RISK TO THE INDO-PACIFIC OCEAN WHALE SHARK POPULATION FROM INTERACTIONS WITH PACIFIC OCEAN PURSE-SEINE FISHERIES

P. NEUBAUER, Y. RICHARD & S. CLARKE
(DRAGONFLY DATA SCIENCE & ABNJ)

SA
WP-12

Western and Central Pacific Fisheries Commission

COMMON OCEANS

FAO FIAT PANIS

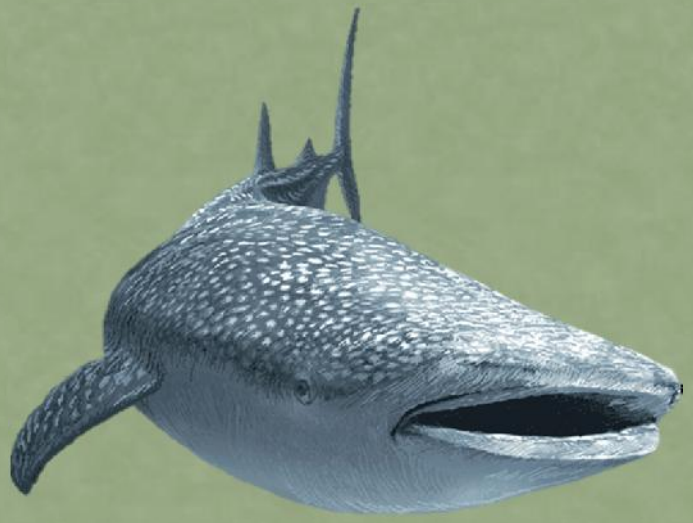
BACKGROUND

- One of four Pacific-wide assessments funded by the ABNJ Tuna Project
- Designed to improve assessment tools for data-poor species
- WCPO may provide world's largest dataset on whale shark-purse seine interactions

SA
WP-12

STATE OF PLAY

- Single Indo-Pacific population (Vignaud et al. 2014)
- Listed by CMS (1999) & CITES (2003) 2014)
- PNA banned purse seine fishing on whale sharks (2010)



- WCPFC CMM banned setting if a whale shark is sighted (2012)
- IATTC followed in 2015

SA
WP-12

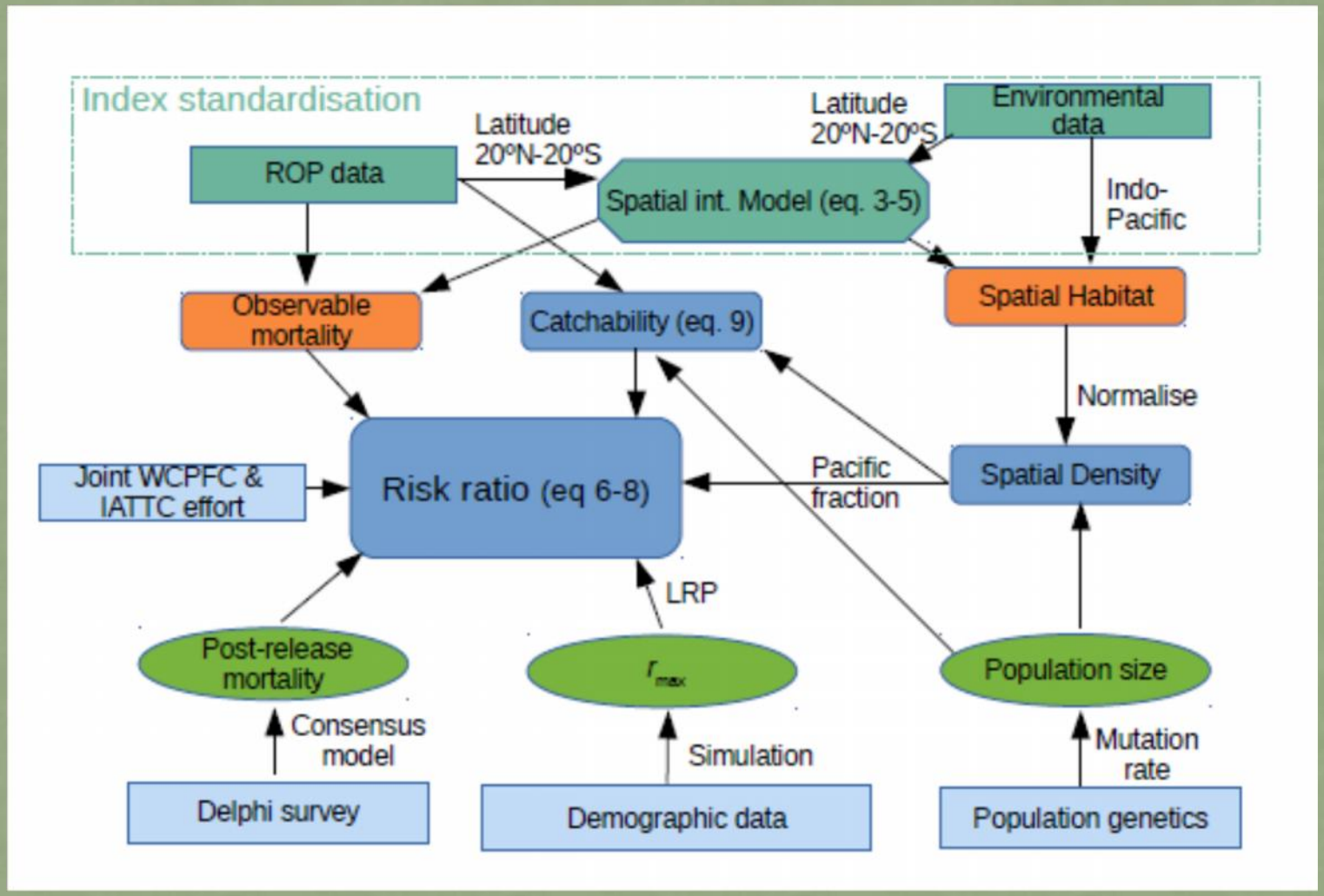
AVAILABLE DATA

- Purse Seine
  - WCPO ROP, logsheets & AR-1s
  - Pacific-wide effort (sets)
  - IATTC observer programme (Román et al. 2018)

