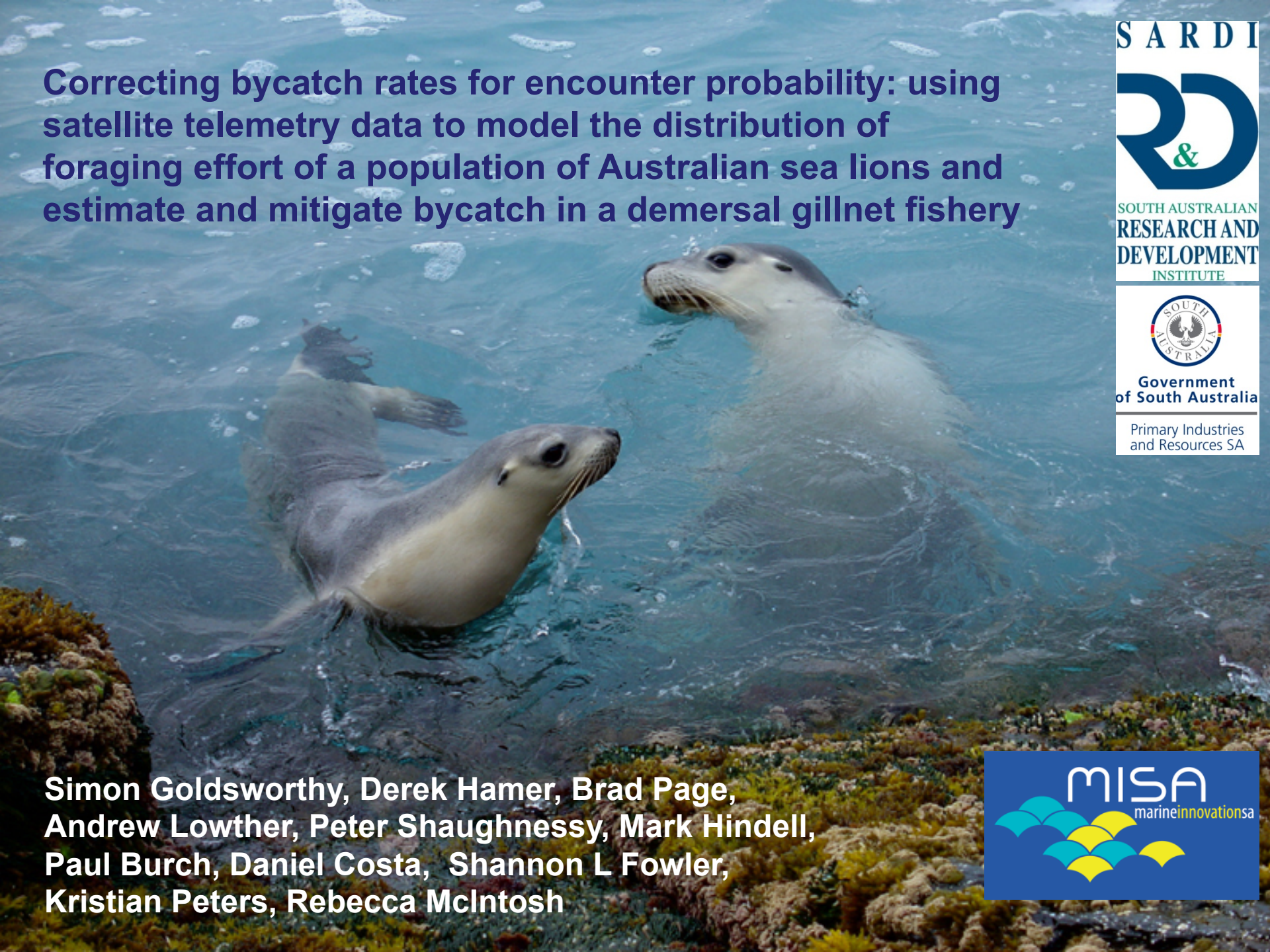
Correcting bycatch rates for encounter probability: using satellite telemetry data to model the distribution of foraging effort of a population of Australian sea lions and estimate and mitigate bycatch in a demersal gillnet fishery



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Fishery bycatch of threatened, endangered and protected species (TEPS) is a critical conservation and fishery management issue

Assessing the impact of bycatch requires:
- estimates of number of caught
- population/demographic implications

Bycatch numbers usually estimated based on rates of bycatch per unit of fishing effort, then extrapolated across the fishery
e.g. individuals per km net-set/trawl hrs/1000 hooks

Bycatch rates can be very imprecise means to estimate bycatch number/impact:
- fraction of total fishing effort is monitored
- bycatch typically rare/chance events
- fishing effort & encounter probabilities (which drive bycatch rates) can be highly spatially heterogeneous across distribution of fishery

Knowledge of distribution and density of bycatch species is critical to:
- assessing how encounter probability affects bycatch rate, and
- improving estimates of bycatch impacts, mitigation methods and targets

