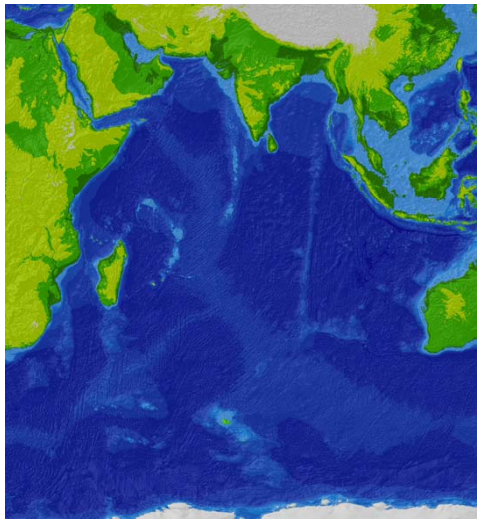
An investigation into the effects of the IOTC and network of Indian Ocean closed areas on yellowfin tuna *Thunnus albacares*



Sarah Martin, Chris Mees, Charles Edwards, and Lauren Nelson
MRAG Ltd, Imperial College London

Background

- Resolution 10/01 requires 2011 SC to evaluate impact of closures on YFT and BET, introduced as IOTC management measure

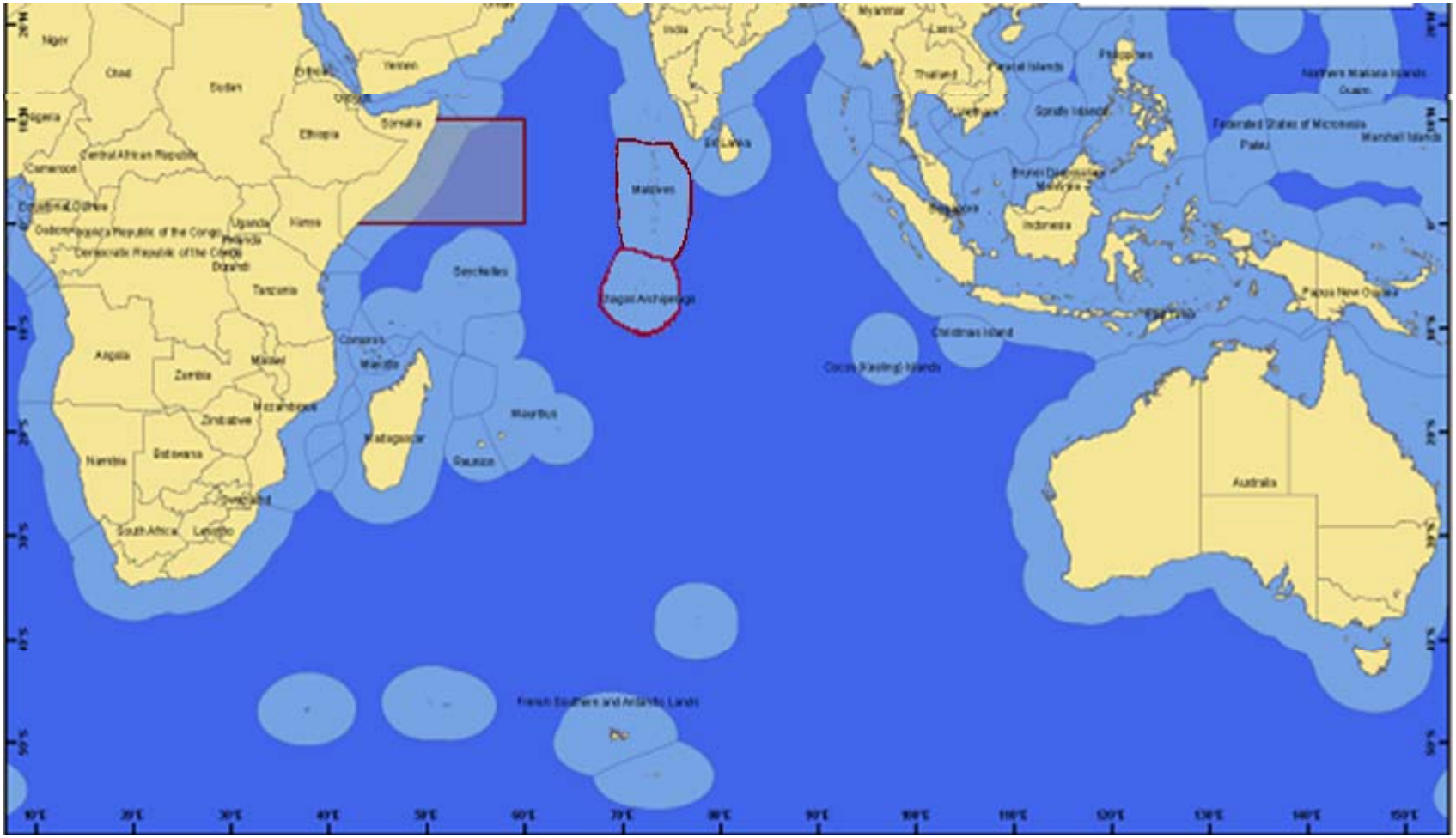
- IOTC performance review panel suggested IOTC should implement management advice based on precautionary principle.

