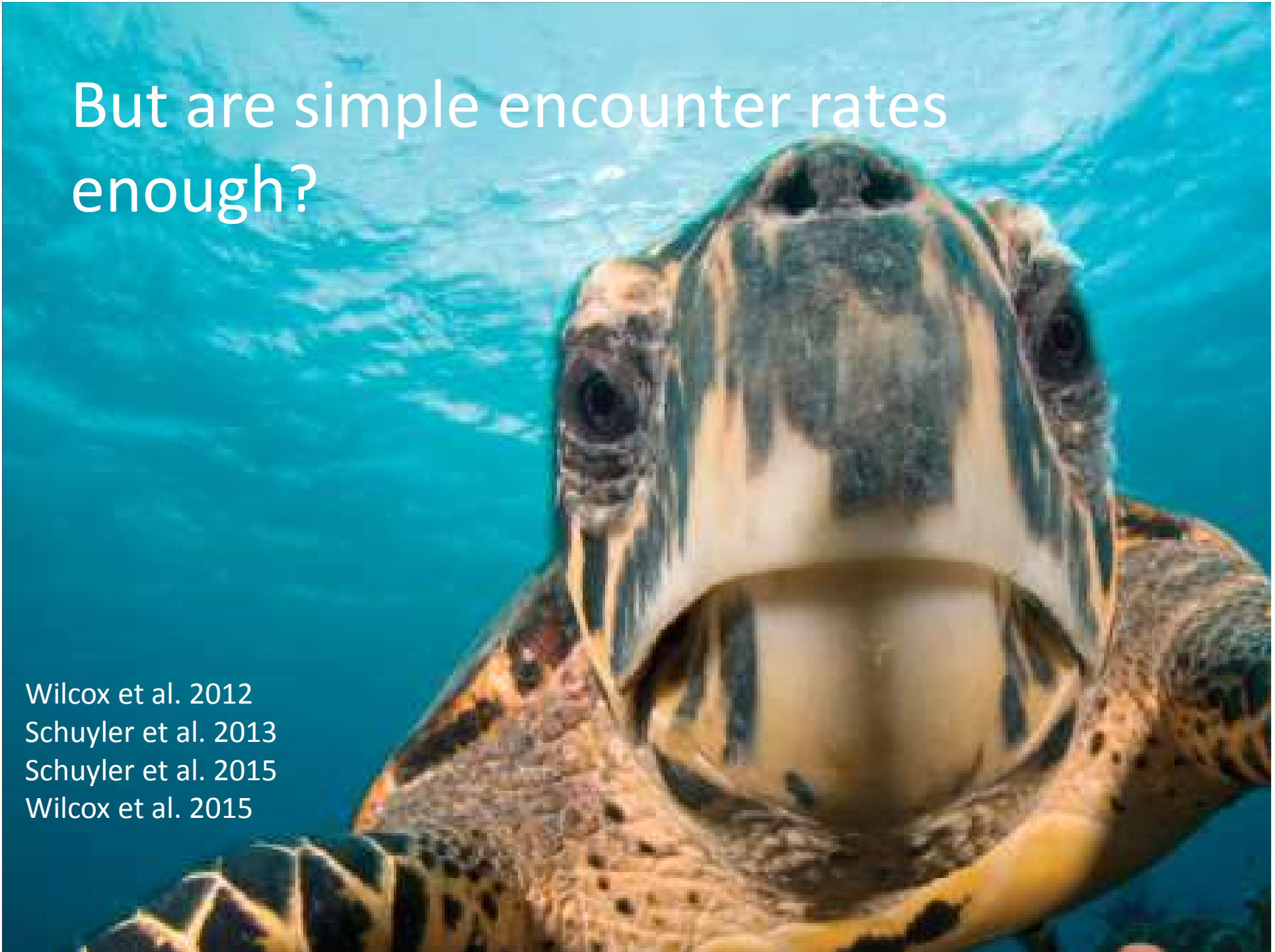


But are simple encounter rates
enough?