Bycatch of Australian sea lions in the demersal gillnet shark fishery

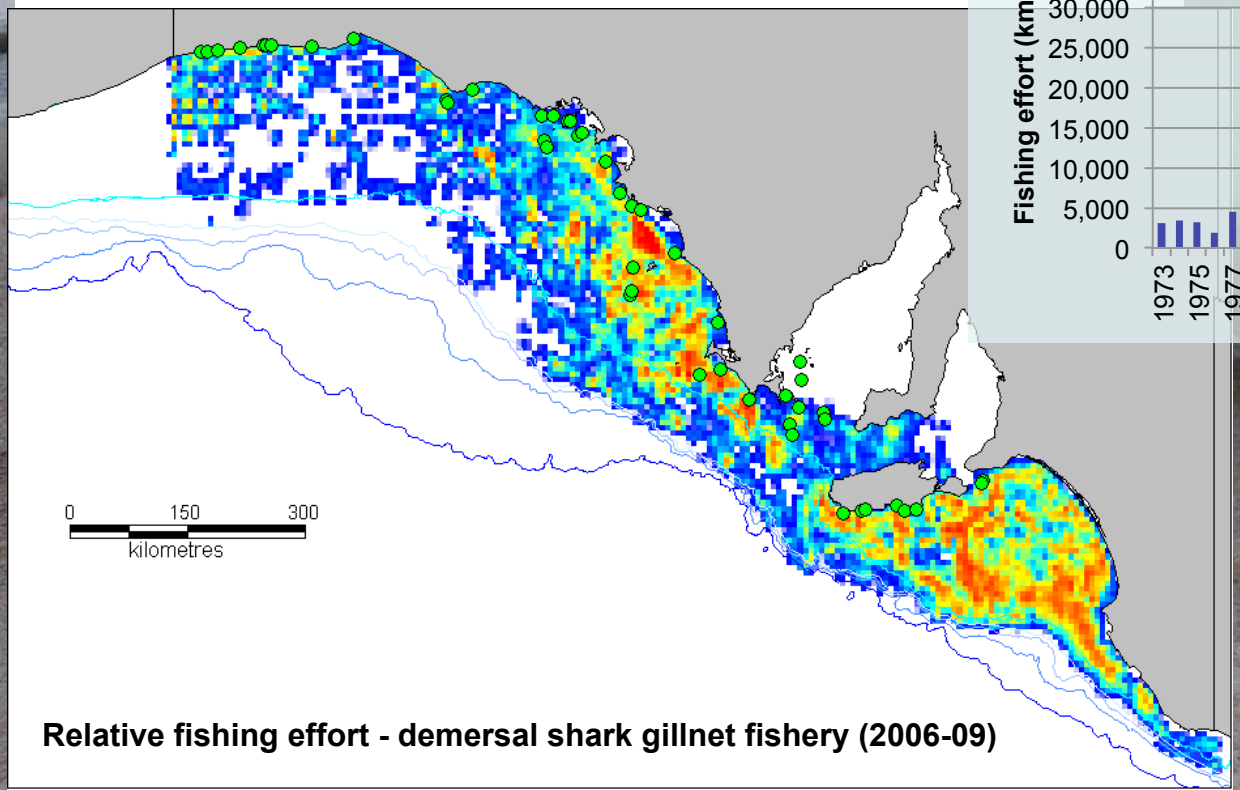
Australian sea lion (ASL)

- Australia's only endemic seal
- Range limited to SA and WA
- unusual breeding biology incl. non-annual (17.5 m) temporally asynchronous breeding cycle
- extreme philopatry/population structure
- limited evidence for recovery of ASL populations since colonial sealing
- Listed as *threatened* under Australian EPBC Act, *endangered* under IUCN Redlist

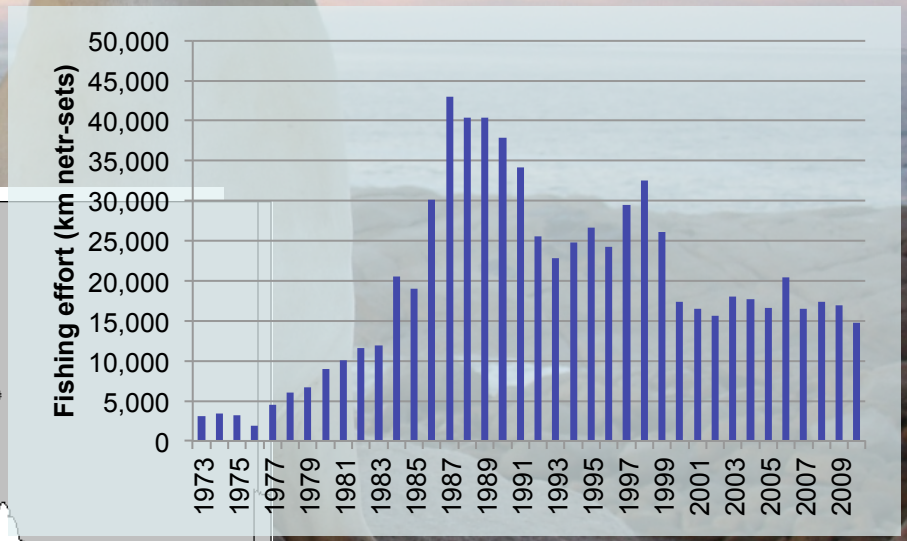
Demersal gillnet fishery

- commenced in early 1970s, targets school and gummy shark
- all SA shelf waters (excl. gulfs & bays)

~17,000 km/years since 2000



Relative fishing effort - demersal shark gillnet fishery (2006-09)



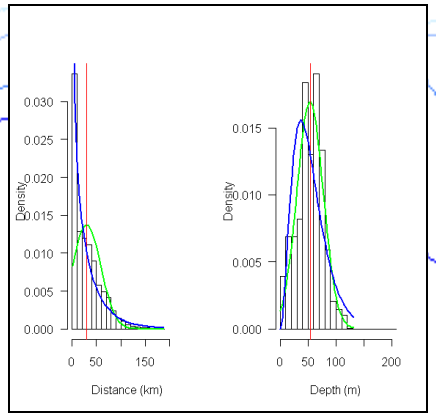
Aims:

