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An Exploratory Analysis of the Effects of Sampling in Marine Surveys for Biodiversity Estimation



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Outline

1. Background
2. Data
3. Impact of sampling process
4. Summary

Background

CERF project: (<http://www.marinehub.org/>)

The Commonwealth Environment Research Facilities (CERF) Marine Biodiversity Hub prediction project analyses patterns and dynamic of marine biodiversity to determine the appropriate units and models for effectively predicting Australia's marine biodiversity.

The project administered through the Australian Government Department of the Environment, Water, Heritage and the Arts.

Major contributors: University of Tasmania (UTas); CSIRO Wealth from Oceans Flagship; Geoscience Australia (GA); Australian Institute of Marine Science (AIMS); Museum Victoria (MV).

Aims: Modelling the relationship between biodiversity (eg presence/absence, richness, biomass etc) and the environment (eg depth, %carbonate, %mud, O₂).

Niche theory

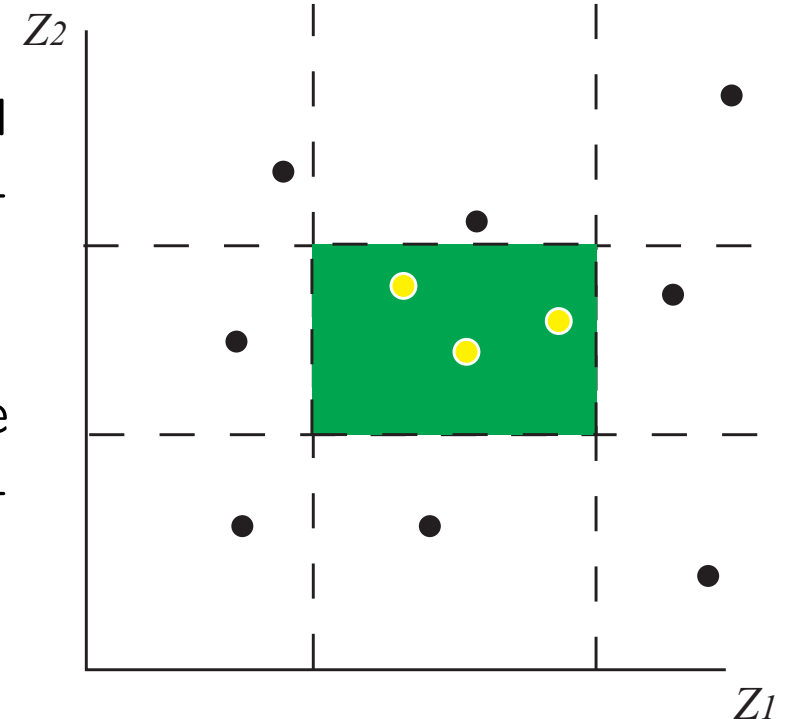
Hutchinson (1957)

Niche: The full range of environmental conditions under which an organism can exist.

Note:

Niche is a sub-space of a hyper space spanned by some physical covariates (environmental conditions).

Two covariate case:



Great Barrier Reef Data

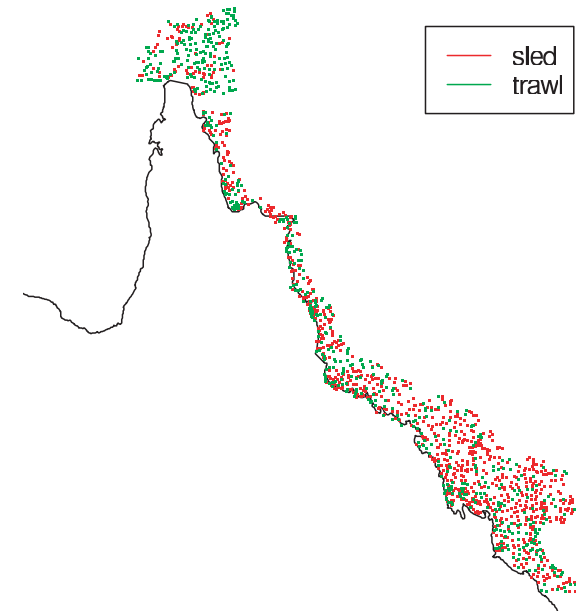
Pitcher *et al.* (2007)

