

Marine reserve assessments are sensitive to habitat, fishing activity and survey method: a 30-year meta-analysis from Ningaloo Reef

Anna K Cresswell, Timothy Langlois, Shaun Wilson, Joachim Claudet, Damian Thomson, Mat Vanderklift, Russell Babcock, Rick Stuart-Smith, Christopher Fulton, Mick Haywood, Rebecca Fisher, Martial Depczynski, Mark Westera, Anthony Ayling, Ben Fitzpatrick, Andrew Halford, Dianne McLean, Richard Pillans, Alistair Cheal, Paul Tinkler, Graham Edgar, Michael Renton, Thomas Holmes

Ningaloo Outlook – A partnership between BHP and CSIRO

WESTERN COASTAL/OCEAN & ATMOSPHERE

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Ningaloo Outlook is a BHP-CSIRO Industry-Science Marine Research Partnership investing A\$5.4 million over five years to gather new knowledge on the Ningaloo reef and its important ecological values

A large school of Spangled Emperors (Lethrinus nebulosus) is shown swimming in clear blue water. The fish are silvery with a fine, spangled pattern of darker spots. They are arranged in a loose, coordinated group, moving towards the left. The background is a deep blue, suggesting an underwater environment. The text "Spangled Emperor" is written in a large, white, sans-serif font, and "*Lethrinus nebulosus*" is written below it in a smaller, white, italicized serif font.

Spangled Emperor

Lethrinus nebulosus



Department of **Biodiversity,
Conservation and Attractions**

Tony Ayling

Mark Westera

Ben Fitzpatrick



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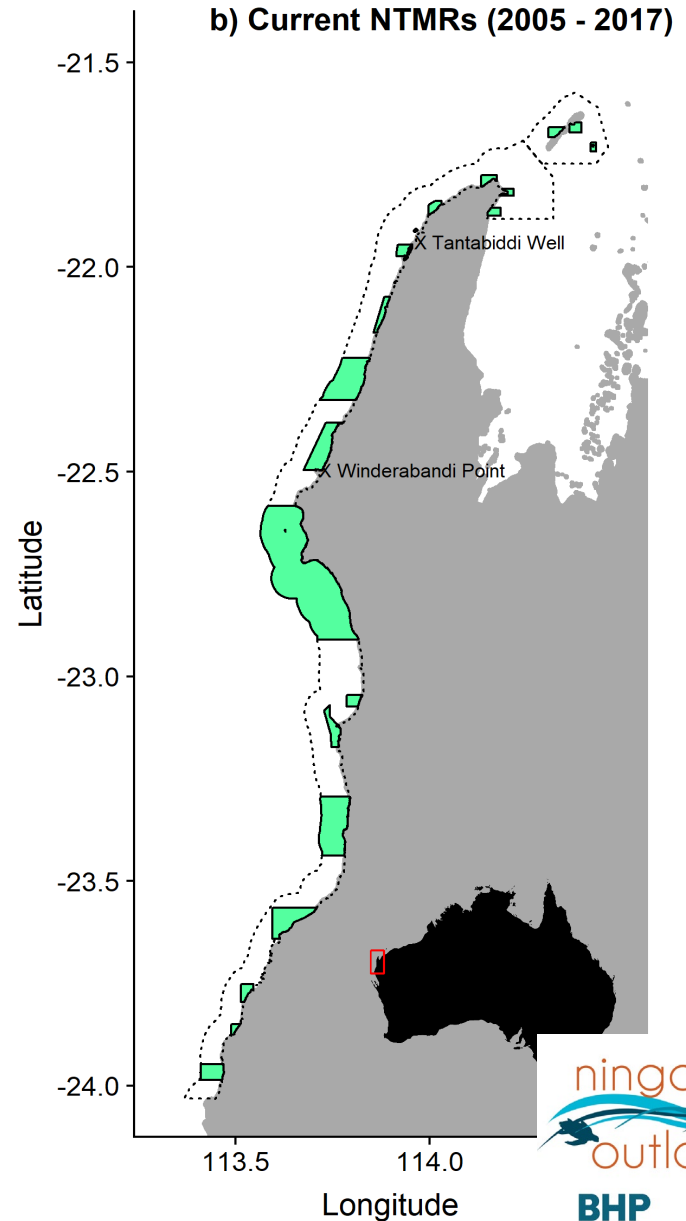
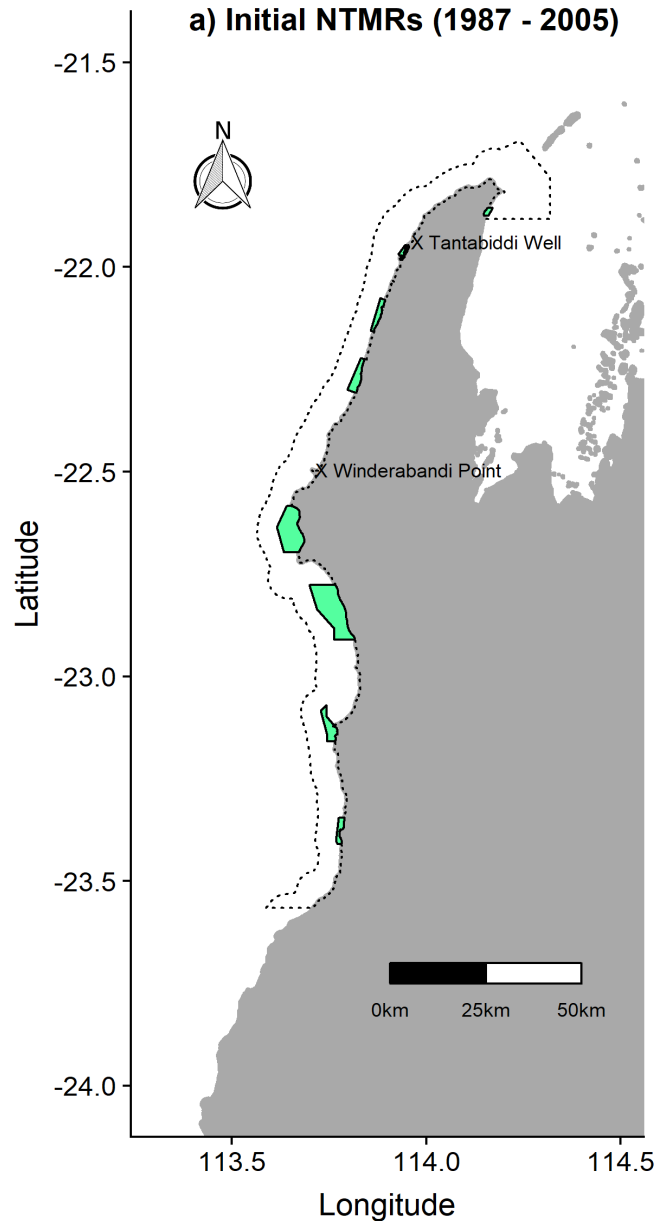
AUSTRALIAN INSTITUTE
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National
University



