Comparisons of ecological risk assessment and stock assessment

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Introduction: ERAEF

Hierarchical approach:

- Level 1 – qualitative risk assessment (SICA)

- Level 2 – semi-quantitative: PSA (Productivity, susceptibility analysis).
- Level 2.5 – SAFE (Sustainability assessment for fishing effect), quantitative.
- Level 3 – full quantitative: stock assessment.

Objectives

- A brief comparison of PSA and SAFE methodology by examining their basic assumptions, input data, and risk computation.
- Comparing the performance of PSA and SAFE using real fisheries data.
- Comparing PSA and SAFE with classic stock assessments for target species.
- Comparing PSA and SAFE with stock status determination in the Fishery Status Report for target species.

Data sources

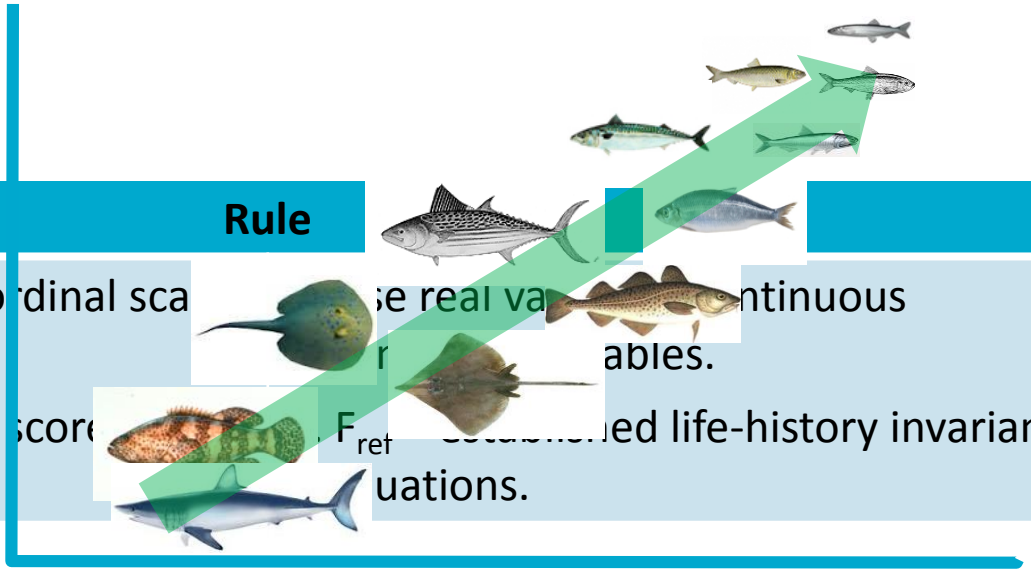
- PSA and SAFE for Australian Commonwealth fisheries conducted in the past several years.
- Full quantitative stock assessment on target species in the Southern and Eastern Scalefish and Shark Fishery (SESSF).
- Fisheries Status Report (FSR) on target species in multiple Australian fisheries.

PSA and SAFE: Key assumptions

PSA	SAFE
1. Risk is measured by **productivity** and **susceptibility**. 2. Productivity relates to **life history traits**. 3. Fish randomly or homogeneously distribute over their distribution range.	1. Risk is measured by **reference points** and **fishing mortality**. 2. Reference points relate to **life history traits**. 3. Same as PSA.

PSA and SAFE:

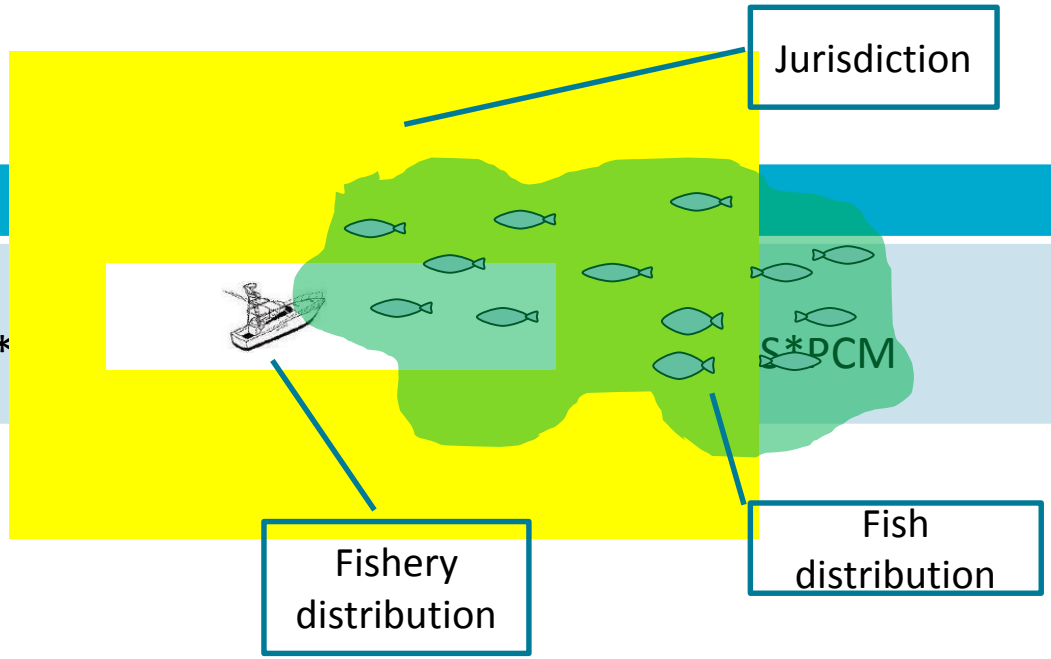
Productivity score	Reference point
1. Maximum size	1. Maximum size (or asymptotic size)
2. Age at maturity	2. Age at maturity
3. Maximum age	3. Maximum age
4. Fecundity	**4. Natural mortality**
5. Size at maturity	**5. Intrinsic population increase**
6. Reproductive strategy	**6. Growth rate**
7. Trophic level	