1. **Assess the significance of ASL bycatch in the gillnet shark fishery**
2. **Develop spatial management options to mitigate bycatch**

Modelling ASL distribution of foraging effort

ASL foraging models

Overall model of distribution of foraging effort of ASL population in South Australia (all males and females >1.5 yrs)



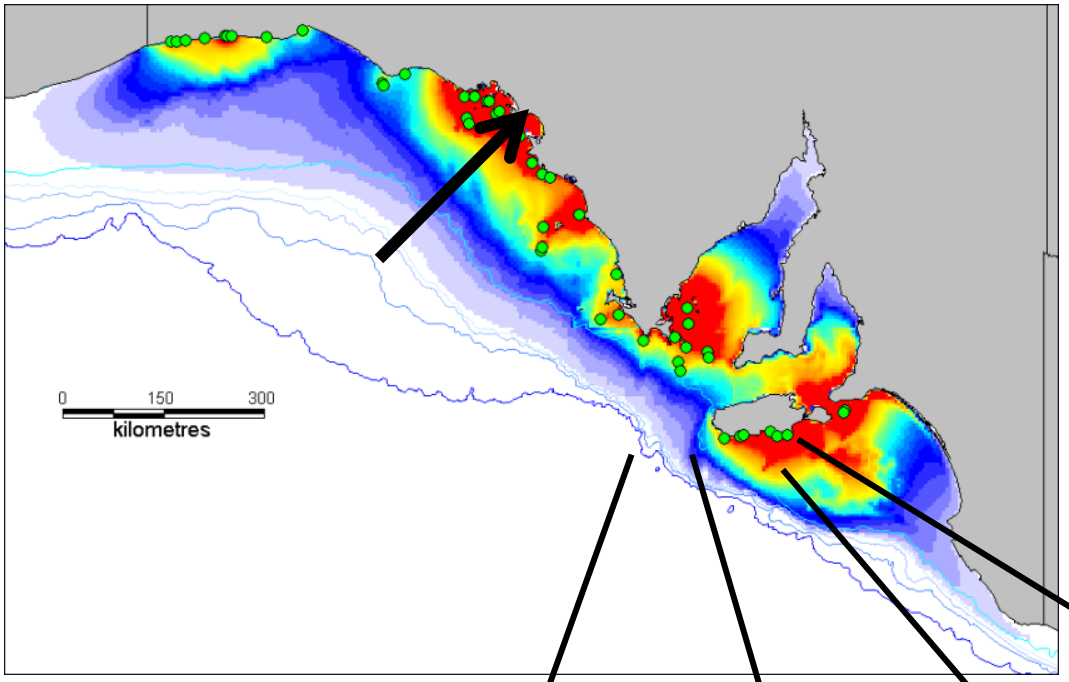
Foraging models

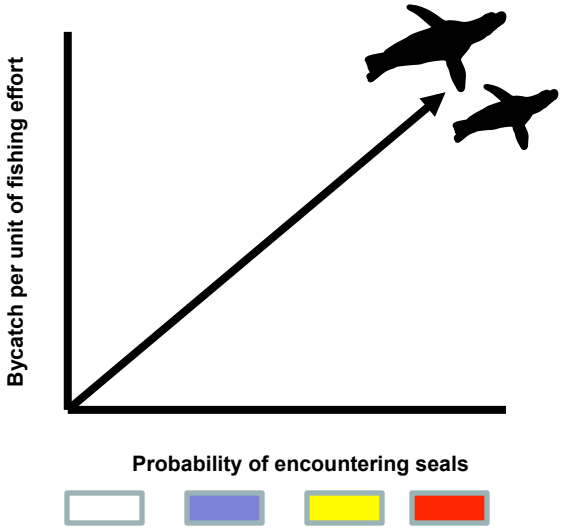
- time spent at distance & depth
- Fit to gamma or normal prob. density functions
- joint probabilities (product of depth & distance)
- applied to 1 x1 km node array ~350,000 nodes
- subpopulation (sex/age-class) models developed where tracking data available
- pooled models used for non-tracked sites

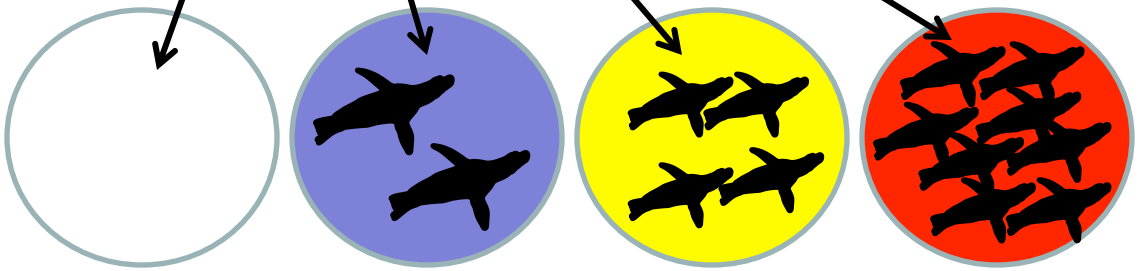
Modelling ASL bycatch rates: bycatch estimator