Two networks of sanctuary zones



Broad questions

1. What is the effect of recreational fishing on target fish groups?
2. Are Ningaloo sanctuary zones effective in maintaining higher abundance of targeted fish groups?
3. What other factors influence observed differences inside to outside the sanctuaries?

Variables

Survey method

Reef habitat

Reserve Size

Years of protection

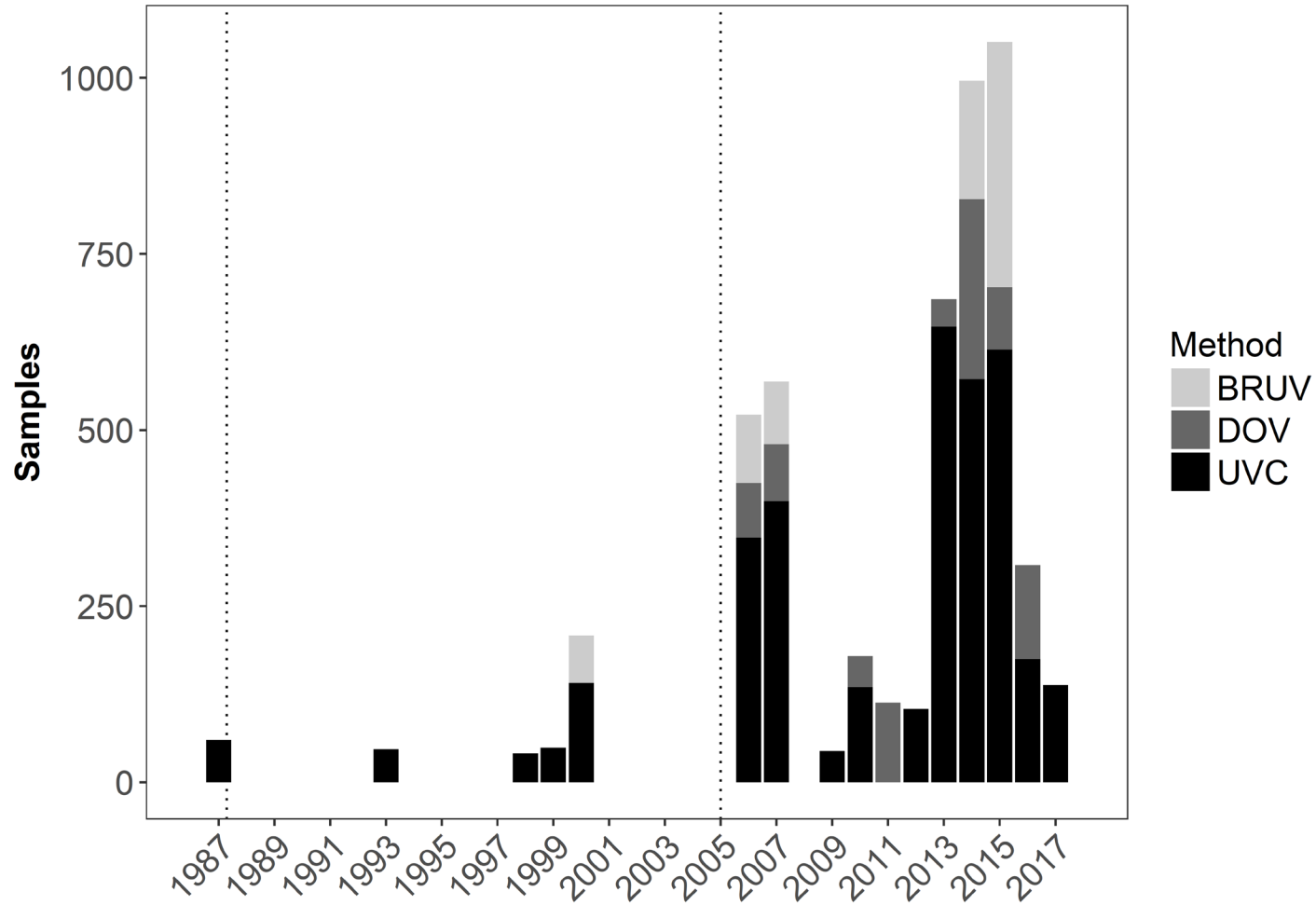
Zoning scheme

Boat fishing

Shore fishing

Available data

Total: >4800 samples



30 years

Meta-analysis

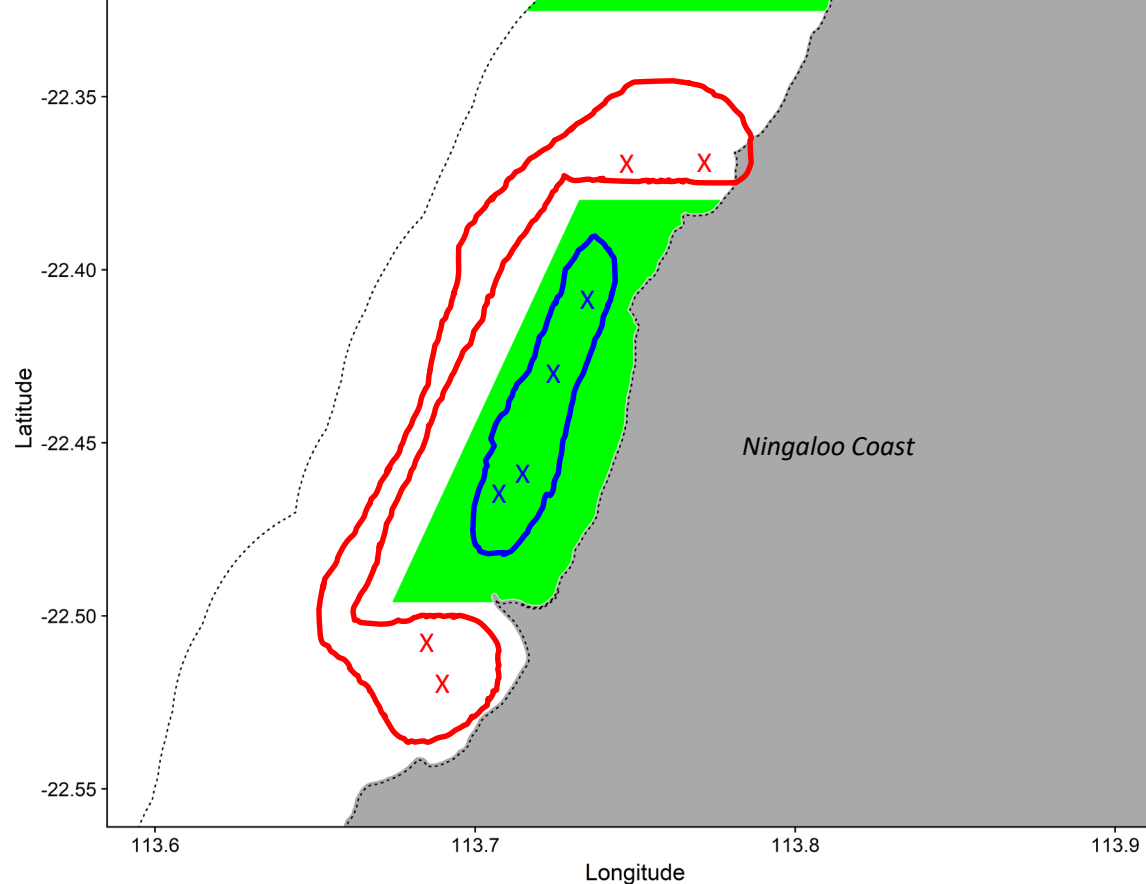
Examination of data from a number of independent studies of the same subject, in order to determine overall trends