Background

- RTTP-IO provides evidence of large movements of yellowfin tuna, supporting the assumption of a single stock for the Indian Ocean

- Purse seiners currently take the bulk (33%) of the yellowfin catch followed by longliners (31%)

Network of Protected Areas



IOTC area established with fisheries objectives; Chagos established for biodiversity conservation and as a scientific reference site; Maldives to secure domestic fisheries

Methods

- Simulate fishing under different scenarios to 2030
- Age-structured population model
- 3 month time steps
- Data from 2010 stock assessment (pers comm. Langley, July 2011)
- Recruitment random samples of historic values
- Recruits added Dec - Mar
- 24 fleet categories
- Total fishing mortality – randomly sampled over previous 10 years
- Catch equation used to estimate partial fishing mortality of each fleet
- Time invariant fleet selectivities
- 50 iterations run to account for variability inherent in historic sampling

Methods

Scenarios:

1. All areas open (Baseline Scenario)

Network with Current IOTC closure

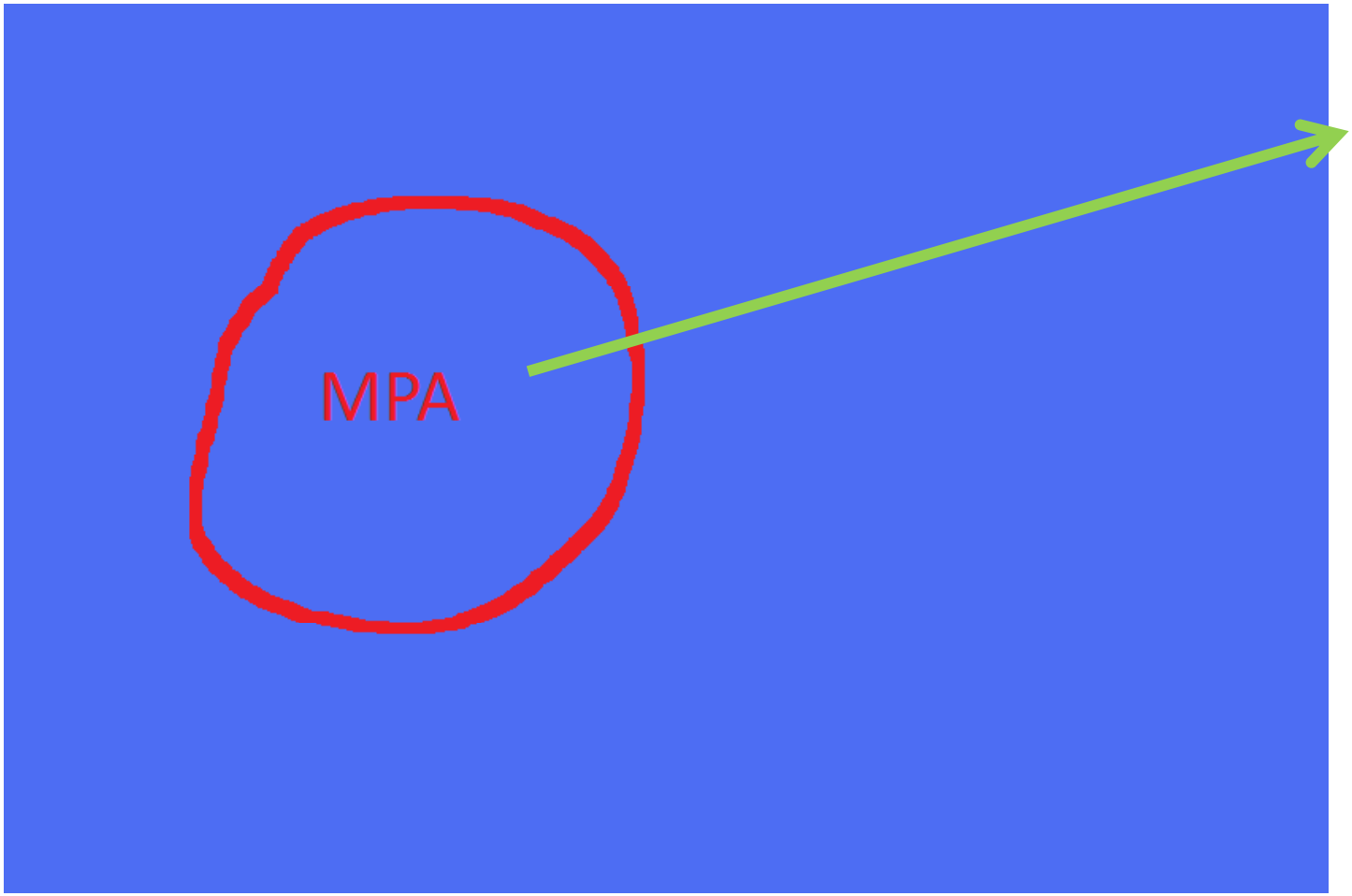
2. Catches eliminated
3. Catches redistributed