Bycatch rate estimation models

Bycatch rate estimation method







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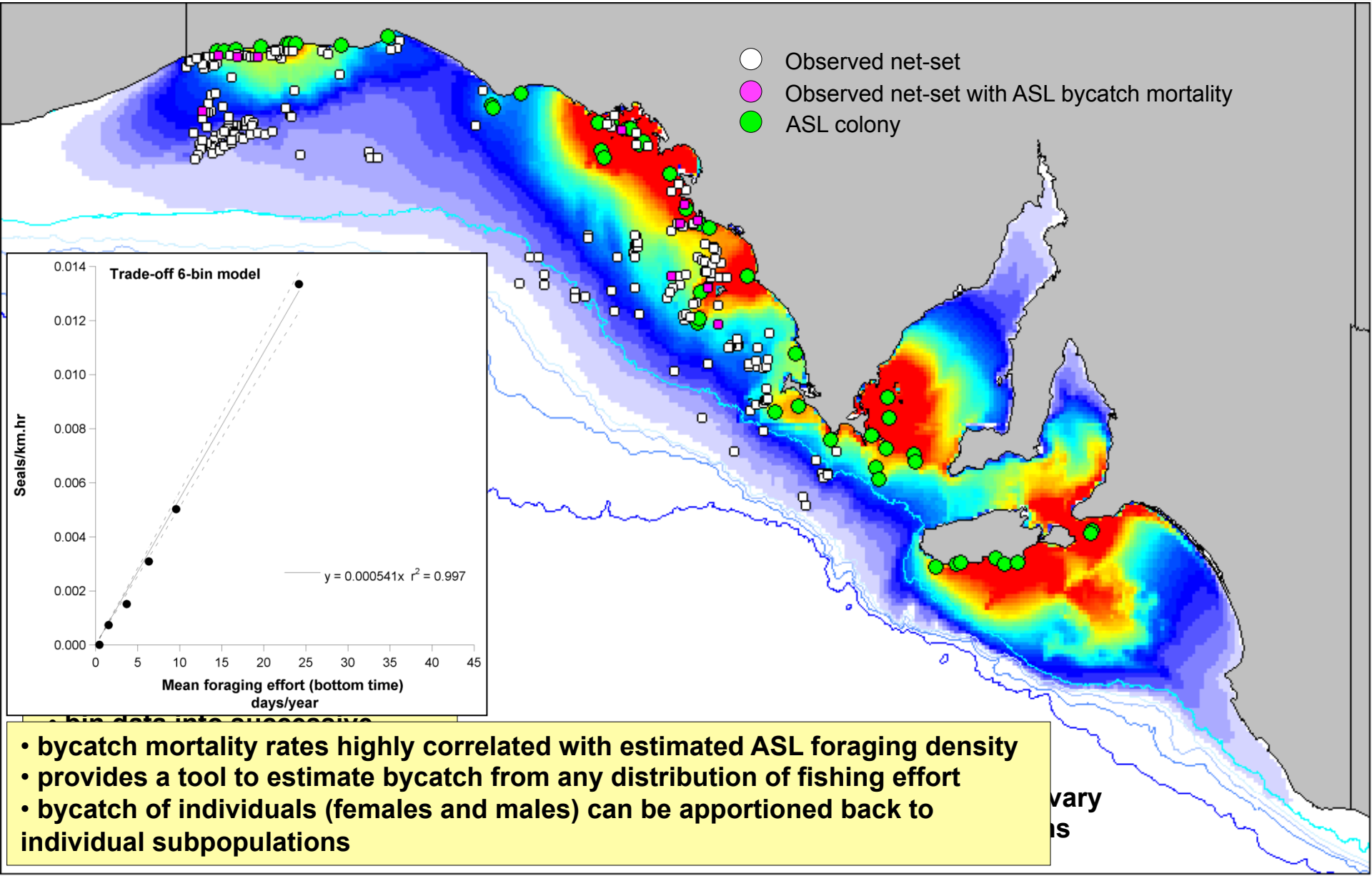
Modelling ASL bycatch rates: bycatch estimator