Survey period: 2003 – 6

Number of observation sites: 1252

Methods: Trawl, Sled

Number of species observed: 2862

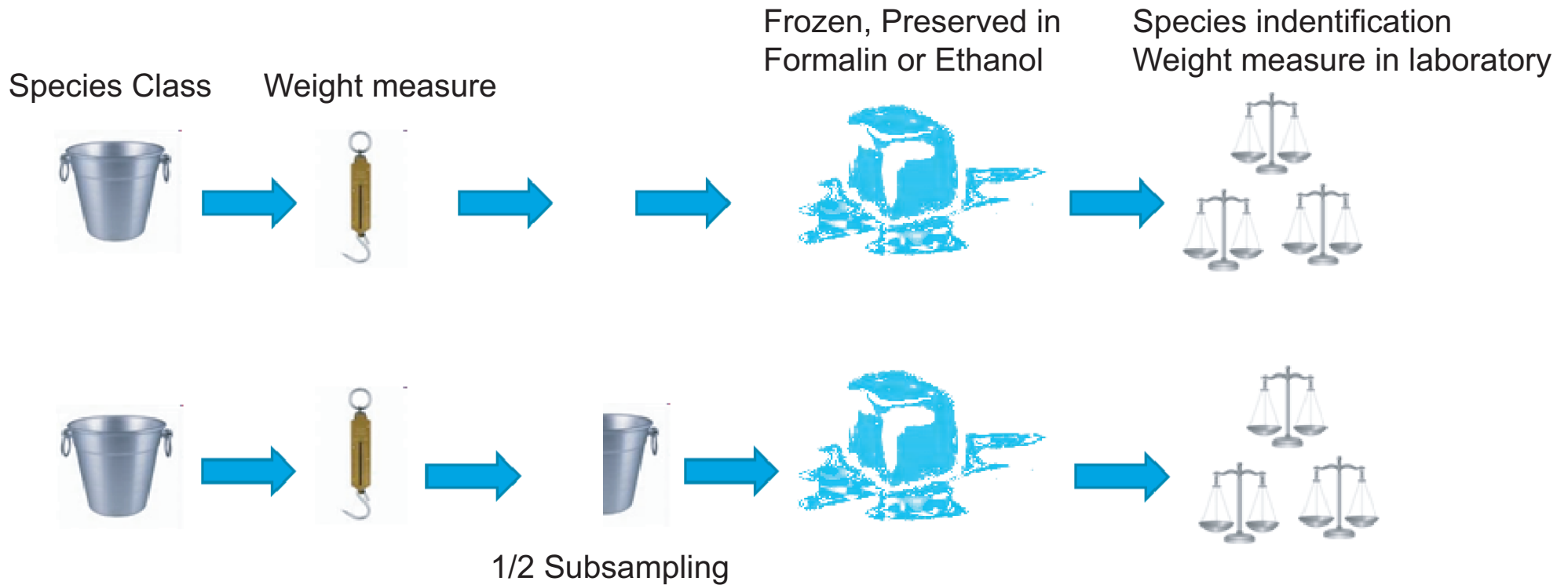


Note

Also physical covariates are given.



Sampling process



Species classes

Algae, Brachiopoda, Bryozoa, Crustacea, Porifera, Seagrass, etc.

