



# Movement of marine megafauna at Ningaloo Reef

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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*

# Movement and spatial management

- Where, when & why?
- Data are required to ensure sustainable development and protect species from anthropogenic impacts
- Limited data on movement of the majority of megafauna relevant to spatial management

# Aims

- Determine residence, home range and habitat use of sharks and turtles
- Compare measures of residence, home range and habitat use between species
- What are the implications for spatial management?



# Methods - Acoustic telemetry

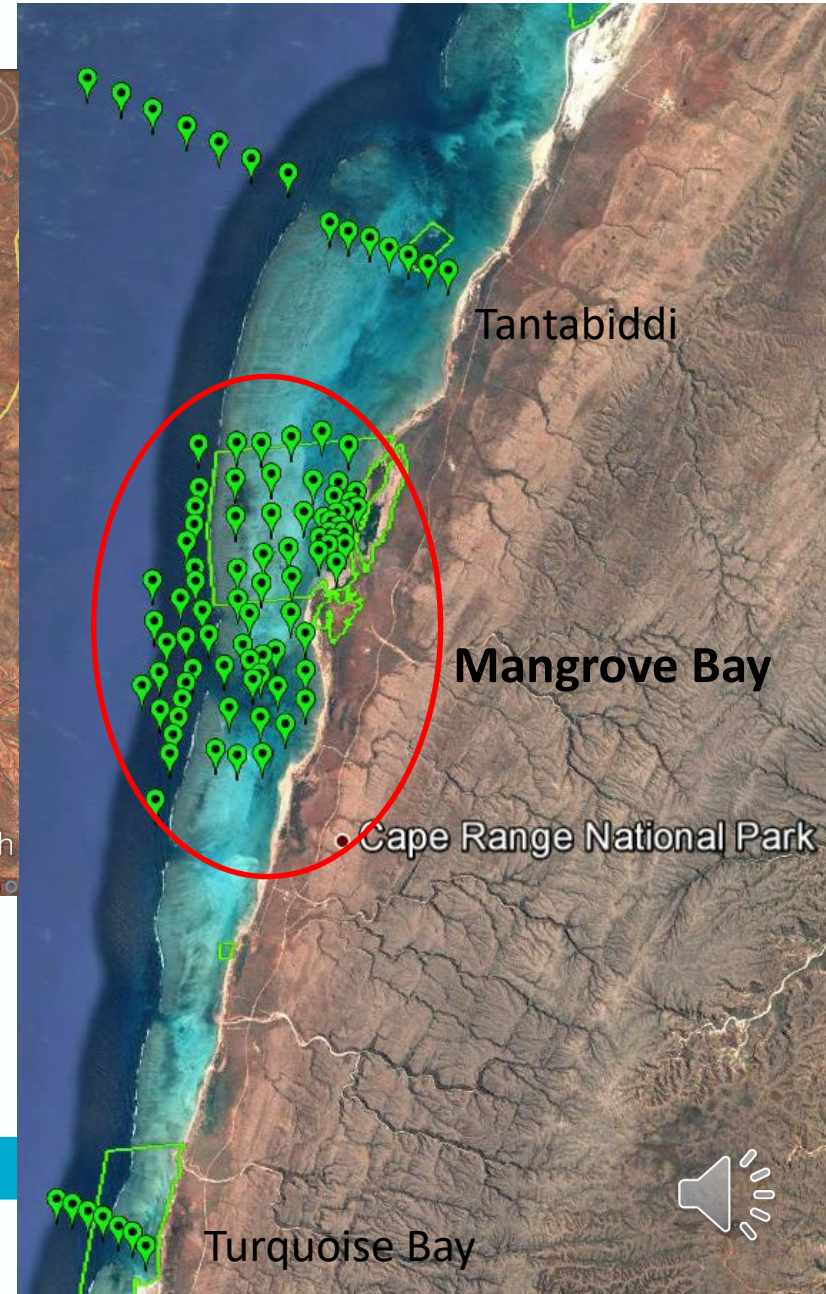
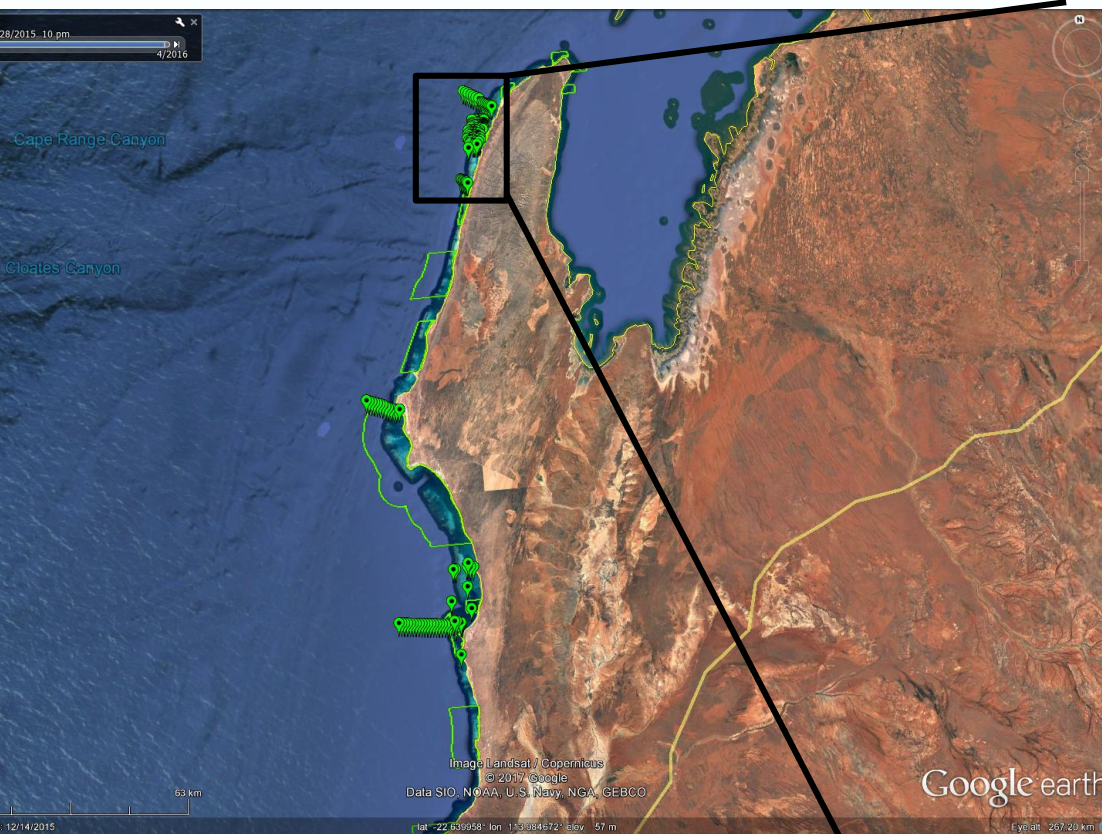
**VEMCO VR2W**