Network with Year-round IOTC closure

4. Catches eliminated
5. Catches redistributed

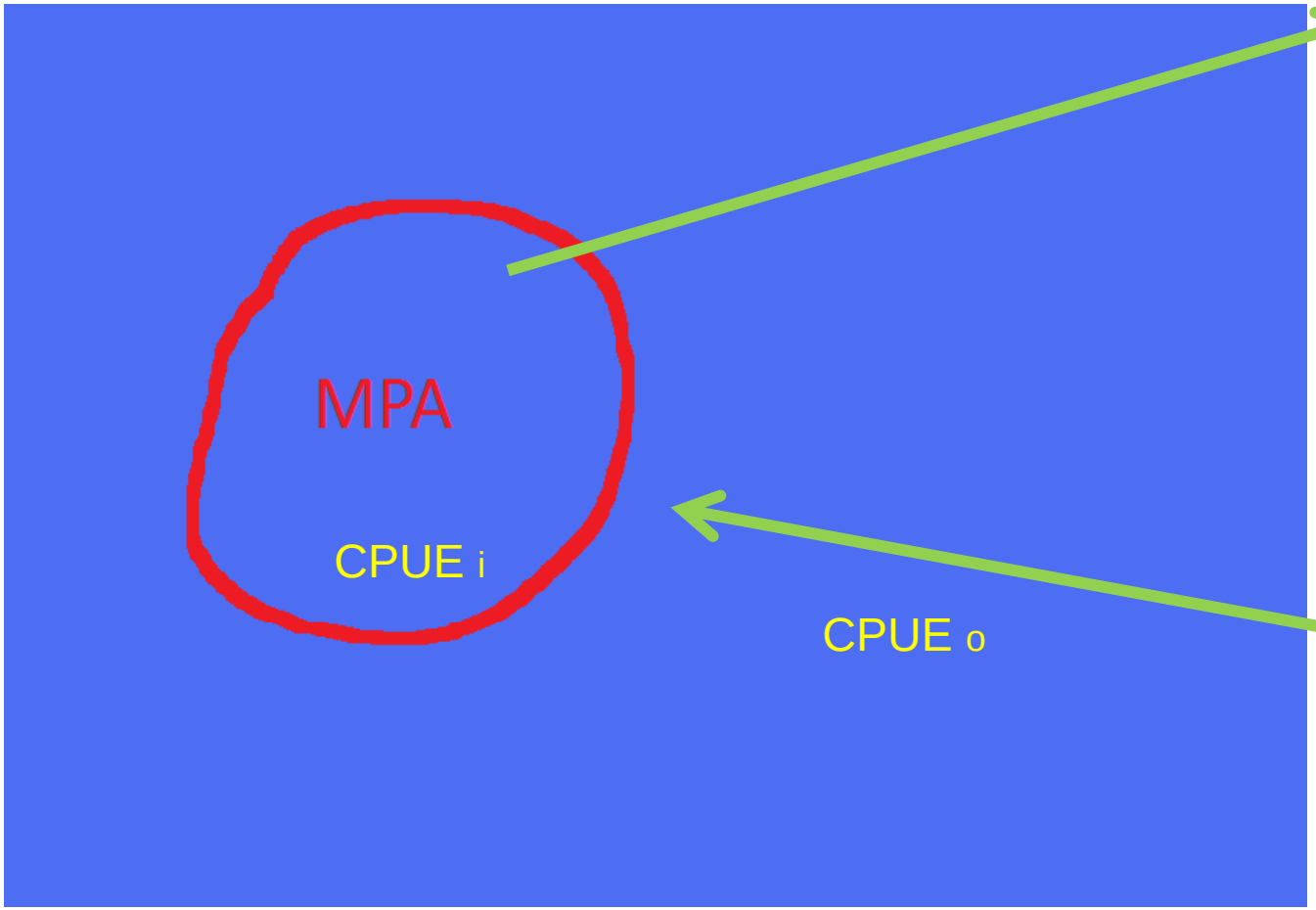
(Redistribution = PS only, but PS catches=94% catch in MPAs)