Wilcox et al. 2012
Schuyler et al. 2013
Schuyler et al. 2015
Wilcox et al. 2015



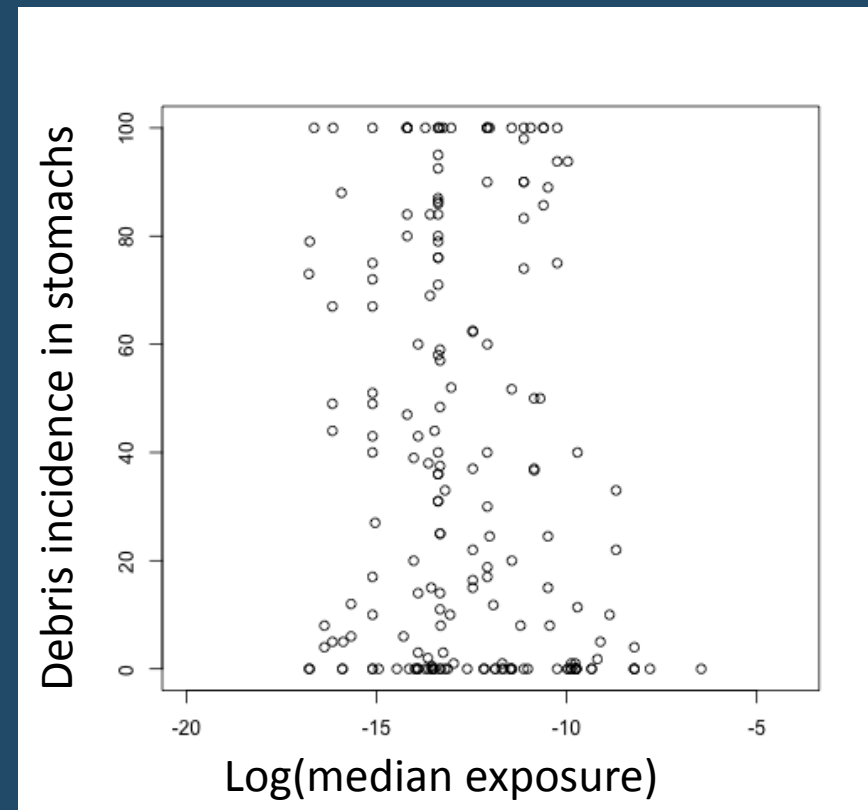
Predictions compared with data

- Comparison with diet studies

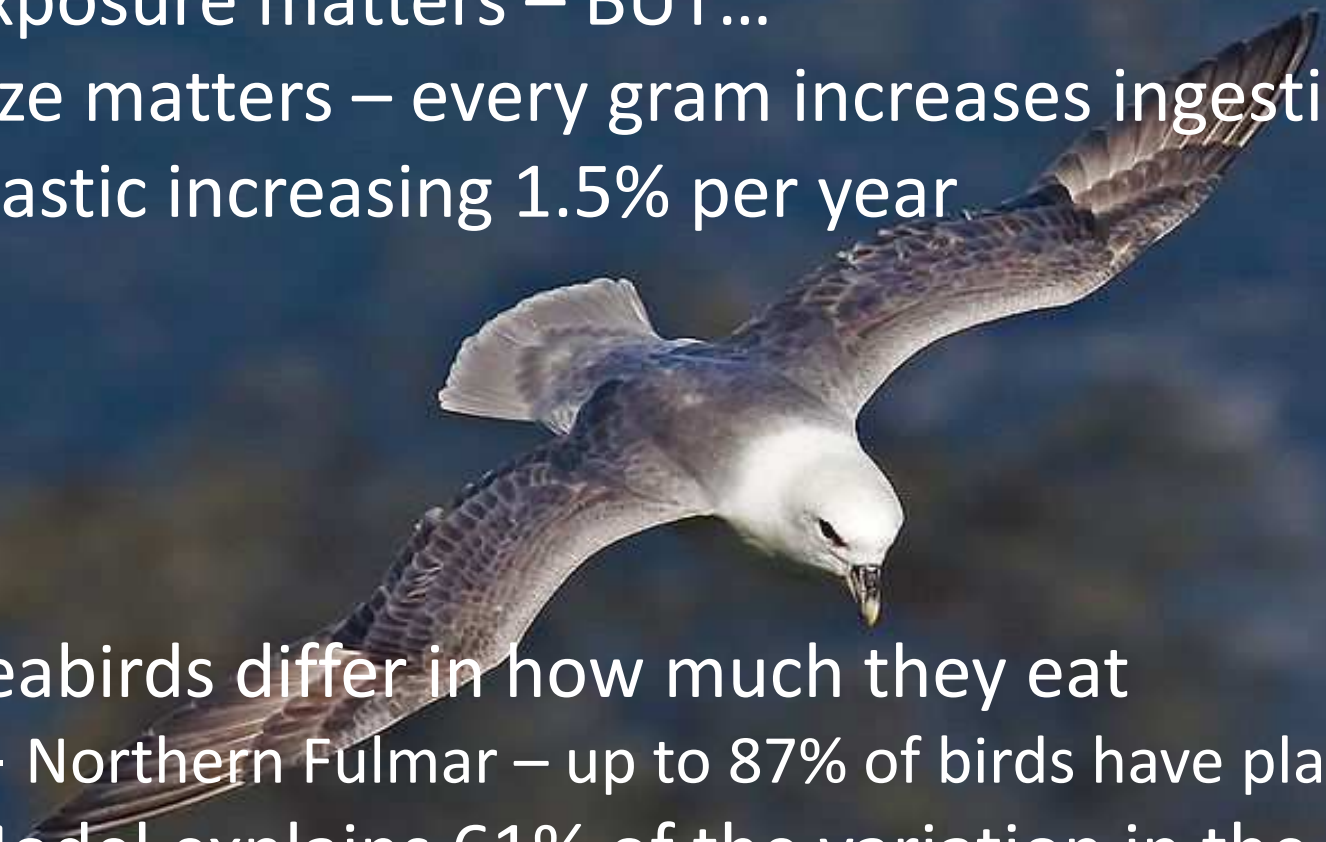
- 272 species/studies
- No relationship!
- But other factors relevant
 - Foraging style
 - Size
 - Regurgitation