**VEMCO VR2WAR**





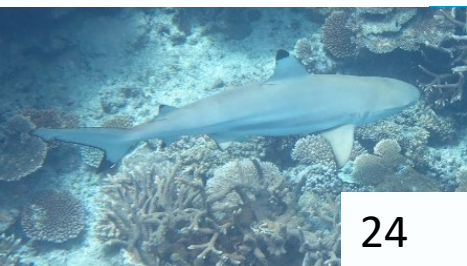
# Ningaloo Reef acoustic array design





# Methods – Acoustic and satellite telemetry

Acoustic tags



24



30



46

16

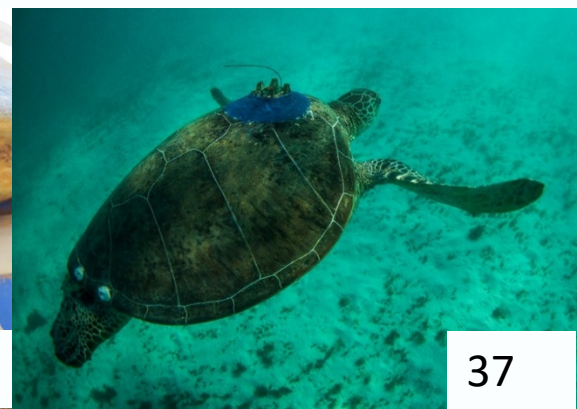
Satellite tags



40



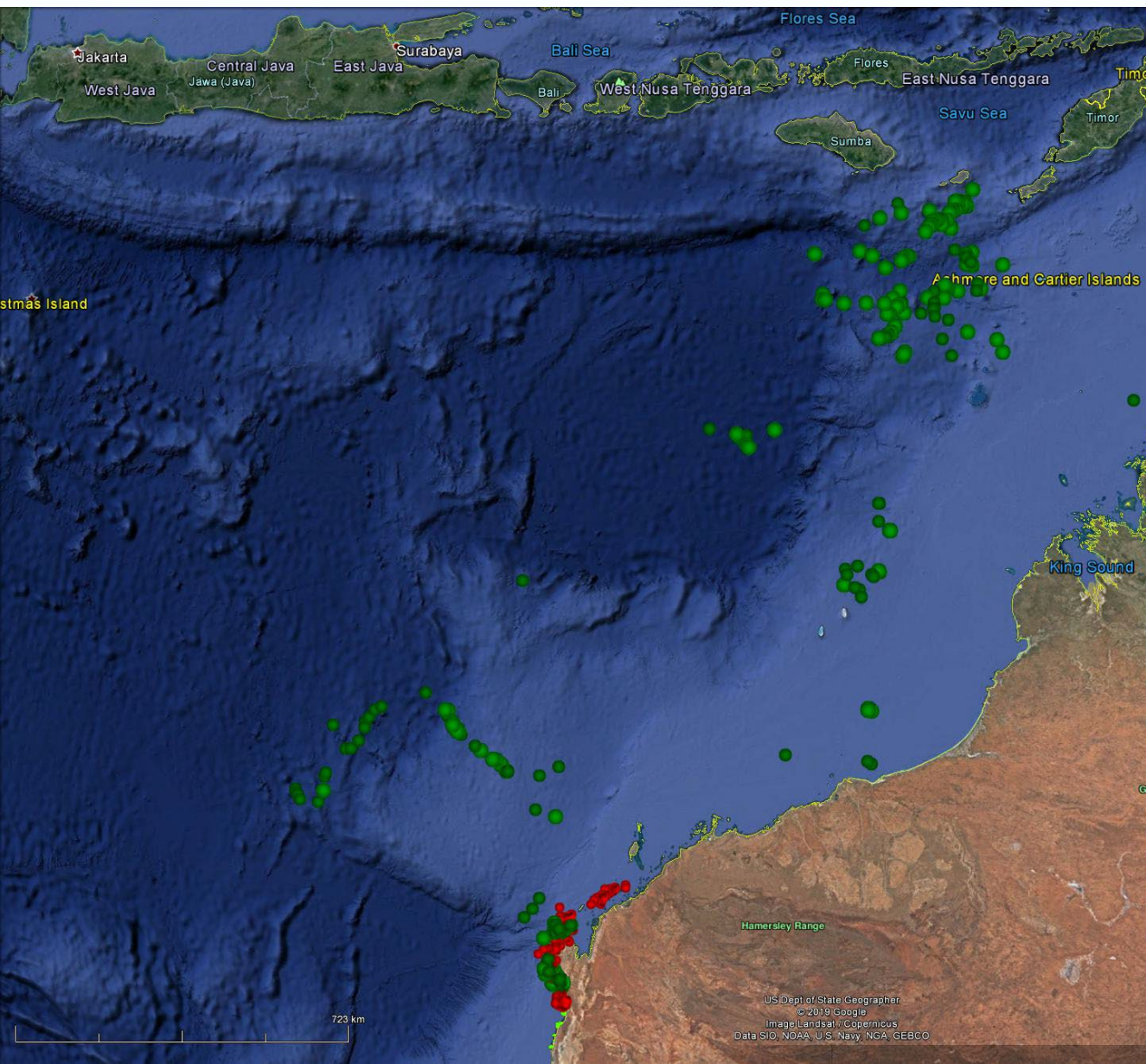
81



37



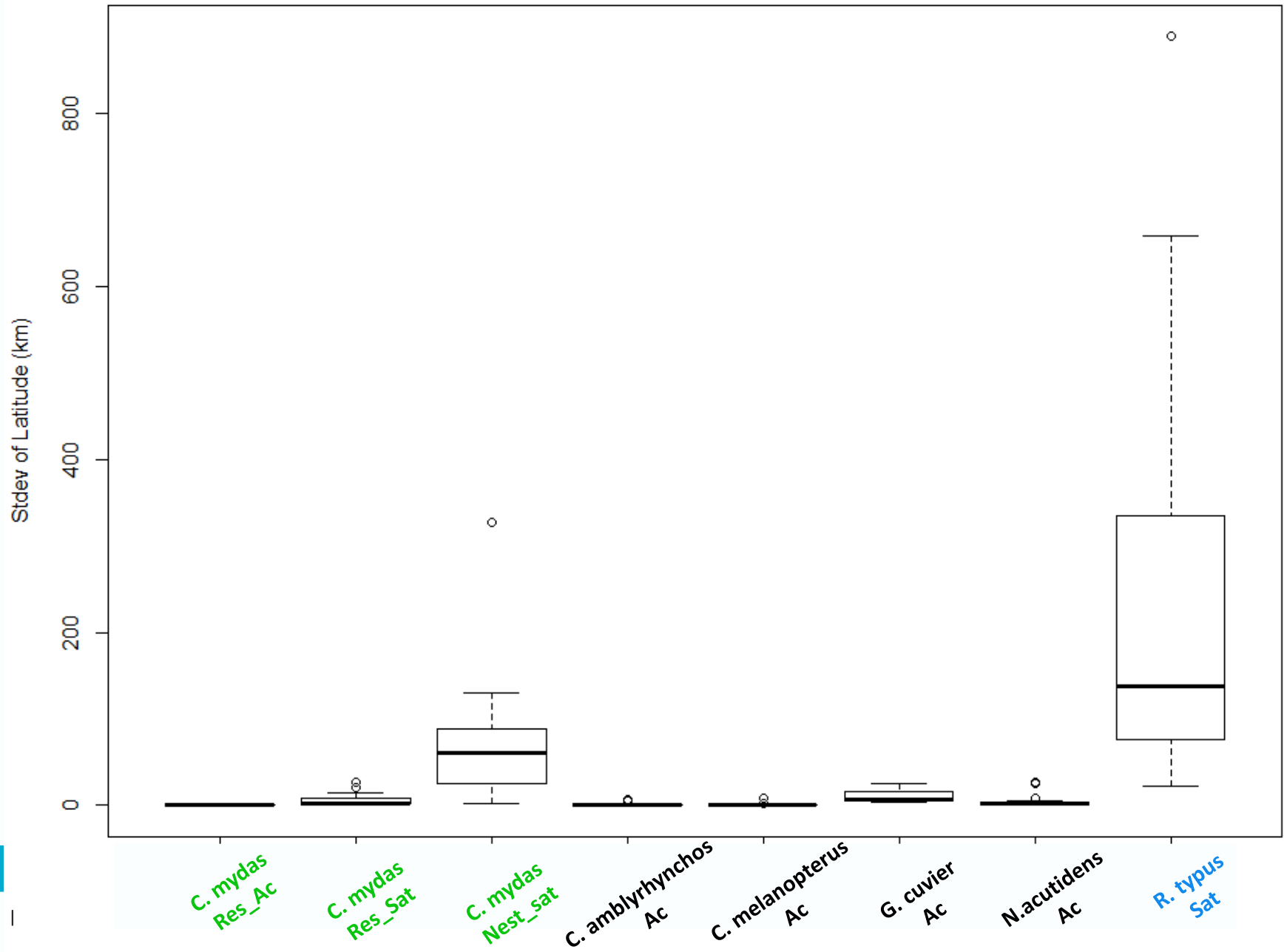
# Results – scale of movement



● whale shark  
Latitude Stdev = 496 km

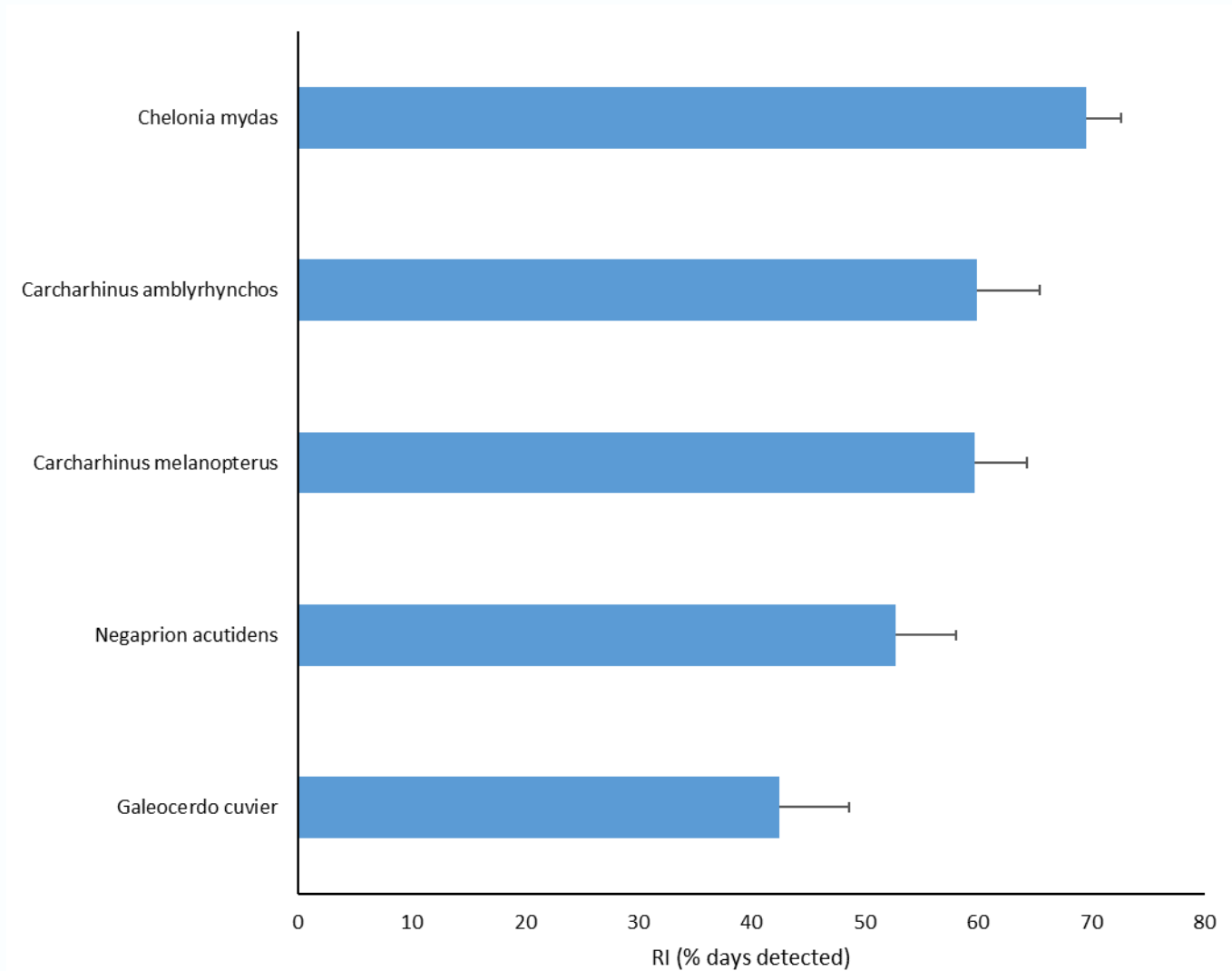
● green turtle (nesting)  
Latitude Stdev = 80 km

# Results – scale of movement





# Results – residence index (acoustic tags)

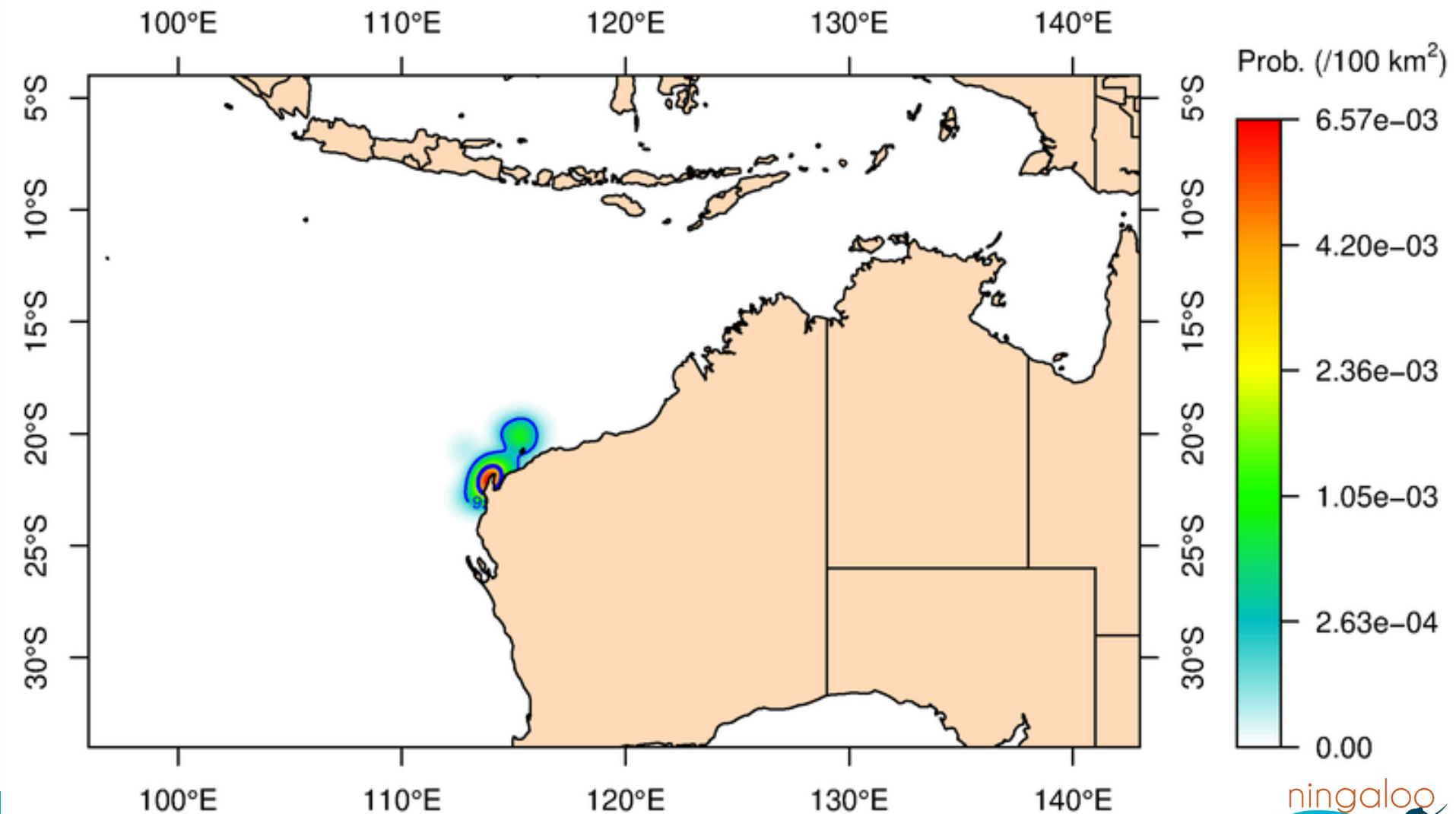


# Results – home range

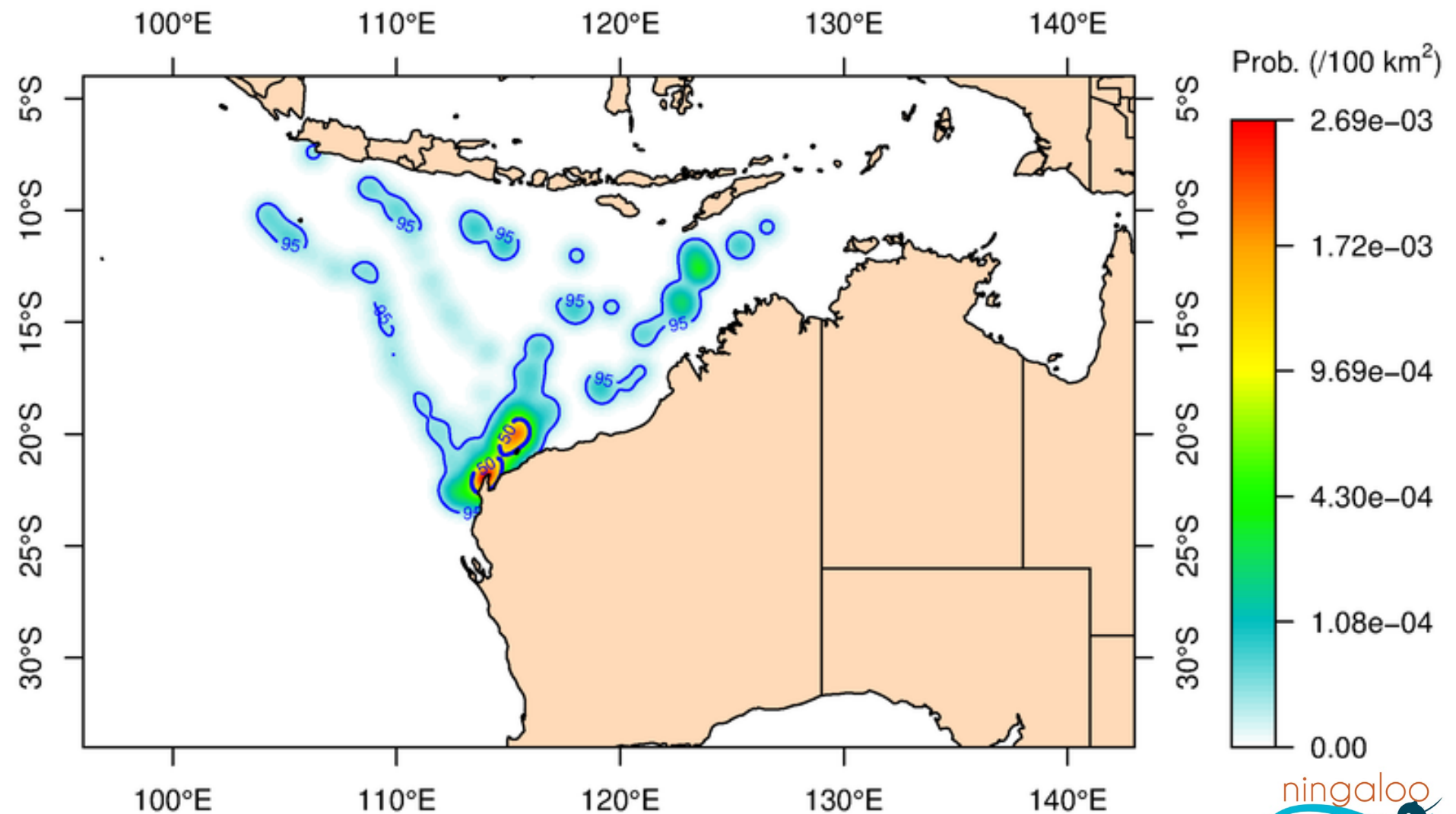
- Home range = 95 % kernel utilisation distribution (KUD)
- KUD = probability density function that quantifies an individual's relative use of space
- The probability of an animal occurring within its home range based on a set of relocation points (satellite or acoustic detections)
- 95 % KUD = 95 % chance the animal will be found in that area during the monitoring period