- Fine scale SST and chlorophyll *a*

SA
WP-12

RISK METHODOLOGY

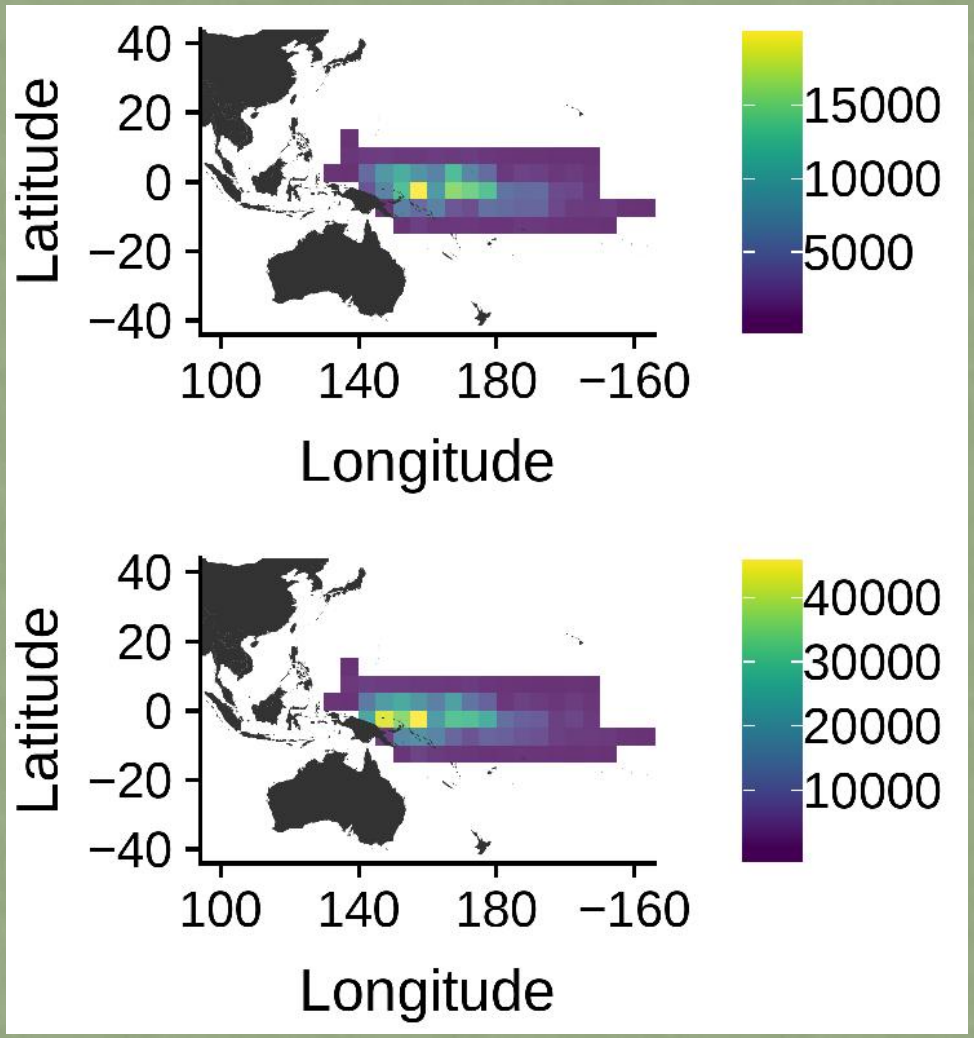


SA

WP-12

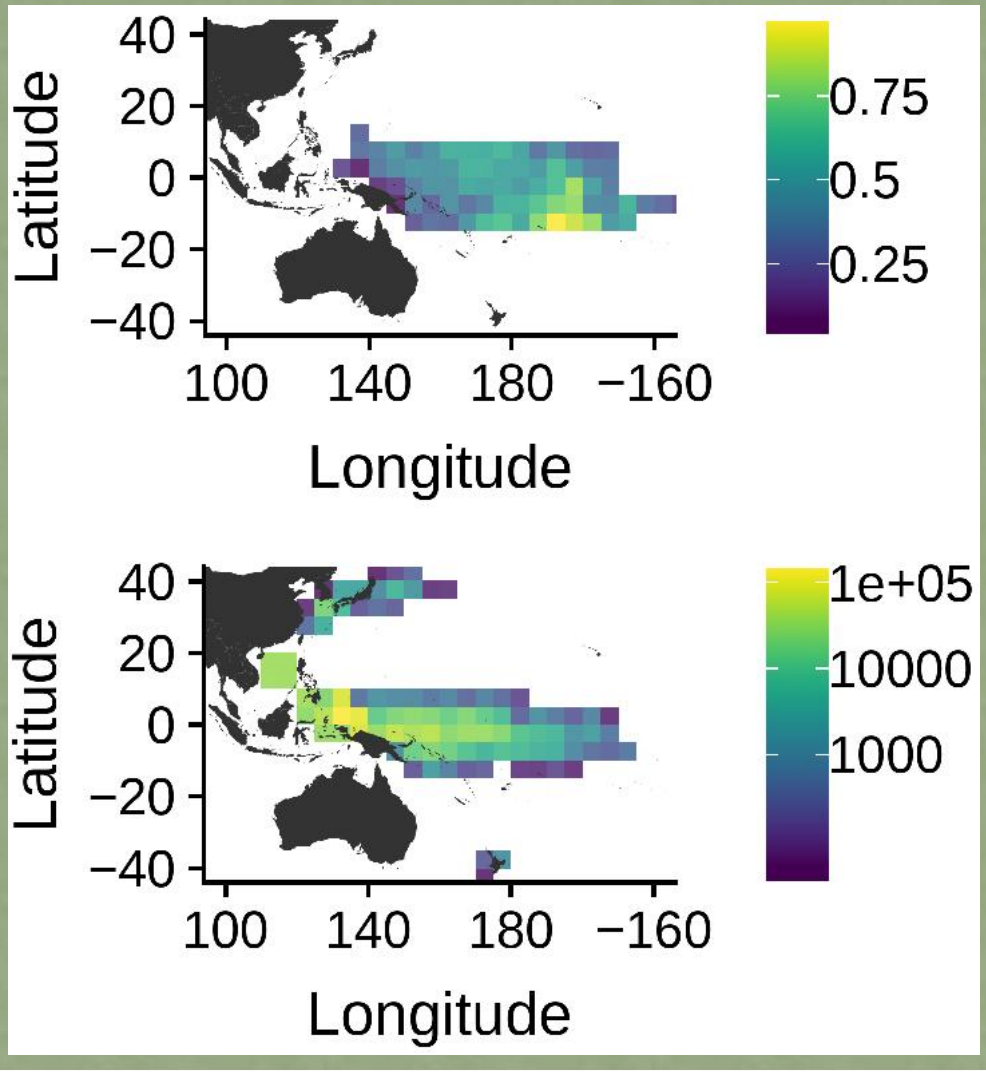
BASIC DATA SUMMARY: WCPO EFFORT

Observed effort a relatively uniform subset of total effort in the tropical purse seine fishery



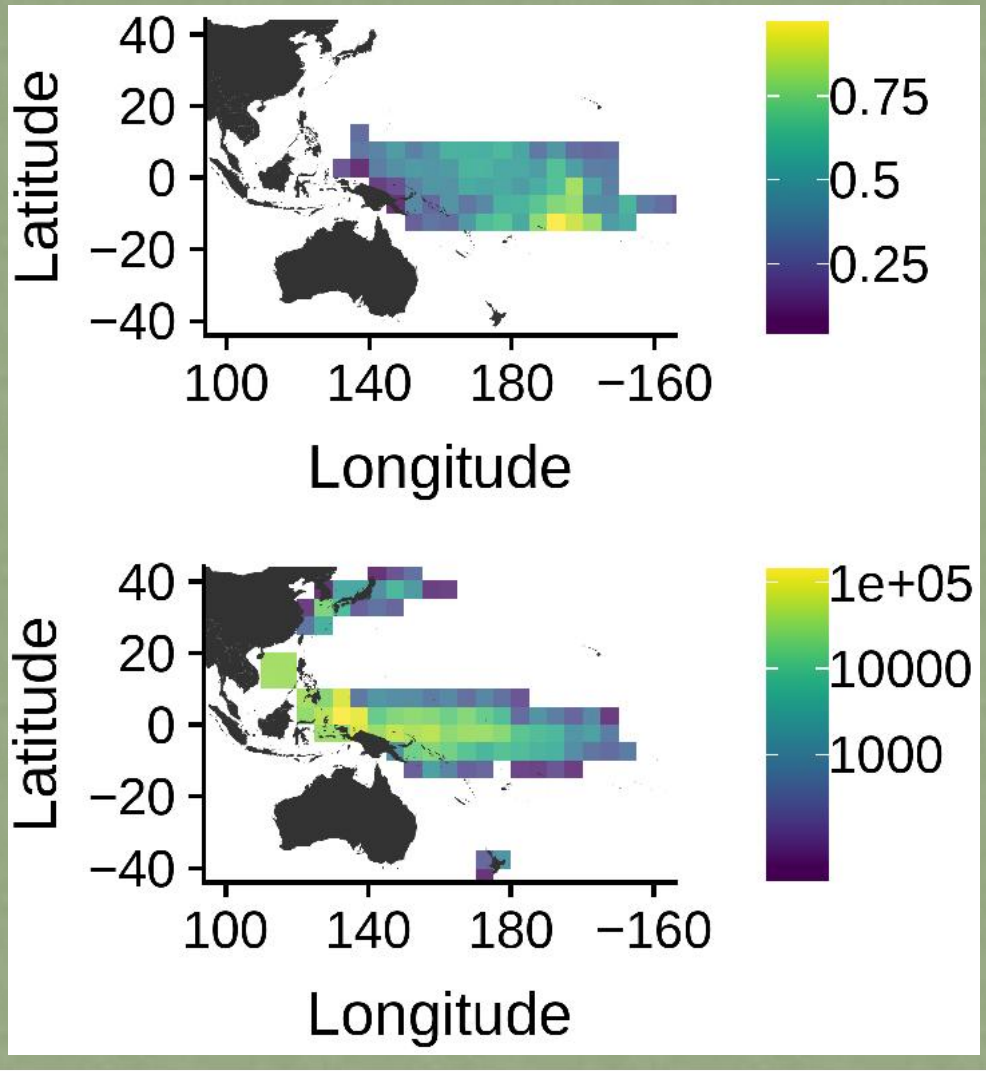
BASIC DATA SUMMARY: WCPO EFFORT

Observed effort a relatively uniform subset of total effort in the tropical purse seine fishery

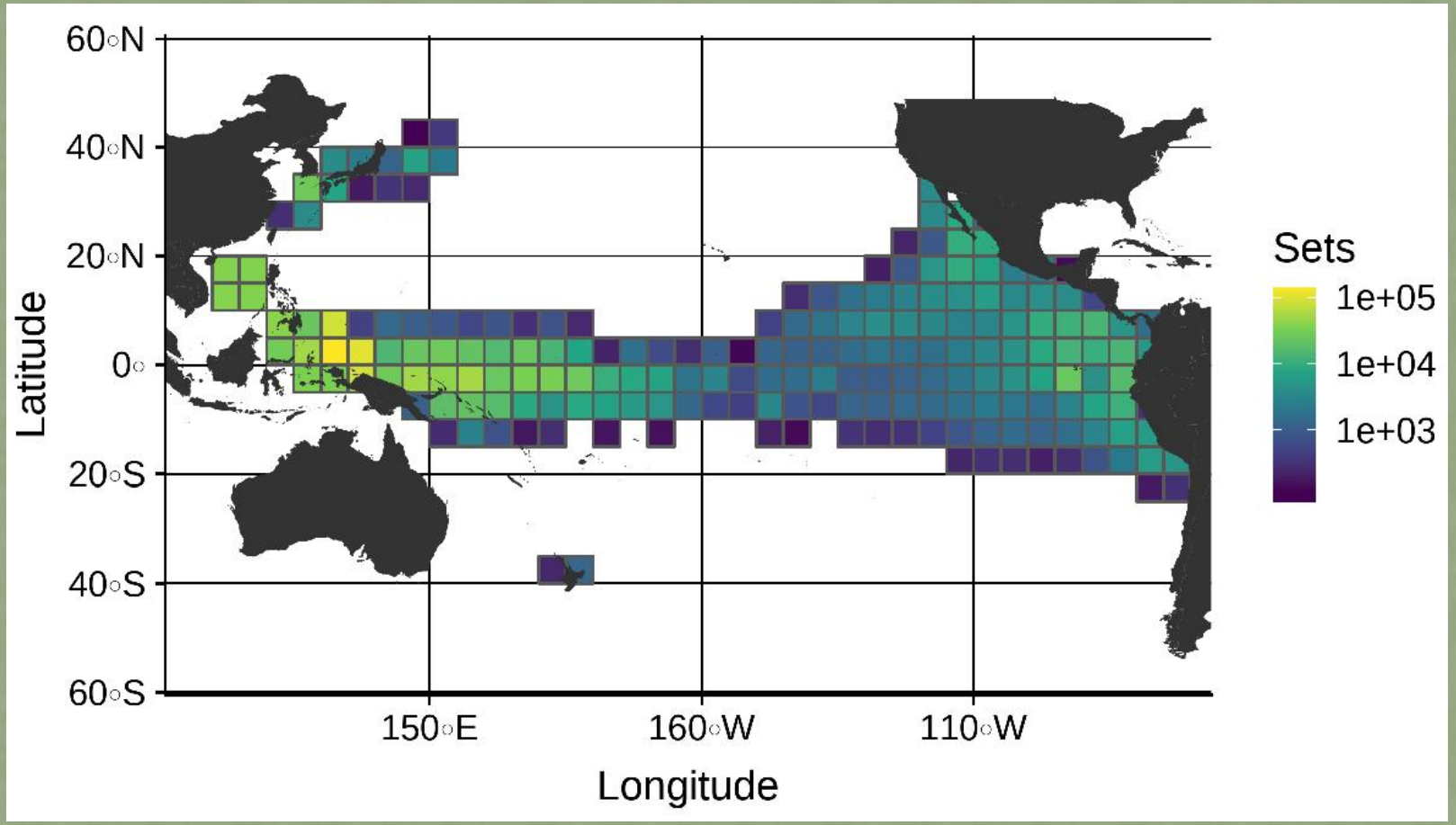


BASIC DATA SUMMARY: WCPO EFFORT

Observed effort NOT a spatially uniform subset of TOTAL effort.