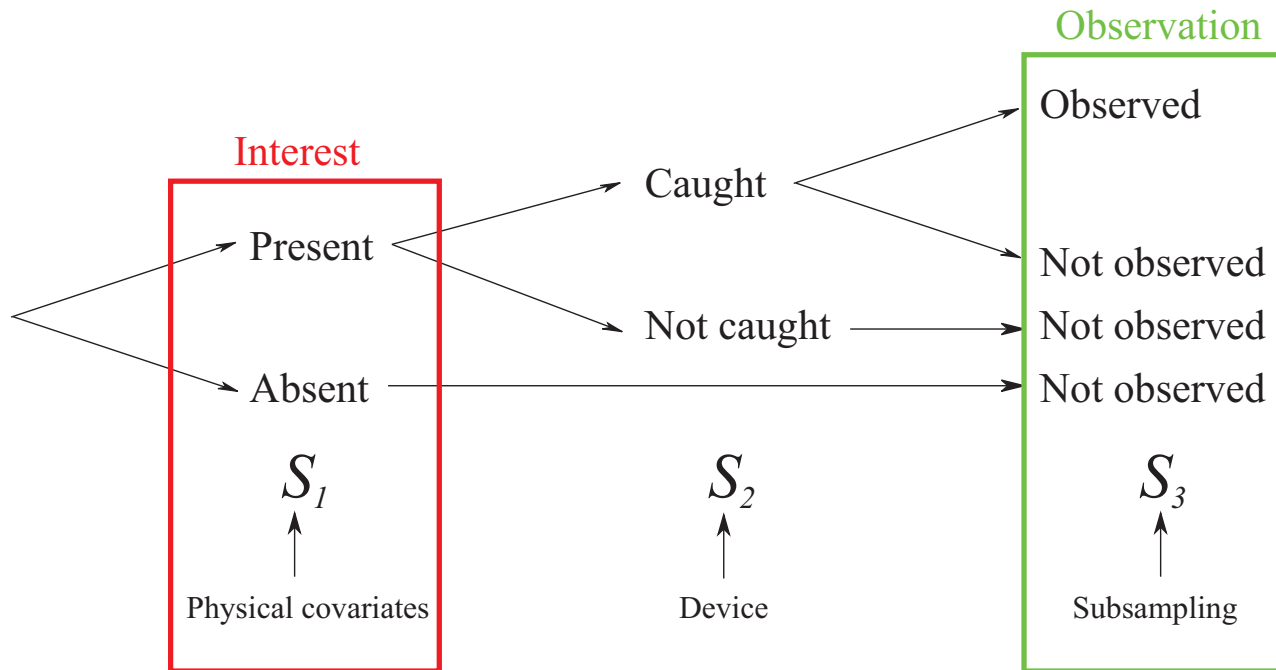
Subsampling

Widely used method in marine surveys.
A part of the whole catch is sorted.
Many variety of subsampling procedures
(survey specific).

Note: Very little research on subsampling
(eg Heales *et al.*, 2003).



Species presence/absence



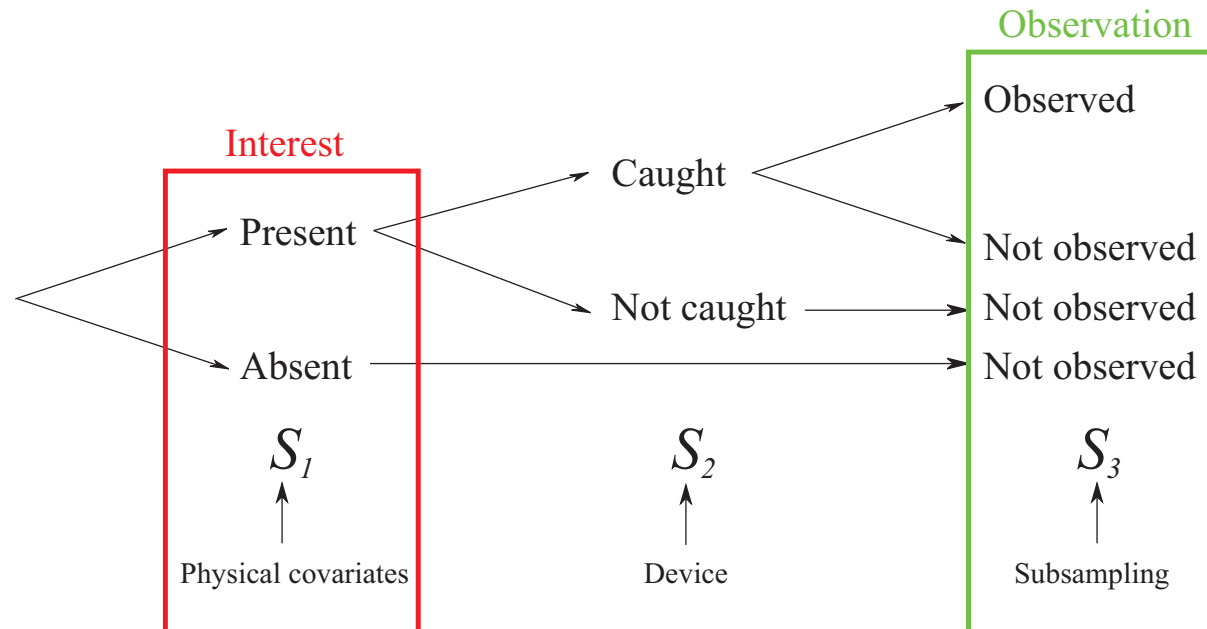
Occupancy – Detectability – Sampling (Compound events)