Meta-analysis

Examination of data from a number of independent studies of the same subject, in order to determine overall trends

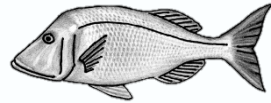
Data selection criteria

- >2 samples inside and outside
- Same time
- Same survey method
- Same habitat



➡ Inside/outside comparison pairs (n = 330)

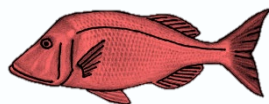
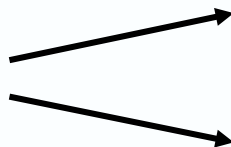
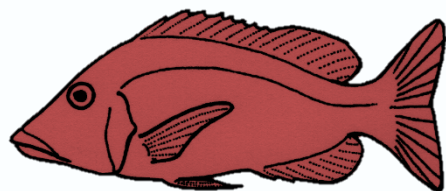
➡ Effect size = $\left(\frac{\text{Mean abundance inside}}{\text{Mean abundance outside}} \right)$



Spangled emperor
Lethrinus nebulosus

FAMILY/SUBFAMILY

SPECIES

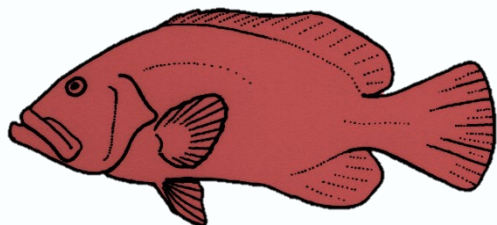


Spangled emperor
Lethrinus nebulosus



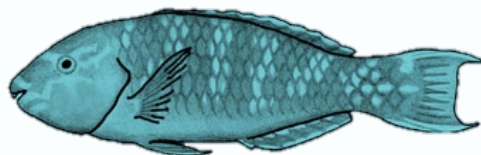
Yellow-tailed emperor
Lethrinus atkinsoni