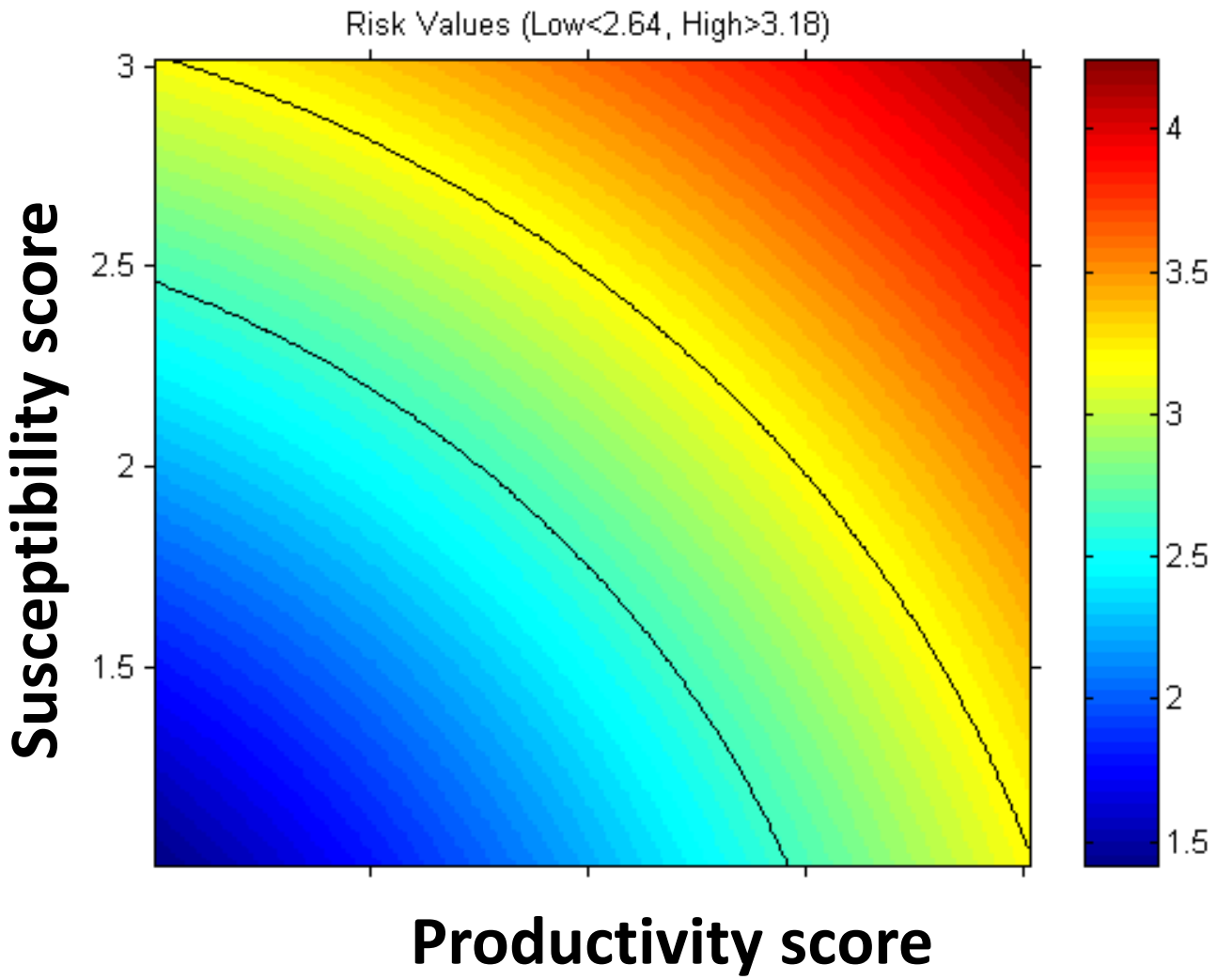
Rule
1. Downgrade real values to o dinal sca se real va ntinuous of 1, 2, 3. r ables.
2. P score = average attribute score F_{ref} ed life-history invariant uations.

PSA and SAFE:

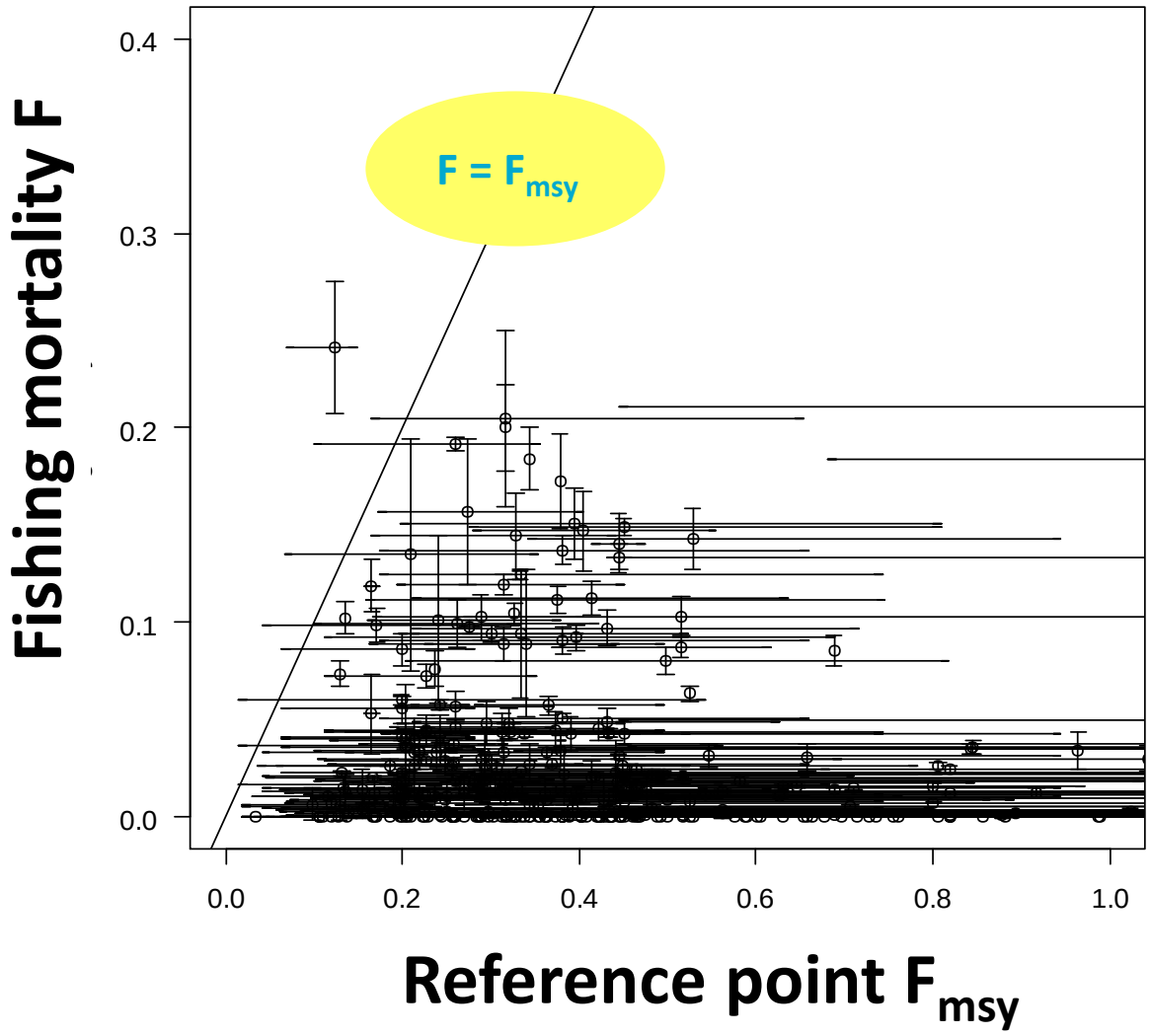
Susceptibility score	Fishing mortality
1. Availability: high, medium, low.	1. Availability: **actual fished area** over fish distribution range
2. Encountability	2. Encountability
3. Selectivity	3. Selectivity
4. Post-Capture Mortality	4. Post-Capture Mortality
1. Downgrade to 1, 2, 3.	
2. S score = multiply A*E*	S*PCM