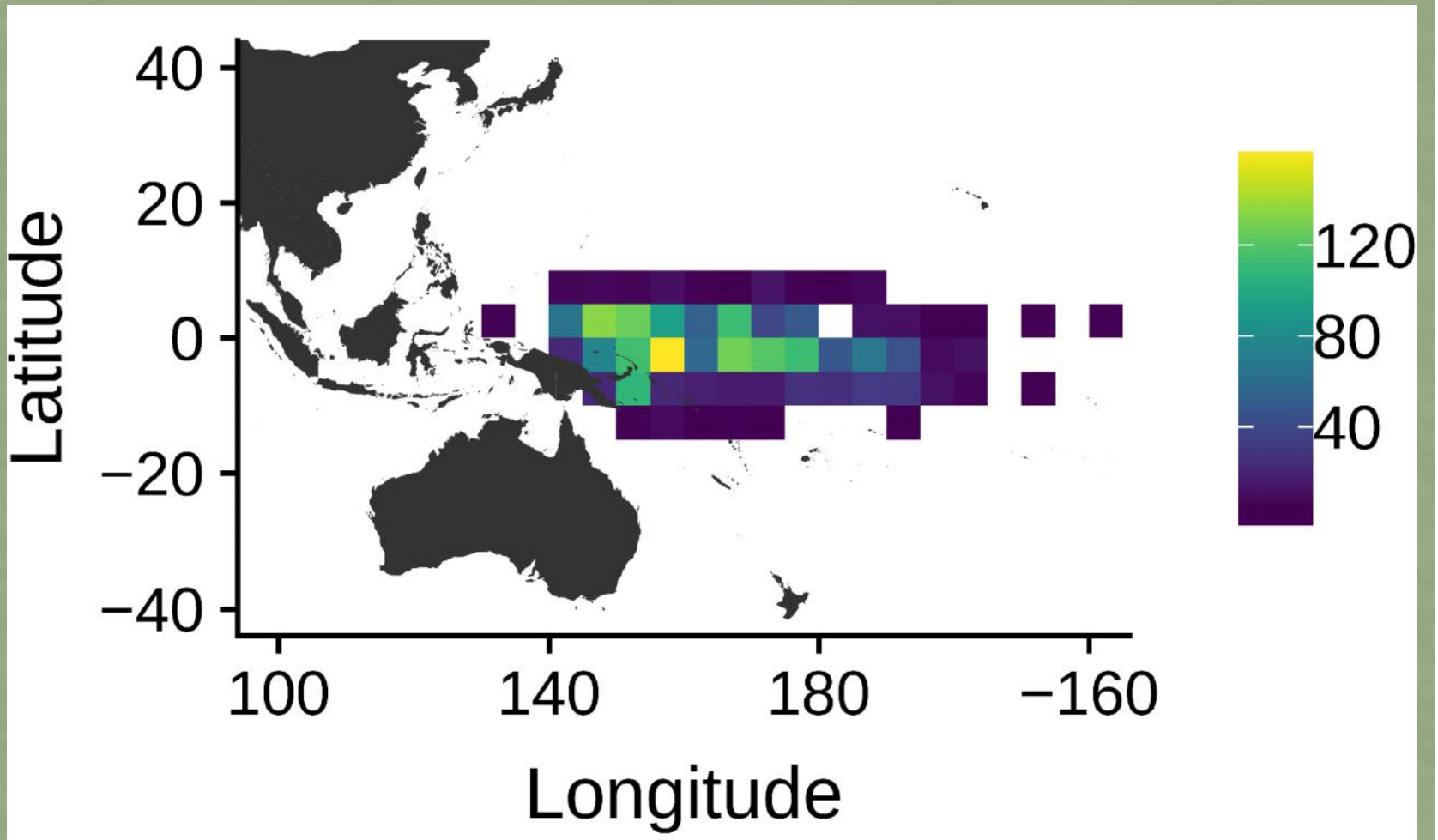
BASIC DATA SUMMARY: COMBINED EFFORT



SA

WP-12

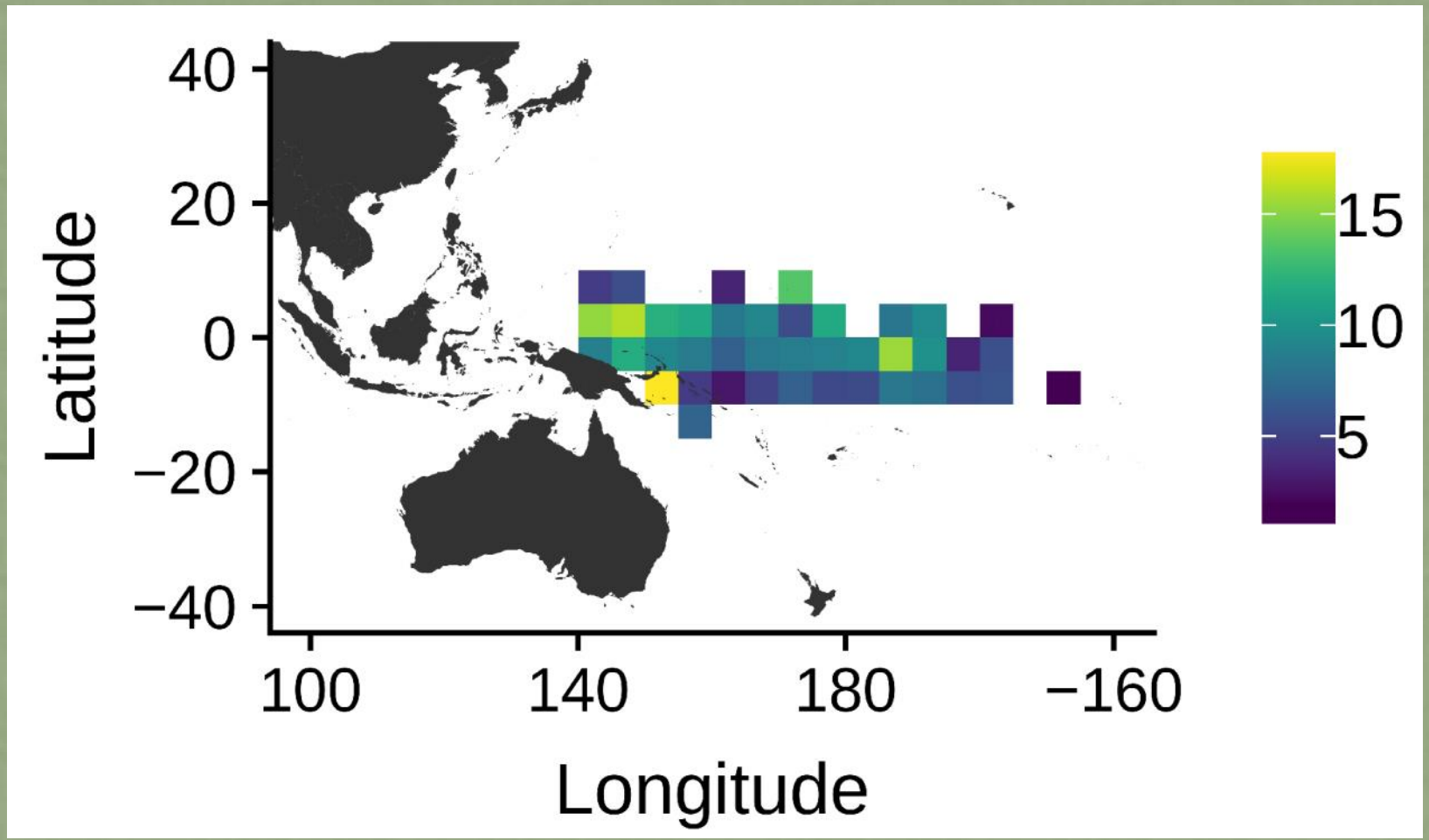
BASIC DATA SUMMARY: OBSERVED WHALE SHARK INTERACTIONS



SA

WP-12

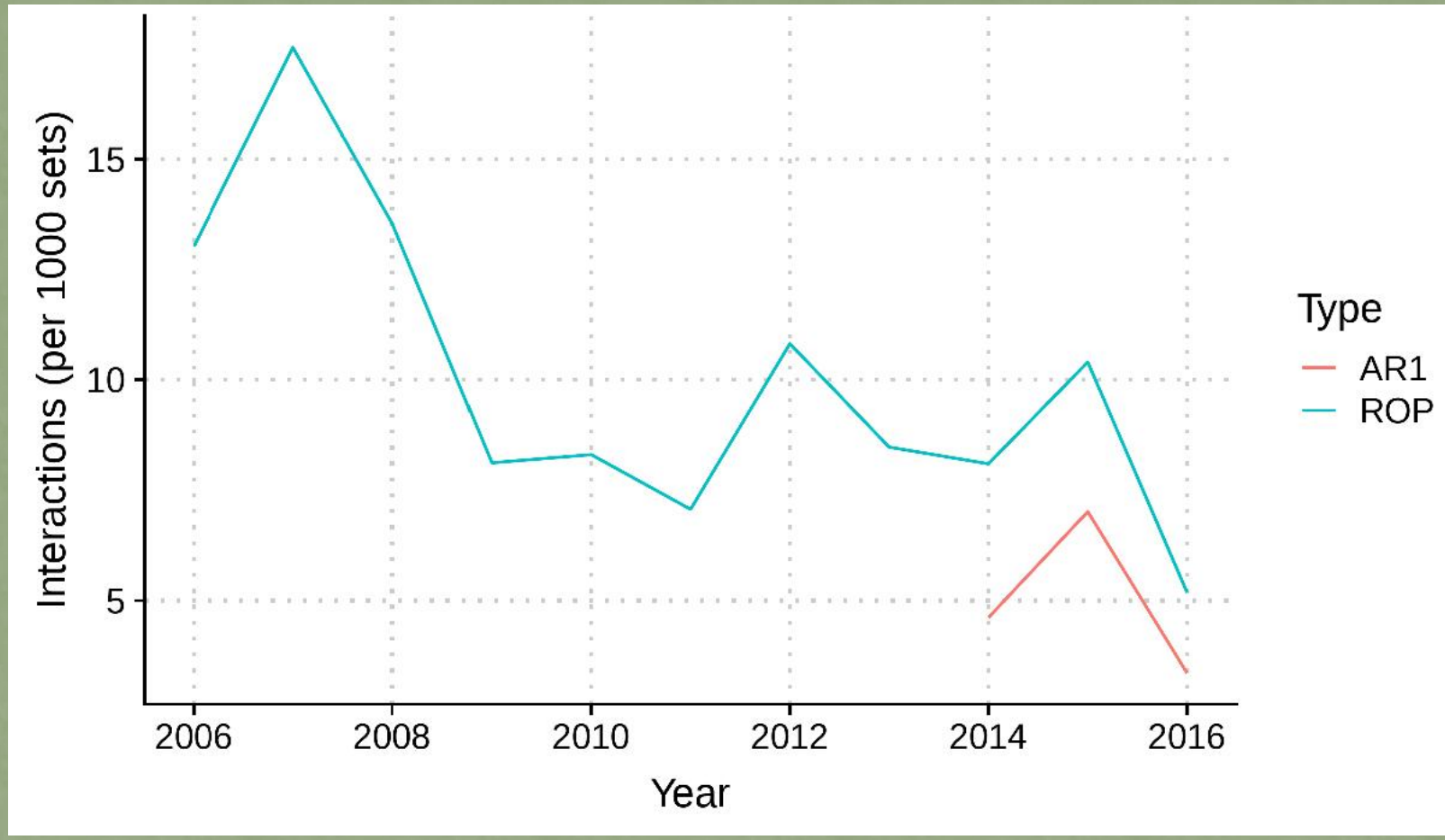
BASIC DATA SUMMARY: OBSERVED WHALE SHARK INTERACTION RATE



SA

WP-12

BASIC DATA SUMMARY: OBSERVED WHALE SHARK INTERACTION RATE



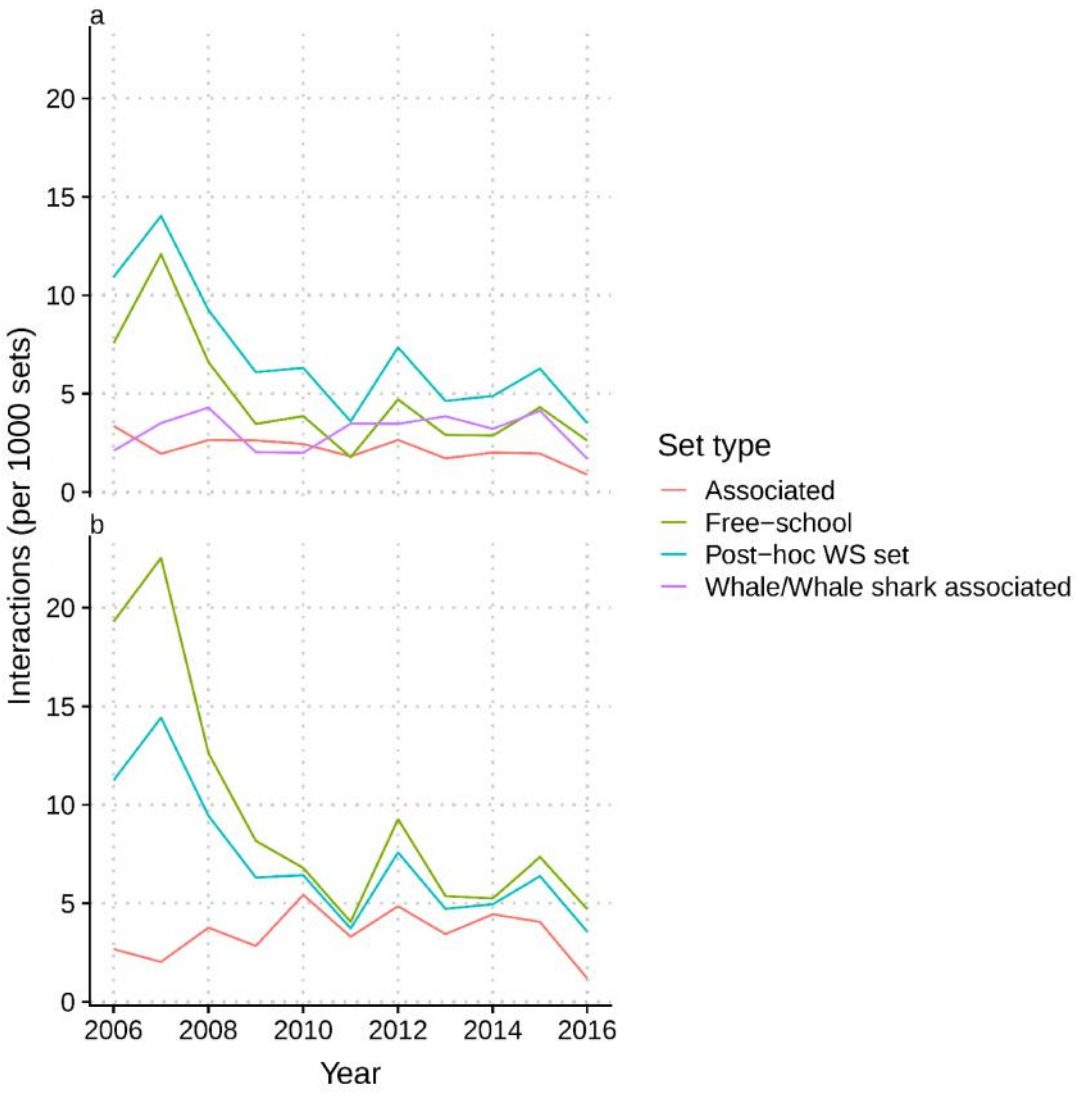
SA

WP-12

BASIC DATA SUMMARY: OBSERVED WHALE SHARK INTERACTION RATE

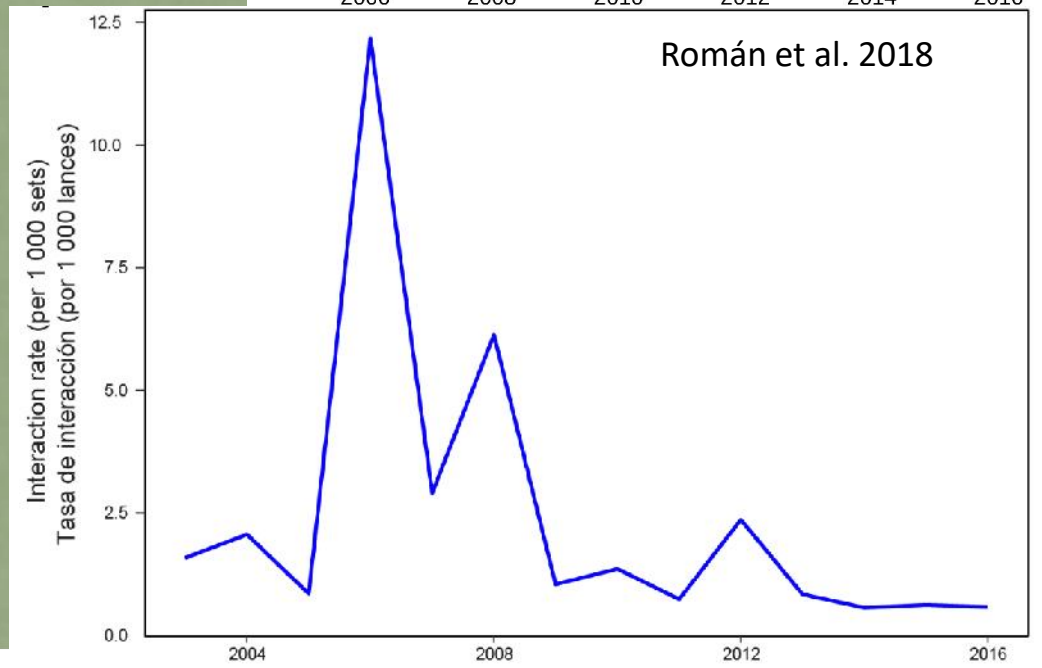
Free school sets dominate interaction rates, and drive decline in rates from 2006-2010

Similar trends among set-types after ~2010



BASIC DATA SUMMARY: OBSERVED WHALE SHARK INTERACTION RATE

Similar decline in interaction rates in the EPO, but to lower absolute levels



SA

WP-12

EXPLANATION FOR THE SIMULTANEOUS DECLINE IN RATES?

- Change in fisher behaviour?
- Change in local/global abundance?
- Temporal changes in oceanography/habitat?
  - Previous paper by Harley et al. (2013) on whale shark interactions suggested standardising interaction rates for habitat variables.
  - Published species distribution models for whale sharks from purse seine interaction data suggested SST and chl-a important in determining distribution.