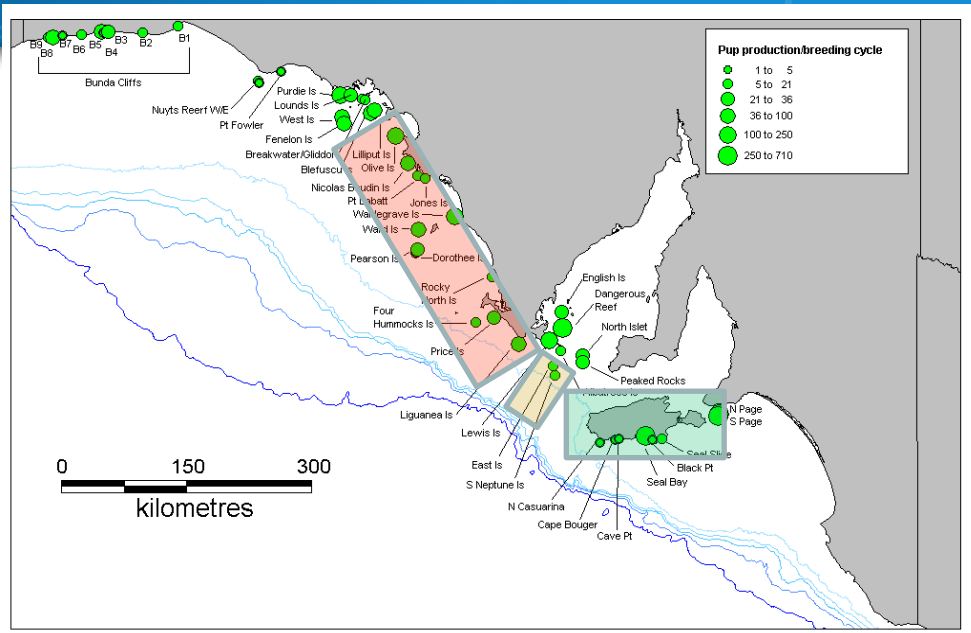
Bycatch estimation models

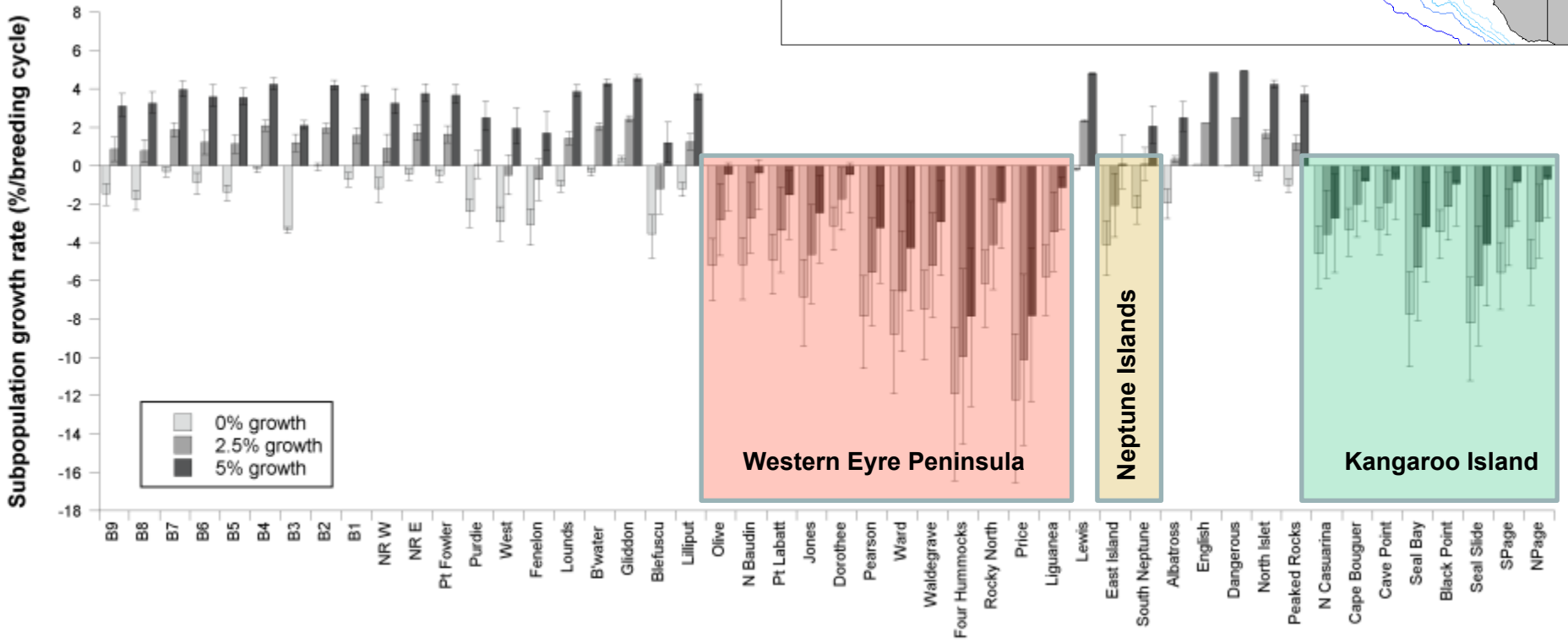


- bycatch mortality rates highly correlated with estimated ASL foraging density
- provides a tool to estimate bycatch from any distribution of fishing effort
- bycatch of individuals (females and males) can be apportioned back to individual subpopulations

Impact of bycatch on ASL

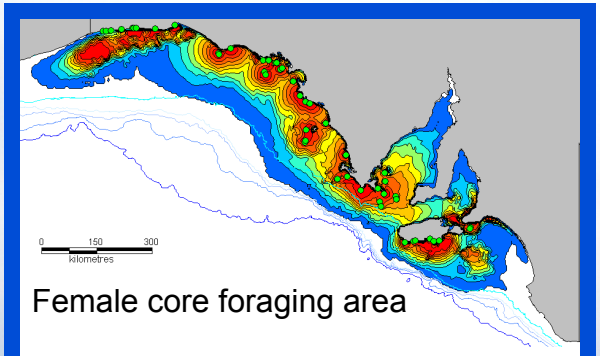
- 374 (272-506) sea lion bycatch mortalities are estimated occur off South Australia each breeding cycle (17.5 months)
- levels of female bycatch mortality represent ~35% increase from natural mortality levels
- PVA of bycatch indicates that the majority (42-96%) of ASL colonies are currently exposed to unsustainable levels of bycatch mortality



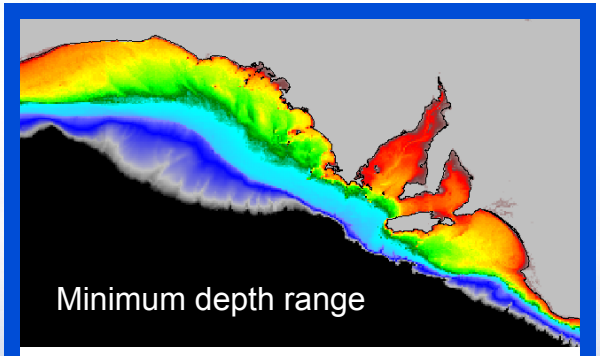


Spatial closure scenarios

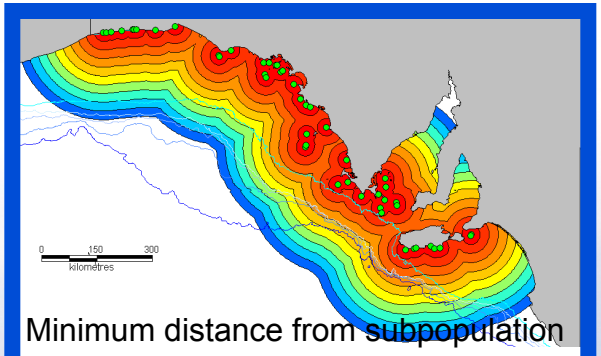
Examined expected bycatch mortality reduction from different **spatial closures** in fishery
Scenarios examined both **removal** and **displacement** of fishing effort (100,000 km.hrs/yr)