Emperors
Lethrinidae



Chinaman cod
Epinephelus rivulatus

Gropers
Epinephelinae



Parrotfishes
Scarinae

Fishers preference

Highly targeted

Retained / unclear

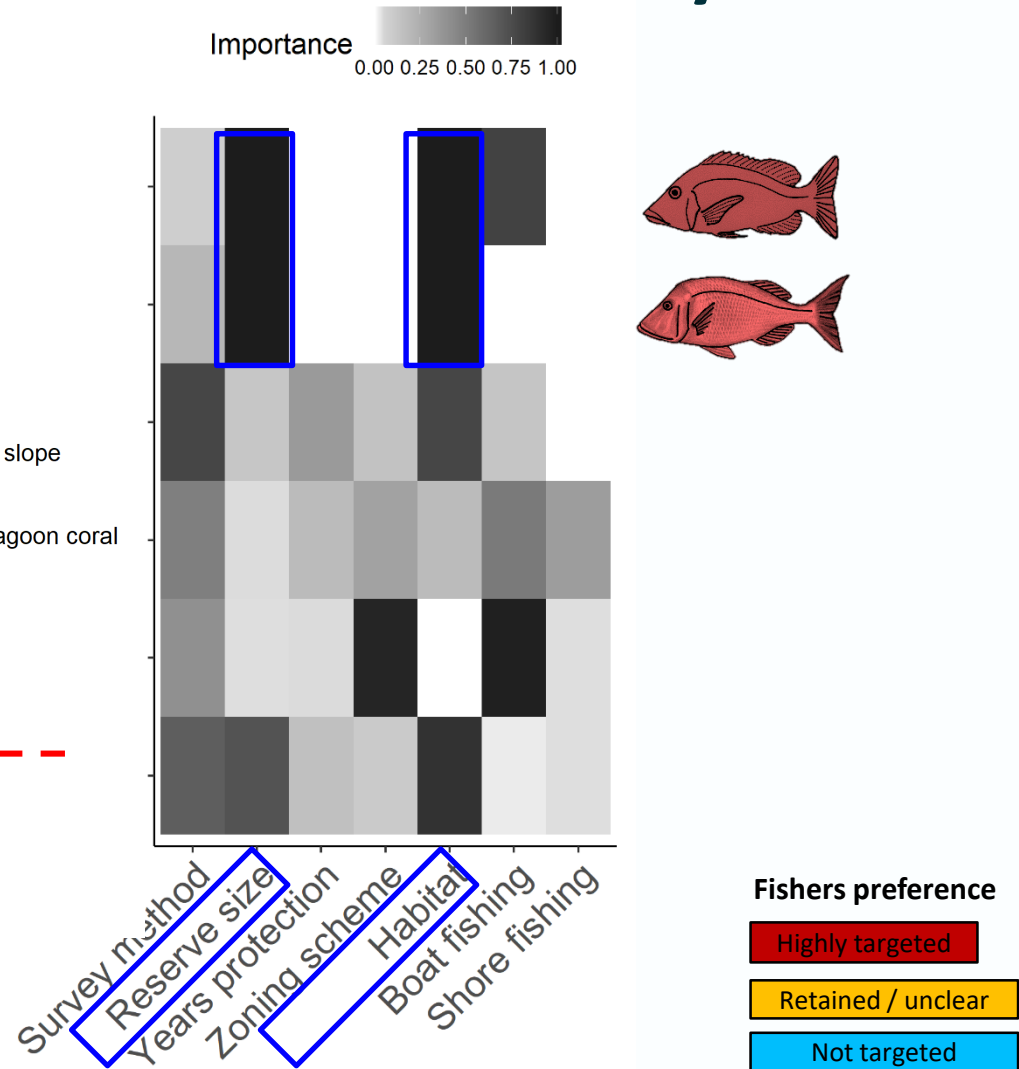
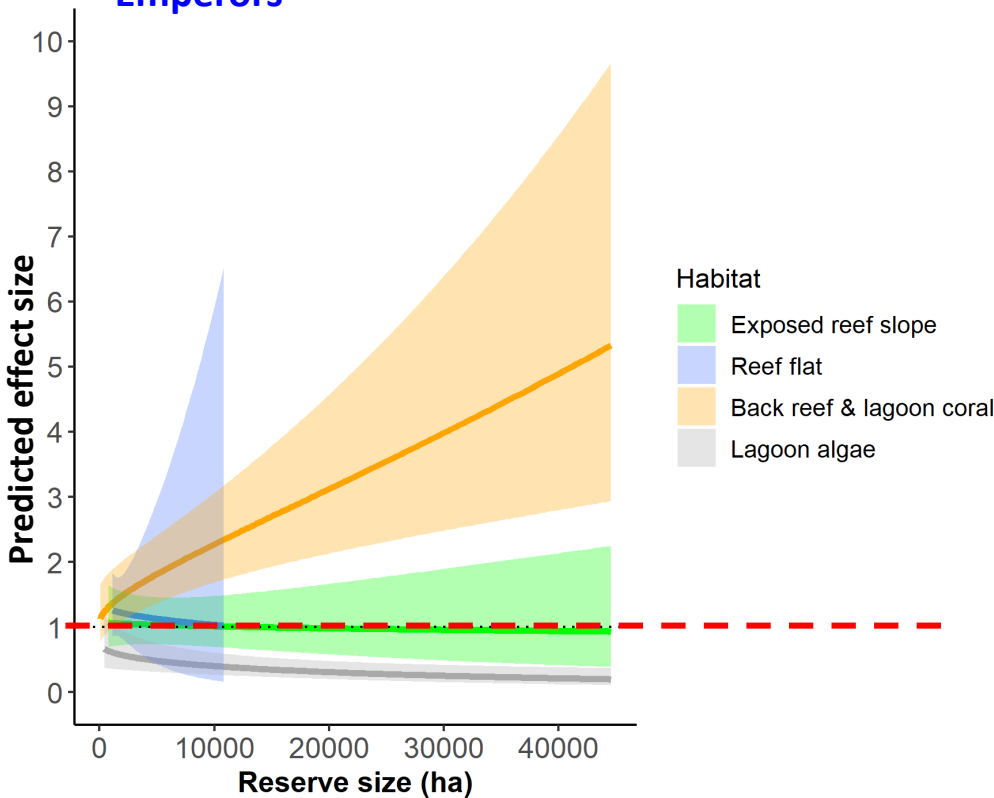
Not targeted