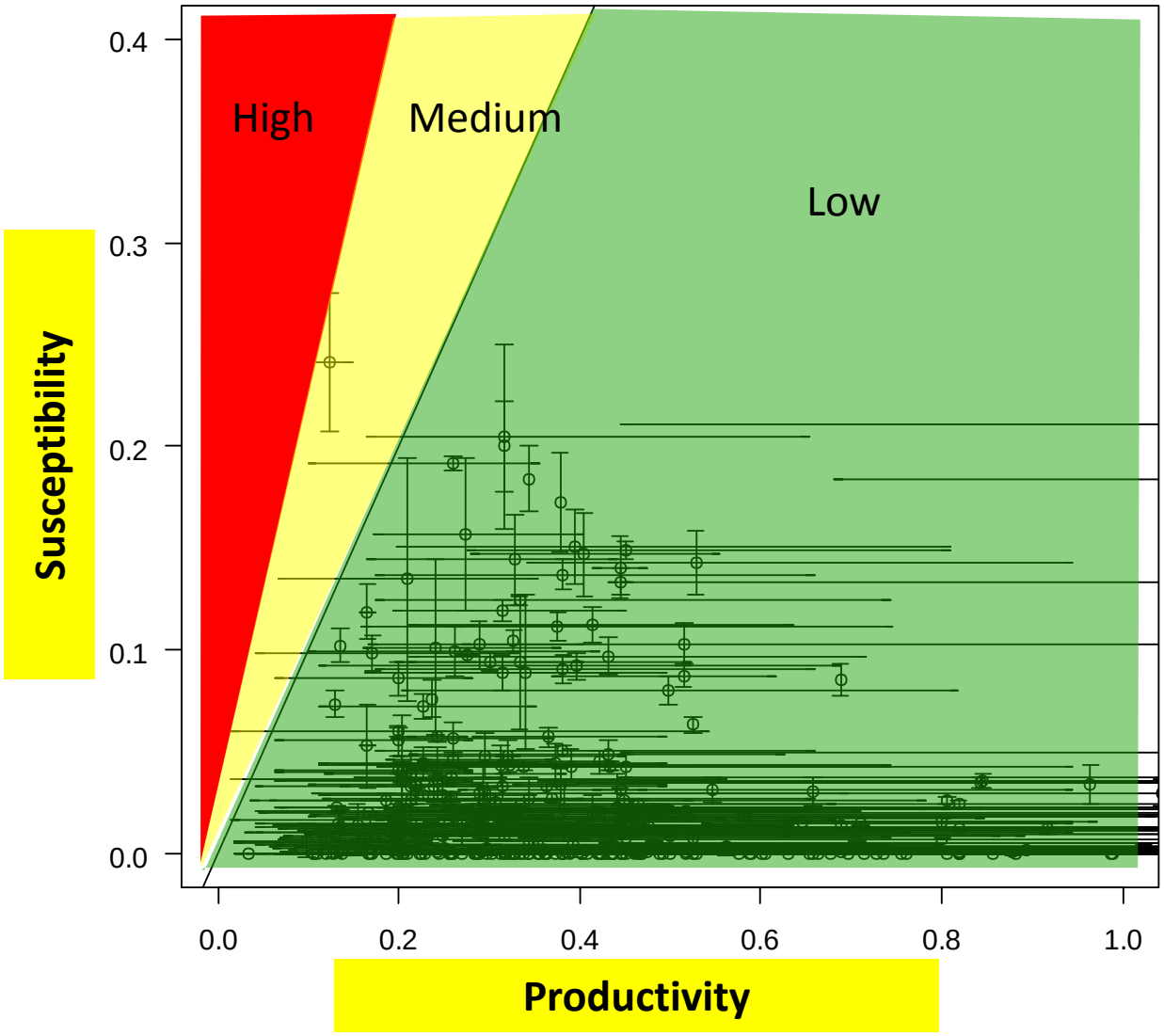
PSA


Risk Values (Low<2.64, High>3.18)
Susceptibility score
3
2.5
2
1.5
Productivity score
4
3.5
3
2.5
2
1.5

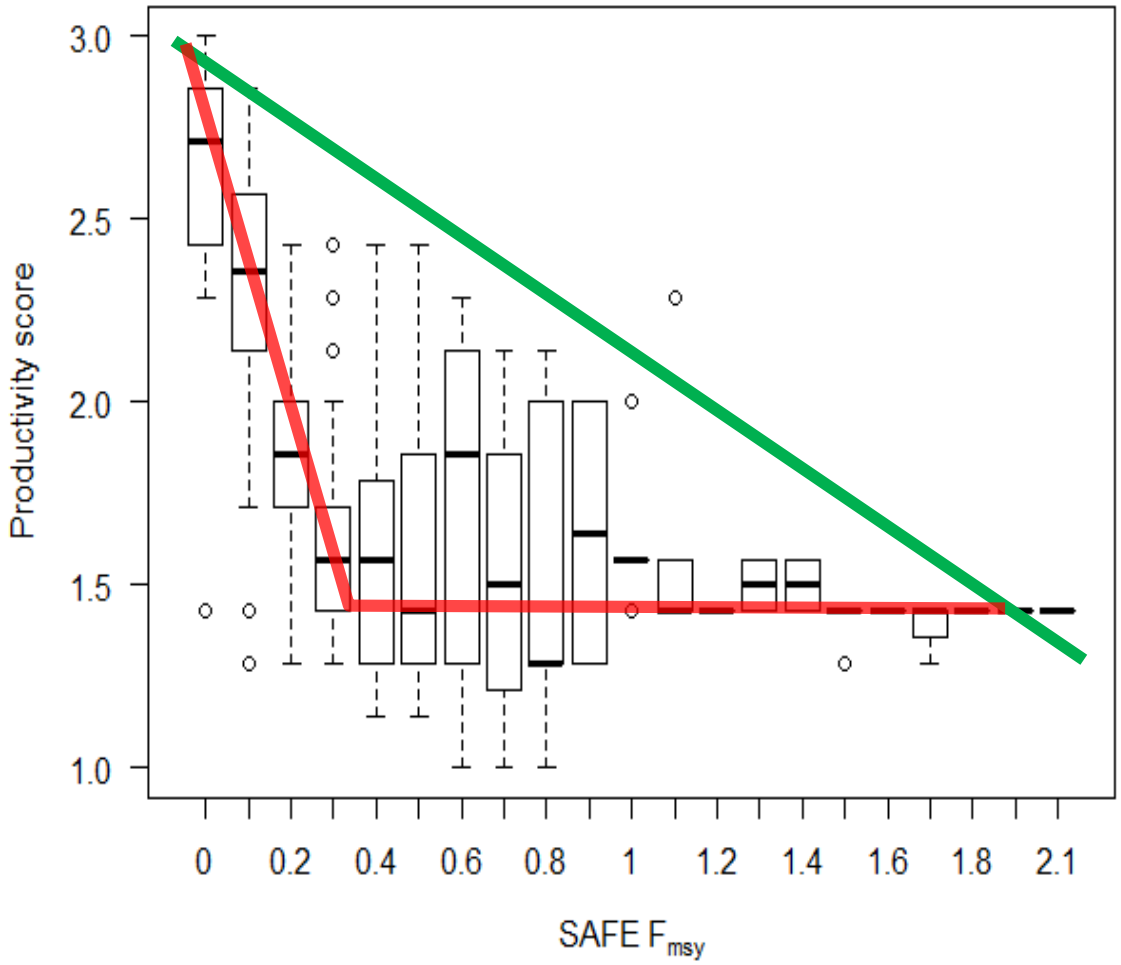
SAFE


F = F msy
Fishing mortality F
0.0
0.1
0.2
0.3
0.4
0.0
0.2
0.4
0.6
0.8
1.0
Reference point F msy