$$\Pr(S_3 = s_3) = \sum_{S_2} \sum_{S_1} \Pr(S_1, S_2, S_3) = \sum_{S_2} \sum_{S_1} \Pr(S_1) \Pr(S_2|S_1) \Pr(S_3|S_2, S_1)$$

Our approach

Restrict our attention on the effect of subsampling:

- Fully sampled vs. subsampled;
- Sled;
- Site matching



Site matching

For survey sites $\{j : j = 1, 2, \dots, n\}$, matched pair sites such that one is fully sampled and the other is subsampled are

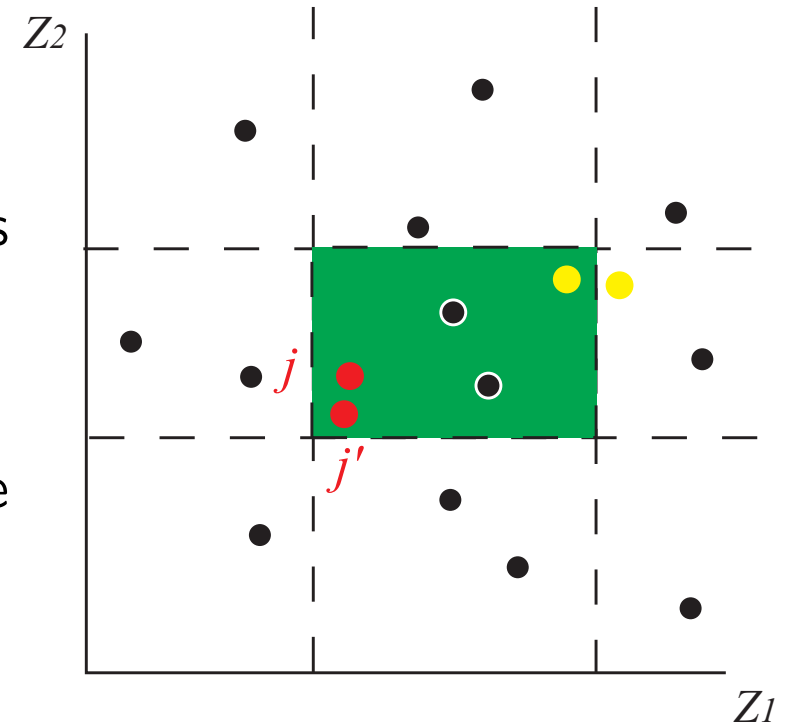
$$\left\{ (j, j') : \min_{j' \in \mathcal{J}'} \|z_j - z_{j'}\|, j \in \mathcal{J} \right\},$$

where z_j is a vector of physical covariates at site j .