- Logistic regression

$$\text{Pr(ingestion)} = \text{exposure} + \text{genus} + \text{size} + \text{time}$$

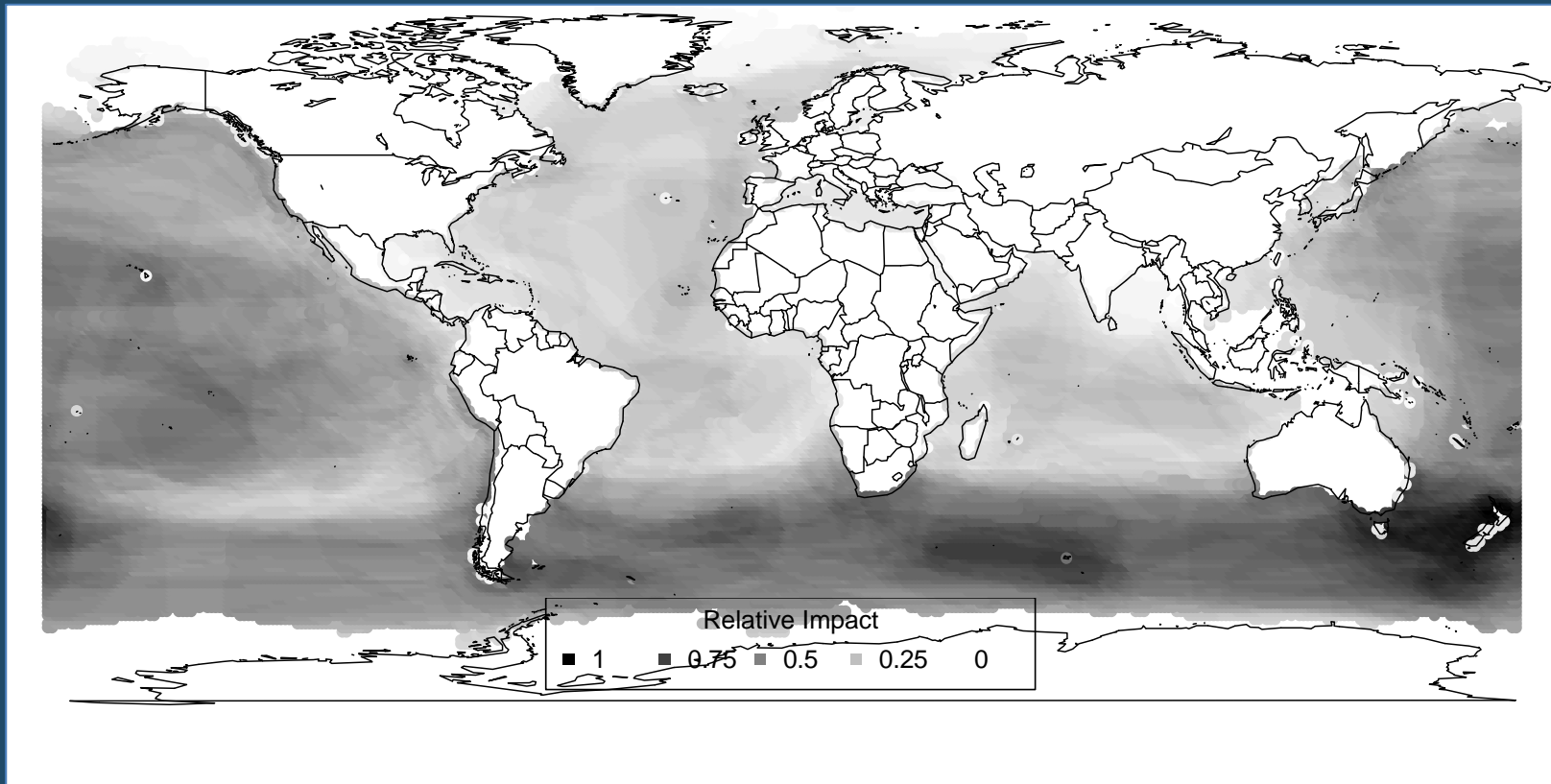


Some seabirds like trash

- Exposure matters – BUT...
 - Size matters – every gram increases ingestion by 5%
 - Plastic increasing 1.5% per year
- 
- Seabirds differ in how much they eat
 - Northern Fulmar – up to 87% of birds have plastic
 - Model explains 61% of the variation in the data

Translating predictions into biodiversity risk

- Statistical model – probability of ingestion
- Predictions summed for all species to ID high risk regions



I. Summary

Risk analysis is a useful lens for the problem
Identify species and areas with high impacts

Good news on gathering information

Encounters are a reasonable measure of risk

- Global debris for seabirds - Wilcox et al. 2015
- Global debris for turtles - Schuyler et al. 2013, 2015
- Ghost nets and turtles - Wilcox et al. 2013, 2015

Ecology is important

Traits are essential in making predictions

Utility????