June, 30 tags, 3073 detections

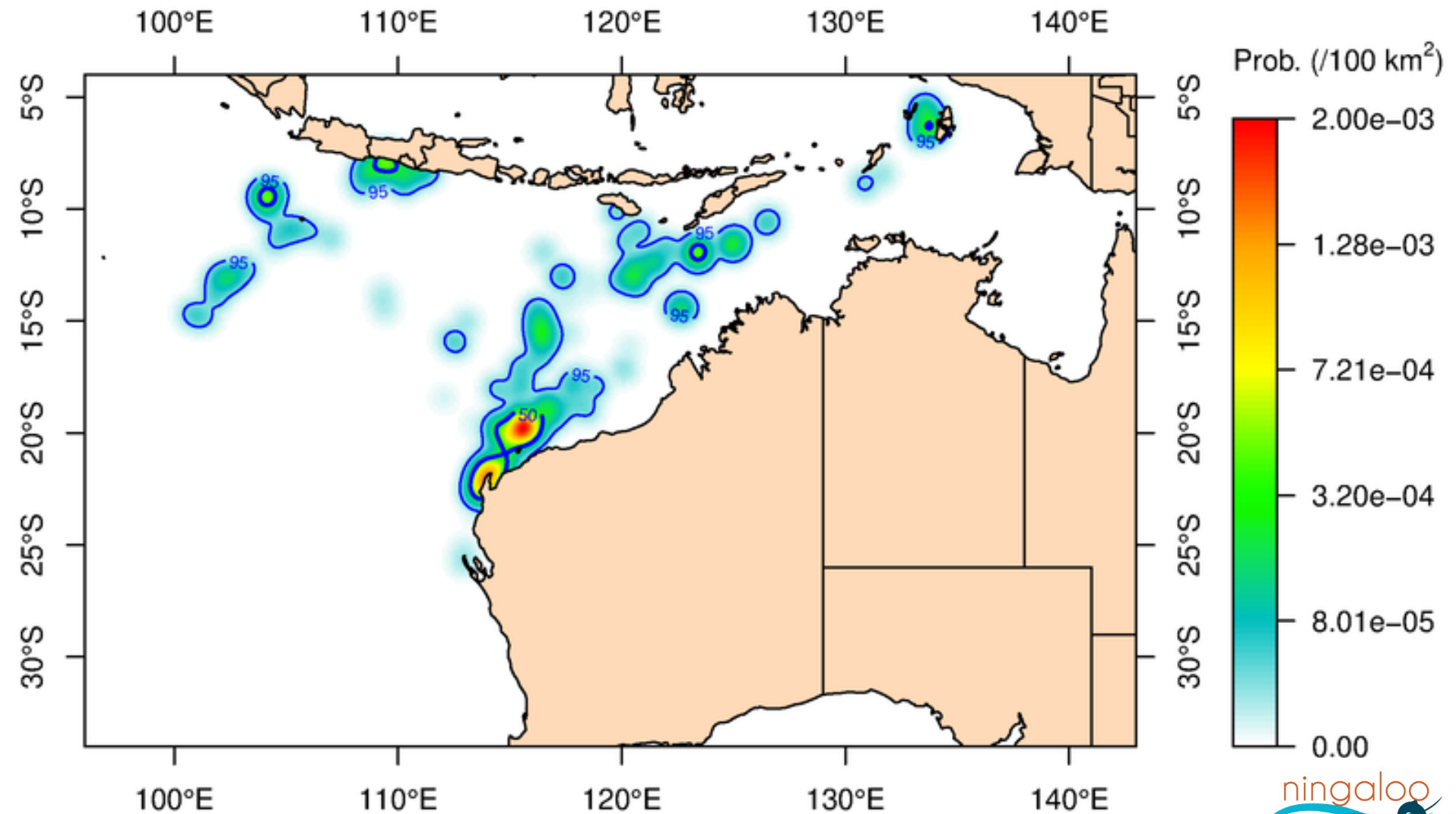


# July, 31 tags, 2605 detections

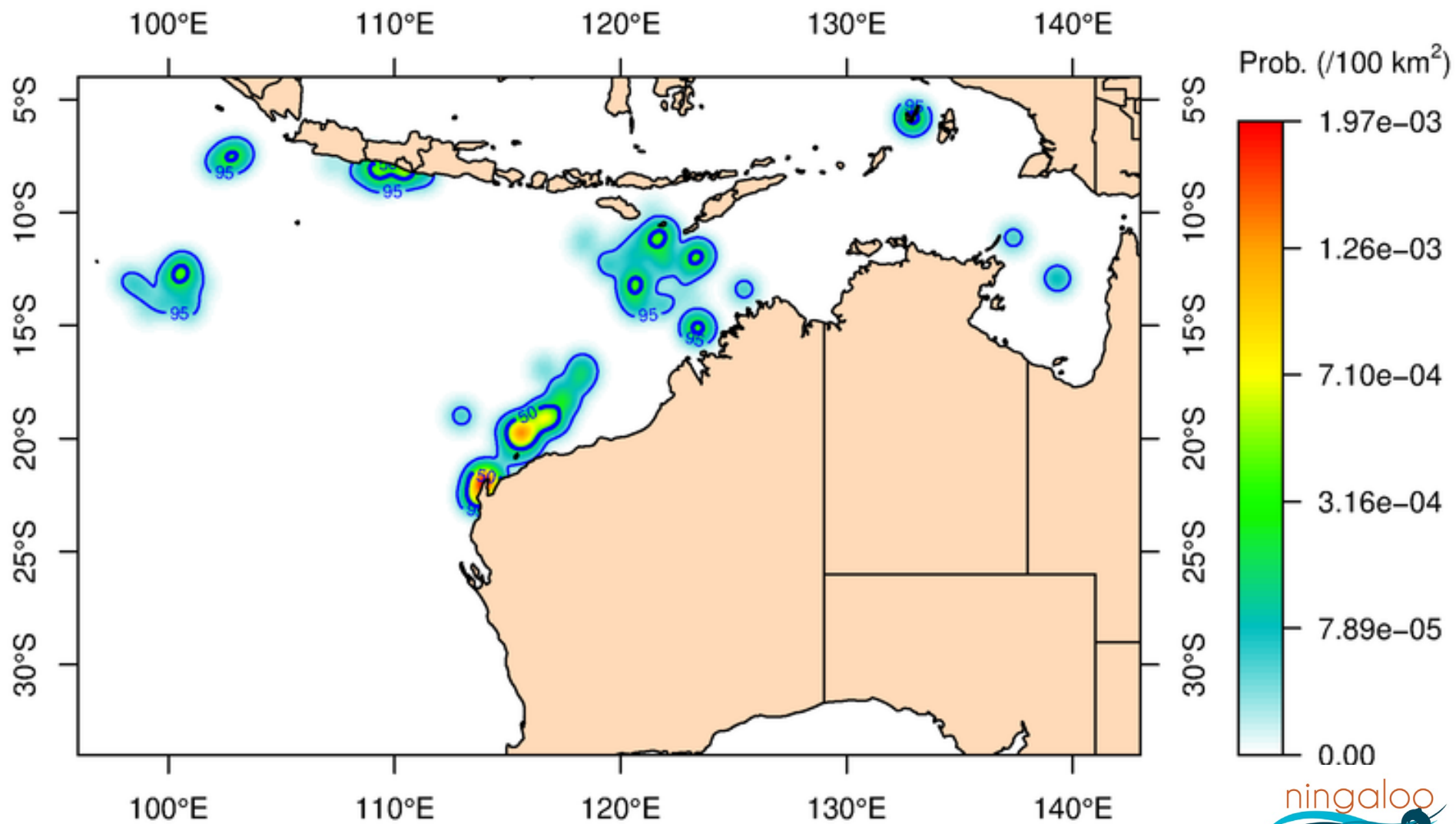




# August, 25 tags, 1418 detections

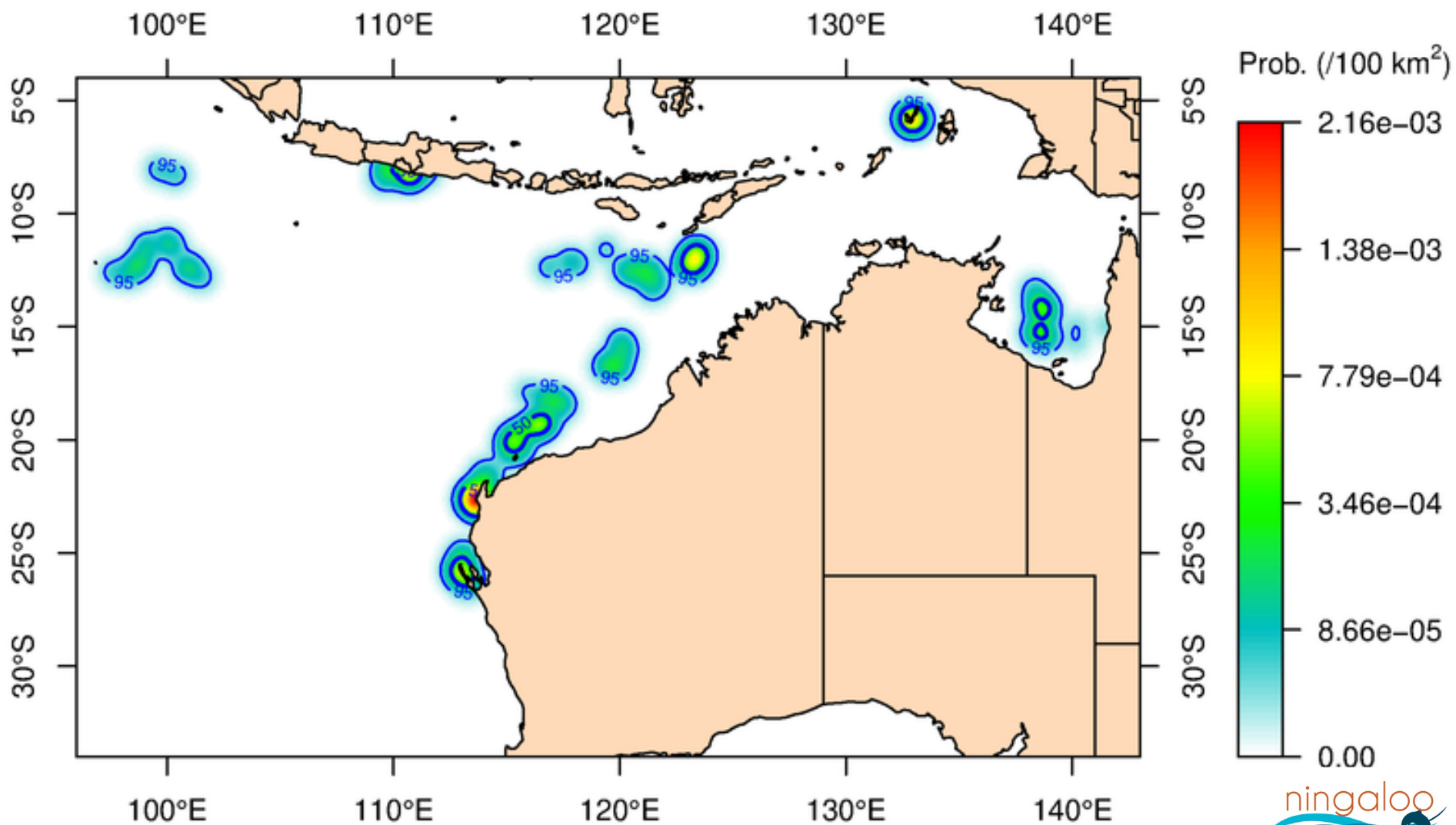


# September, 18 tags, 1269 detections

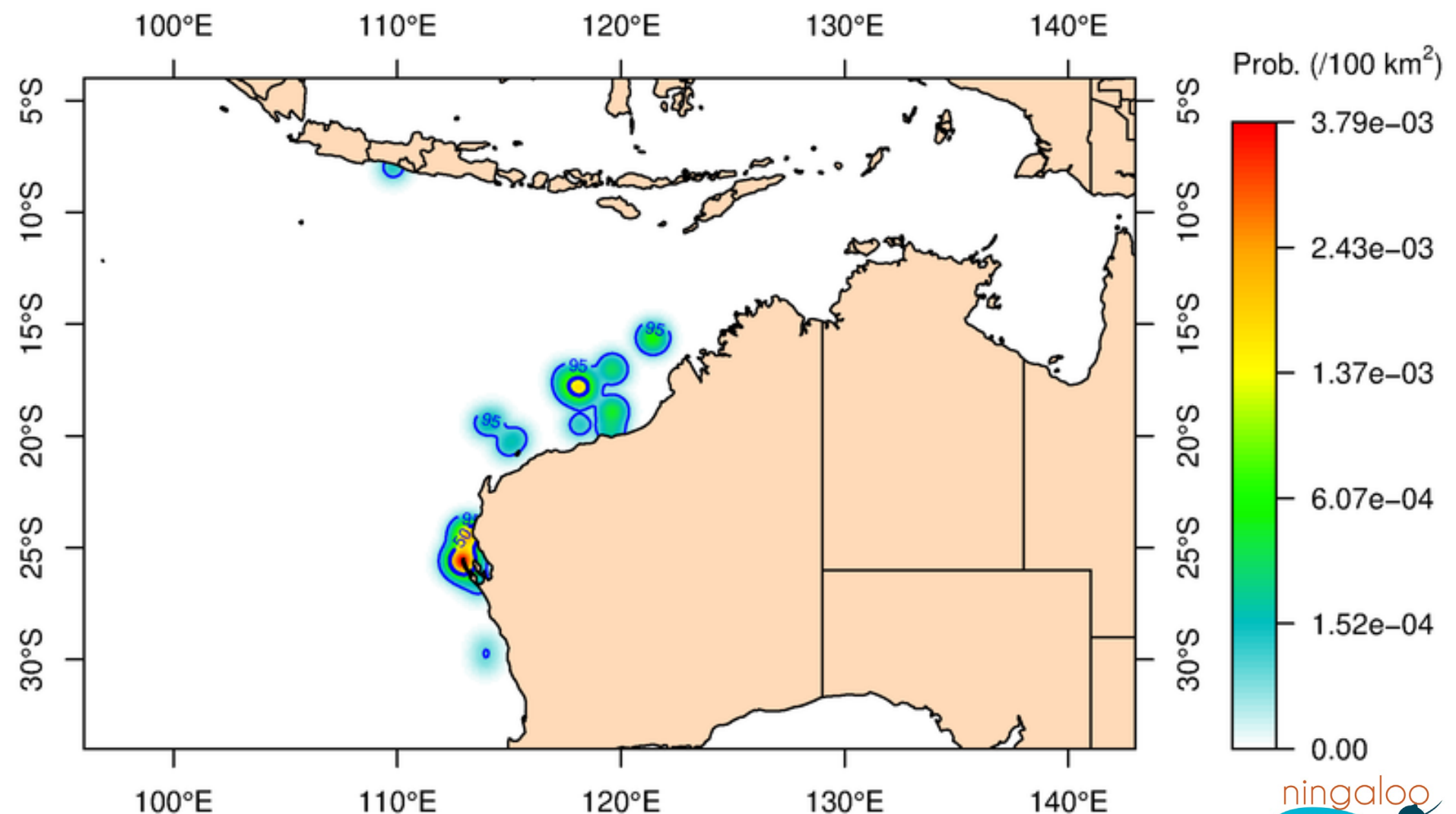




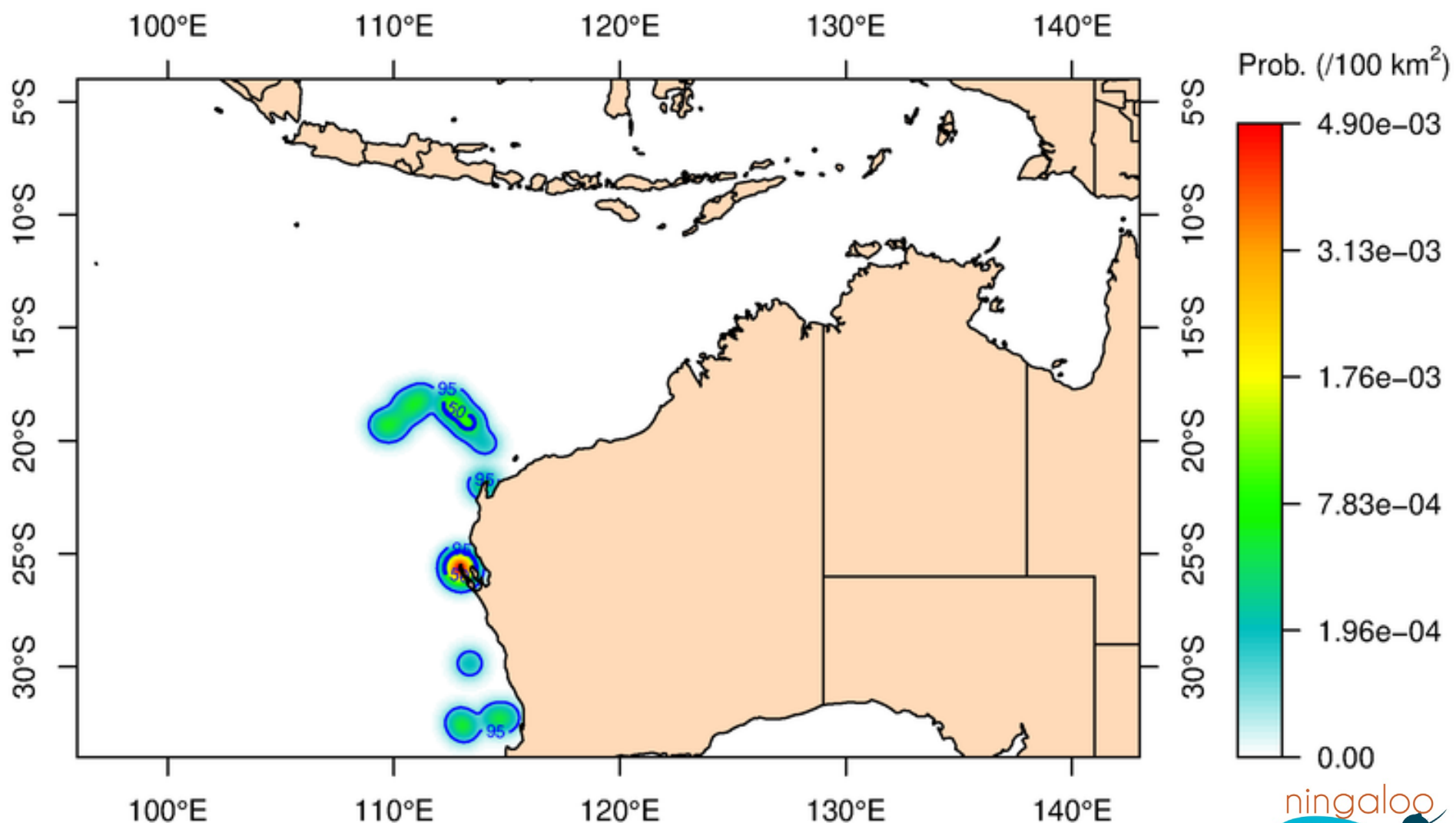
## October, 15 tags, 479 detections



# November, 8 tags, 220 detections

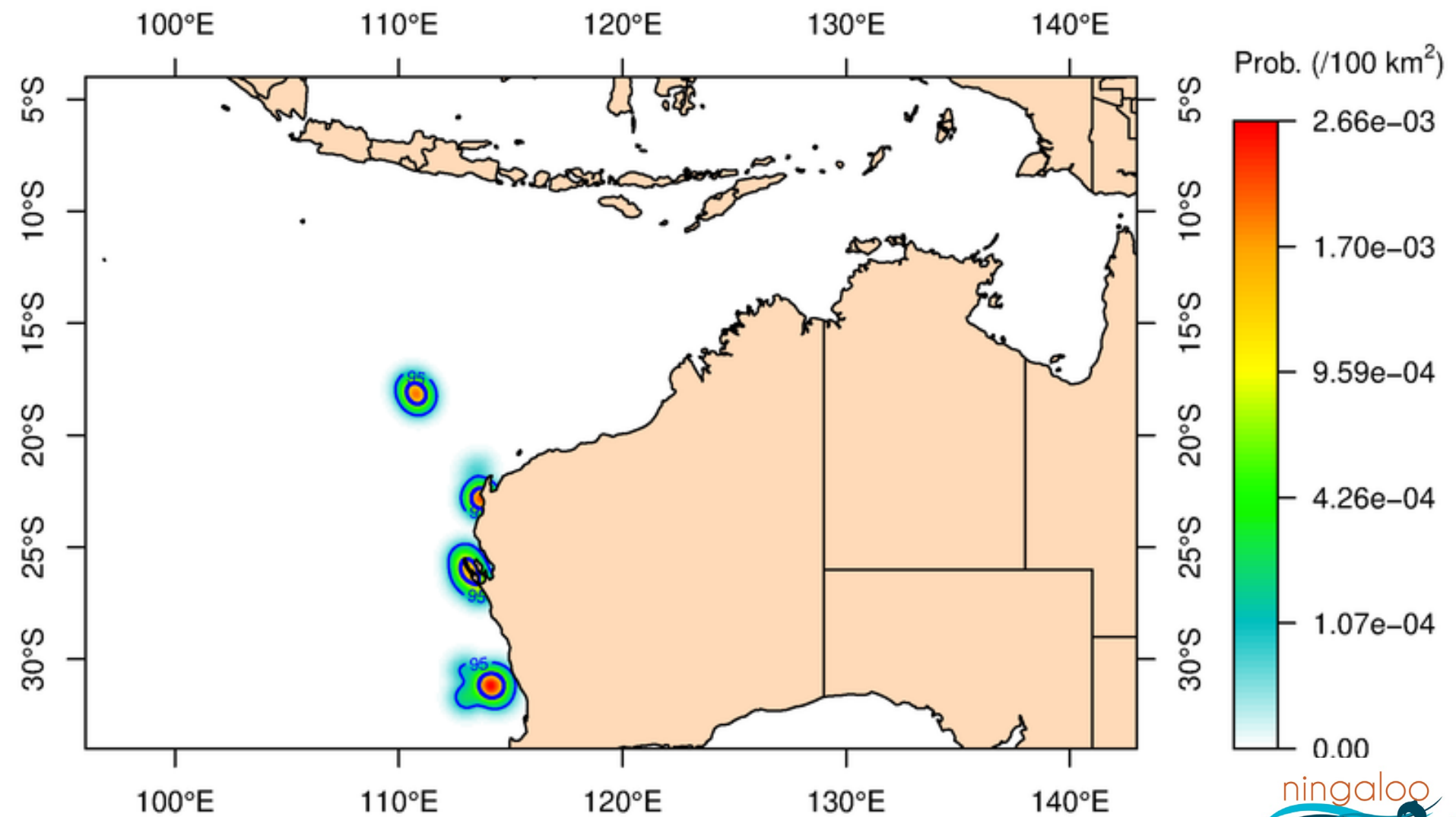


# December, 4 tags, 73 detections

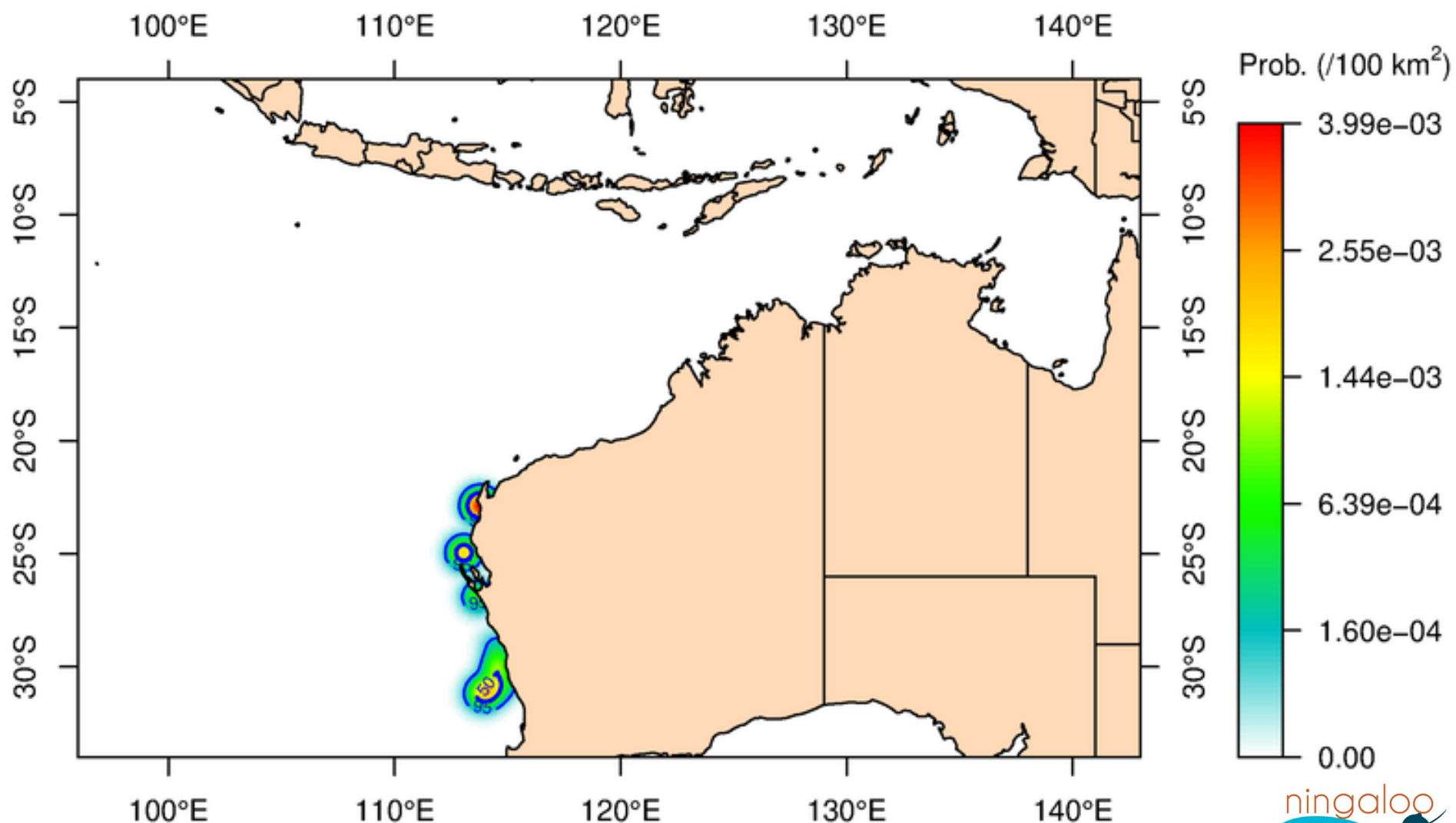