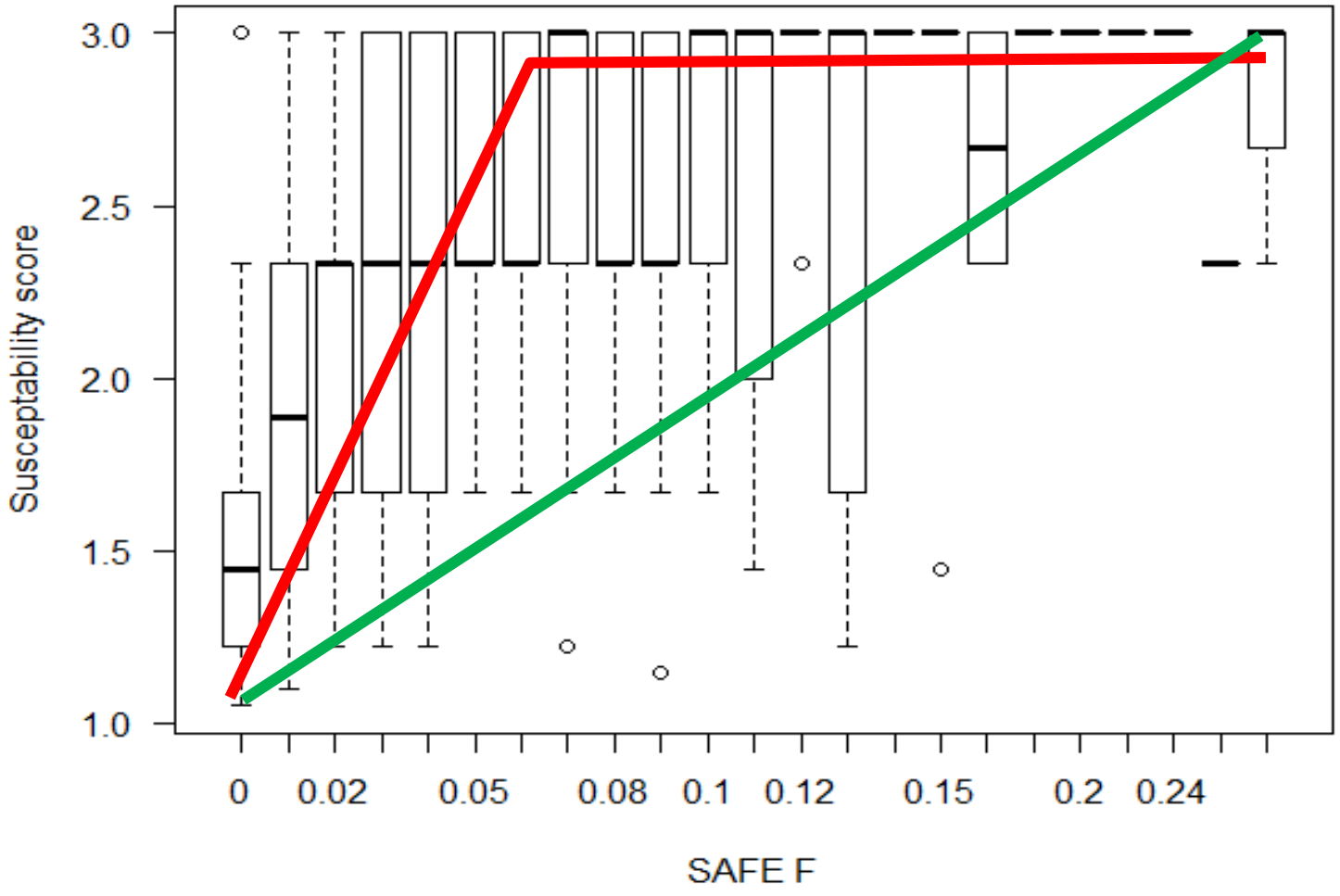
SAFE with PSA



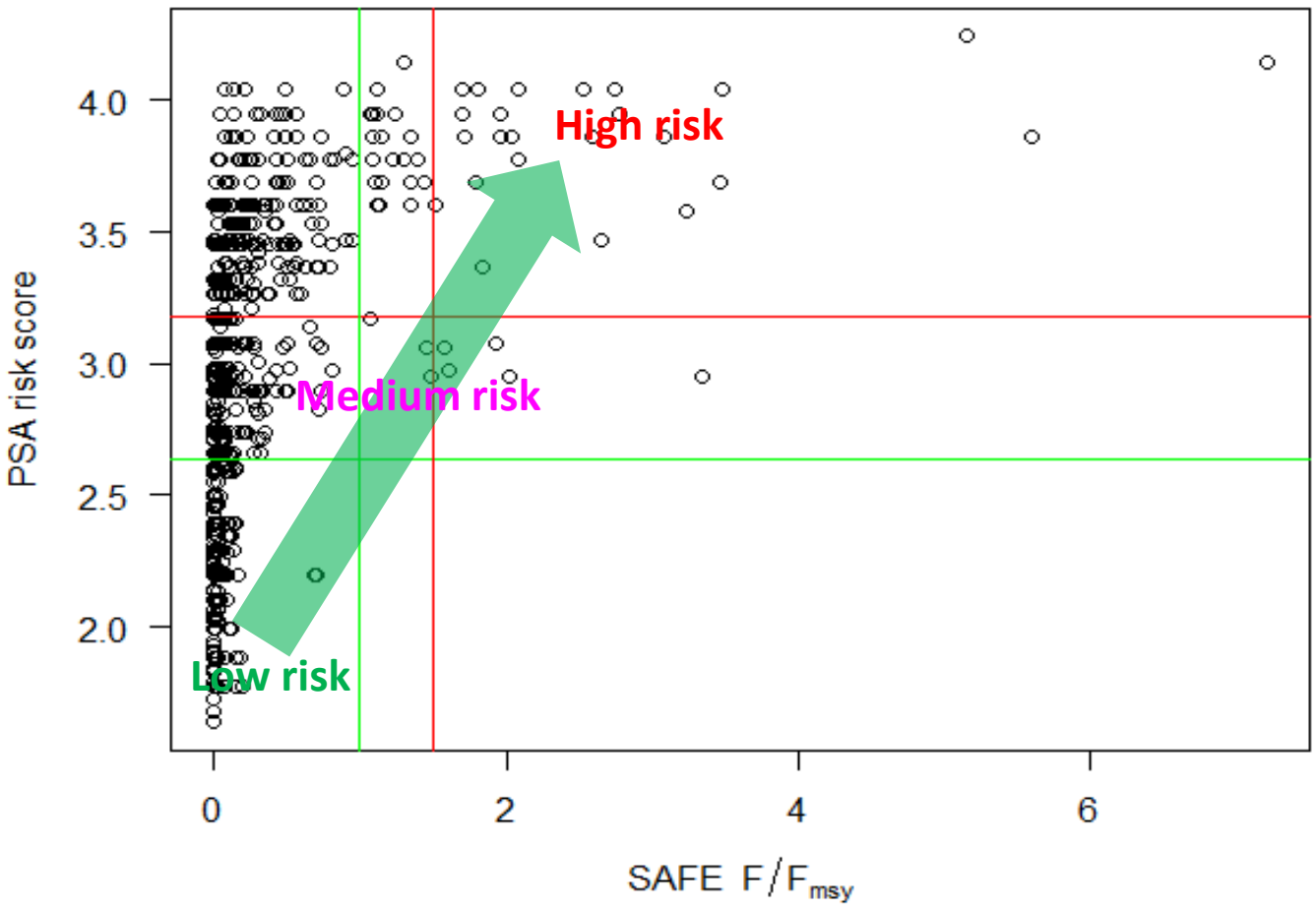
Compare PSA and SAFE using real fishery data (1)