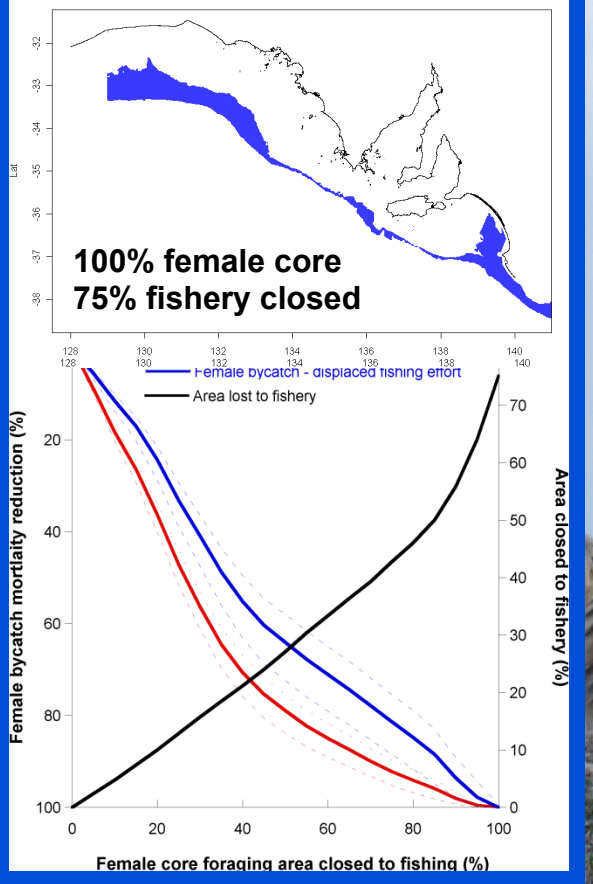
Female core foraging area

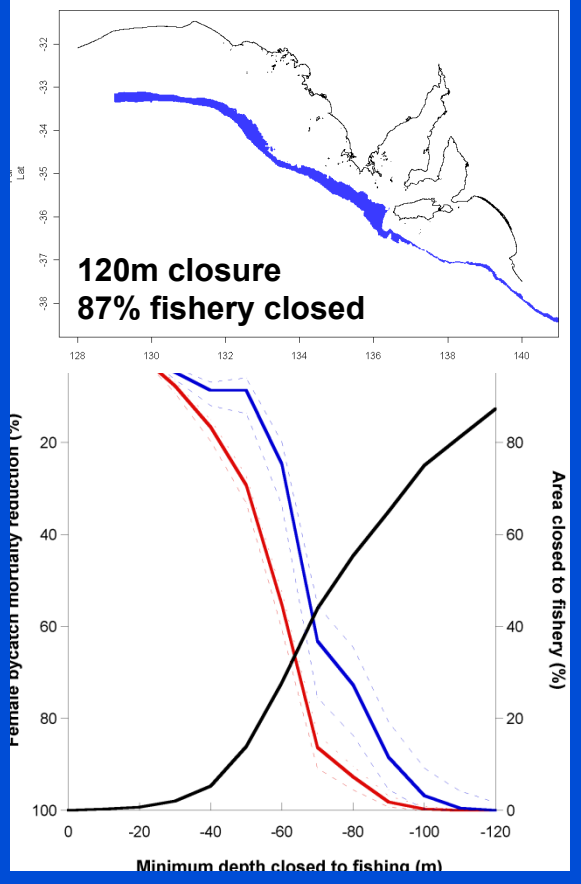


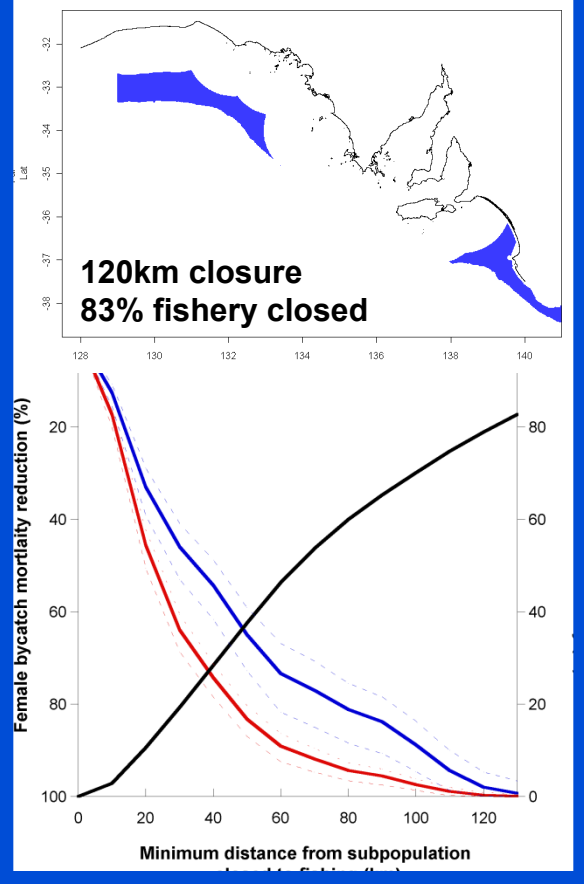
Minimum depth range



Minimum distance from subpopulation







Australian Fisheries Management Authority (AFMA) – Management Response

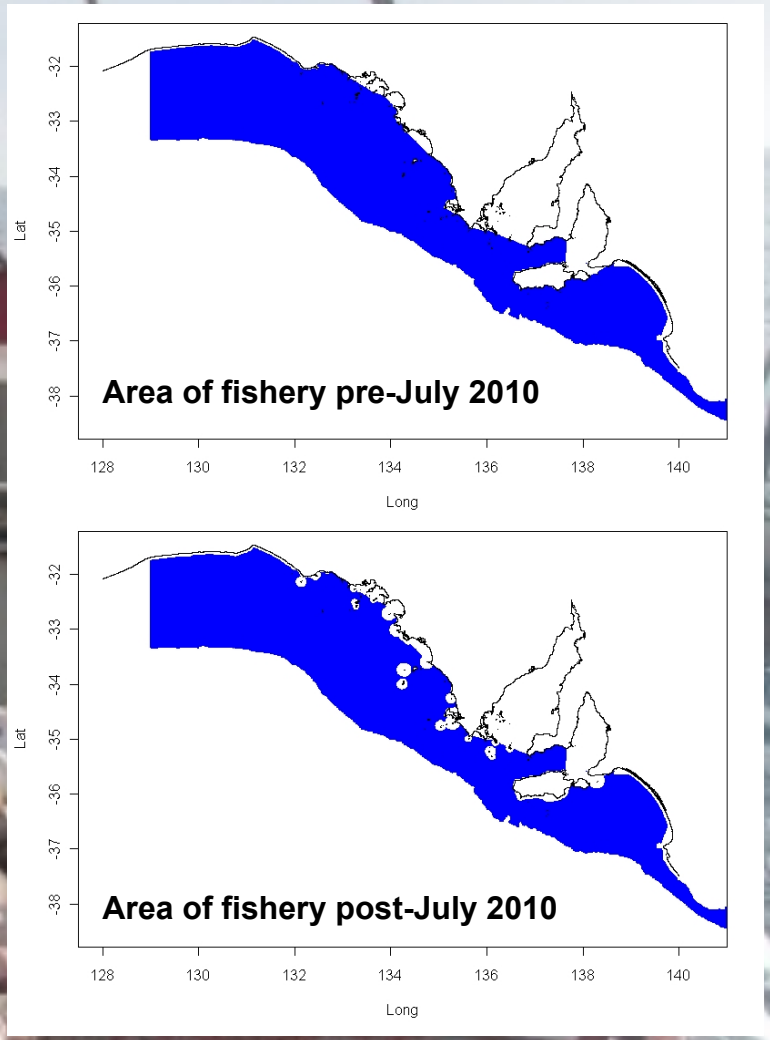
ASL Management Strategy July 2010

1. Fishery closures (4-10nm) around all ASL colonies

- 3.9% reduction in area open to fishery
- 19% reduction in ASL bycatch
- limited reduction in percentage colonies with decreasing growth rates

2. Trigger limits (limit allowable bycatch) with 11% observer coverage within 7 zones

- problems with trigger limits (set too high); observer effort (too low); and observer quality (missing drop-outs)



AFMA's management measures are required to significantly reduce ASL bycatch and enable the recovery of the species and all subpopulations