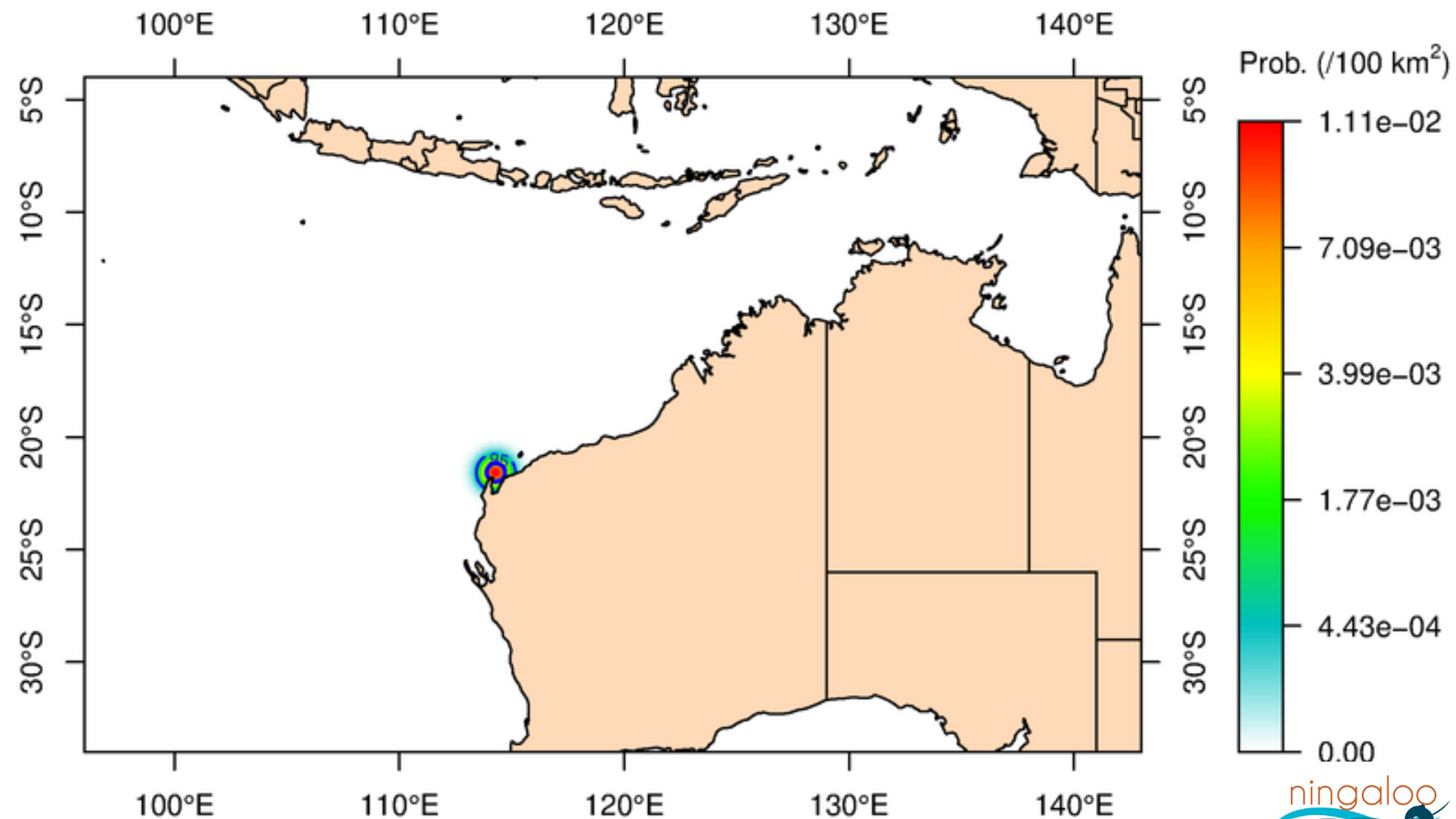
# January, 6 tags, 540 detections



# February, 5 tags, 660 detections

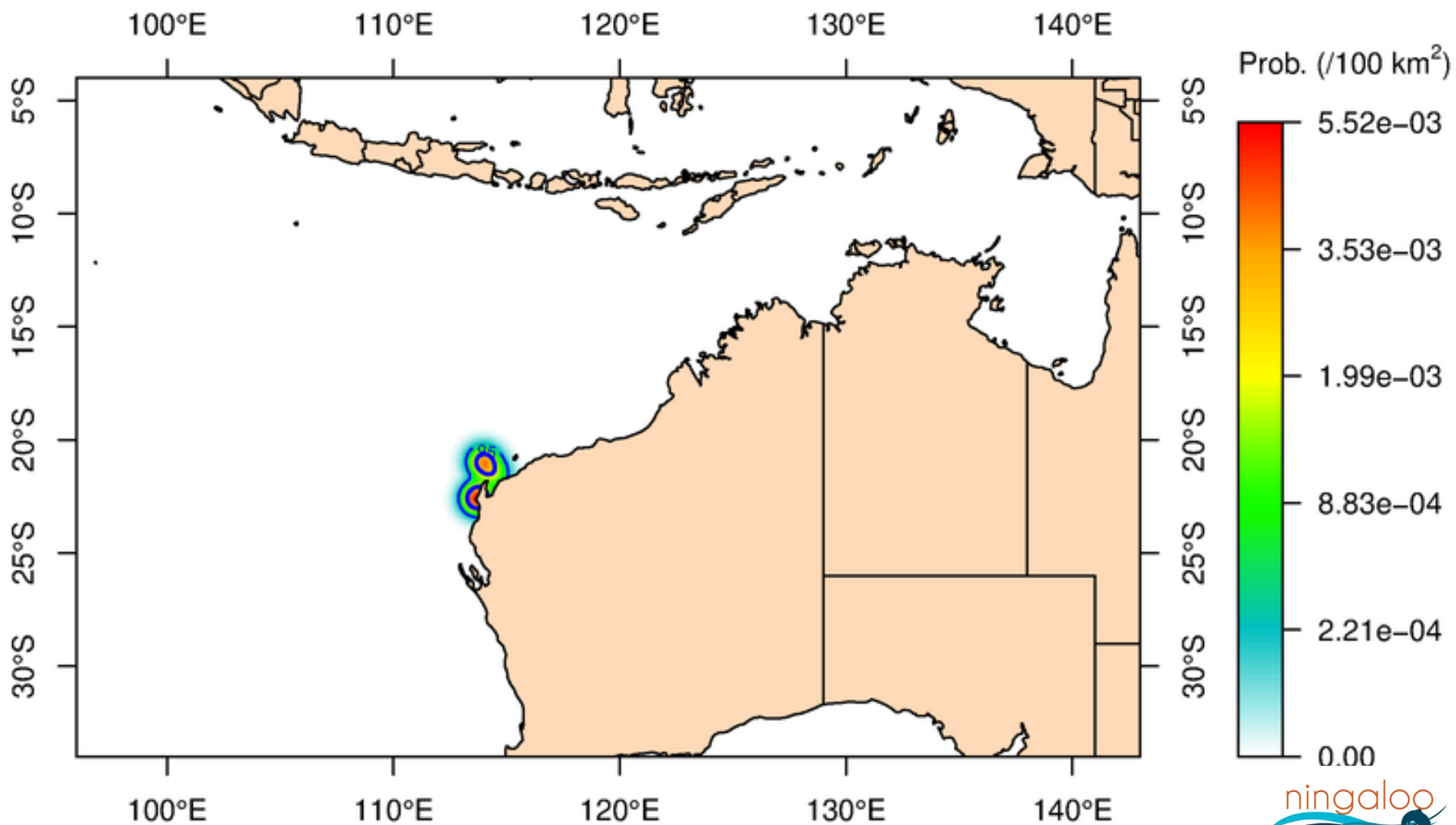


# March, 1 tags, 13 detections

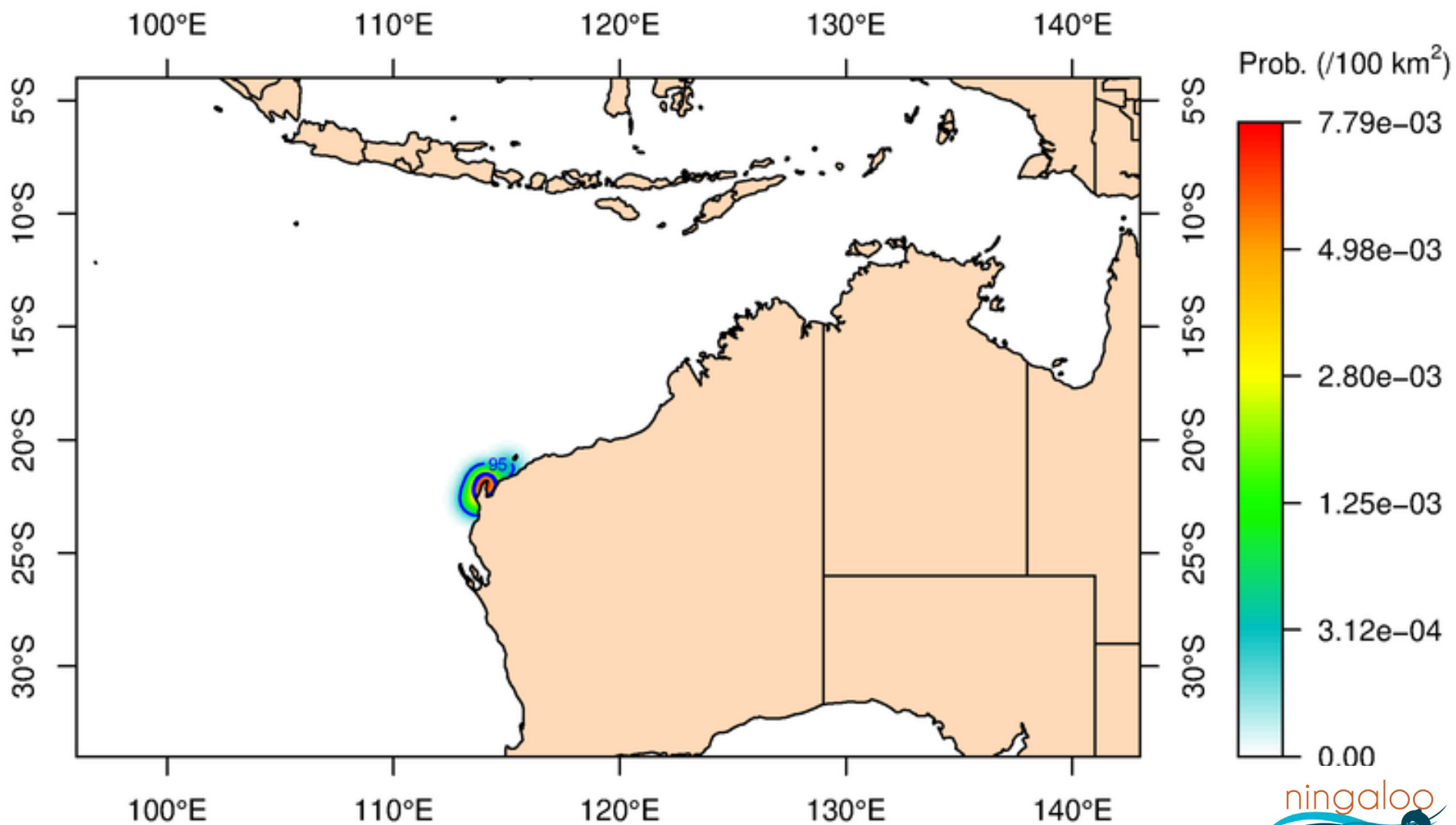




# April, 3 tags, 213 detections



# May, 3 tags, 104 detections

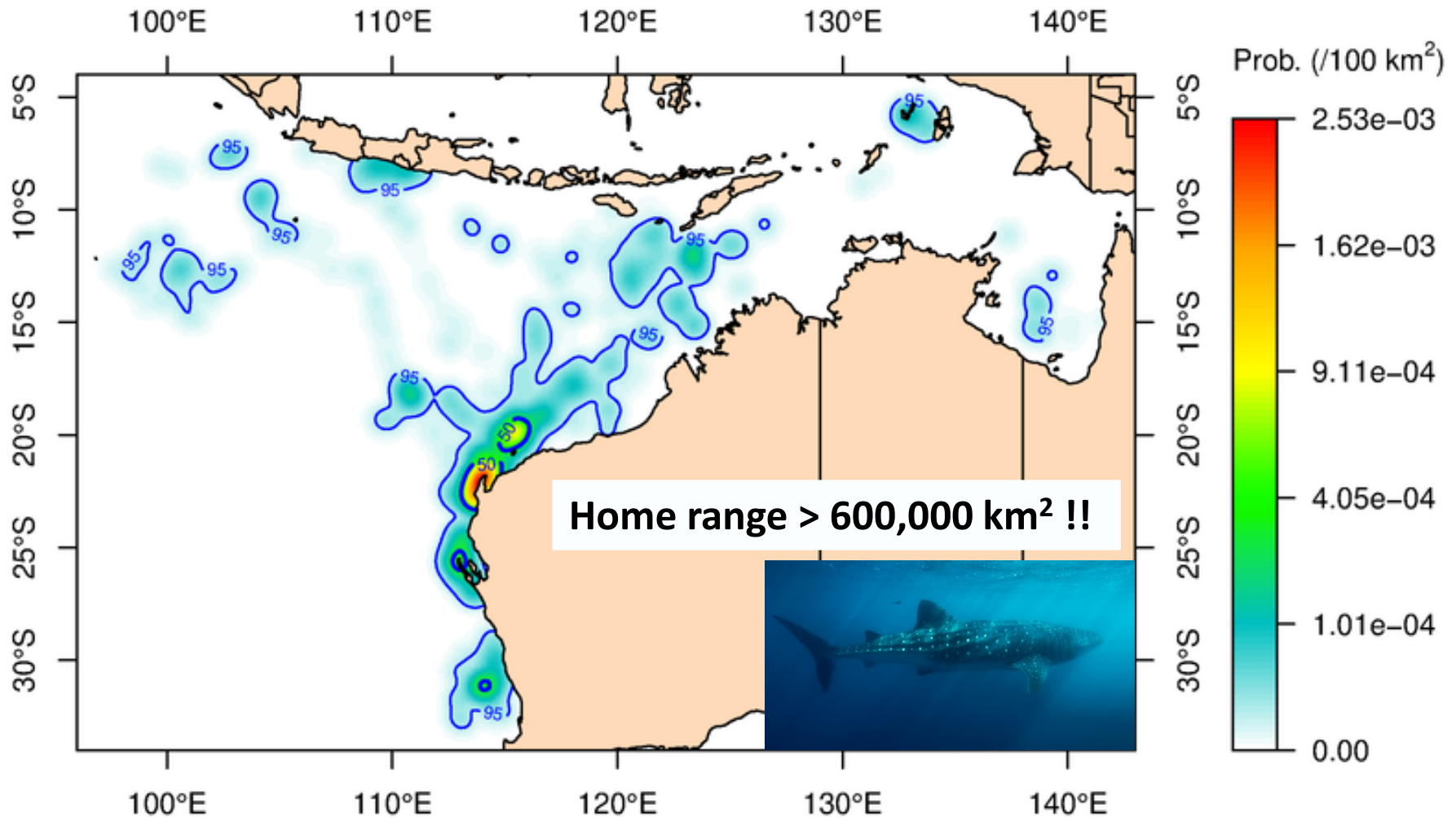


# Results – whale shark home range



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Combined KUD (34 sharks, 10667 detections)