Compare PSA and SAFE using real fishery data (2)

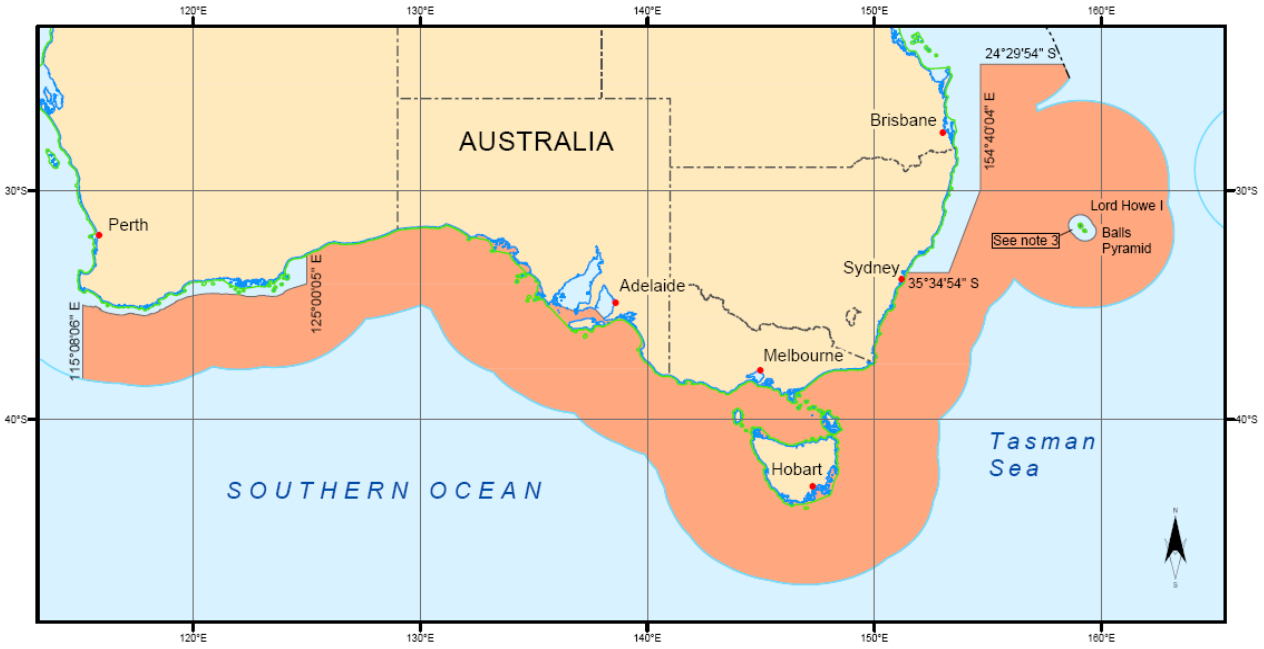


Compare PSA and SAFE using real fishery data (3)