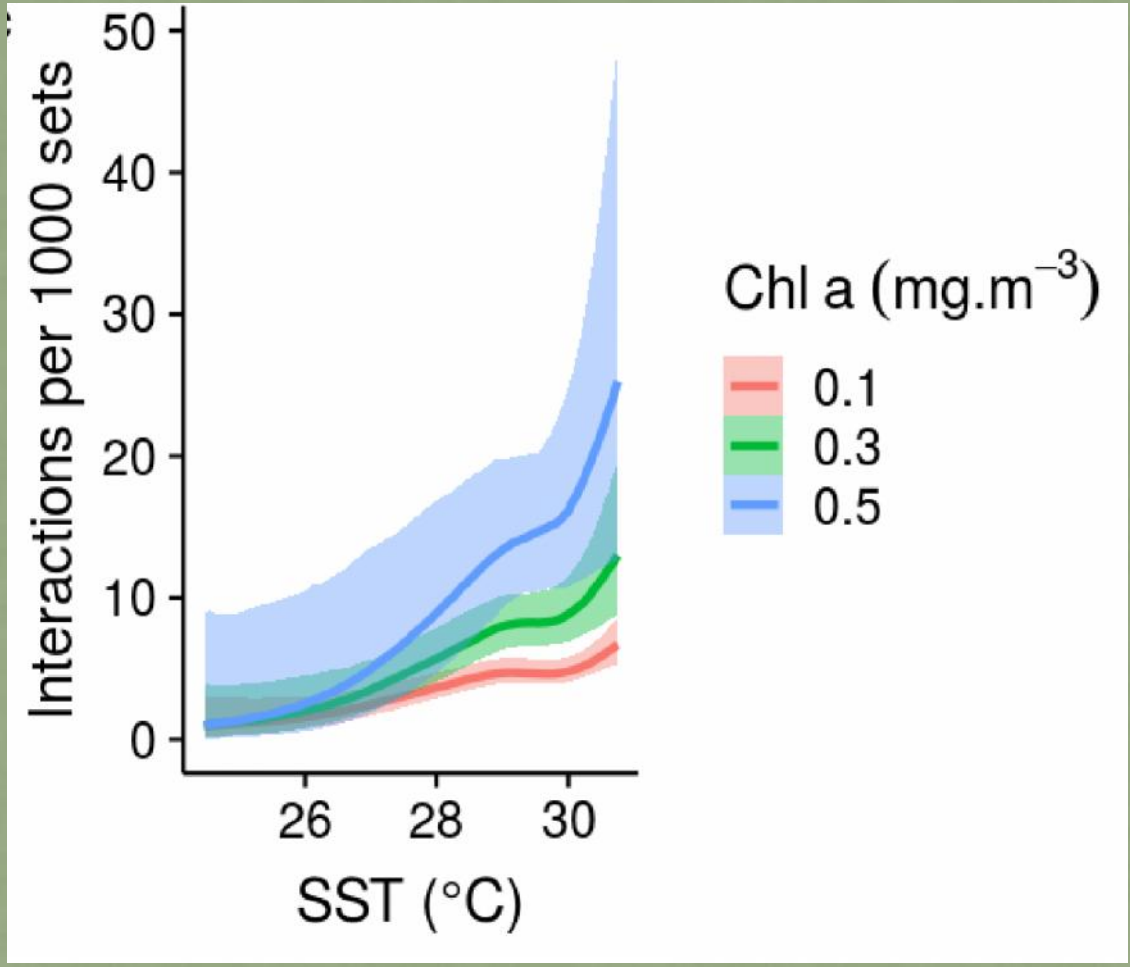
HABITAT STANDARDIZATION

- Used fine-scale monthly SST and chl-a products, as well as static variables (distance from land, depth).
- Bayesian binomial GLMM model with smooth (GAM) effect for SST, chl-a and conditional auto-regressive spatial model on 5x5 grid.
- Essentially a species distribution model (SDM).

DATASETS

1) All set types (associated & un-associated)
2) Removing whale shark and whale associated sets – potential bias against setting on whale sharks.
3) Free-school sets only – used in previous analysis (Harley 2013), but no reason to exclude all associated sets.

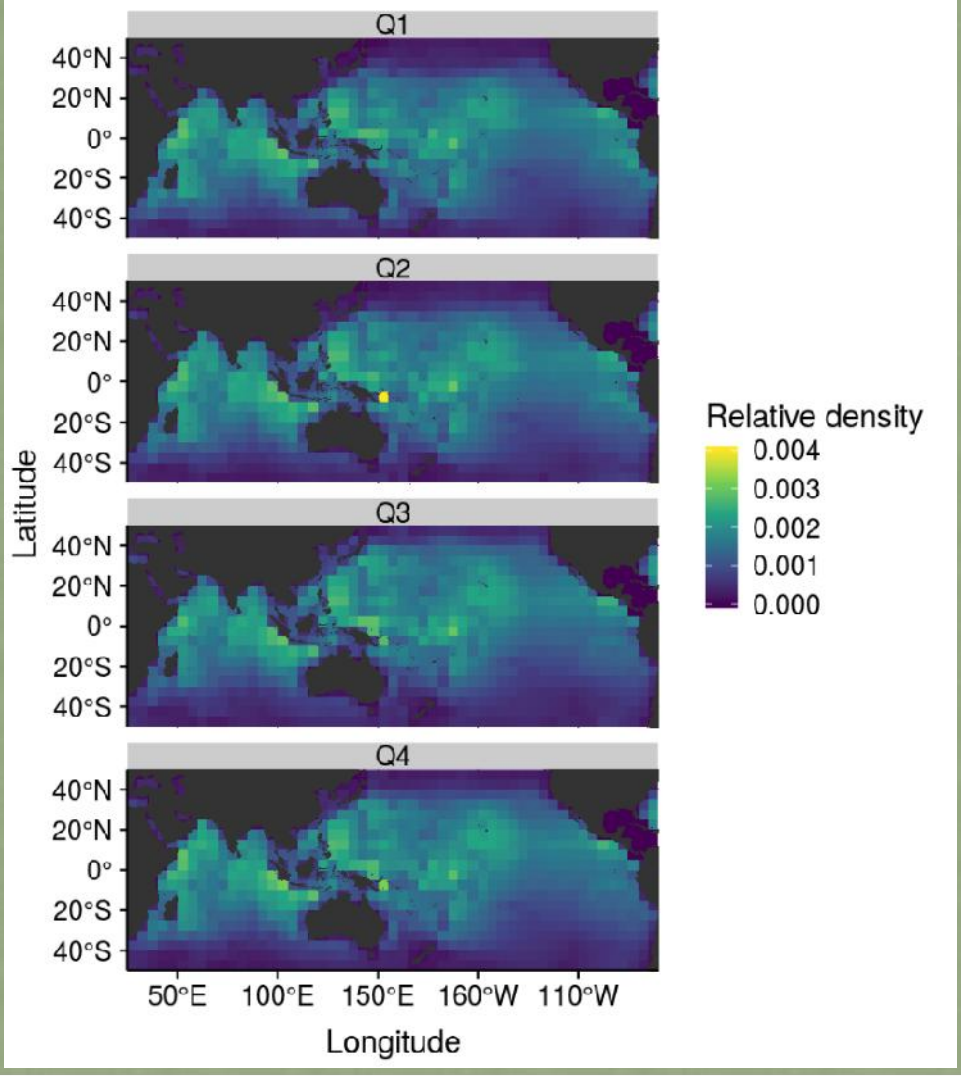
HABITAT STANDARDISATION/SDM: DATASETS 1 AND 2



SA

WP-12

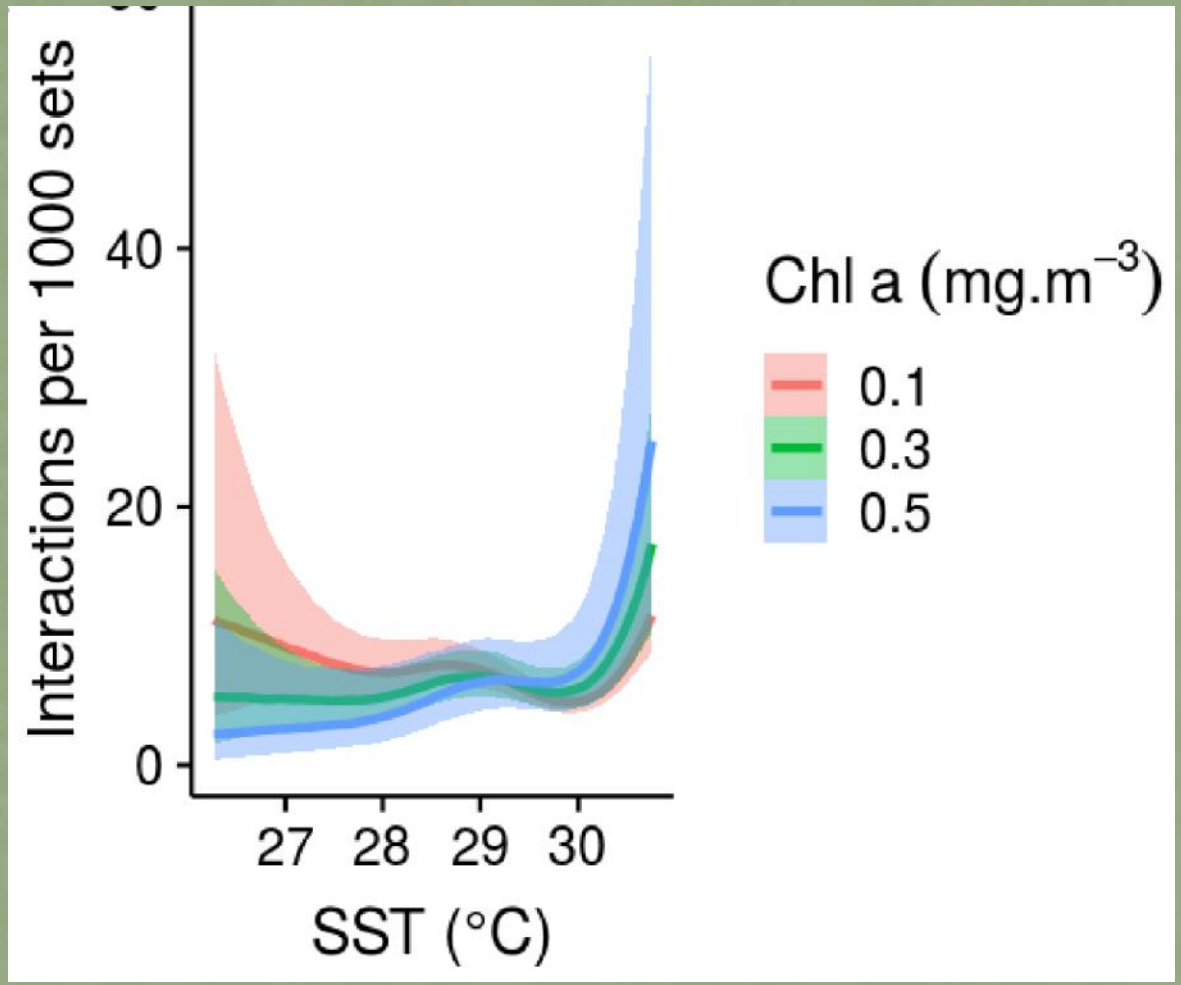
HABITAT STANDARDIZATION/SDM: DATASETS 1 AND 2



SA

WP-12

HABITAT STANDARDIZATION/SDM: DATASET 3 (FREE SCHOOL ONLY)