# Home range and habitat use – Mangrove Bay

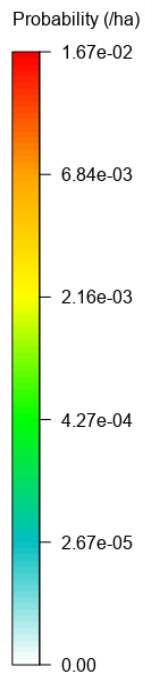
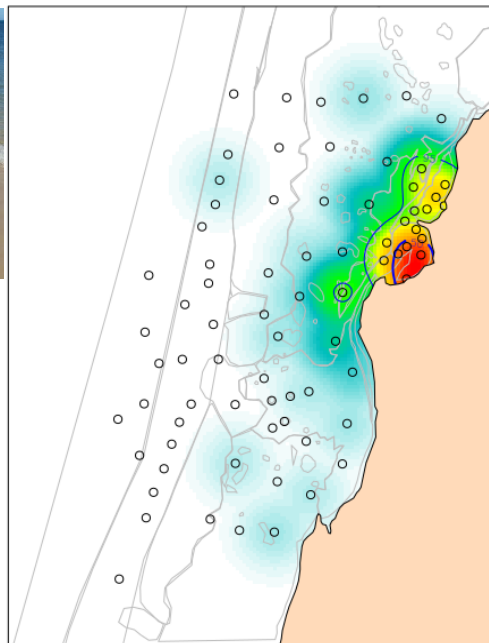




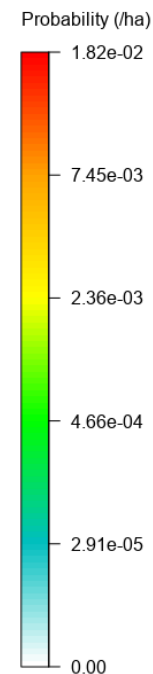
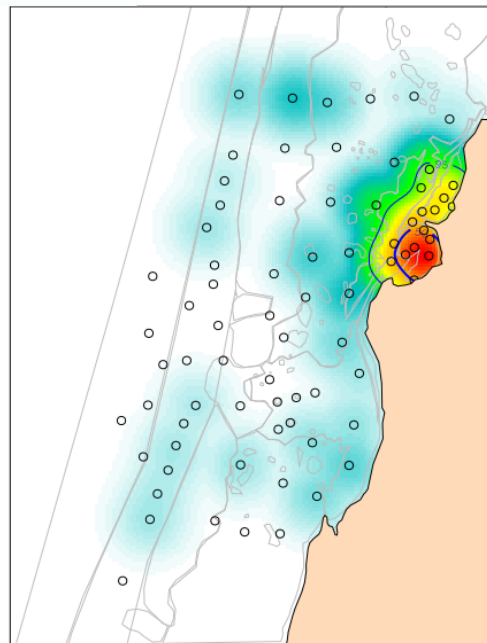
**Small juveniles - 10 individuals, 1233920 detections**



**< 50 cm CCL**



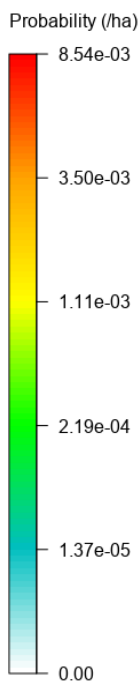
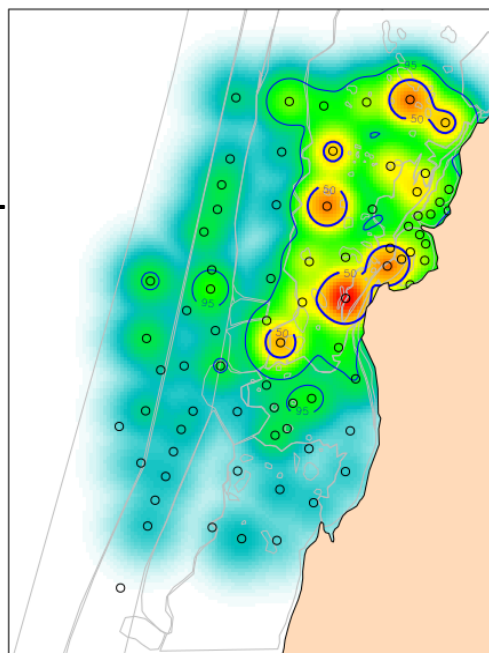
**Juveniles - 19 individuals, 1806094 detections**



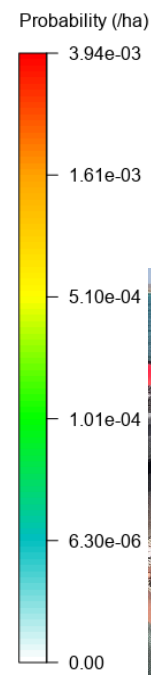
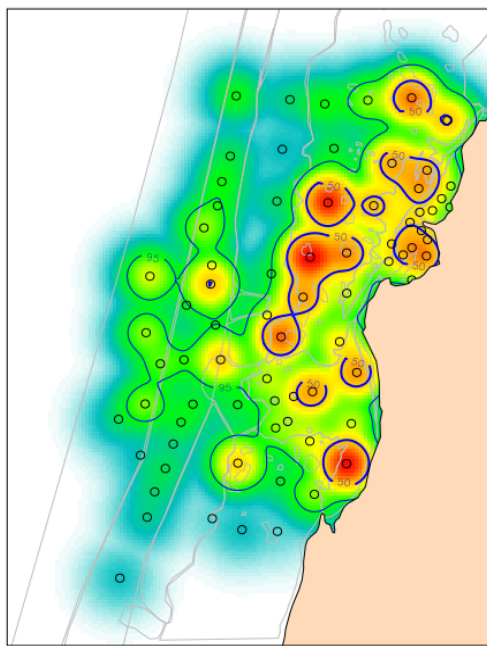
**50 – 70 cm CCL**