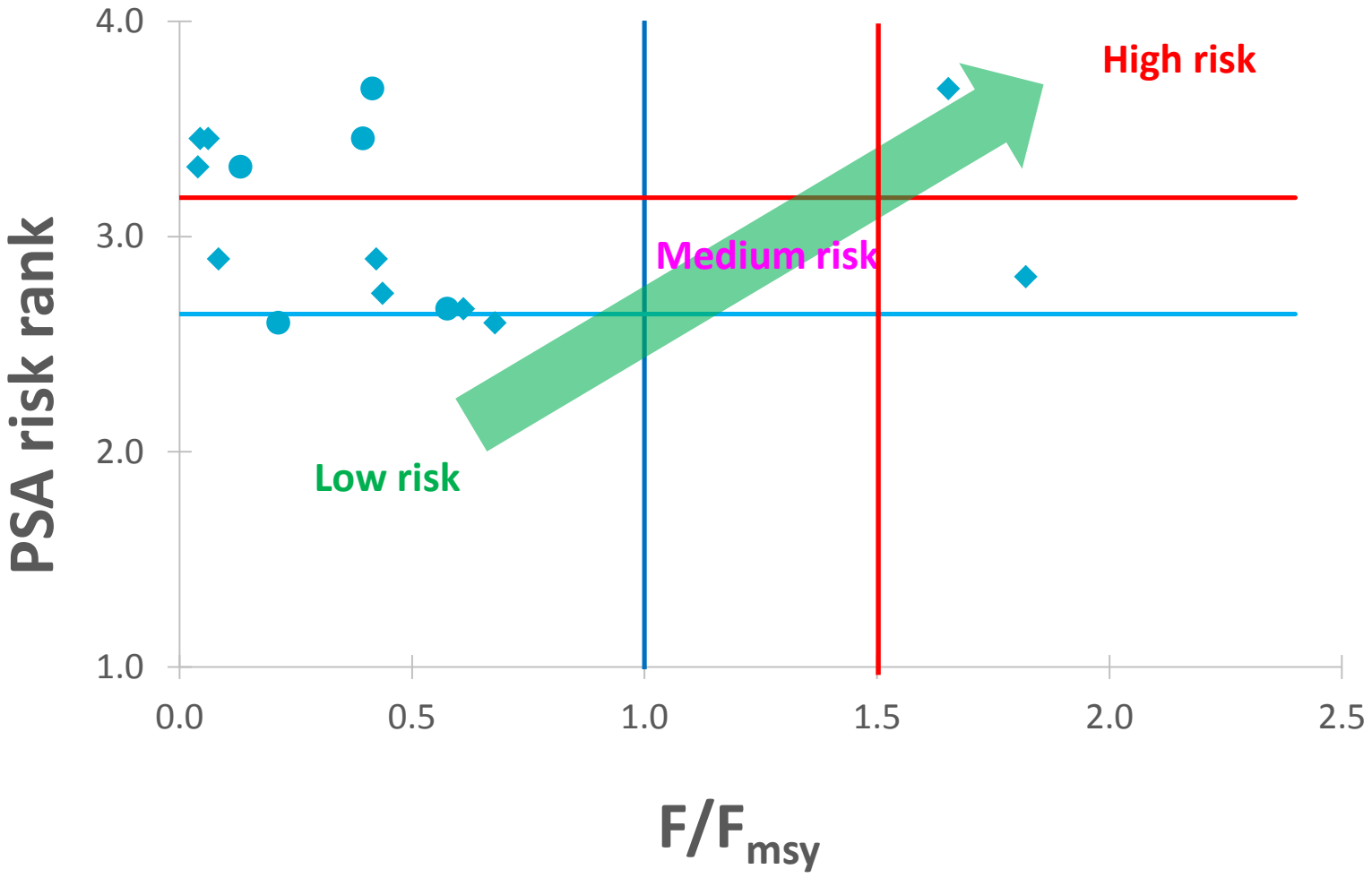


Stock assessment

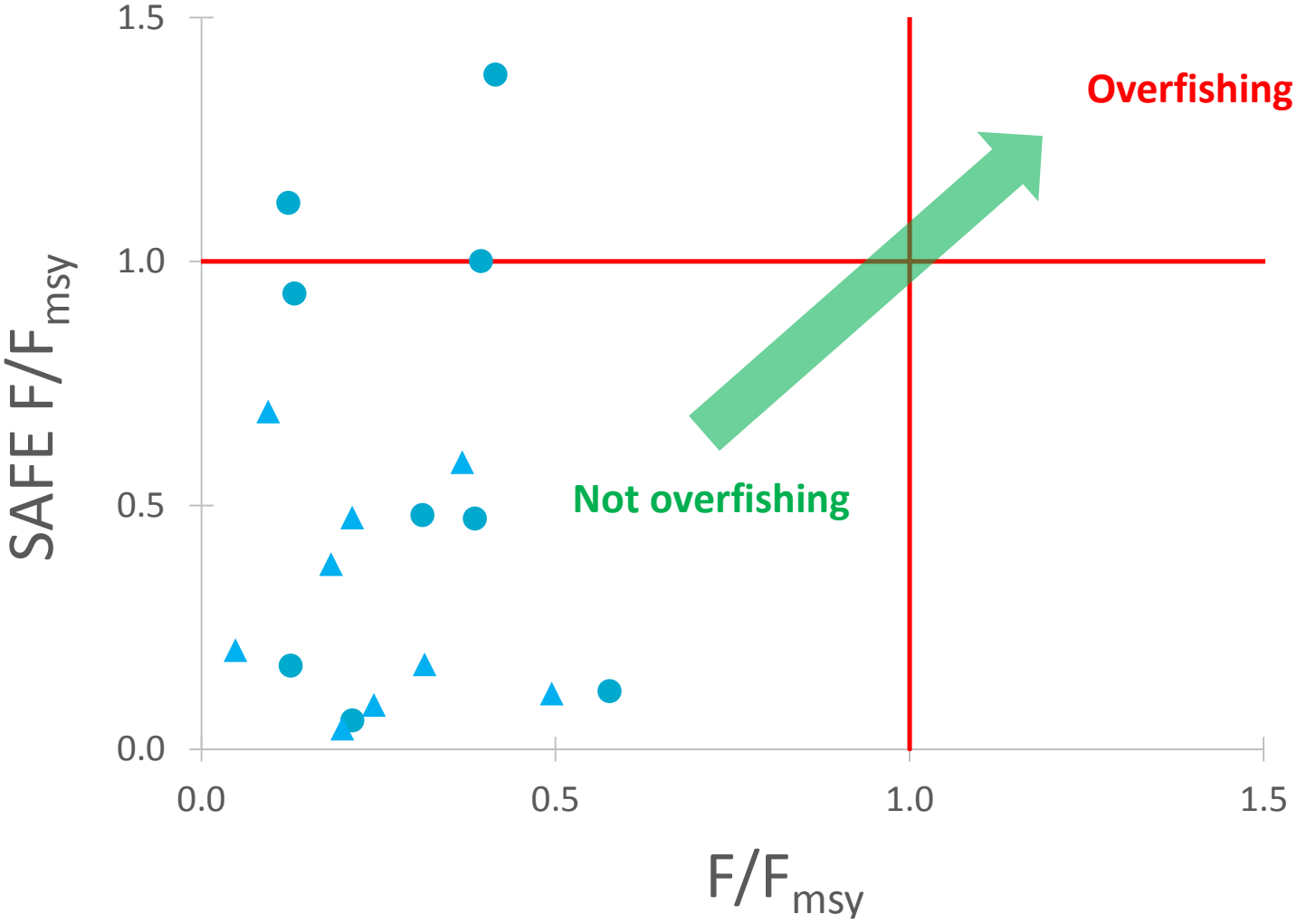
- Target commercial species in the Southern and Eastern Scalefish and Shark Fishery (SESSF).
- Age-structured Stock Synthesis assessment and yield-per-recruit analysis.



PSA risk rank and stock assessment



Compare SAFE overall risk vs stock assessment



PSA and SAFE vs stock assessments

	False **positive** error rate	False **negative** error rate
PSA: Medium or High risk = overfishing	**89%**	**0**
PSA: High risk = overfishing	**50%**	**0**
SAFE	**11%**	**0**

Compare PSA and SAFE with FSR

	False **positive** error rate	False **negative** error rate
PSA: Medium or High risk = overfishing	**50%**	**0%**
PSA: High risk = overfishing	**27%**	**0%**
SAFE	**3%**	**3%**

Conclusions

- PSA and SAFE use very similar data.
- By using actual data and existing equations, SAFE is less subjective.
- PSA is more conservative, resulting in large number of false positive.
- SAFE is more neutral, producing a low error rate in all cases.

SAFE papers

- **Zhou, S.**, and S. Griffiths. 2008. Sustainability assessment for fishing effects (SAFE): A new quantitative ecological risk assessment method and its application to elasmobranch bycatch in an Australian trawl fishery. *Fisheries Research*, 91: 56-68.
- **Zhou, S.,** S.P. Griffiths, and M. Miller. 2009. Sustainability assessments for fishing effects (SAFE) on highly diverse and data-limited fish bycatch in a tropical Australian trawl fishery. *Marine and Freshwater Research*, 60, 563-570.
- **Zhou, S**., A.D.M. Smith, M. Fuller. 2011. Quantitative ecological risk assessment for fishing effects on diverse data-poor non-target species in a multi-sector and multi-gear fishery. *Fisheries Research* 112: 168-178.
- **Zhou, S.**, Milton, D.A., and Fry, G.C. 2012. Integrated sustainability assessment for protected rare species and its application to sea snakes impacted by fishing. *ICES Journal of Marine Sciences* 69: 271-280.
- **Zhou, S.,** Yin, S., Thorson, J.T., Smith, A.D.M., Fuller, M. 2012. Linking fishing mortality reference points to life history traits: an empirical study. *Canadian Journal of Fisheries and Aquatic Science* 69: 1292–130.

Enhanced SAFE

Two versions of SAFE

- **Base SAFE** uses very similar data as PSA. It assumes three levels of gear catch efficiency, and assumes that fish density is random or homogeneous within its distribution range. Base SAFE can be quickly applied to many species at once.
- **Enhanced SAFE** attempts to estimate species-specific gear catch efficiency and varying fish density. It generally requires some shot-by-shot catch data, and is carried out species by species.