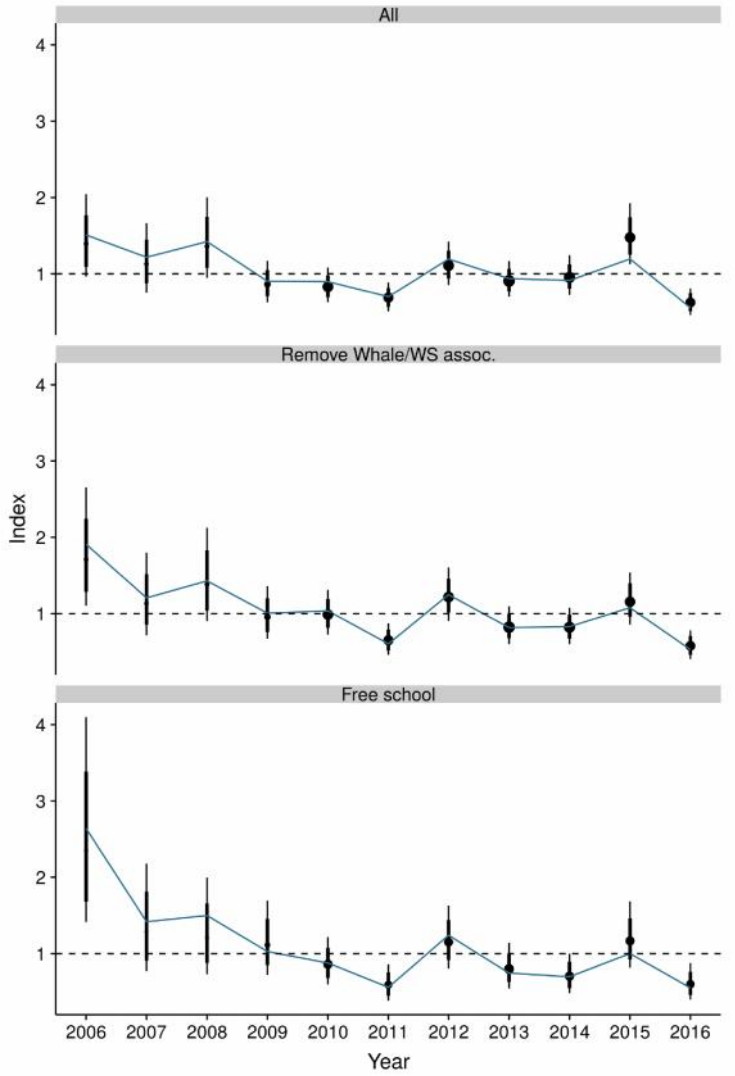


SA

WP-12

HABITAT STANDARDIZATION/SDM

Environmental factors do not adjust temporal interaction rate trajectories for any of the datasets.



SA

WP-12

ESTIMATING RISK

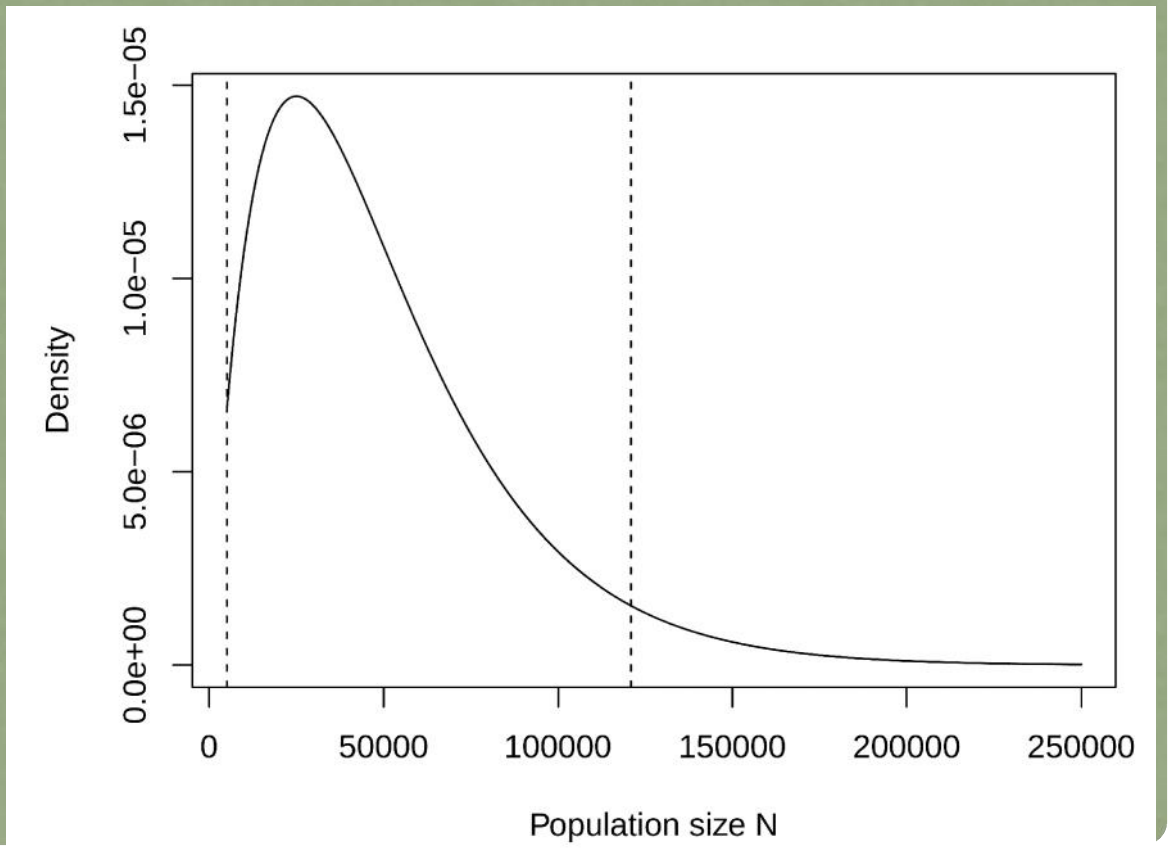
- SDM allows us to estimate risk using relative habitat suitability in space, and overlap with the Pacific purse-seine fishery.
- Need 3 more quantities:
  - population size to estimate total number of animals in area of the fishery
  - population growth rate
  - post-release mortality

ESTIMATING POPULATION SIZE

- Can be estimated from population genetic data, but only with very strong assumptions.
- Need a mutation rate – not known for whale sharks, but estimated for other shark species. Used to bound estimate.
- Assume right-skewed distribution to incorporate a precautionary approach – greater likelihood that the population is near the lower bound.

ESTIMATING POPULATION SIZE

Data from Vignaud et al 2014 on population genetics of the Indo-Pacific whale shark populations.



SA

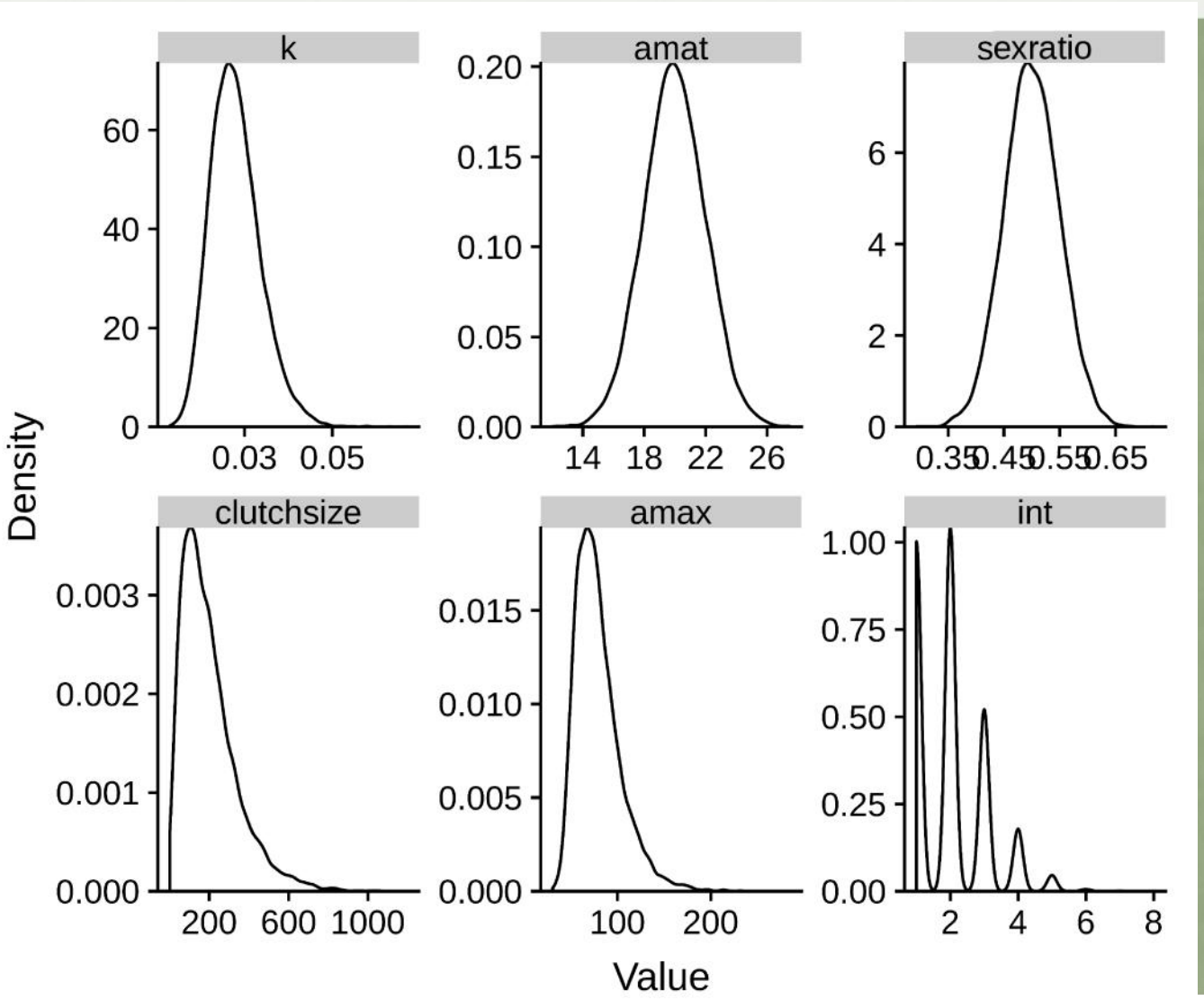
WP-12

ESTIMATING MAXIMUM REPRODUCTIVE POTENTIAL

- Difficult to estimate empirically, but can be determined theoretically from demographic parameters (Pardo et al. 2016)
- Uncertainty can be incorporated by propagating uncertainty in demographic parameters (Pardo et al. 2018)