Eliminating catches



$$\left(\frac{C_{f,closedarea}}{C_{f,Indianocean}} \right)$$

Redistributing catches



$$\left(\frac{C_{f,closedarea}}{C_{f,Indianocean}} \right)$$

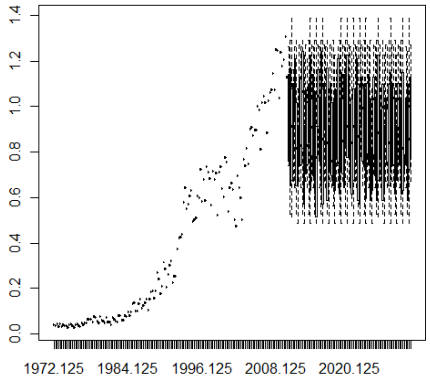
$$\hat{C}_f = \frac{CPUE_o}{CPUE_i} C_{f,closedarea}$$

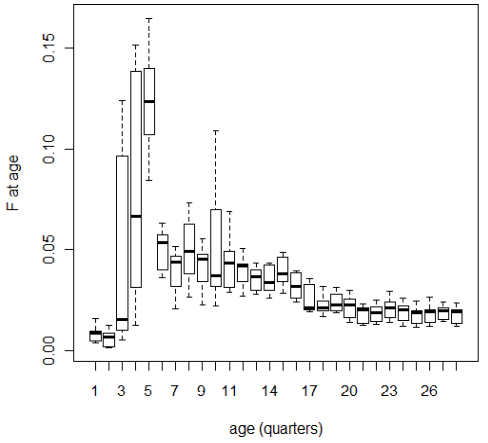
$$\left(\frac{\hat{C}_f}{C_{f,Indianocean}} \right)$$

Results

All scenarios-Stock biomass initially increases to a higher equilibrium - Fishing mortality in 2010 was higher than mean of F sampled from 1999

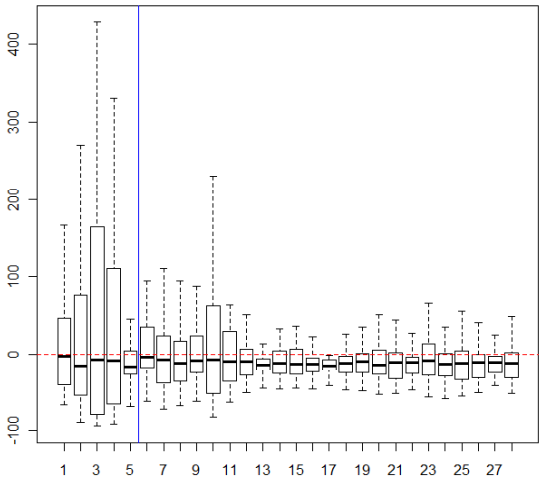
Effects of scenarios 2-5 thus presented relative to the baseline of no closure (Scenario 1)