Results

Awaiting publication so not presented here

Causes of variability: habitat and sanctuary size

Lethrinidae Emperors



Fishers preference

Highly targeted

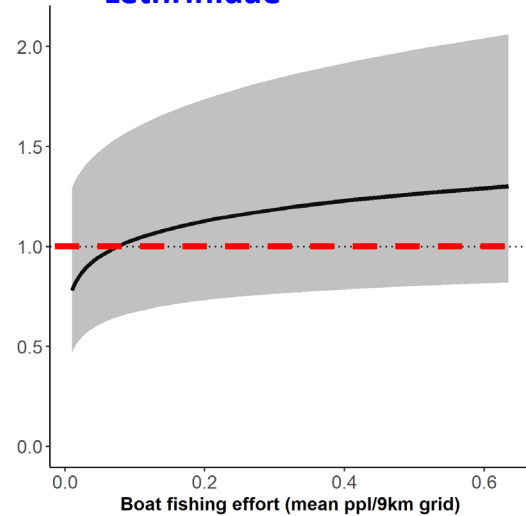
Retained / unclear

Not targeted

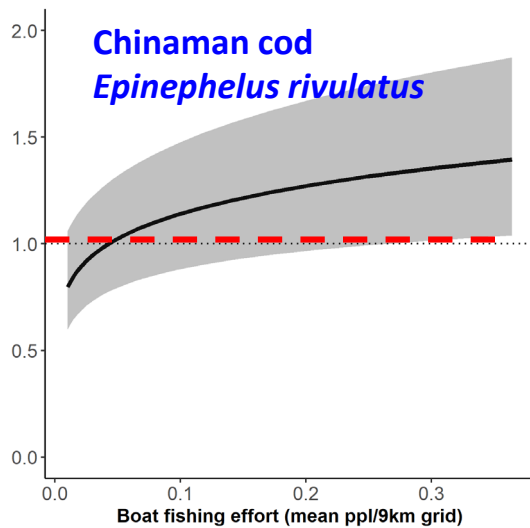
Causes of variability: boat fishing

Emperors
Lethrinidae

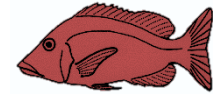
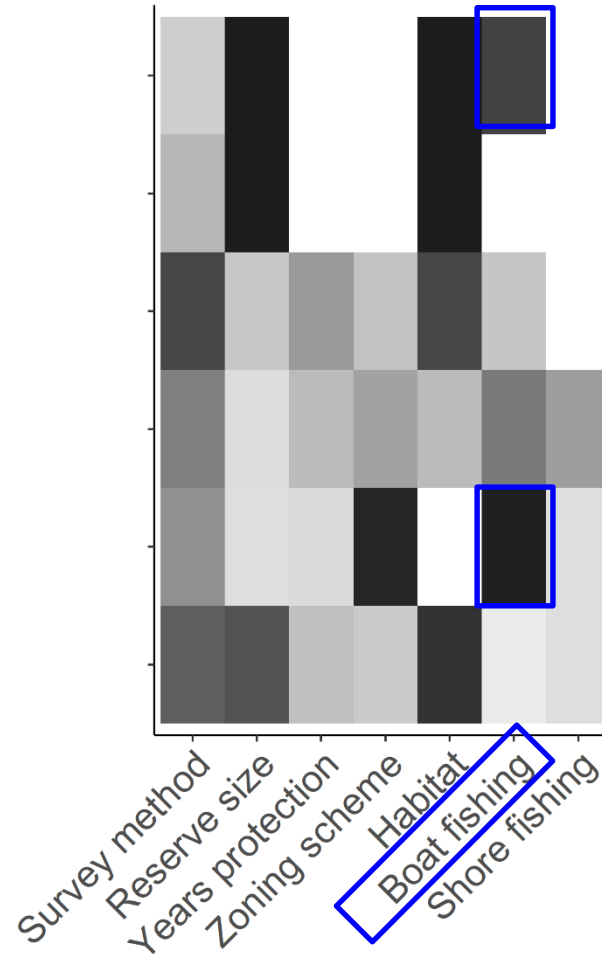
Predicted effect size