SA
WP-12

ESTIMATING MAXIMUM REPRODUCTIVE POTENTIAL

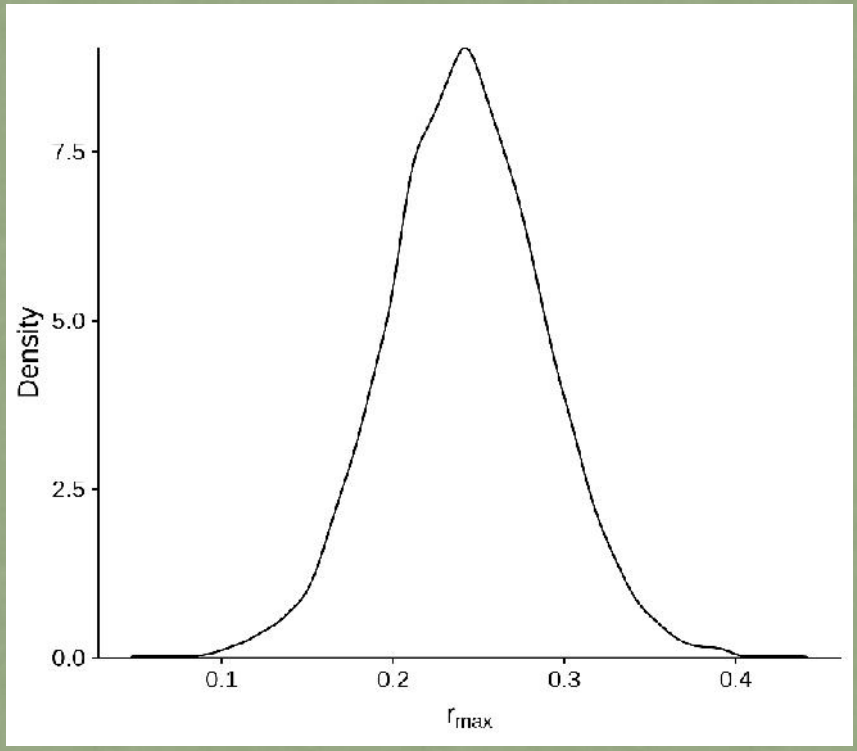


SA

WP-12

ESTIMATING MAXIMUM REPRODUCTIVE POTENTIAL

Predicted r_{max} is high for whale sharks due to large litter size and longevity (low predicted M).



SA
WP-12

ESTIMATING POST RELEASE SURVIVAL

- On-board fate is recorded, but post-release mortality (PRM) highly uncertain.
- One tagging study shows 100% survival, but low sample size and best-practice handling.
- PRM probably depends strongly on release practice.
- Online Delphi survey to obtain a quantitative estimate of PRM.

SA
WP-12

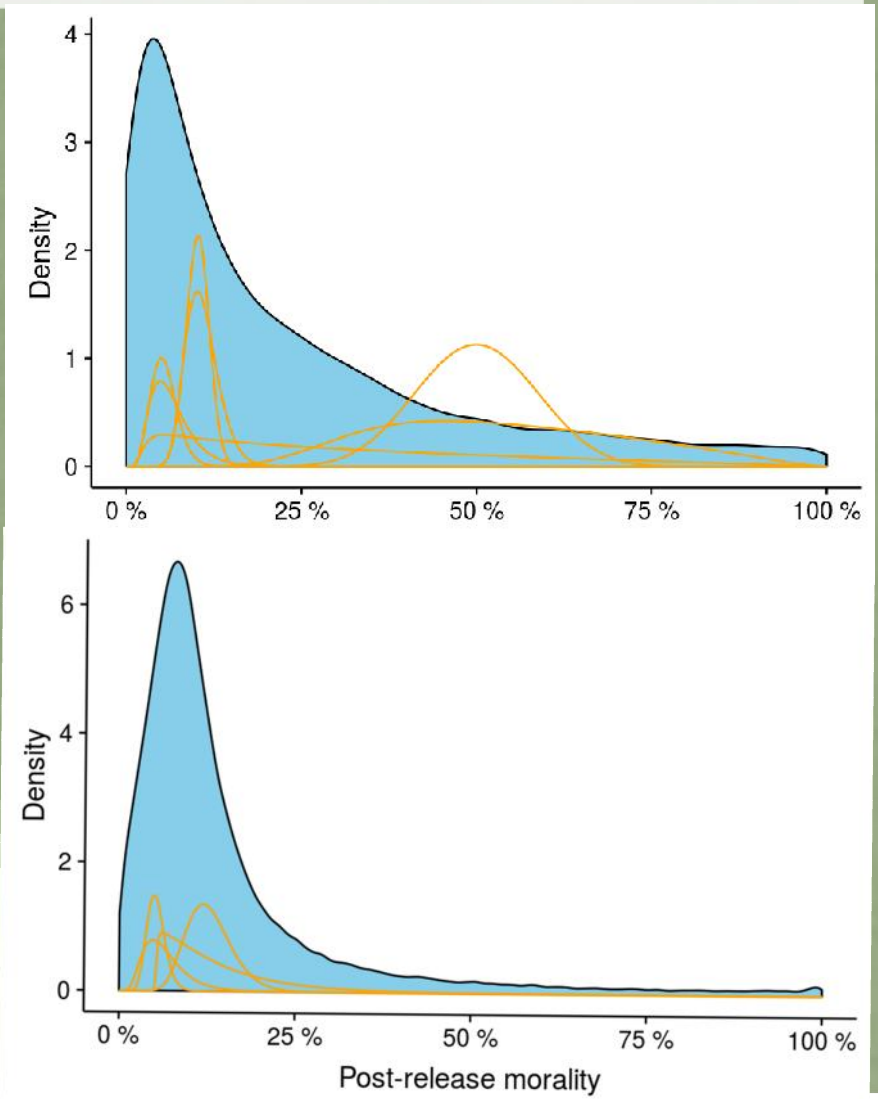
DELPHI SURVEY

- Two stage design to obtain a consensus distribution.
- Respondents can amend answers in round two based on all round one answers.
- Formal statistical model to derive consensus distribution.
- Trialed at ABNJ/WCPFC bycatch mitigation workshop. Final survey sent to experts identified with help of ISSF.

SA
WP-12

ESTIMATING POST RELEASE SURVIVAL

- First round answers show high uncertainty due to both high and low estimates.
- Estimates revised down in round two, still high uncertainty.



SA

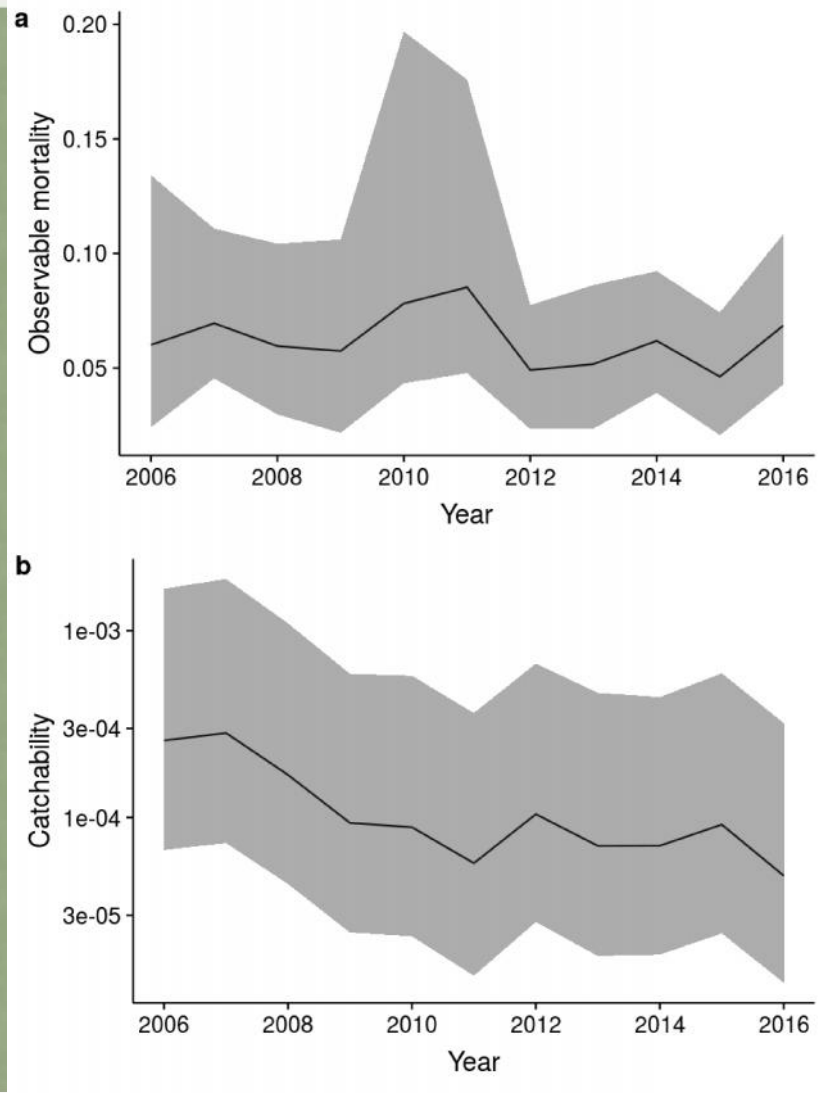
WP-12

NOTIONAL REFERENCE POINTS

- The risk assessment compares estimated mortalities from predicted interactions with a reference point – the risk ratio.
- Reference points depend on management objective – e.g.,
  - Avoid extinction – $F_{crash} = r_{max}$
  - Relative to MSY – $F_{msm} = 0.5\ r_{max}$
  - Other – e.g., F_{lim} – $F_{lim} = 0.75\ r_{max}$
- No agreed risk reference point for WCPFC

ESTIMATING RISK

- Estimated total mortalities are observable mortality plus Delphi estimate of PRM.
- Catchability estimated via ratio of observed interactions relative to predicted abundance in space.