**Sub adults - 22 individuals, 156473 detections**

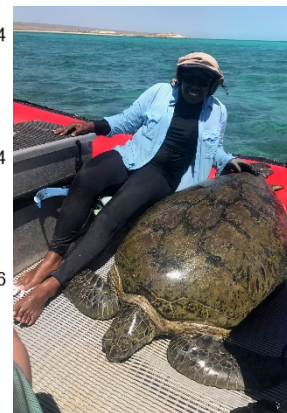
**70 – 85 cm CCL**



**Adults - 23 individuals, 133731 detections**

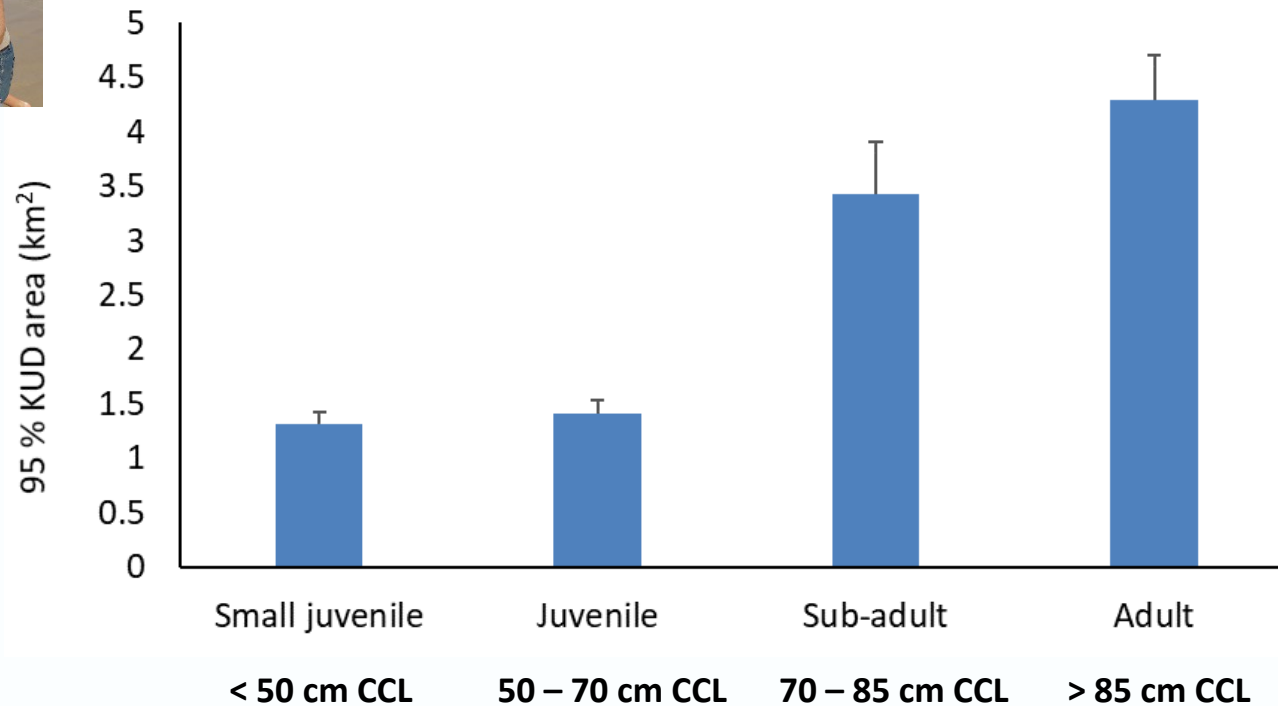


**> 85 cm CCL**



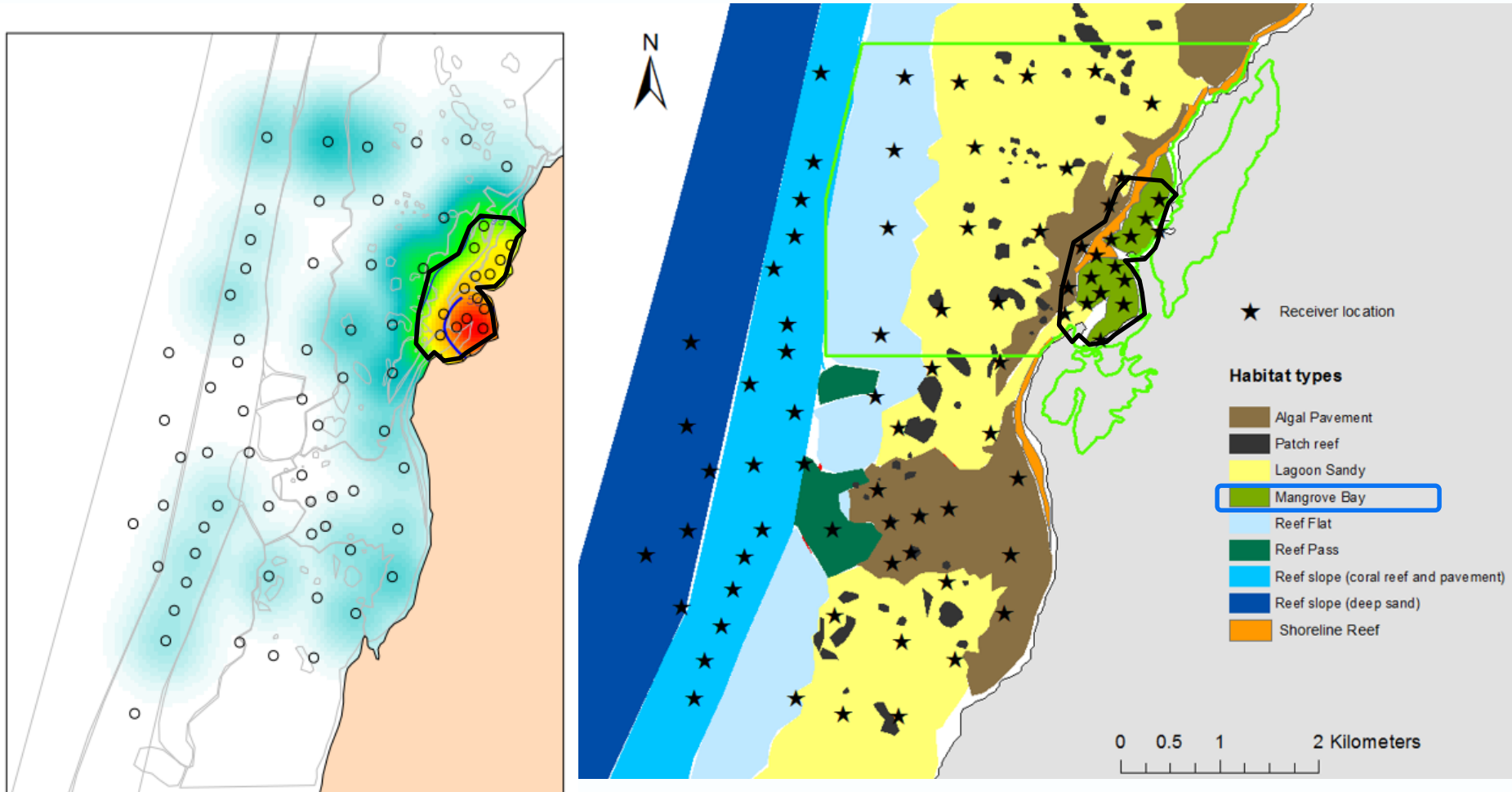


# Results – turtle home range



# Habitat use

Electivity - Relative use of habitat as a proportion of the total habitat



**E = 0.96 Mangrove Bay**

**E = -1.0 Reef Slope**

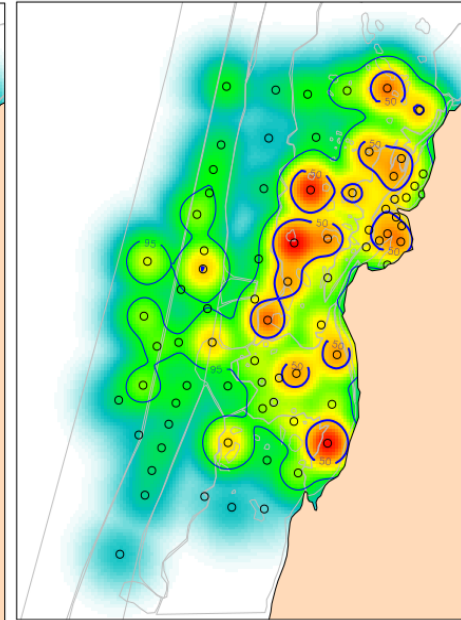
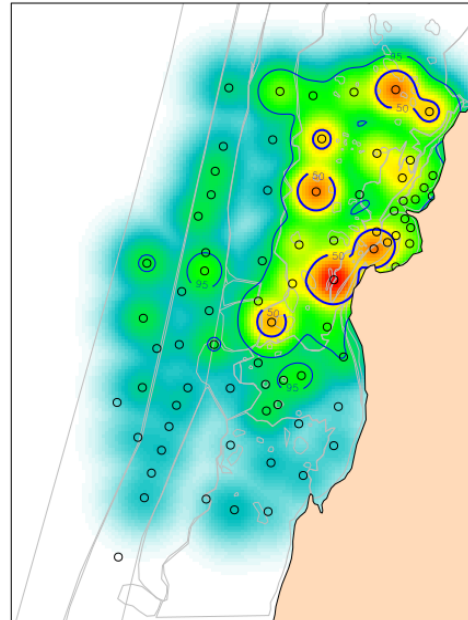
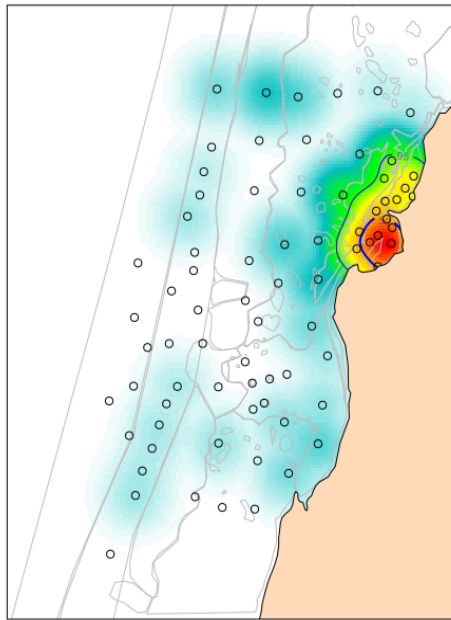
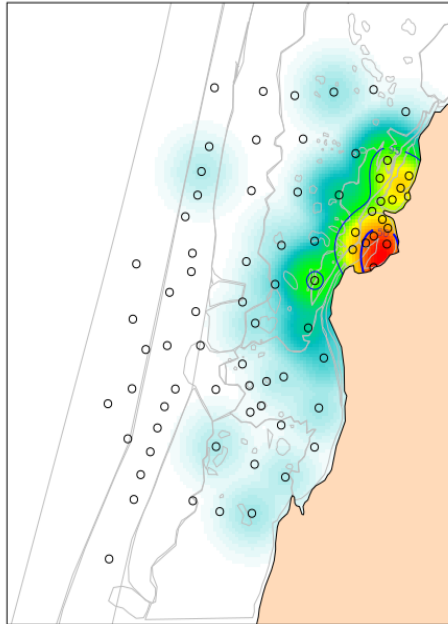
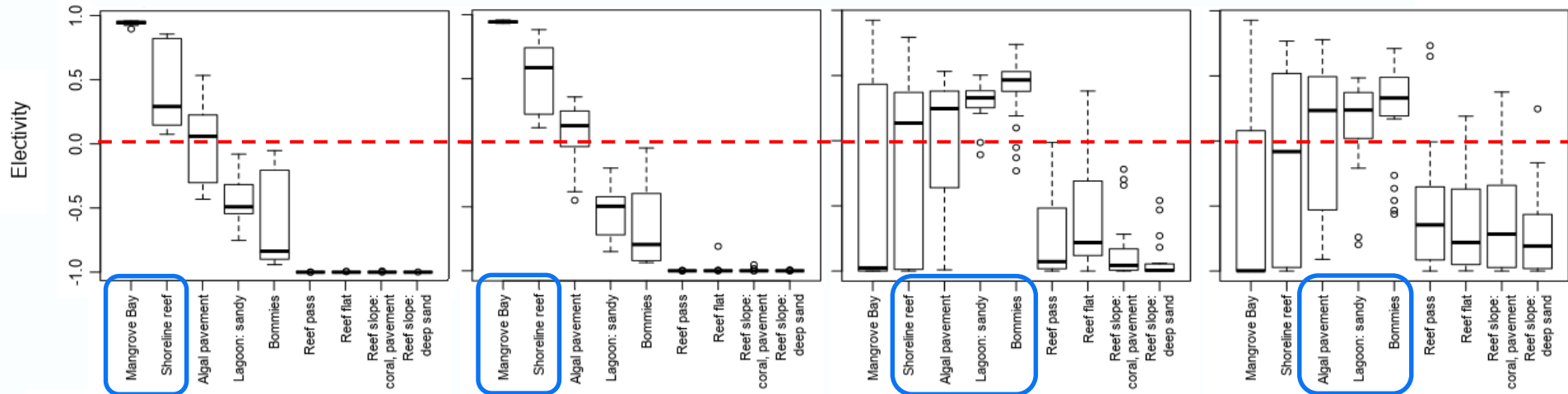
# Results – turtle habitat use