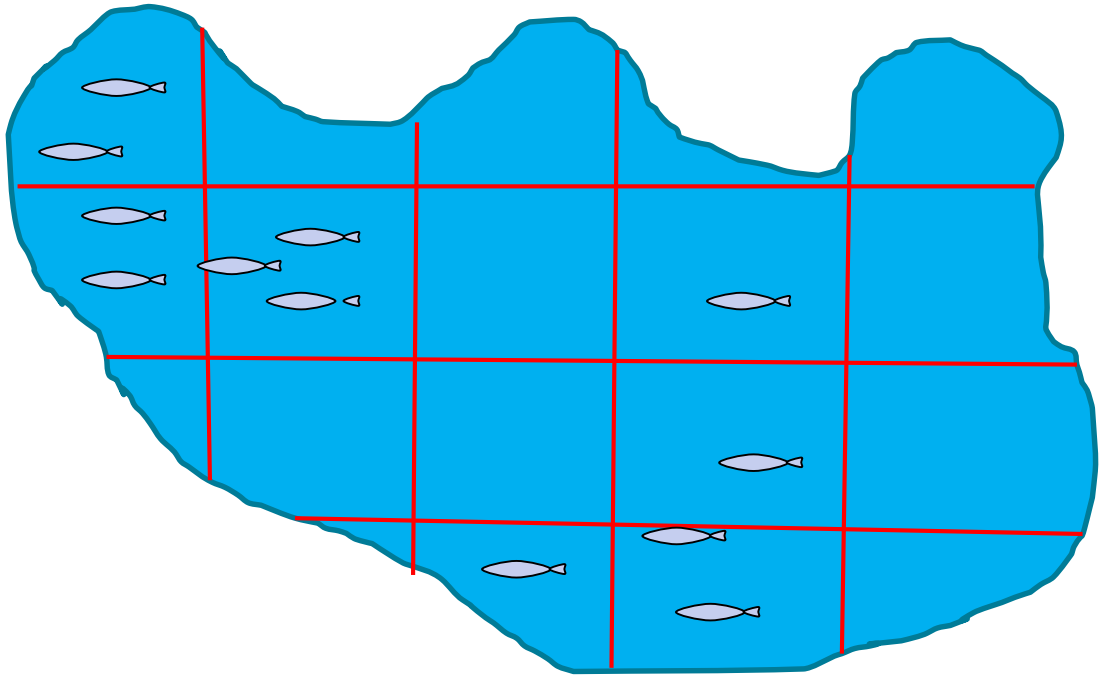
Catch efficiency

$$C = Q \times N$$

C= catch in one shot
N = abundance within gear affect area
Q = gear efficiency (catchability, detectability)

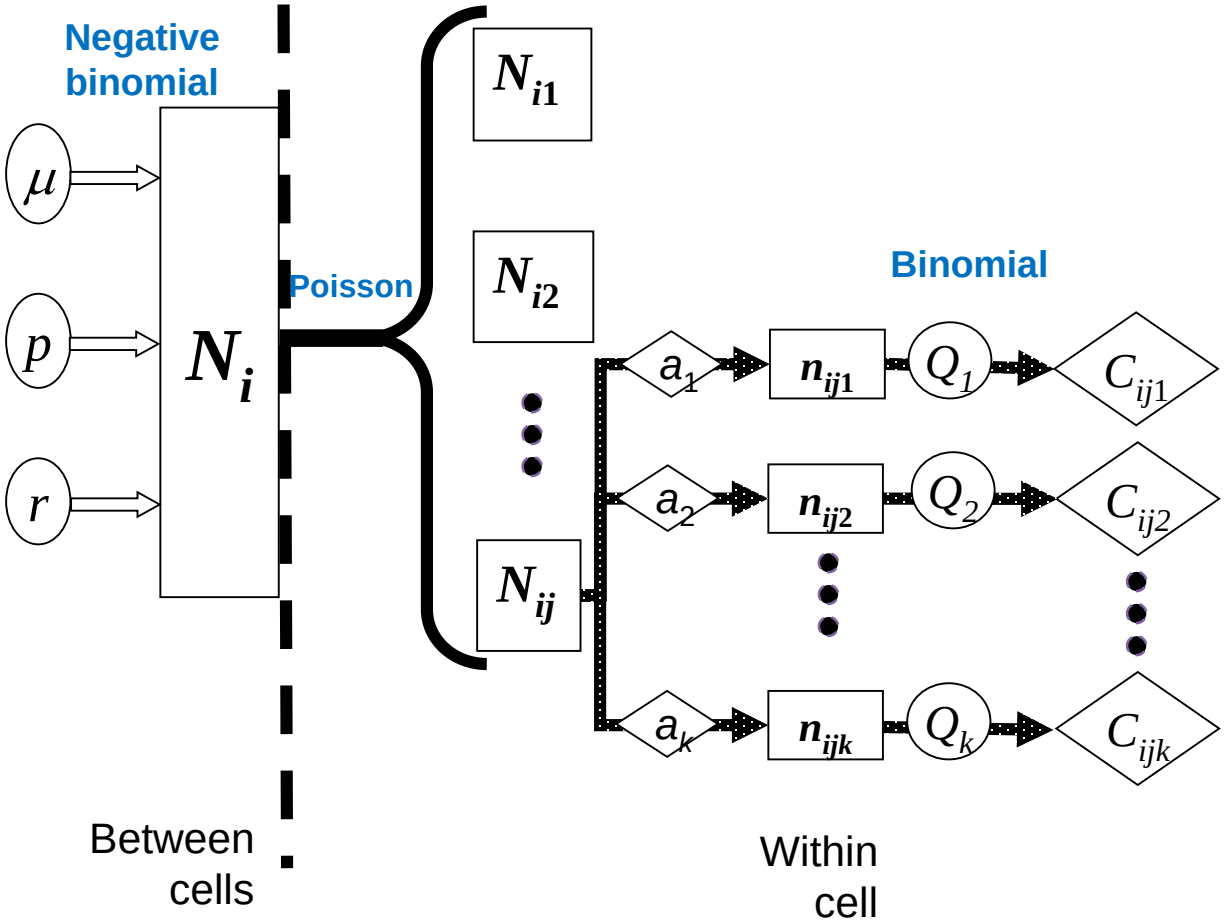
Method

- Fish distribution:
  - Aggregate between grids.
  - Aggregate or random within grid.
- Catch process: binomial distribution.
- Bayesian approach.
- Multiple gears.