Given a pair of species presence/absence $(Y_j, Y_{j'})$, odds ratio is given as

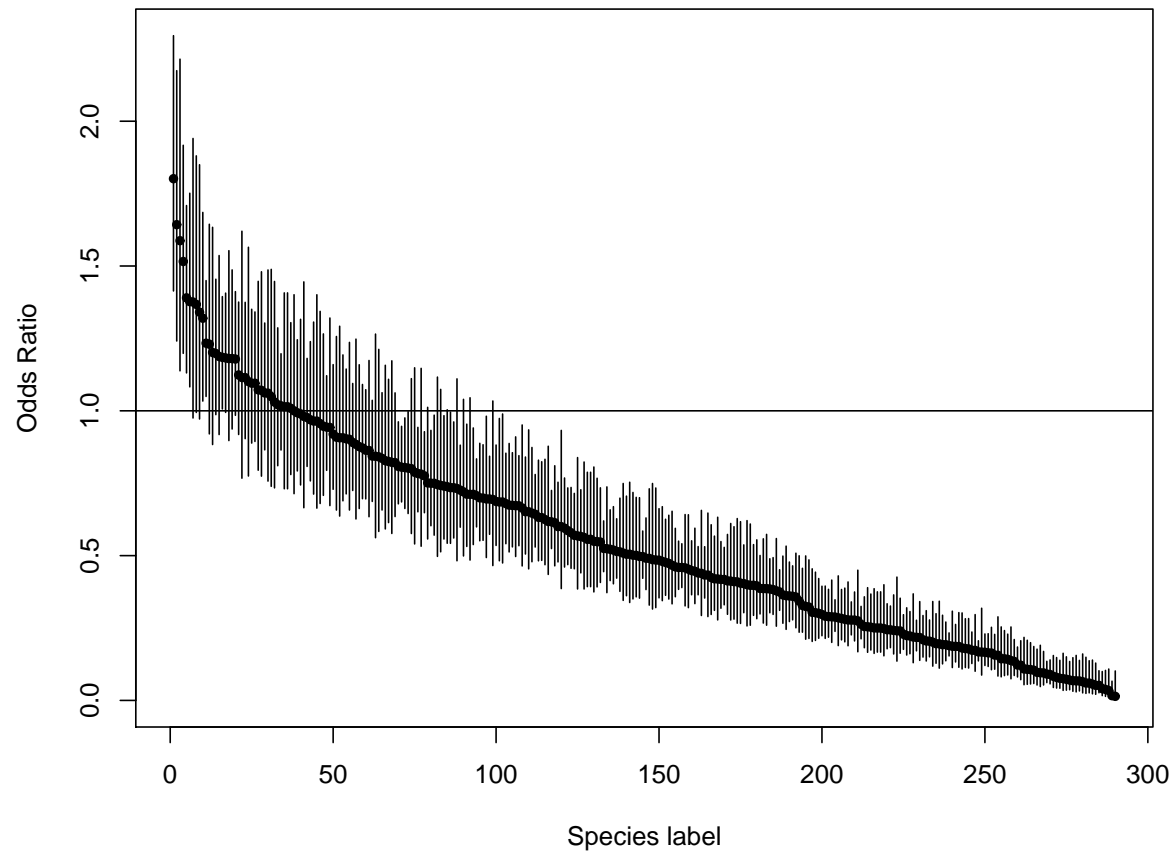
$$\text{OR} = \frac{\sum_j y_j}{|\mathcal{J}|} \bigg/ \frac{\sum_{j'} y_{j'}}{|\mathcal{J}'|},$$

where $|\cdot|$ denotes the number of elements of a set.