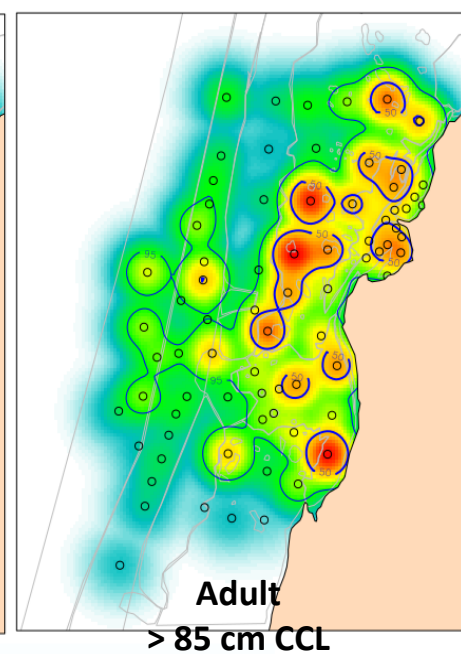
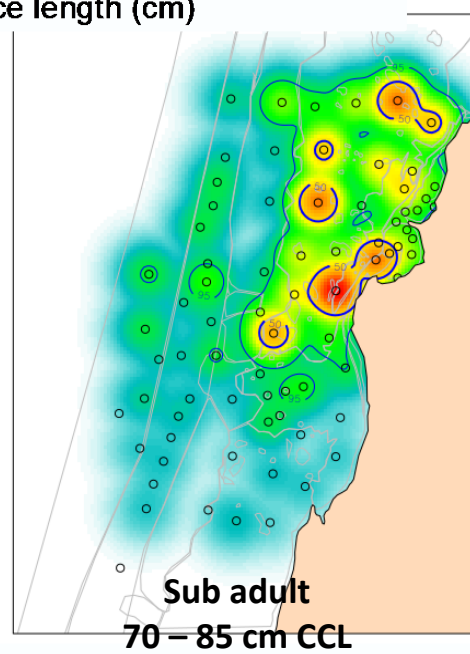
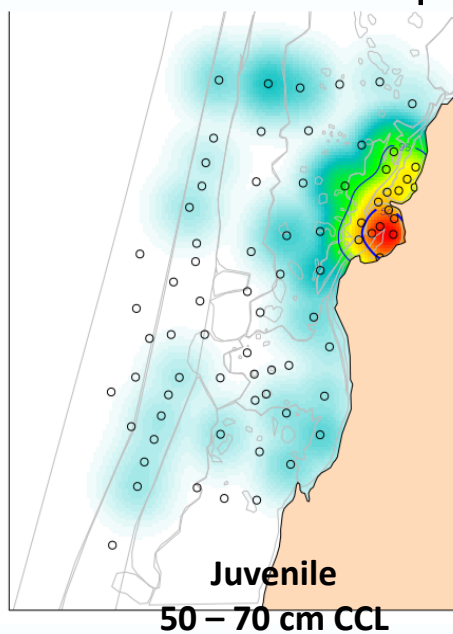
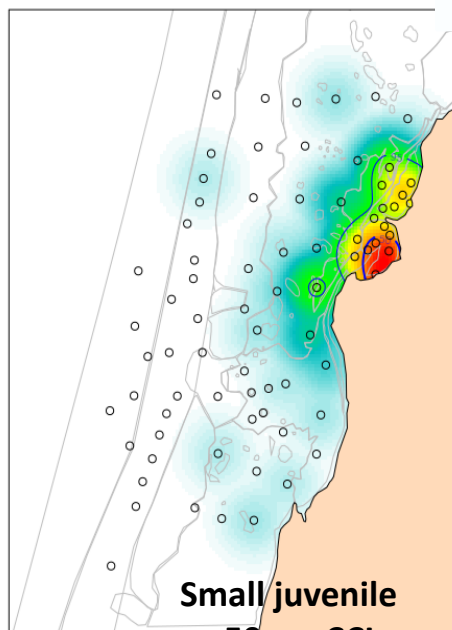
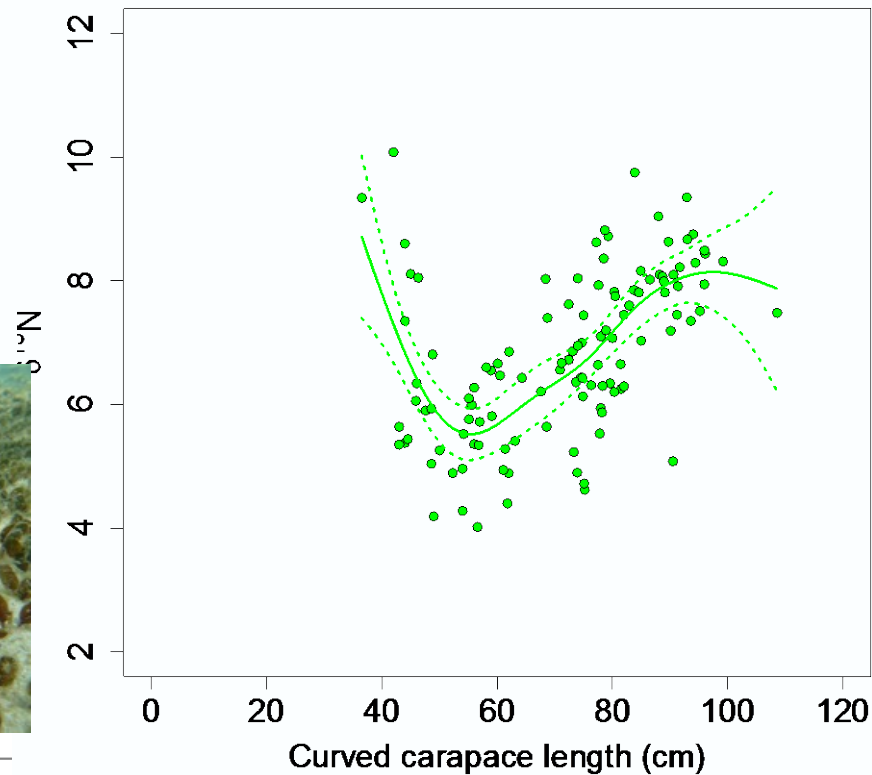
**Small juvenile**  
**< 50 cm CCL**

**Juvenile**  
**50 – 70 cm CCL**

**Sub adult**  
**70 – 85 cm CCL**

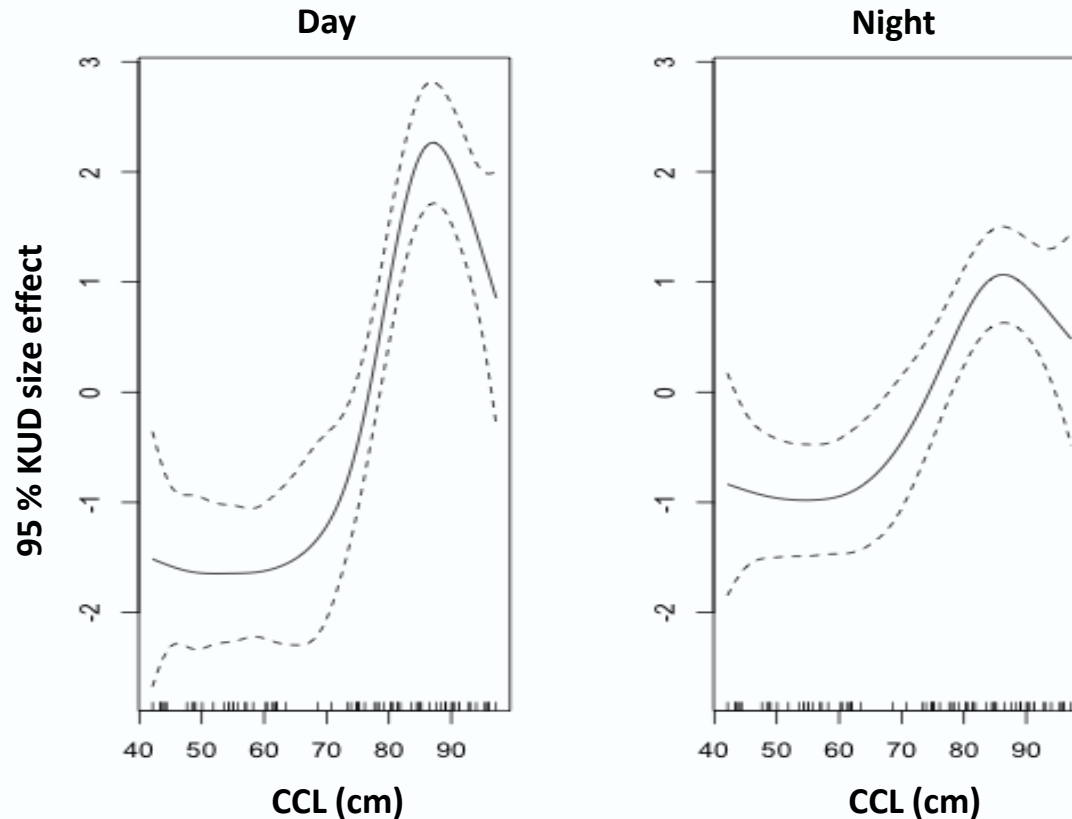
**Adult**  
**> 85 cm CCL**







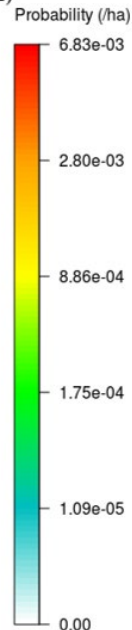
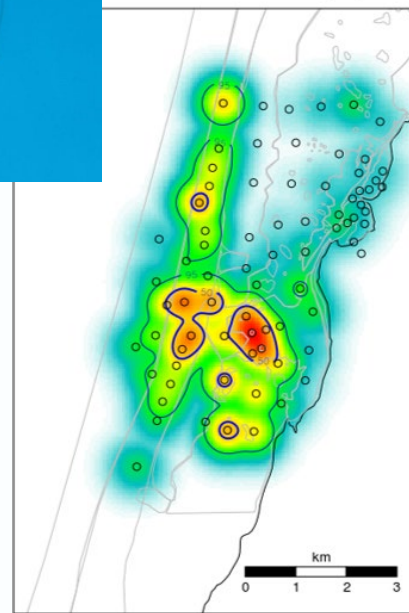
# Results – diurnal change in home range



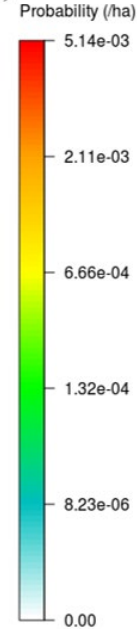
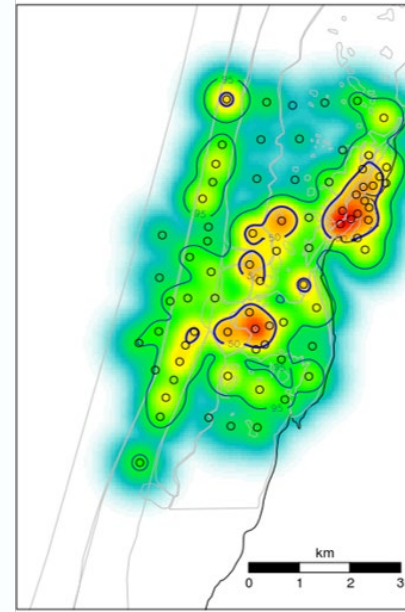
# Results – coastal sharks home range



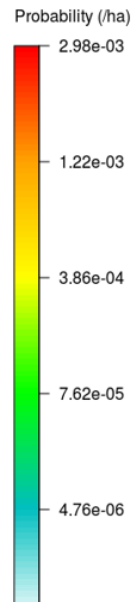
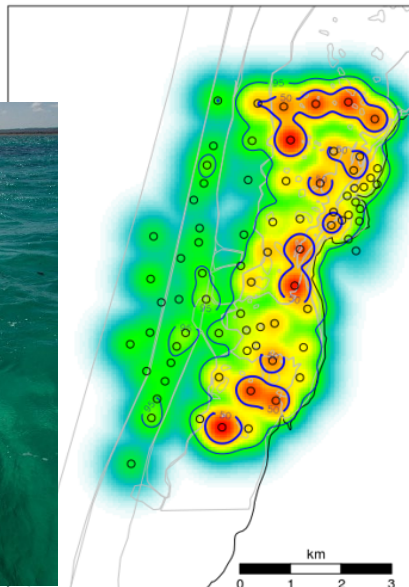
*Carcharhinus amblyrhynchos* (n = 22)



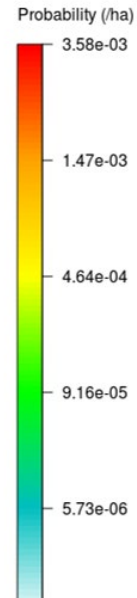
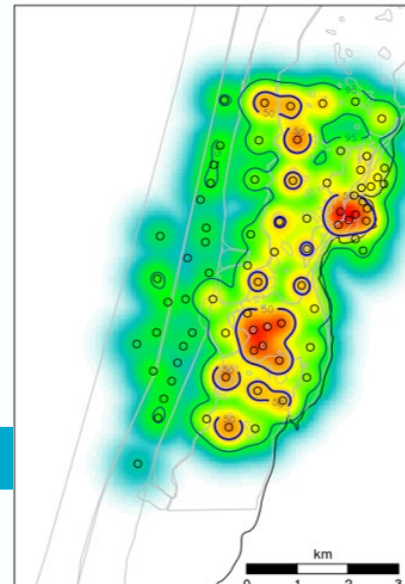
*Carcharhinus melanopterus* (n = 31)



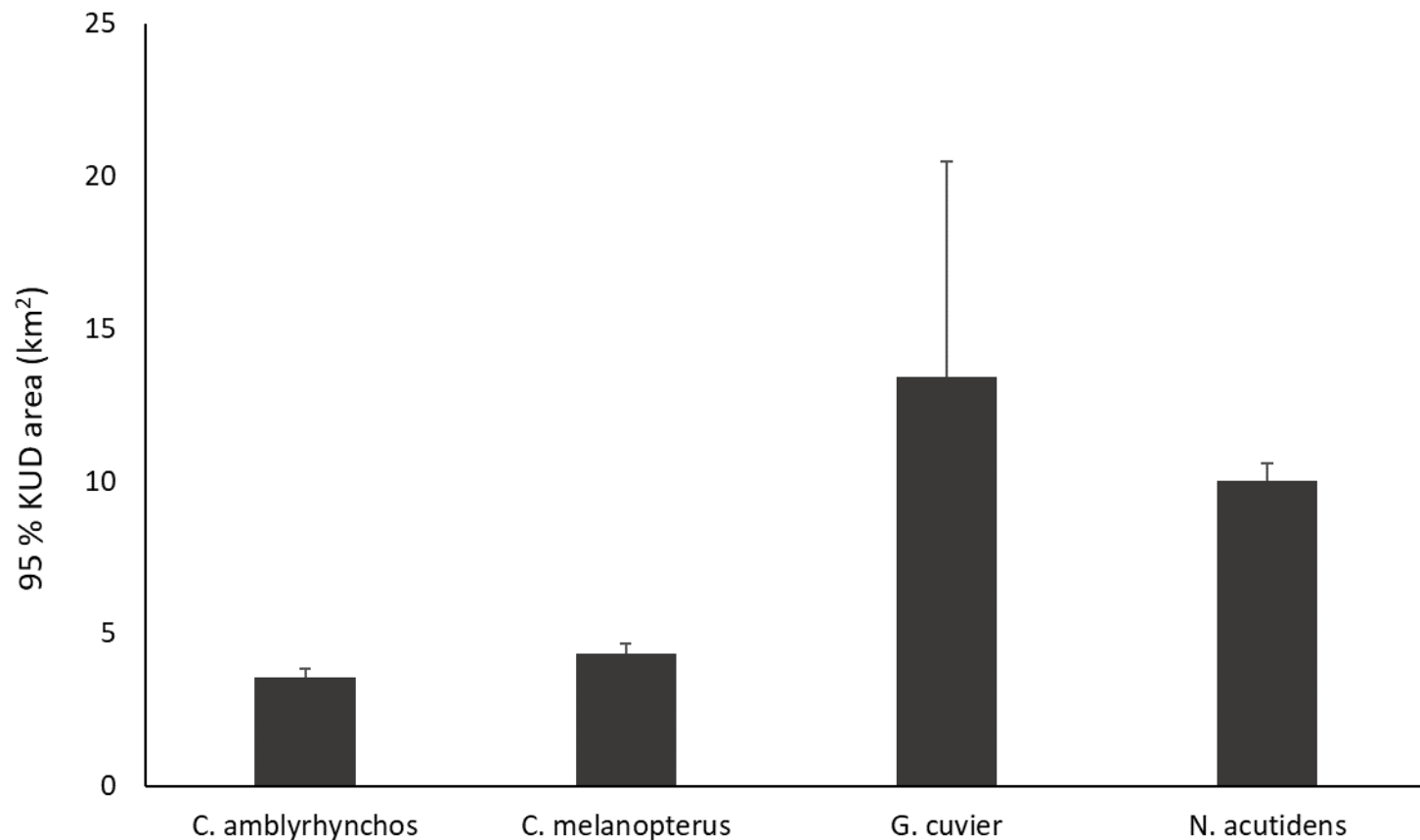
*Galeocerdo cuvier* (n = 8)