Photo D Hamer

Summary

We believe this study represents the first where estimates of at-sea densities using biologging data have been used to correct for encounter probability of bycatch species

This approach can greatly increase precision of bycatch estimates, assessment of impacts on populations and appropriateness of management response

The approach we have developed could be applied to better manage the impacts of fishery bycatch in other threatened marine species

Analyses suggest the majority of ASL subpopulations in SA are currently exposed to unsustainable levels of bycatch mortality, and without appropriate management response , further population declines, subpopulation extinctions and reductions in range are likely

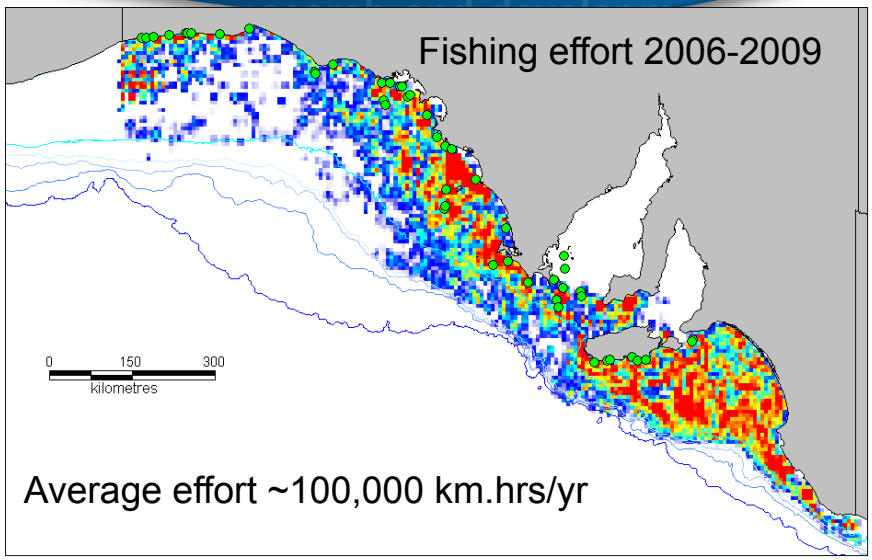
We remain optimistic that results from our study will improve the management of ASL bycatch in the gillnet fishery