We can make REAL management recommendations

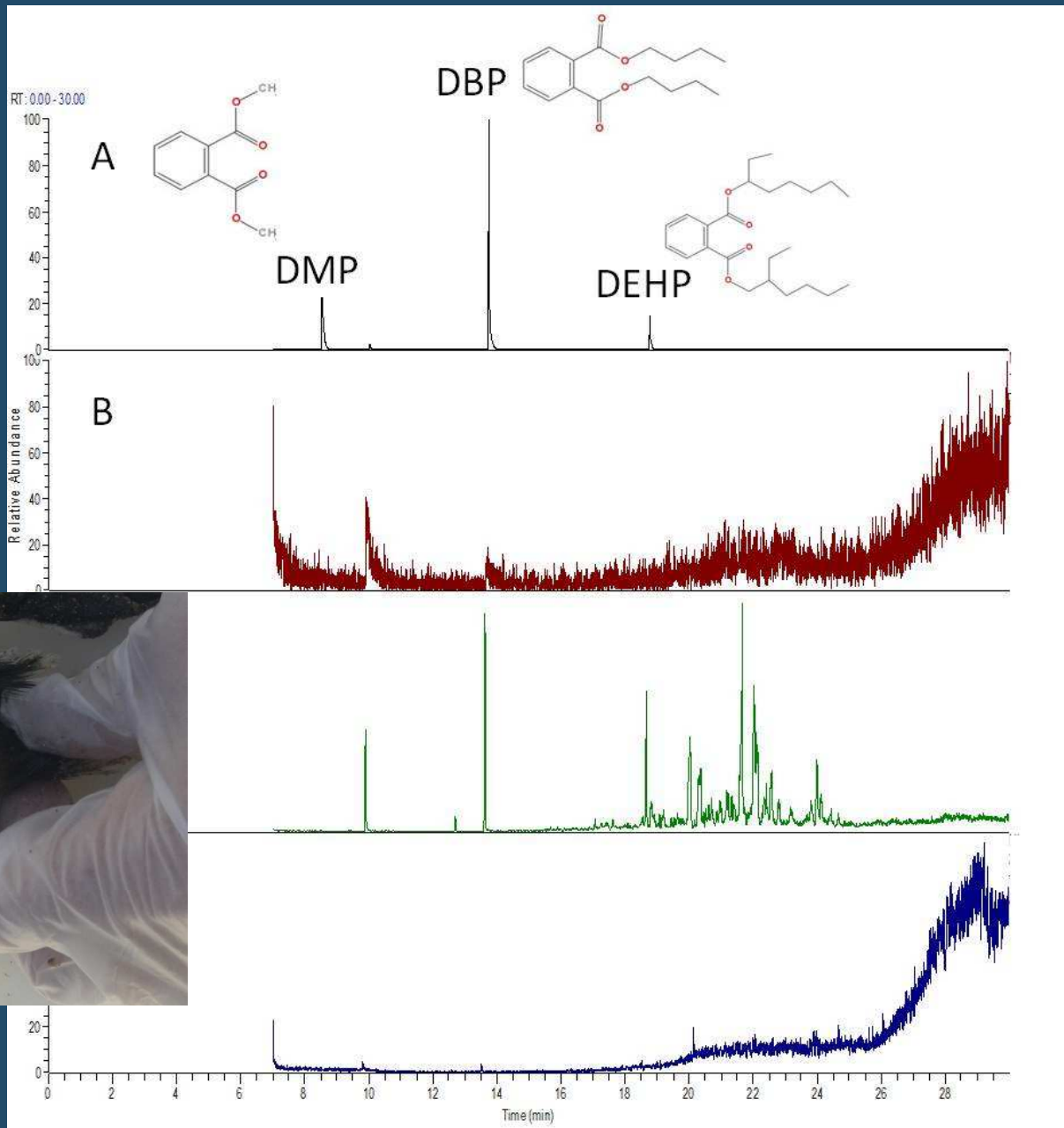
- Species at risk
- Opportunities for intervention

II. Understanding Impact

- **Difficult problem**
 - Often don't observe animals that are dead
 - Sublethal impacts are hard to distinguish
 - Confounding factors probably the rule, not the exception
 - E.g. seabird ingestion of plastic – hard to distinguish impacts
- **Trying three approaches**
 - Noninvasive measurement of ingestion and correlation with condition
 - Hardesty et al. 2015
 - Retrospective analysis of strandings data, with projection of unobserved impacts
 - Wilcox et al. 2014
 - Expert elicitation to predict impacts
 - Wilcox et al. 2016