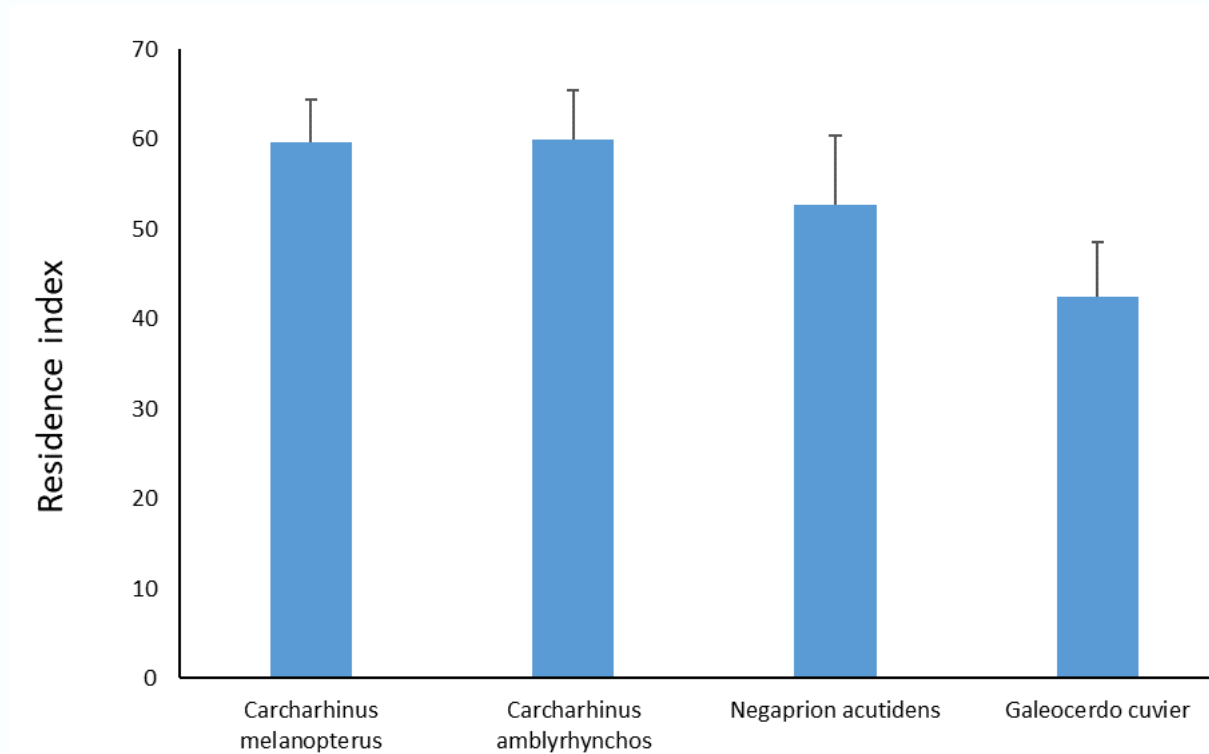
*Negaprion acutidens* (n = 24)



# Results – coastal sharks home range



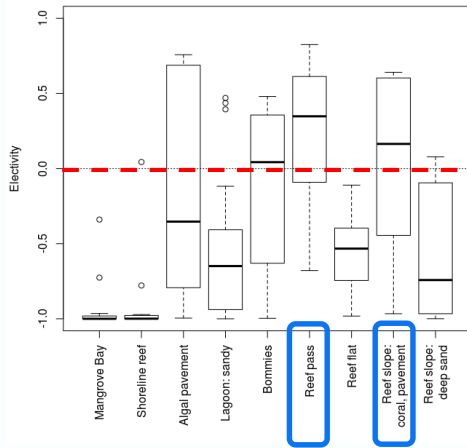
# Results – coastal sharks residence index



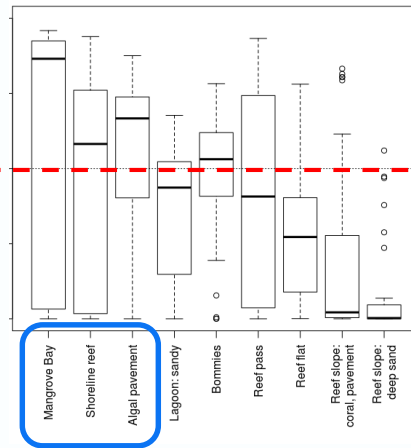


# Results – coastal sharks habitat use

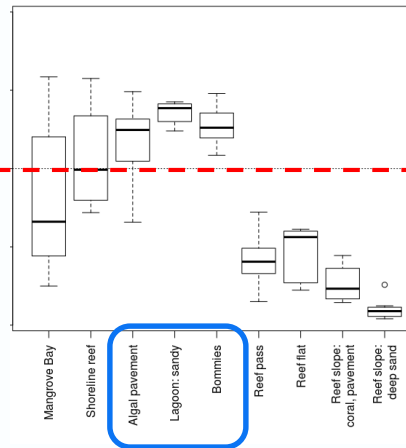
*C. amblyrhynchos*



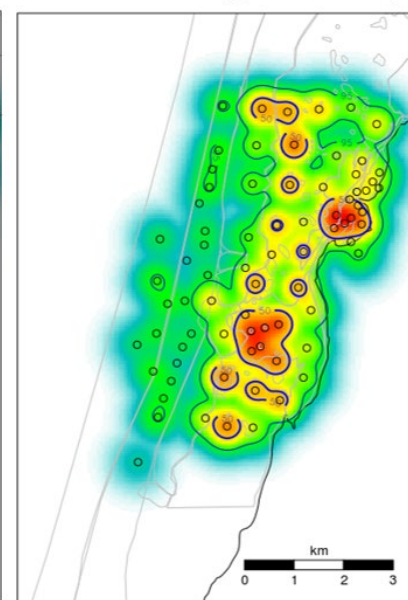
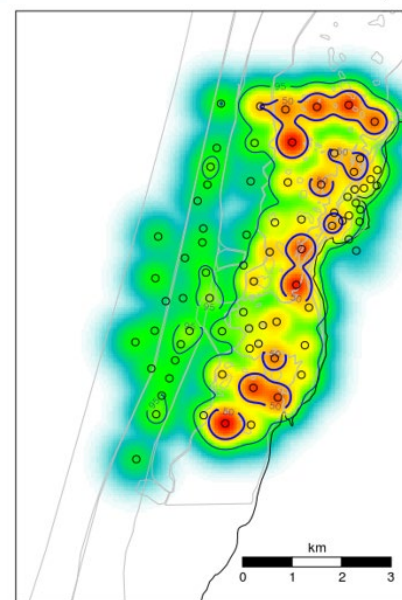
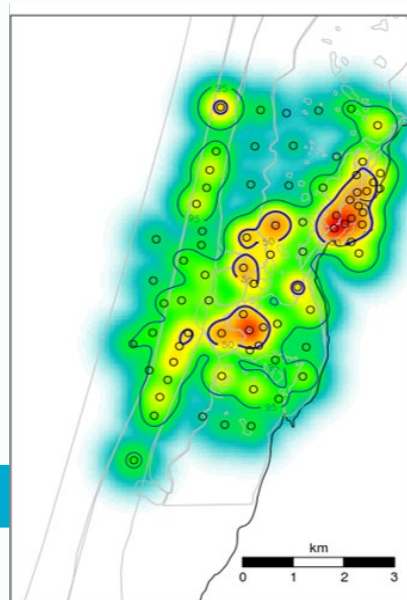
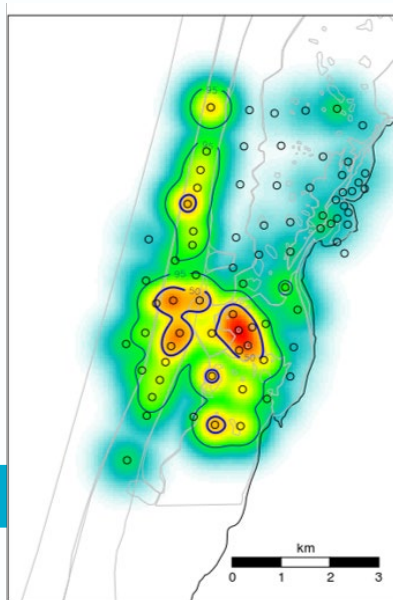
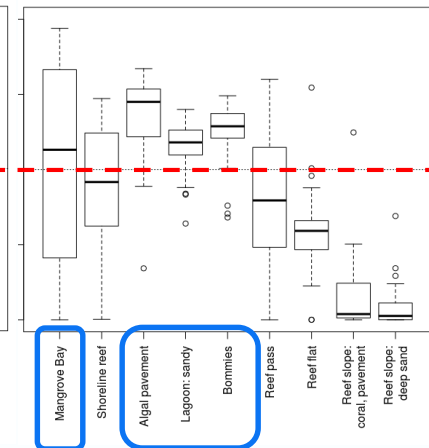
*C. melanopterus*

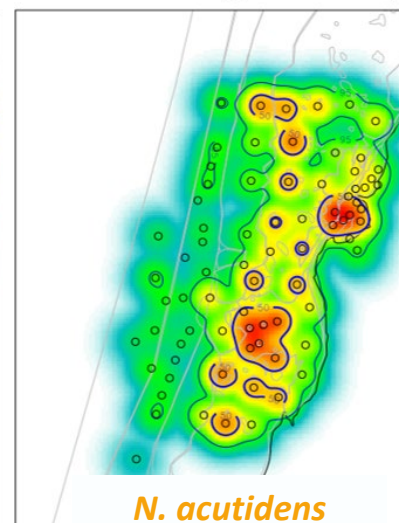
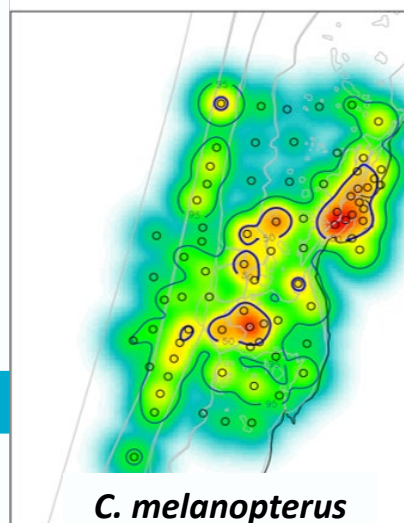
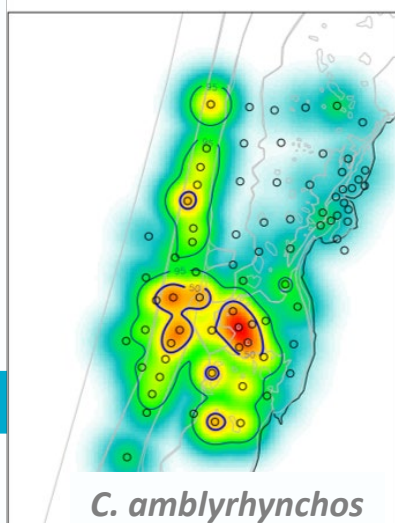
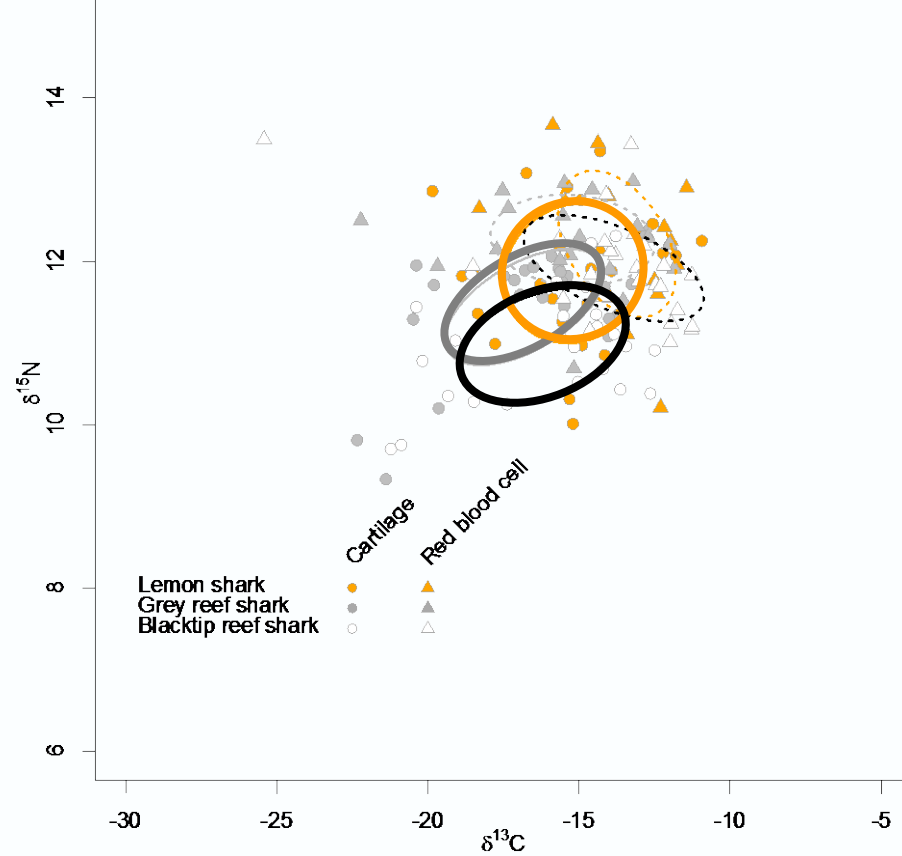


*G. cuvier*



*N. acutidens*





# Conclusions

- Whale sharks have a home range of  $> 600,000$  km
- Whale shark movement patterns are seasonal & directional
- Resident turtles have a small home range ( $<4$  km<sup>2</sup>) that  $\uparrow$  with size
- Blacktip and grey reef shark home range  $\sim 4$  km<sup>2</sup>
- Tiger sharks and lemon sharks home range  $\sim 10 - 13$  km<sup>2</sup>
- Not all individuals are resident (latitudinal range & residence index)
  - Non reproductive green turtles, black tip & grey reef shark, lemon shark, tiger sharks, nesting turtles and whale sharks
- Turtle habitat use changes as they grow
- Grey reef and blacktip sharks have very different habitat use
- Tiger sharks and lemon sharks broadly similar habitat use

# Management implications

- Range and scale of movement varies between species
- Whale sharks move widely - international and national threats
  - cross boundaries, ship strike, illegal harvest
- Turtles very localised for the majority of their life
  - resident in NMP, reproductive movement, manage at local scale
- Coastal shark species mainly localised but move across MPA boundaries
  - only large sanctuary zones provide adequate protection
  - changes in fisheries management, increased fishing would result in increased susceptibility



# Acknowledgements

- BHP-CSIRO Ningaloo Outlook Marine Research Partnership
- DPAW Exmouth Office – Emily Wilson, Dani Rob, Arvid Hogstrom & Peter Barnes
- Jo Myers
- AIMS Whale Shark team
- Ningaloo Aviation