Chinaman cod
Epinephelus rivulatus



Importance
0.00 0.25 0.50 0.75 1.00



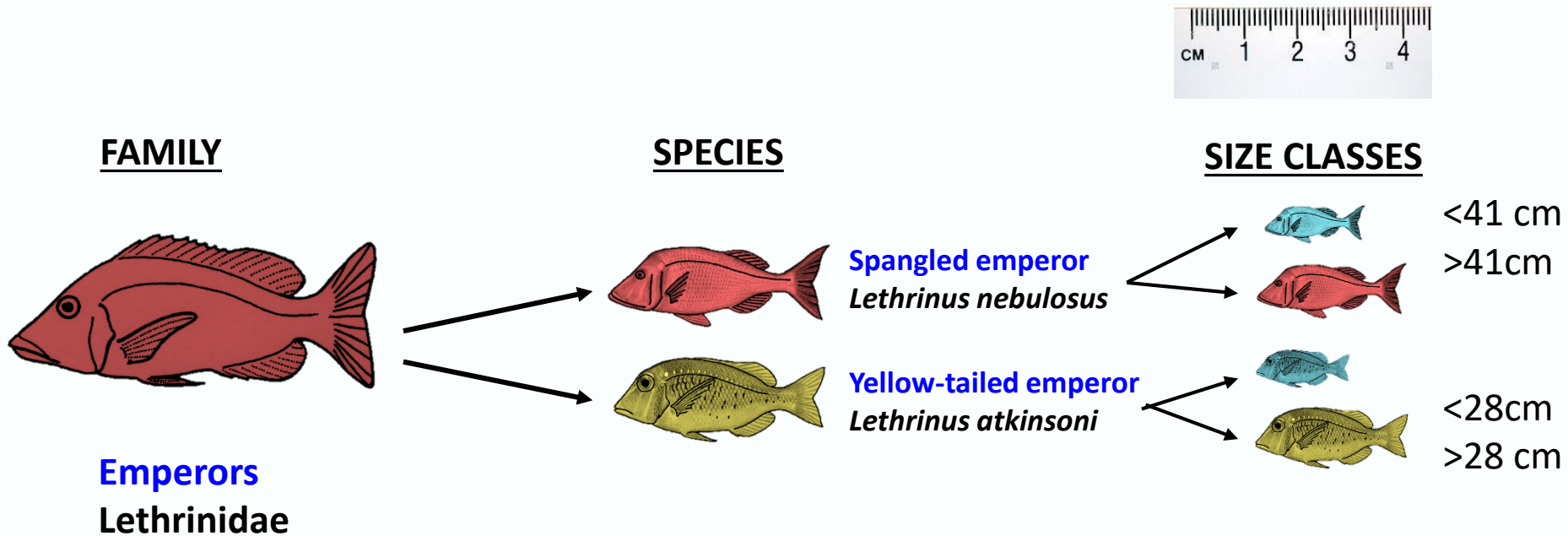
Fishers preference

Highly targeted

Retained / unclear

Not targeted

Investigating minimum legal size limits



Fishers preference

Highly targeted

Retained / unclear

Not targeted

Size limits

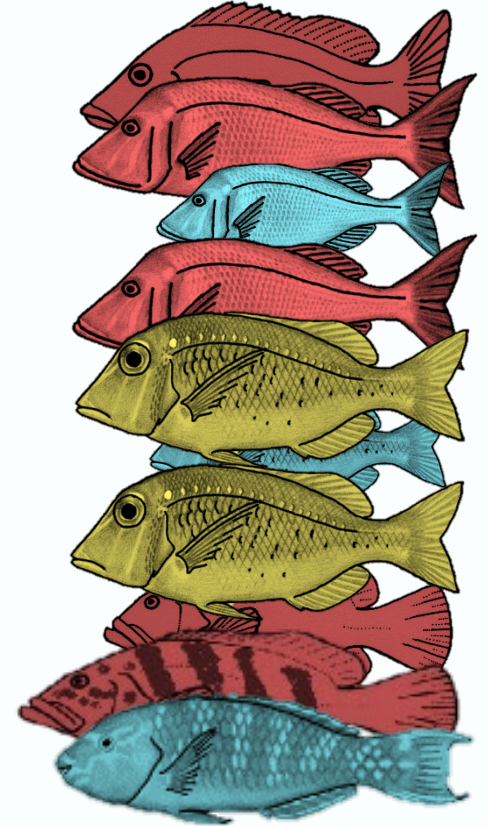
- Not shown, awaiting publication

Plausible explanations

- Recreational fishing is impacting sublegal sized fishes
 - Catch-and-release mortality?
 - Non-compliance?
- Sanctuaries are in preferable habitats for emperors
- A higher concentration of legal sized fishes leads to a higher concentration of sublegal sized fishes

Conclusions

- Variables are important for both assessment and design
- Fishing effort and compliance data alongside fish data
- Consistent monitoring for temporal assessments