2a. Plastic ingestion and seabird fitness

- Lots of studies on seabird ingestion
 - Early experiments show body condition impacts
 - Field studies confusing
 - more plastic = higher weight
- Need noninvasive methods so sampling can be done on random birds
 - Random dead birds – limited supply by location, species, etc.
 - Lavage – increasingly difficult permitting, incomplete sampling
 - Biochemical markers



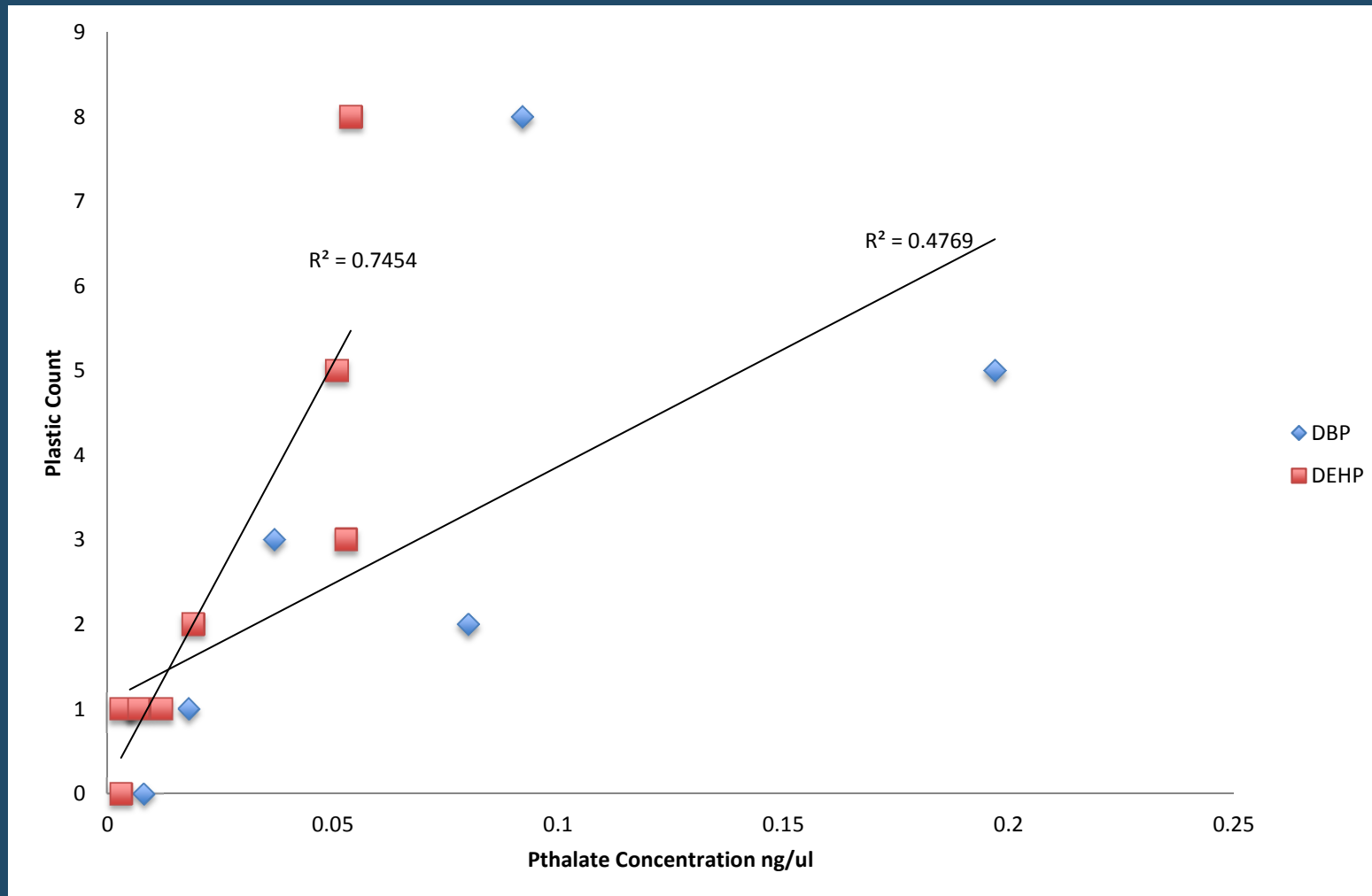
Plasticizers

Blank

Flesh-footed
shearwater

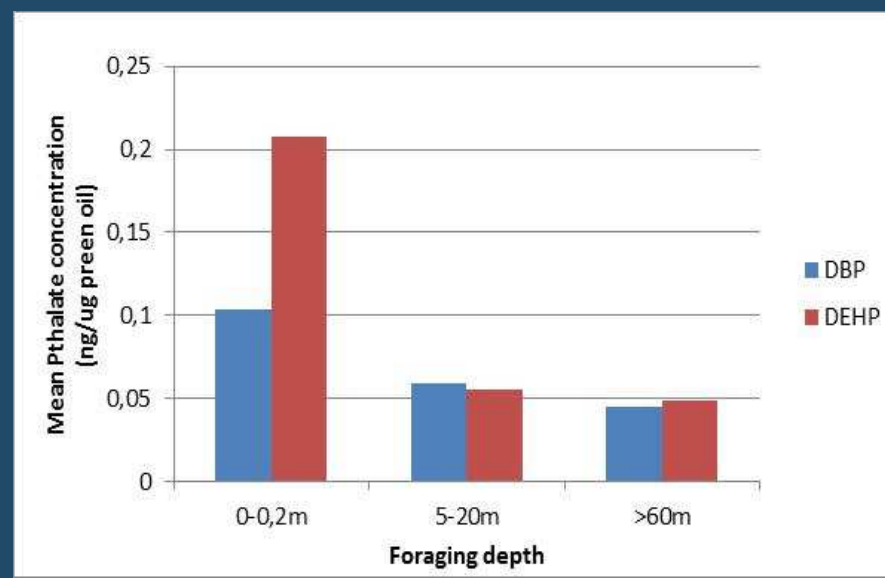
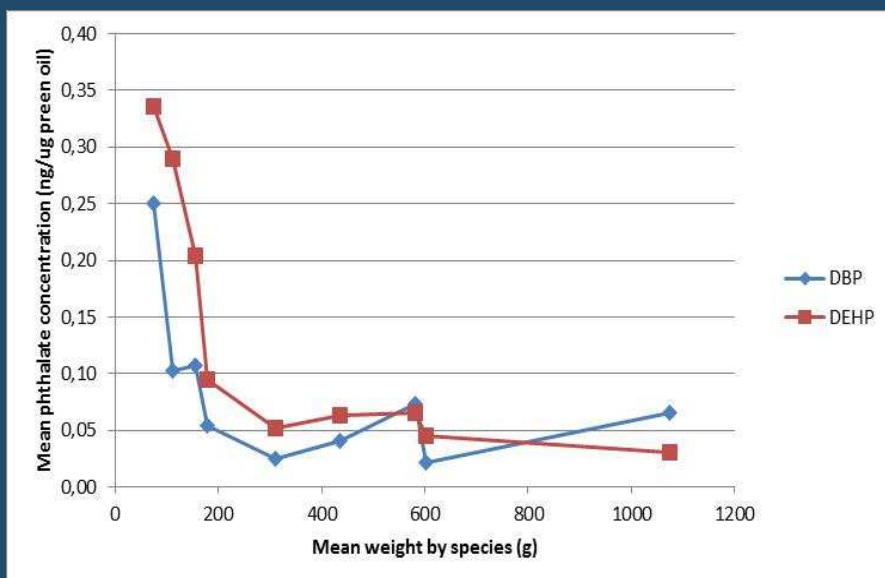
Bridled tern

Are break-down products a reliable marker?



Using markers to understand plastic ingestion and impacts

- Trial phase –8 species in Australia
 - Targeting a global survey with collaborators
- But, we can already get useful things from the markers
 - e.g. how does seabird ecology relate to ingestion rates



2b. What to do where there is little data?

- Retrospective data analysis isn't possible
- Expert elicitation is an alternative
 - Multiple approaches – few experts, many experts, qualitative, quantitative
 - See “Wisdom of the Crowds” by James Surowiecki
- Structured questionnaire
 - Broken into components that respondents can conceptualize
 - Categories, but quantitative

Ocean Conservancy's survey

- 3 marine taxa: Seabirds, Turtles, Marine Mammals
- 3 impacts: Entanglement, Ingestion, Contamination
- 20 most frequent items found in coastal cleanups (ICC)

SEVERITY

If a single, individual animal within the animal group experiences the threat, what is the impact of the interaction? When considering the severity of a product's impact, account for the product's impact both in its entirety as well as its fragmented or degraded state. [Example: If a whale becomes entangled in a fishing net, what is the impact? **NOTE:** We are NOT asking what the chance is of that whale becoming entangled.]

4 = Very High: The individual animal **dies** as a result of the interaction.

3 = High: The individual animal **may die** as a result of the interaction

2 = Medium: The individual animal experiences a **nonlethal impact** (e.g., reduced mobility, increased risk of predation, etc.) as a result of the interaction.

1 = Low: There is **no impact** to the individual animal as a result of the interaction.

SPECIFICITY

For the group of animals impacted by the product, what fraction of animals do you expect to experience this level of severity? [Example: What fraction of whales do you expect to die from becoming entangled in a fishing net.]

4 = Very High: 76-100% of animals experience the specified severity.

3 = High: 26-75% of animals experience the specified severity.