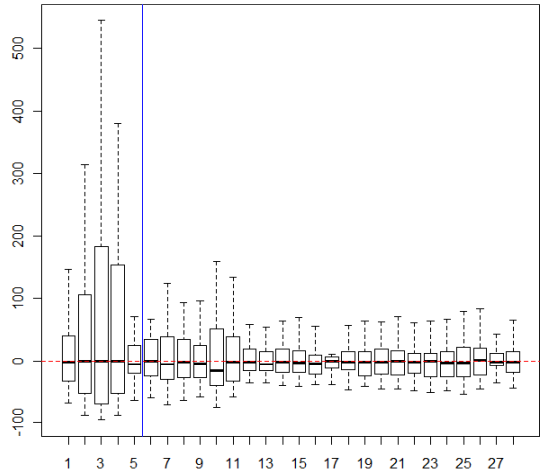


Fishing mortality at age

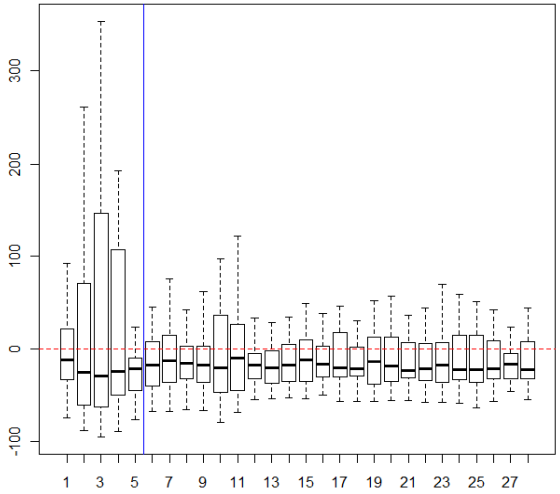
Effort eliminated

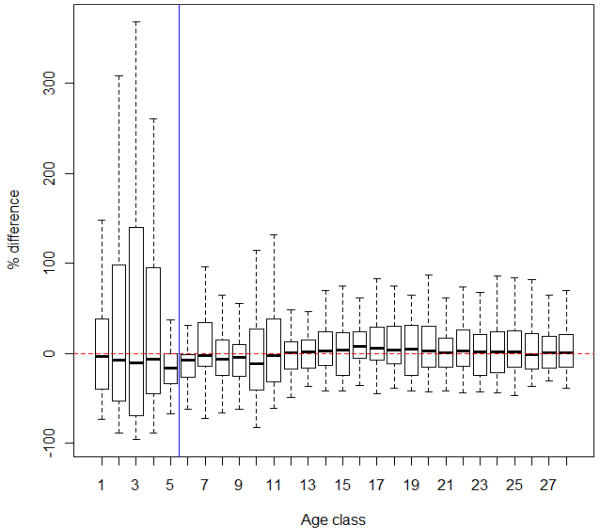


Effort redistributed



Current closures



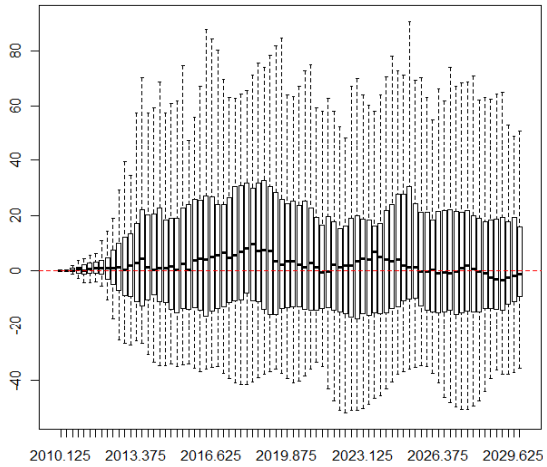


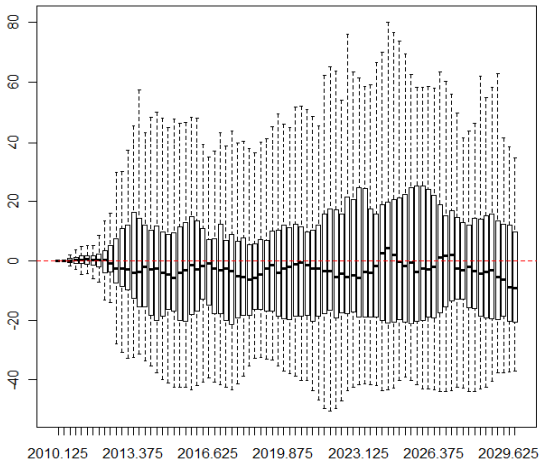
Year-round closures

Spawning stock biomass

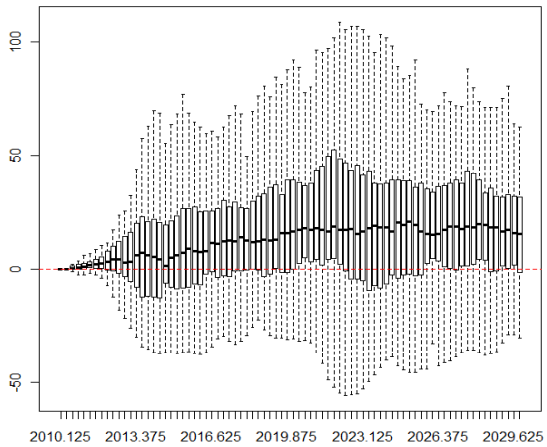
Effort eliminated

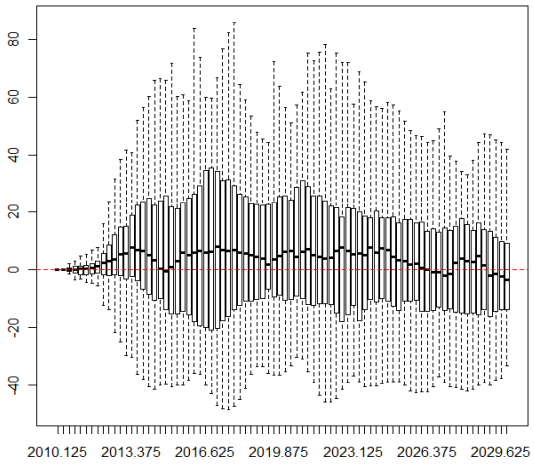
Effort redistributed





Current closures

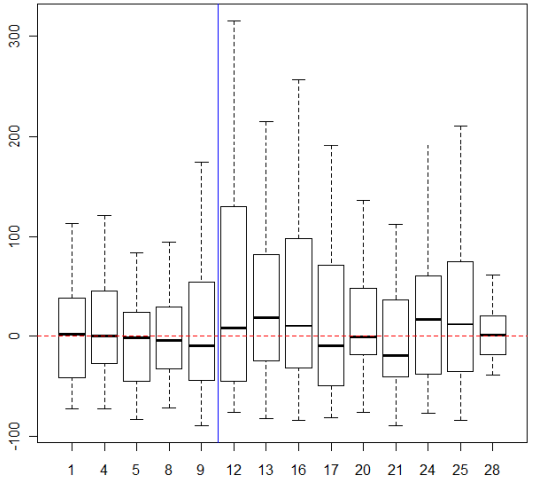




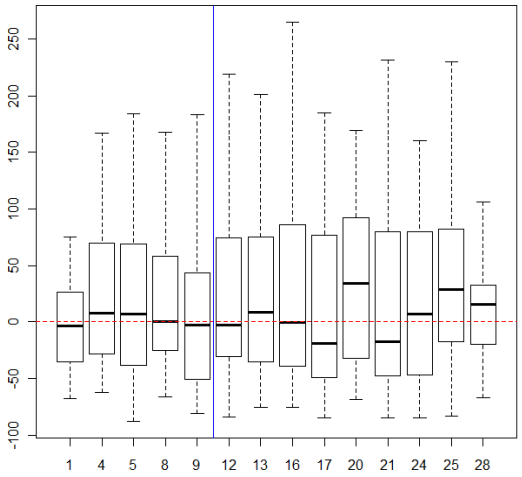
Year-round closures

Numbers at age

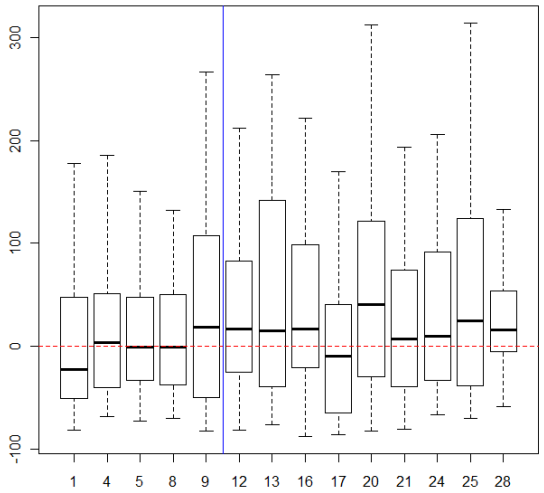
Effort eliminated

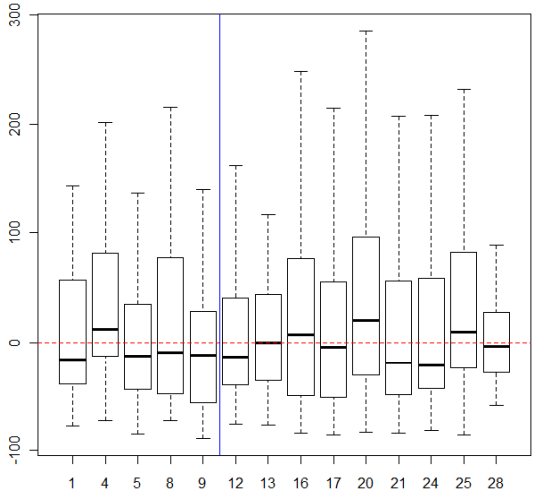


Effort redistributed



Current closures





Year-round closures

Summary

[1] Mean total fishing mortality over projected years

	Scenario	Fishing mortality	Stock numbers (% difference)	Adults: juveniles (% difference)	Stock biomass(% difference)	Spawning stock biomass (% difference)	Total catch biomass (% difference)