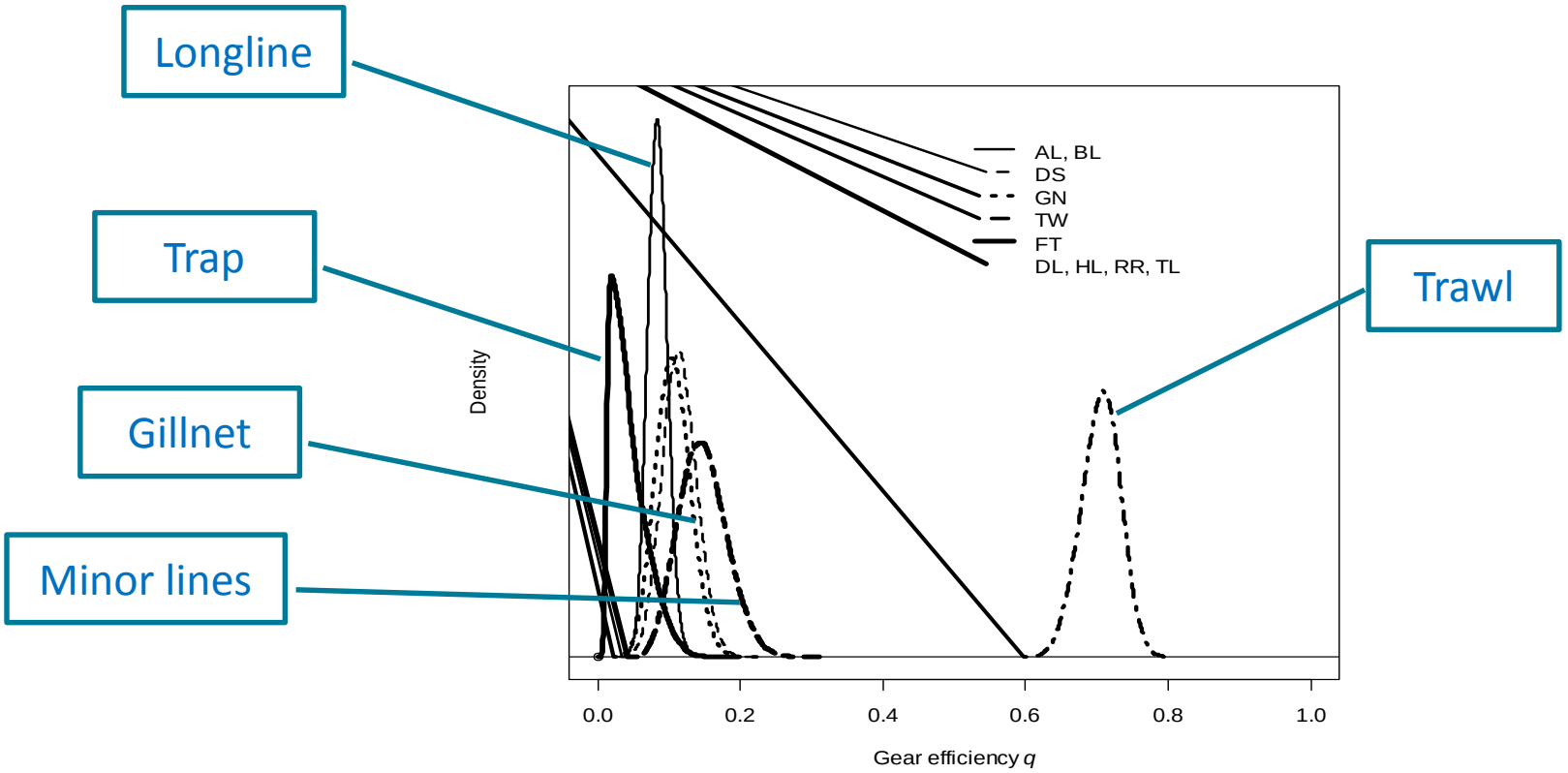


Three-stage process

Circle: parameter
Rectangle: latent variable
Diamond: known



Example: Jackass Morwong



Zhou, S. et al. 2014. Modelling multiple fishing gear efficiencies and abundance for aggregated populations using fishery or survey data. ICES Journal Marine Science.

Estimating density

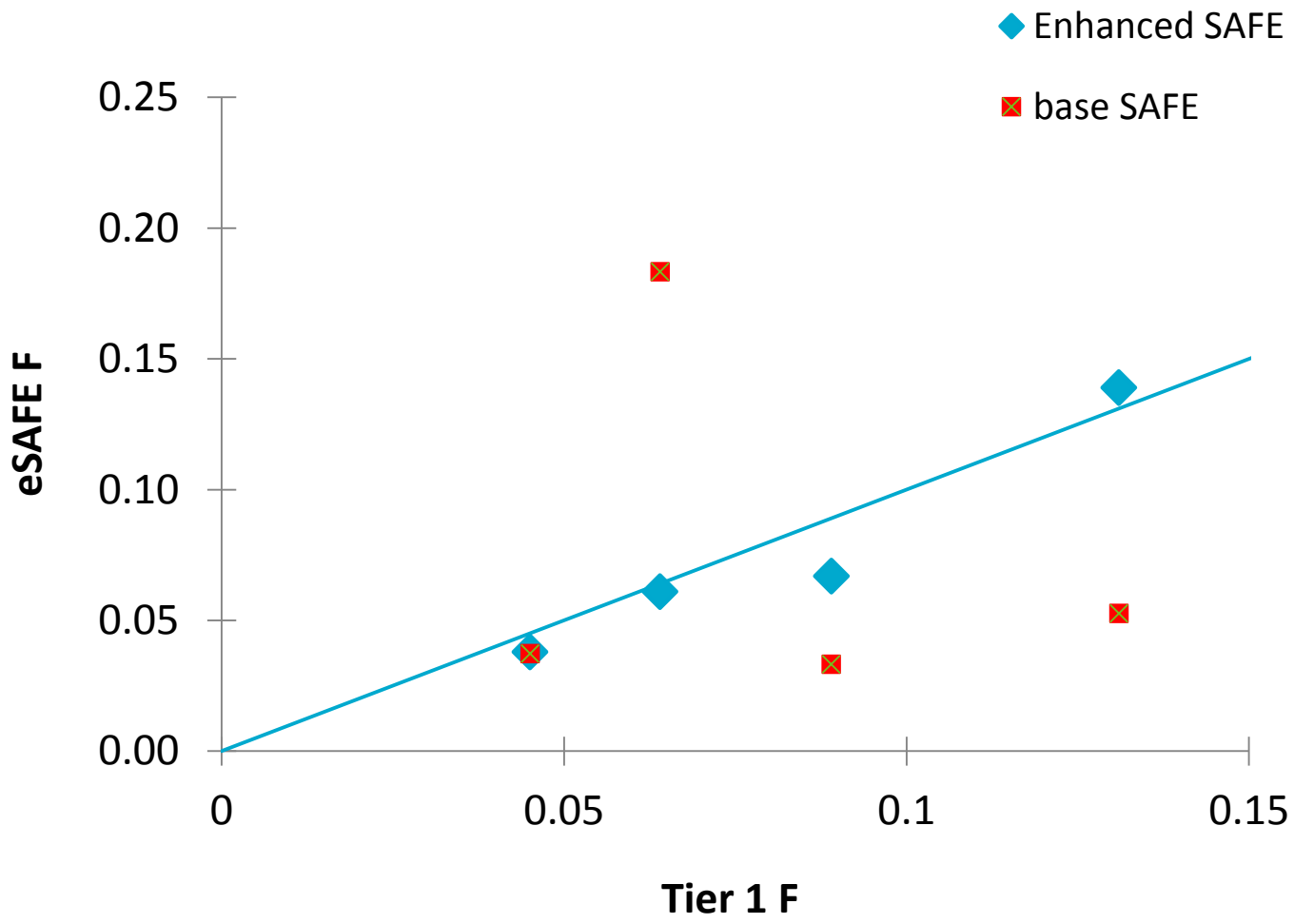
- Observed density:

$$D_{yij} = \frac{C_{yijk}}{a_{yijk} Q_k}$$

- Smoothing GAM:

$$\log(D_{yij}) = \beta_0 + f_1(\text{lon,lat}) + f_2(\text{year}) + f_3(\text{depth})$$

Compare Enhanced SAFE with Tier 1



Thank you

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