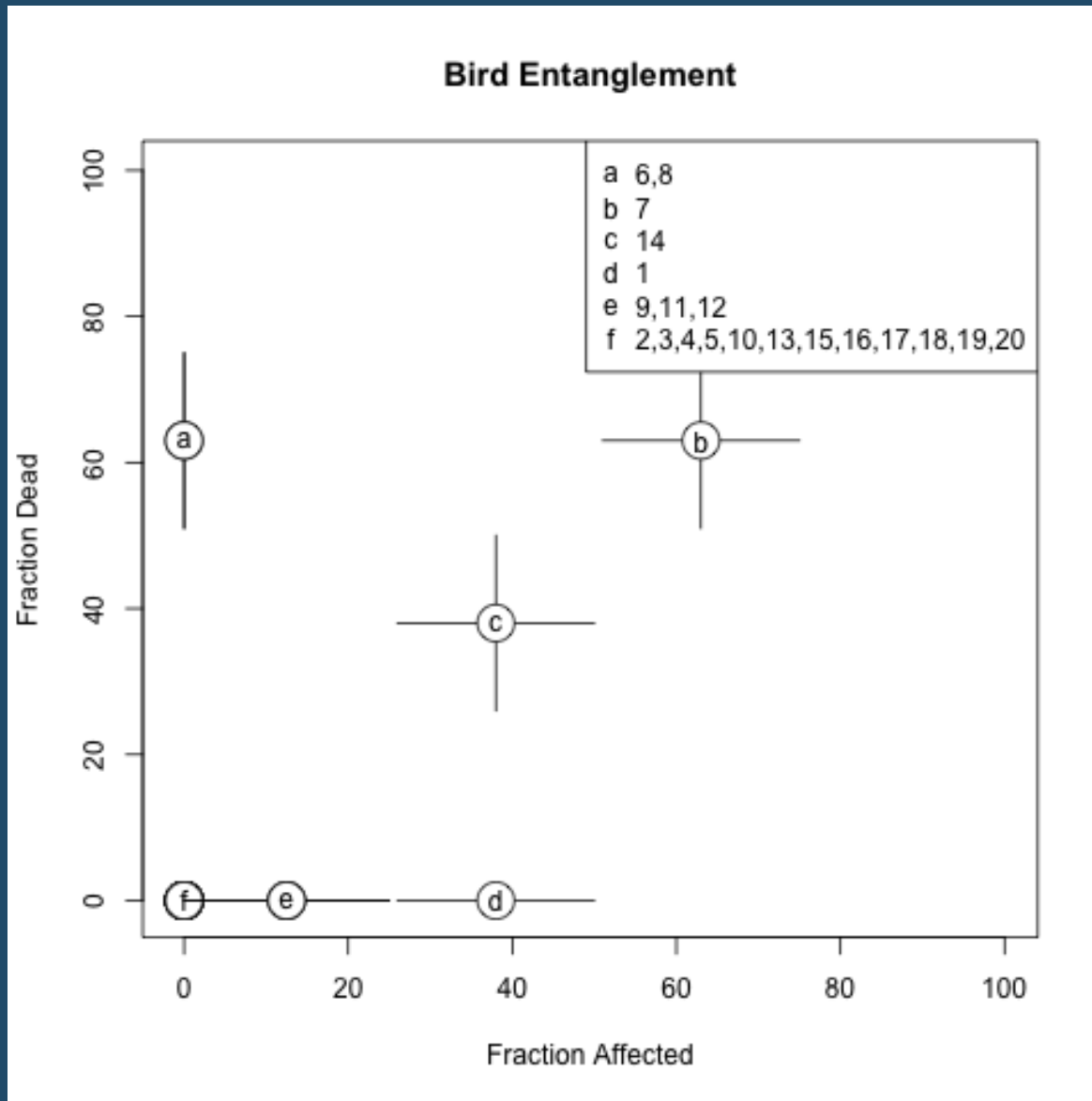
2 = Medium: 11-25% of animals experience the specified severity.

1 = Low: Less than 10% of animals experience the specified severity.