2	**IOTC (month), BIOT, Maldives eliminated**	0.868	-3.23 (±4.64) (44%)	9.50 (±10.52) (54%)	2.66 (±5.21) (56%)	3.88 (±5.82) (54%)	-6.74 (±5.30) (24%)
3	**IOTC (month), BIOT, Maldives redistributed**	0.903	-9.13 (±6.75) (28%)	6.33 (±10.12) (56%)	-6.55 (±4.46) (36%)	-6.05 (±4.72) (40%)	-7.20 (±6.27) (36%)
4	**IOTC (all yr), BIOT, Maldives eliminated**	0.764	1.36 (±6.38) (38%)	20.81 (±11.46) (66%)	12.67 (±4.65) (76%)	13.86 (±5.00) (76%)	-7.85 (±4.90) (36%)
5	**IOTC (all yr), BIOT, Maldives redistributed**	0.893	3.997 (±5.91) (54%)	-8.28 (±9.65) (26%)	-1.96 (±3.36) (46%)	-2.50 (±3.88) (44%)	-3.55 (±5.83) (38%)

Baseline F = 0.899 with all areas open

Conclusions

- Current network with only two month IOTC closure likely to have little impact on stock status whether effort is eliminated or redistributed

- Year-round closure of the IOTC area in addition to the BIOT and Maldivian closures under the assumption that fishing effort was removed entirely resulted in the most beneficial conservation outcomes. With reallocation, little impact. Precautionary approach requires us to consider effort would be reallocated.

