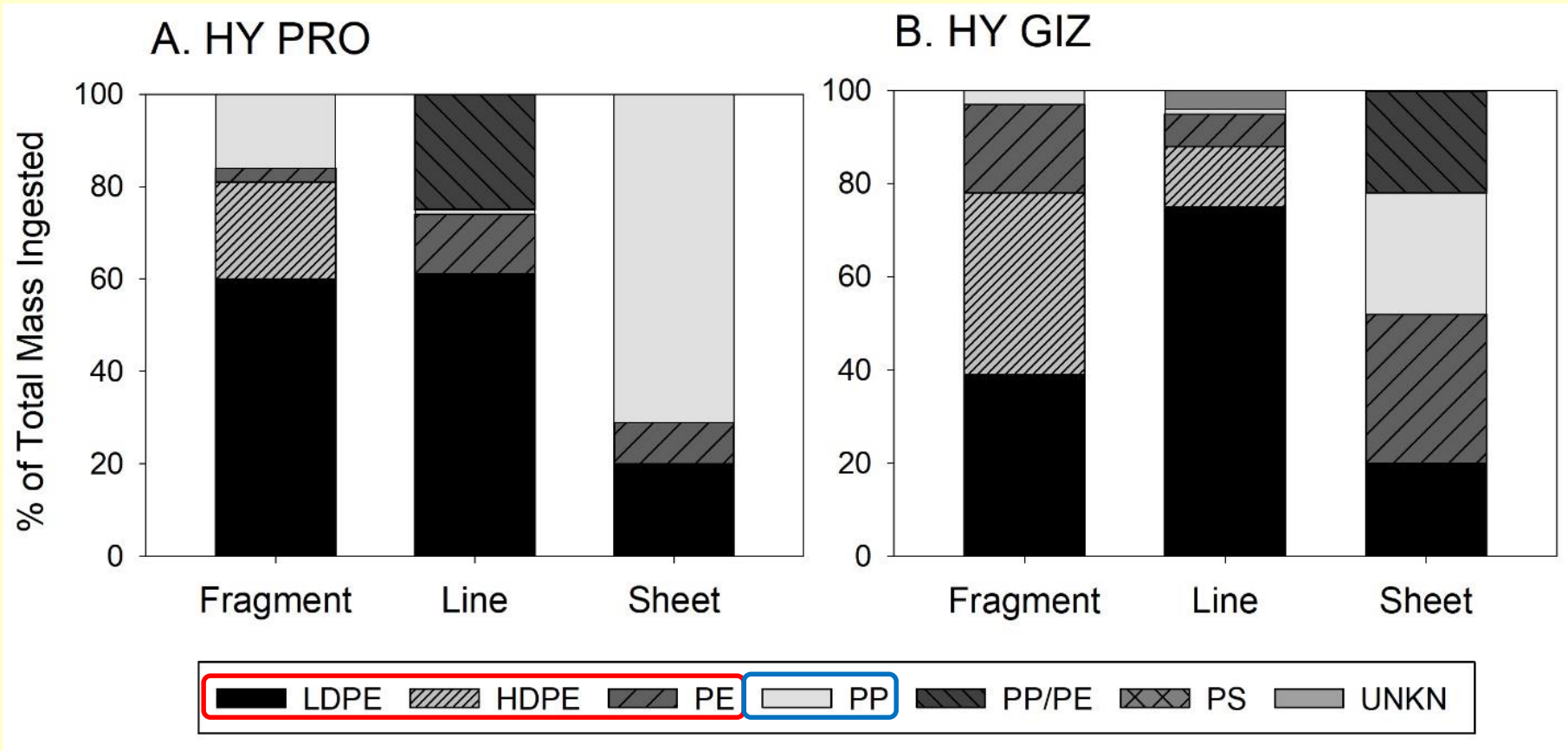
50 %

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)



Results - Plastic Polymers



➤ 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

- Four of five guilds
- F.O. higher for chicks

New plastic ingestion records:

- Brown booby - Tern Island
(Rapp et al. 2017)
- White-tailed Tropicbird - O'ahu
(Hyrenbach et al. 2013)