Turning survey results into estimates of impact

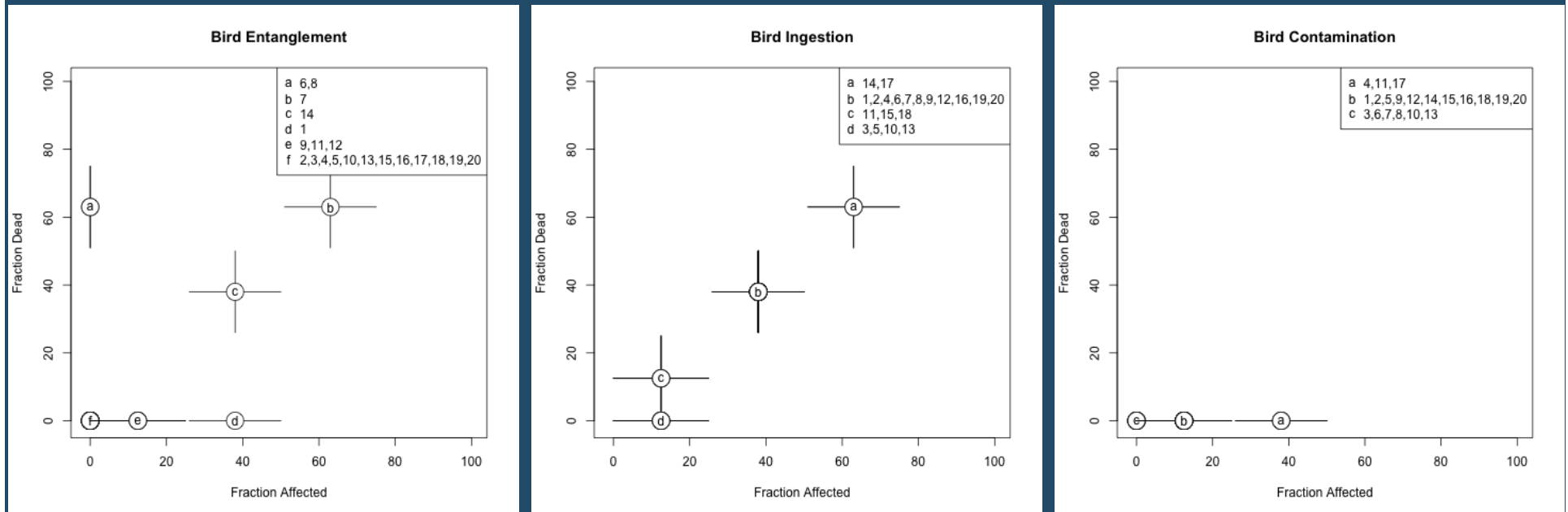
- Need to deal with respondent bias
 - Some observers score their species/threat/area higher or lower
 - Donlan et al. 2010 Cons Letters
- Need to deal with semi-quantitative scores
 - Intervals – e.g. 26% - 75%
- Use 2 tools
 - Random effects models – account for observer bias
 - Interval statistics – can deal with intervals properly
- Goal
 - Standardize survey data to remove bias
 - Impact = Severity x Specificity
 - i.e. how bad is individual affected x how many are effected

Results



1. Balloons
2. Caps
3. Beverage cans
4. Cigarette butts
5. Cups and plates
6. Fishing buoys, traps and pots
7. Fishing line
8. Fishing nets
9. Film-like plastic wrappers
10. Glass beverage bottles
11. Hard plastic containers
12. Other EPS Packaging
13. Paper bags
14. Plastic bags
15. Plastic beverage bottles
16. Plastic Food and Beverage Lids
17. Plastic utensils
18. Straws and Stirrers
19. Takeout food containers
20. Unidentifiable plastic fragments

Results



- Entanglement > Ingestion >> Contamination
- Contamination reflects level of uncertainty
- Generally matches observations
 - Rope, fishing gear, bags worst for entanglement – fairly specific risks
 - Ingestion: bags, food utensils worst, but many other items trail closely – some specific, followed by larger items
 - Contamination – low level, most things fairly similar, most impacts nonlethal

What does all this mean?

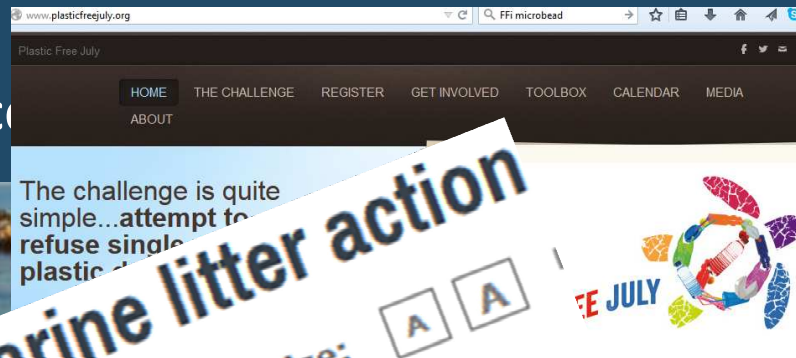
- Risk analysis is a useful lens for the problem
 - Good for structuring the problem
 - Can make estimates of both scope of the problem and impacts
 - Can adjust methods based on data available
- Impacts harder than exposure
 - New data needed, but manageable?
 - e.g. exposure via phthalates in fat
 - Combine with existing data sets like photo mark-recapture
 - but some ways to use existing information
 - Strandings etc.
- This can be connected to policy in a direct way
 - We compared debris distribution to local policy
 - Strong effect of a) regs on illegal dumping and b) education/outreach

Opportunities and Solutions

Societal view

Technology

Product



energy

parco

Science should drive marine litter action

Targeted

Illegal

By **Steve Toloken**
STAFF REPORTER / ASIA BUREAU CHIEF
Published: November 12, 2014 11:31 am ET



Garbage



on produ



CSIRO Oceans and Atmosphere

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Thanks!