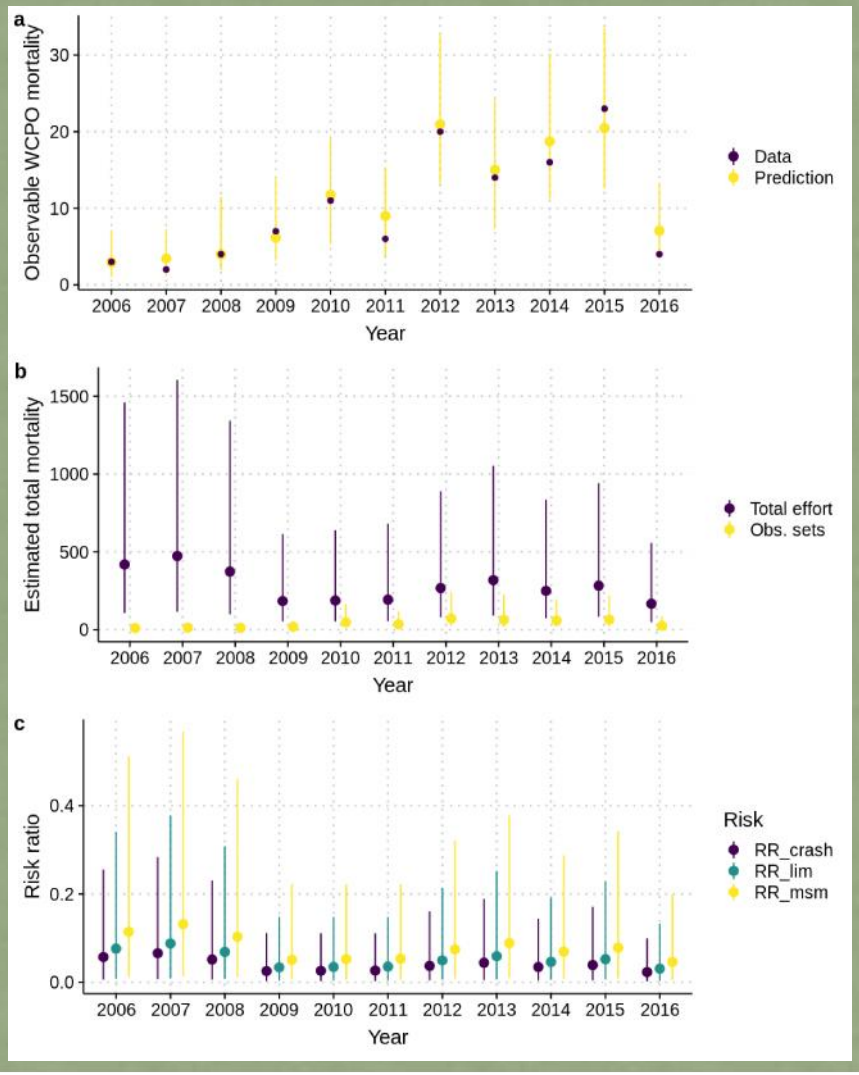


SA

WP-12

RESULTS

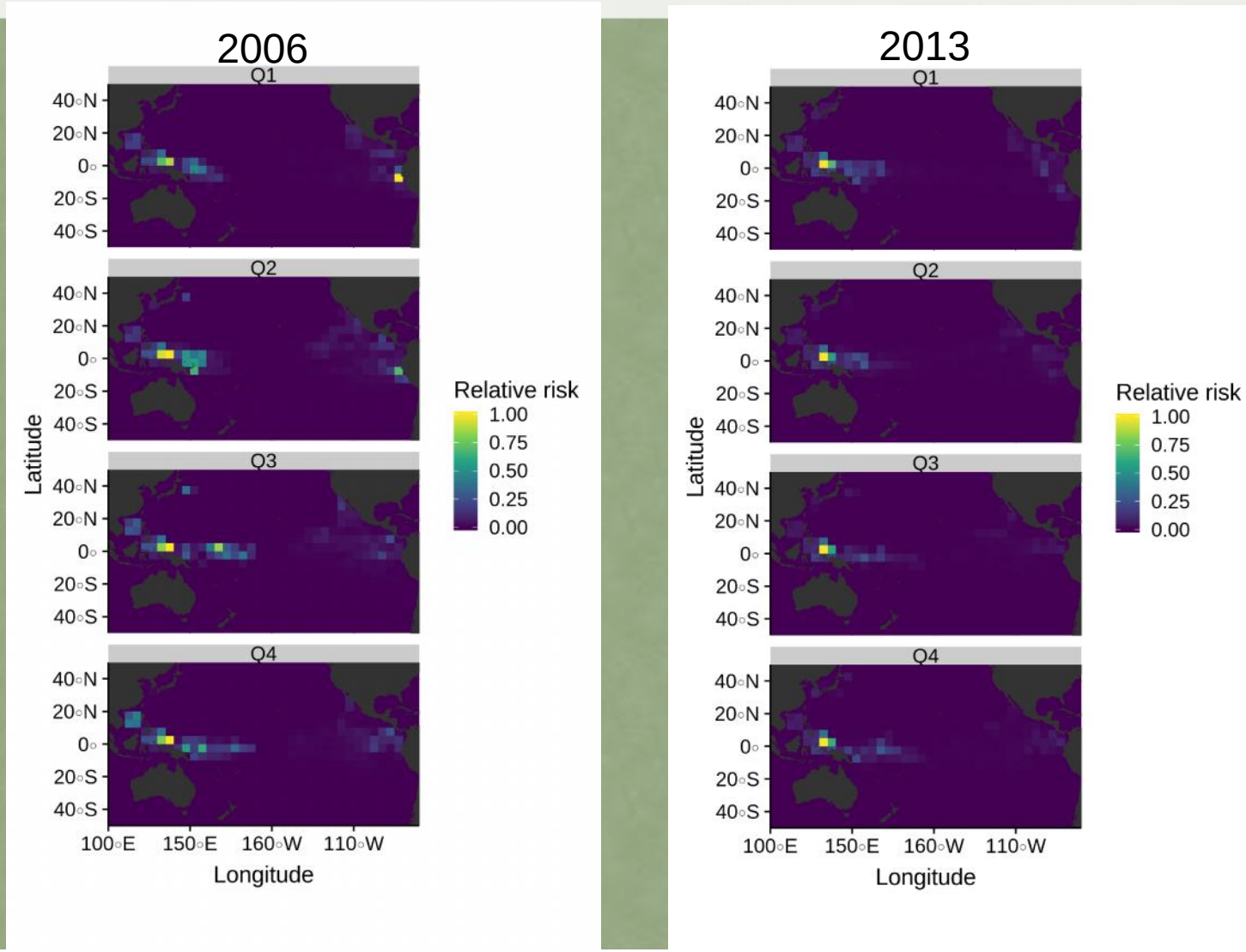
- Model can reproduce observable mortality
- Mortality estimates are scaled up to total effort (WCPFC & IATTC), and combined with post-release mortality
- Risk ratio for all three limit reference points suggests risk from Pacific purse seine alone is low to moderate



SA

WP-12

RESULTS



SA

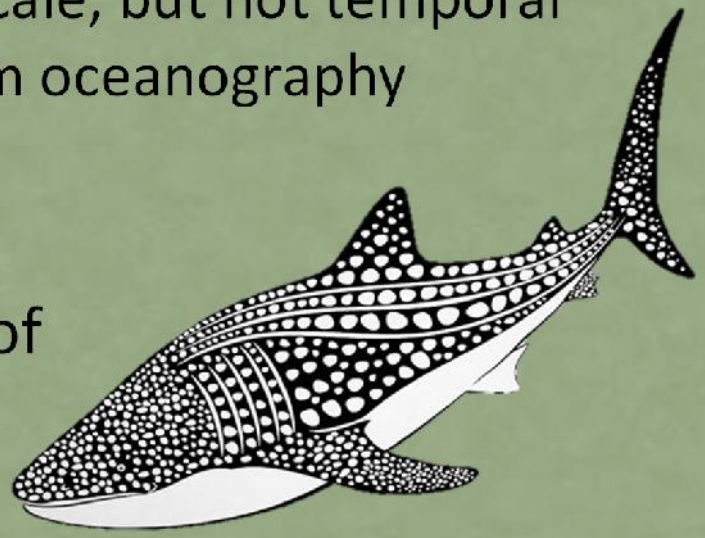
WP-12

CAVEATS

- High uncertainty about PRM drives uncertainty in risk
- Uncertainty about total effort not quantified
- Impacts calculated for vulnerable Pacific population segments only – total risk from all factors may be >1.
- Only tentative data on population size, no way to estimate trend over the whole Indo-Pacific population. Temporal trends assumed to reflect changes in q, but may well be changes in N.

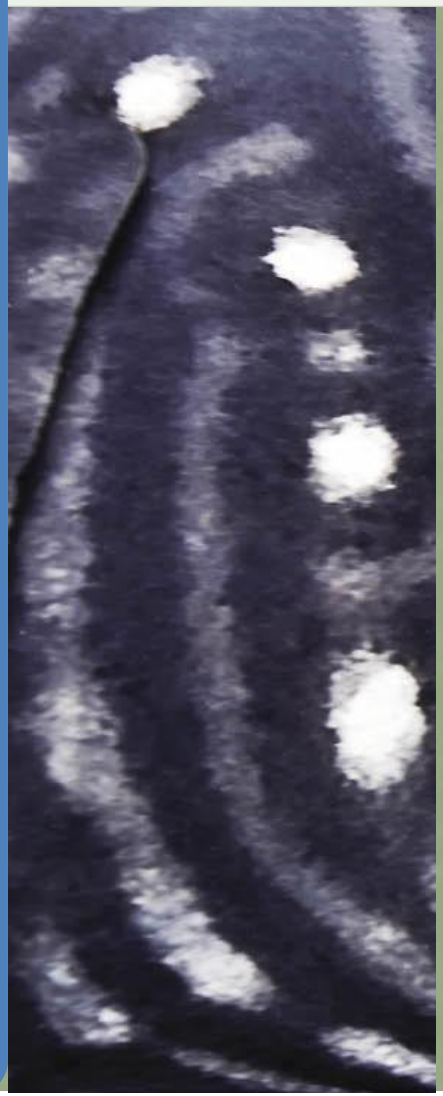
SUMMARY

- Trends in annual interaction rates
  - decreased as of 2009
  - may not be related to management
  - may relate to basin-wide environmental conditions, movements, changes in N...
- Can predict habitat at a broad scale, but not temporal changes in interaction rates from oceanography
- Risk from Pacific purse-seine fishery alone is moderate-to-low (generally less than 20% of the most conservative reference point)



SA
WP-12

SC14 CONSIDERATIONS



1. Accept the whale shark risk assessment results?

2. Conclude that median risk levels from Pacific purse-seine alone are moderate-to-low (~ <20% of notional LRPs)?

3. Promote best practice safe release?

4. Quantify post-release mortality?

SA
WP-12

ACKNOWLEDGEMENTS

- Peter Williams and team (SPC)
- Marlon Román, Alex DaSilva, Nick Vogel (IATTC)
- Sebastian Pardo (Dalhousie University)