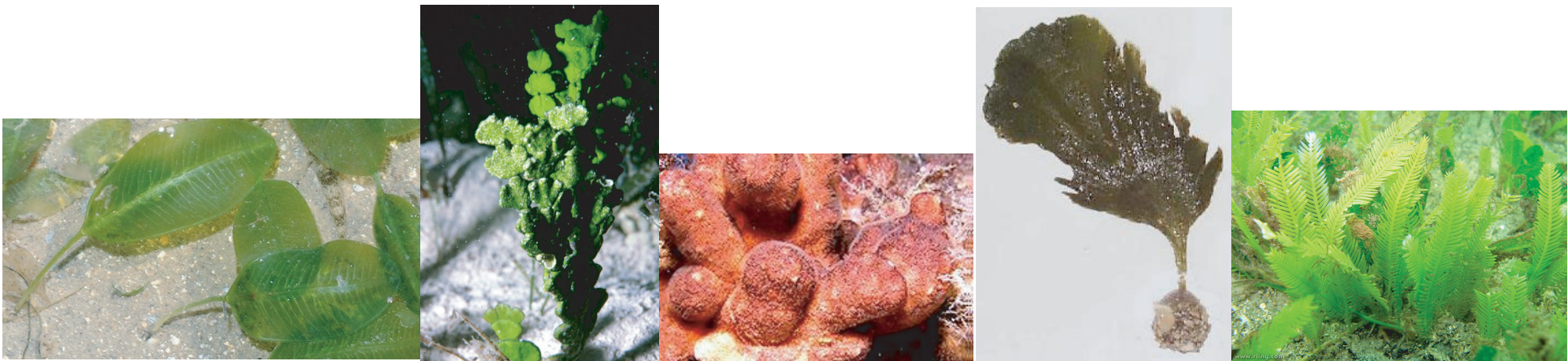


Subsampled vs. fully sampled

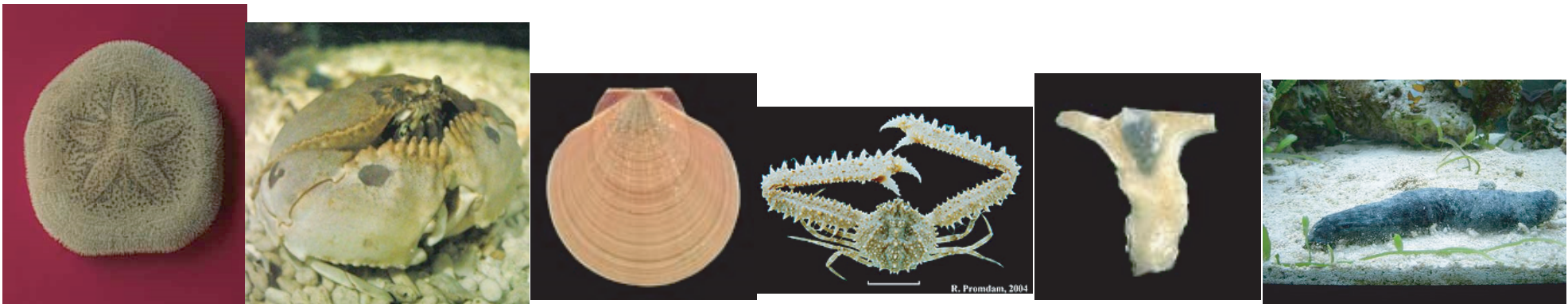
When subsample was taken species are more likely to be observed...