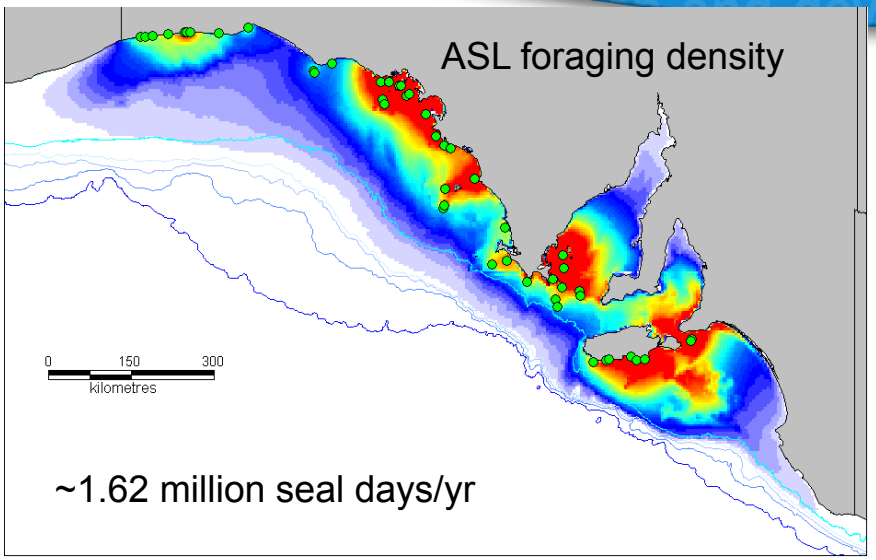
Acknowledgments

We thank the Fisheries Research and Development Corporation and the Department of the Environment, Water, Heritage and the Arts for financial support for this project. We thank the Fish Factory, and skippers and crew for support of the bycatch observer programs, and Alex Ivy (SARDI) for assistance with observer work. We thank Members of GHATMAC, and Shane Gaddes, Beth Gibson, Trent Timmiss, Matt Daniel (AFMA), and Jeremy Prince (Shark RAG Chair) and Ian Knuckey for their advice and support. We also thank Caroline Stewardson, Crispian Ashby (FRDC), Barbara Muso (DEWHA), and Geert Aarts, Sophie Brasseur (IMARES)

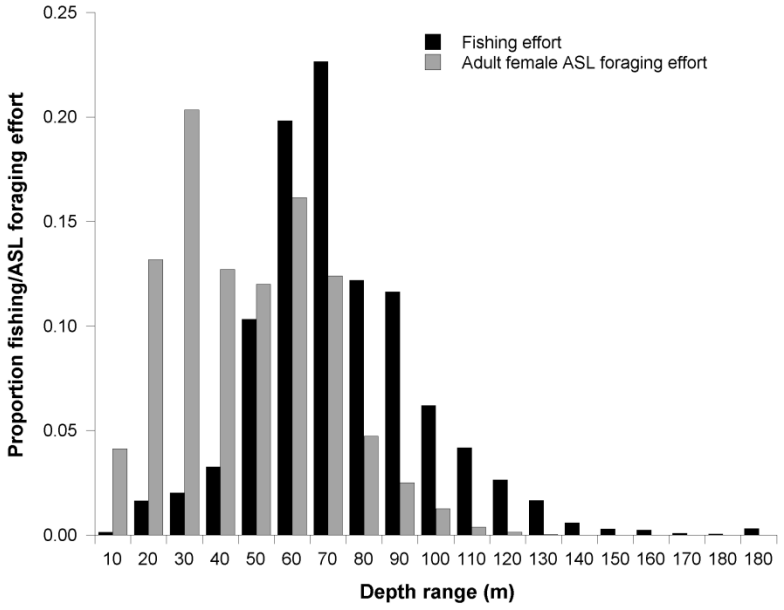
Overlap in fishing effort and ASL foraging effort

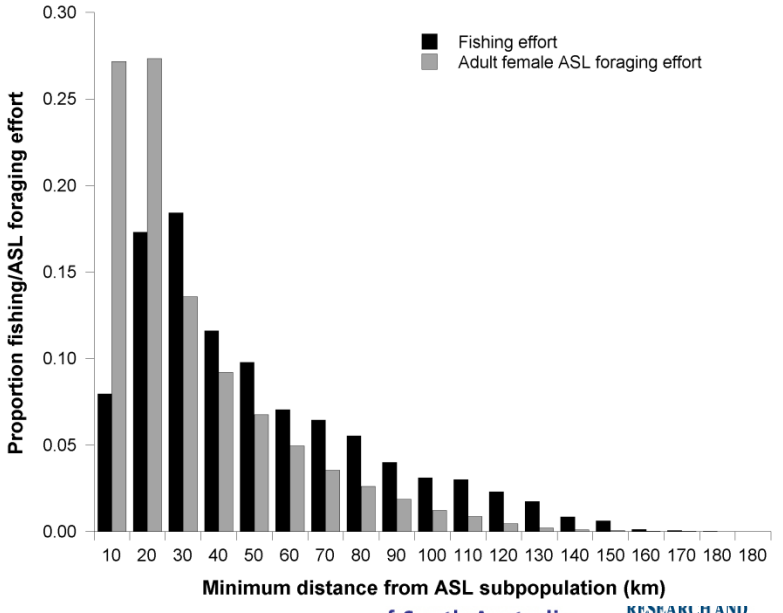
Sea lion & fishing distribution





Overlap in proportion fishing effort / adult female sea lion foraging density





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