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END

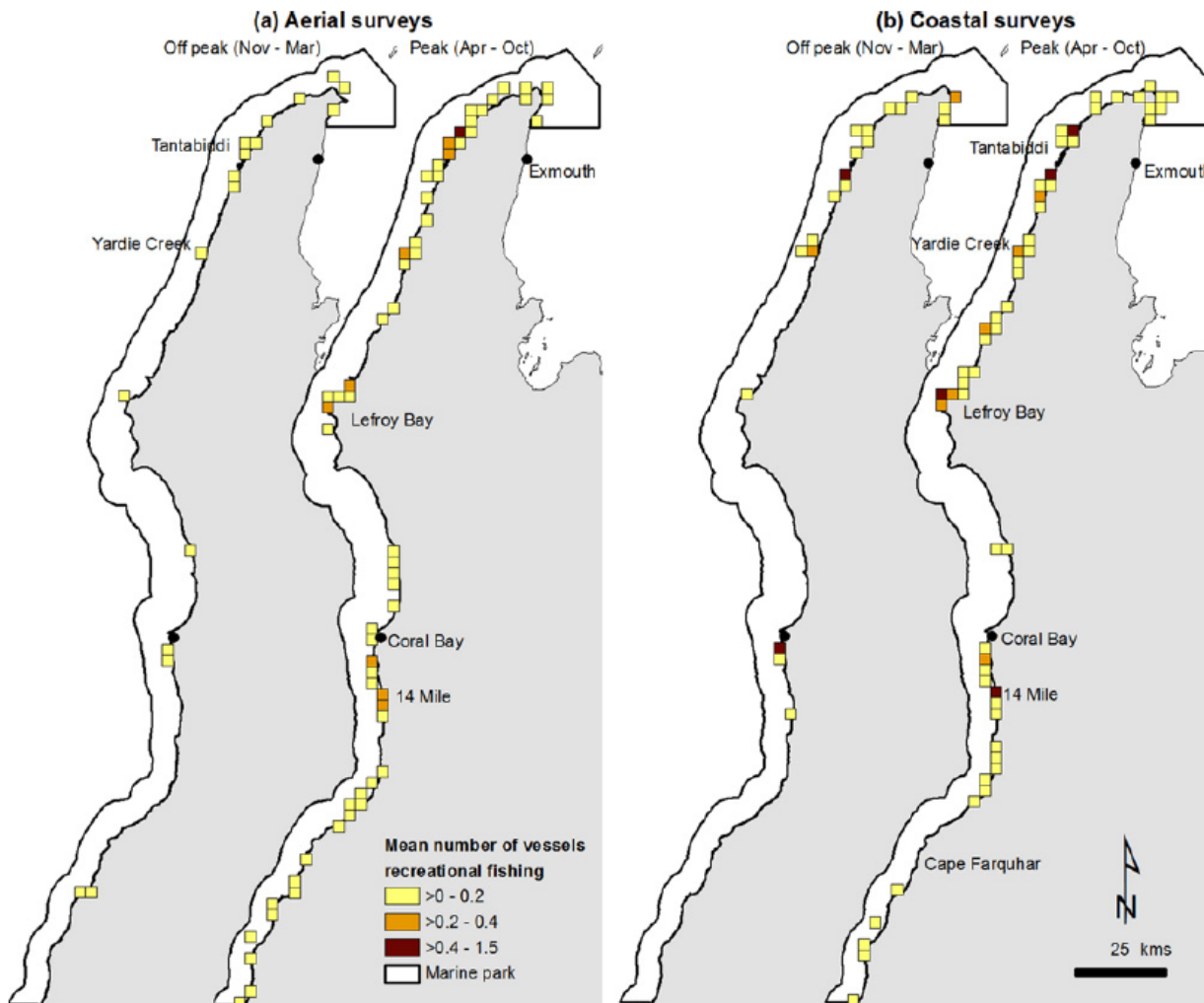
Summary of previous studies

| Author | Finding on fishing effects |
|-------------------------------------|--|
| Westera 2003 | Greater biomass, size, and abundance of lethrinids in Mandu Osprey & Maud sanctuary zones (2000) |
| Fitzpatrick <i>et al.</i> 2015 | Greater abundance and/or size inside Osprey and Mandu sanctuary (2006/7) |
| Babcock <i>et al.</i> 2008 | Greater biomass inside sanctuaries, but complex effects of zoning (12 reserves) (2006/7) |
| Wilson 2012 | Habitat, in particular structural complexity, more important than fishing. Jurabi, Mangrove & Mandu (2010/11) |
| Vanderklift <i>et al.</i> In review | Greater abundance and biomass of many fish taxa (especially emperors and parrotfish) in Mandu (2007 – 2016) with declining trends inside and outside. |
| Tom Holmes & Shaun Wilson | Synthesis of fish data inside and outside reserves |

Epinephelinae species

- *Aethaloperca rogae*
- *Anyperodon leucogrammicus*
- *Cephalopholis* spp.
- *Cephalopholis argus*
- *Cephalopholis boenak*
- *Cephalopholis cyanostigma*
- *Cephalopholis formosa*
- *Cephalopholis miniata*
- *Cephalopholis sexmaculata*
- *Cephalopholis sonnerati*
- *Cromileptes altivelis*
- *Epinephelus* spp.
- *Epinephelus amblycephalus*
- *Epinephelus areolatus*
- *Epinephelus bilobatus*
- *Epinephelus coeruleopunctatus*
- *Epinephelus coioides*
- *Epinephelus corallicola*
- *Epinephelus fasciatus*
- *Epinephelus fuscoguttatus*
- *Epinephelus hexagonatus*
- *Epinephelus lanceolatus*
- *Epinephelus macrospilos*
- *Epinephelus maculatus*
- *Epinephelus malabaricus*
- *Epinephelus melanostigma*
- *Epinephelus merra*
- *Epinephelus microdon*
- *Epinephelus multinotatus*
- *Epinephelus polyphekadion*
- *Epinephelus quoyanus*
- *Epinephelus retouti*
- *Epinephelus rivulatus*
- *Epinephelus sexfasciatus*
- *Epinephelus tauvina*
- *Epinephelus tukula*
- *Plectropomus leopardus*
- *Plectropomus maculatus*
- *Plectropomus* spp.
- *Variola albimarginata*
- *Variola louti*
- *Grammistes sexlineatus*

Boat fishing



Smallwood & Beckley (2012)