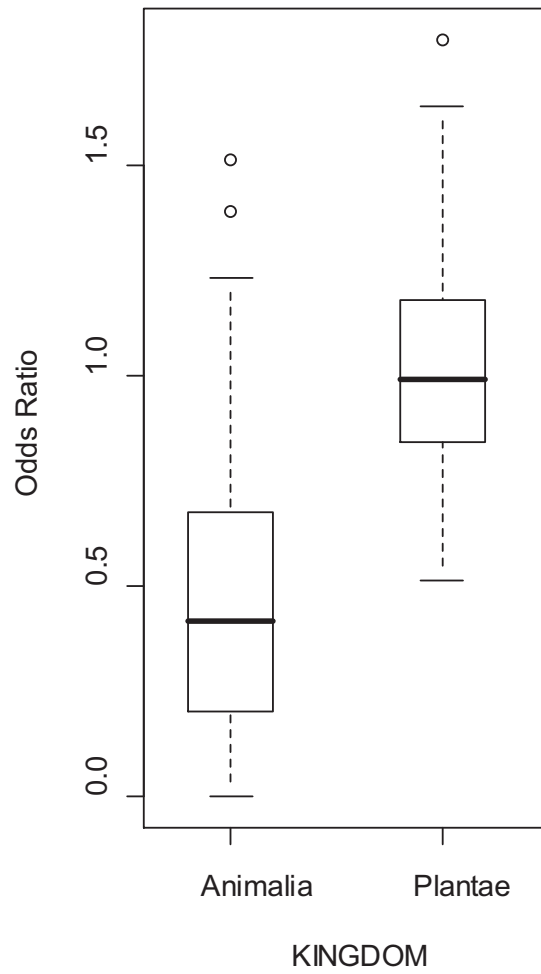


Odds ratio	Scientific name
1.801	<i>Magnoliophyta Liliopsida Hydrocharitales Hydrocharitaceae Halophila ovalis</i>
1.643	<i>Chlorophyta Chlorophyceae Caulerpales Codiaceae Halimeda gigas</i>
1.587	<i>Chlorophyta Chlorophyceae Caulerpales Codiaceae Halimeda borneenses</i>
1.516	<i>Bryozoa Gymnolaemata Cheilostomata Margarettidae Margaretta spp</i>
1.390	<i>Bryozoa Gymnolaemata Cheilostomata Schizoporellidae Stylopoma spp</i>
1.377	<i>Chlorophyta Chlorophyceae Caulerpales Codiaceae Udotea flabellum</i>
1.376	<i>Chlorophyta Chlorophyceae Caulerpales Caulerpaceae Caulerpa taxifolia</i>
1.367	<i>Chlorophyta Chlorophyceae Cladophorales Boodleaceae Phyllocladon sp1</i>
1.341	<i>Chlorophyta Chlorophyceae Caulerpales Caulerpaceae Caulerpa brachypus</i>
1.320	<i>Phaeophyta Phaeophyceae Dictyotales Dictyotaceae Lobophora variegata</i>

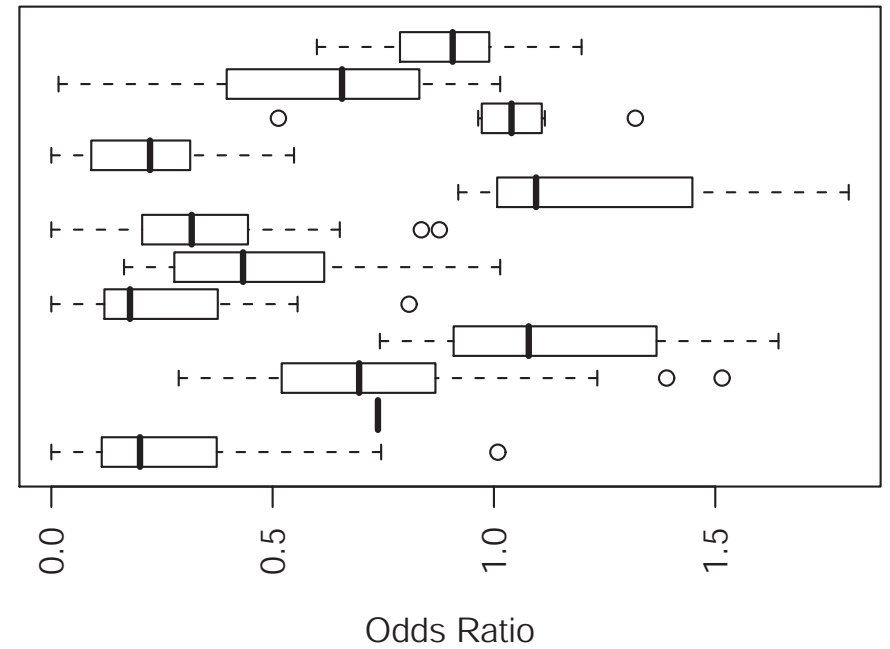


Odds ratio	Scientific names
0.014	<i>Echinodermata Echinoidea Clypeasteroidea Laganidae Laganidae</i>
0.016	<i>Porifera Demospongiae Hadromerida Tethyidae Xenospongia patelliformis</i>
0.034	<i>Arthropoda Crustacea Decapoda Calappidae Calappa</i>
0.038	<i>Mollusca Bivalvia Ostreoida Pectinidae Amusium pleuronectes</i>
0.041	<i>Arthropoda Crustacea Decapoda Xanthidae Actumnus squamosus</i>
0.052	<i>Arthropoda Crustacea Decapoda Parthenopidae Parthenope longimanus</i>
0.052	<i>Mollusca Bivalvia Pterioidea Malleidae Malleus albus</i>
0.056	<i>Echinodermata Holothuroidea Holothuroidea Holothuroidea Holothuroidea</i>
0.060	<i>Mollusca Gastropoda Sorbeoconcha Bursidae Bufonaria rana</i>
0.060	<i>Chordata Actinopterygii Tetraodontiformes Monacanthidae Paramonacanth</i>





- Rhodophyta
- Porifera
- Phaeophyta
- Mollusca
- Magnoliophyta
- Echinodermata
- Cnidaria
- Chordata
- Chlorophyta
- Bryozoa
- Brachiopoda
- Arthropoda



- Challenges in marine survey data;
- The impact of subsampling;
- Need more investigation of the factor related to odds ratio.

Thank you for your kind attentions.
Comments and suggestions are welcome!

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