- Current network of closures unlikely to be sufficient to protect yellowfin stocks without additional management measures (e.g. quota allocation system)

Further work

- Feedback between SSB and level of recruitment
- Fleet dynamics – more realistic scenario somewhere between two extremes?

Mean % changes in catches

		BIOT closure (% change in catches)			IOTC closure (% change in catches)			Maldives
Scenario	Quarter	FAD	FS	LL	FAD	FS	LL	LL
2 IOTC (month), BIOT, Maldives eliminated	1	-4.51	-10.40	-0.58	-	-	-5.48	-0.13
	2	-	-	-1.38	-	-	-4.77	-0.35
	3	-	-	-3.59	-	-	-0.71	-0.44
	4	-0.78	-15.48	-4.14	-21.57	-8.97	-5.84	-0.53
3 IOTC (month), BIOT, Maldives redistributed	1	+10.37	+3.55	-	-	-	-	-
	2	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-
	4	+8.38	-7.67	-	-9.53	+1.90	-	-
4 IOTC (all yr), BIOT, Maldives eliminated	1	-4.51	-10.40	-0.58	-30.01	-4.54	-5.48	-0.13
	2	-	-	-1.38	-21.46	-2.97	-4.77	-0.35
	3	-	-	-3.59	-62.45	-4.66	-0.71	-0.44
	4	-0.78	-15.48	-4.14	-60.22	-12.99	-5.84	-0.53
5 IOTC (all yr), BIOT, Maldives redistributed	1	+10.37	+3.55	-	-24.12	+3.49	-	-
	2	-	-	-	-8.99	+12.44	-	-
	3	-	-	-	-18.92	+105.83	-	-
	4	+8.38	-7.67	-	-38.29	+34.99	-	-