Implications - Focal Species



NOCTURNAL PETRELS

Tristram's
Storm-petrel:
100 %

Bonin Petrel:
98 %

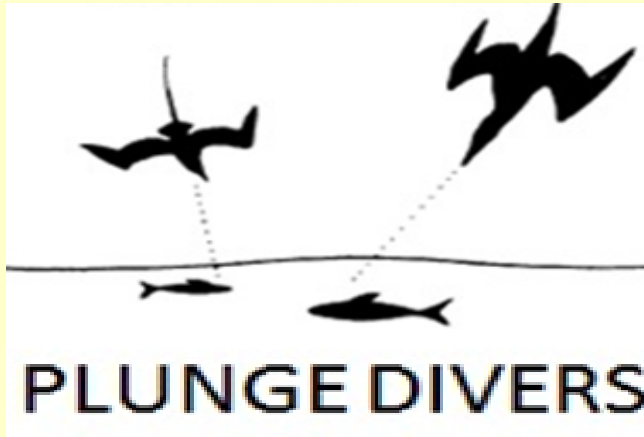


SURFACE SEIZING

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:

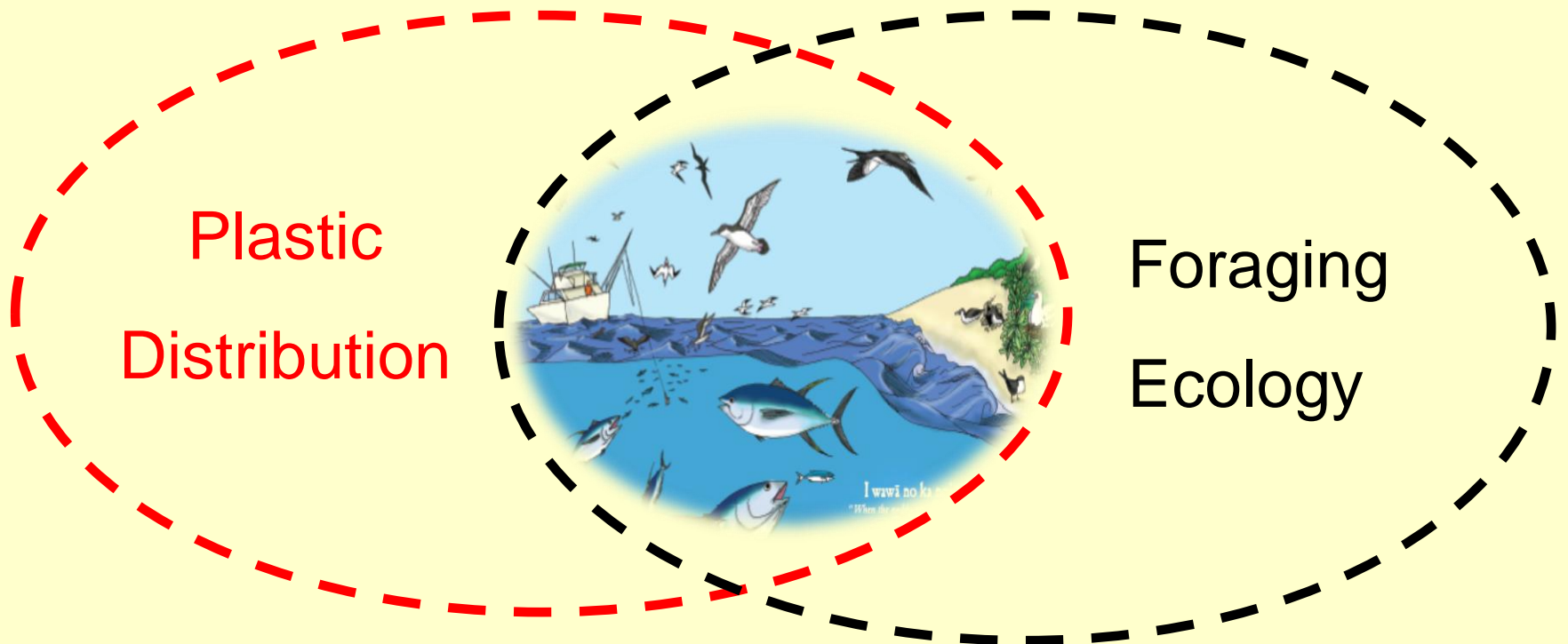
0.0 %

White Tern:

0.0 %

Seabird Bioindicators of Plastic Pollution

- Opportunity: Time Series
- Challenge: Interpretation





It Takes a Big Flock



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