Residence times and vertical behaviour of tunas around drifting fish aggregating devices (FADs) in the Indian Ocean

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Introduction

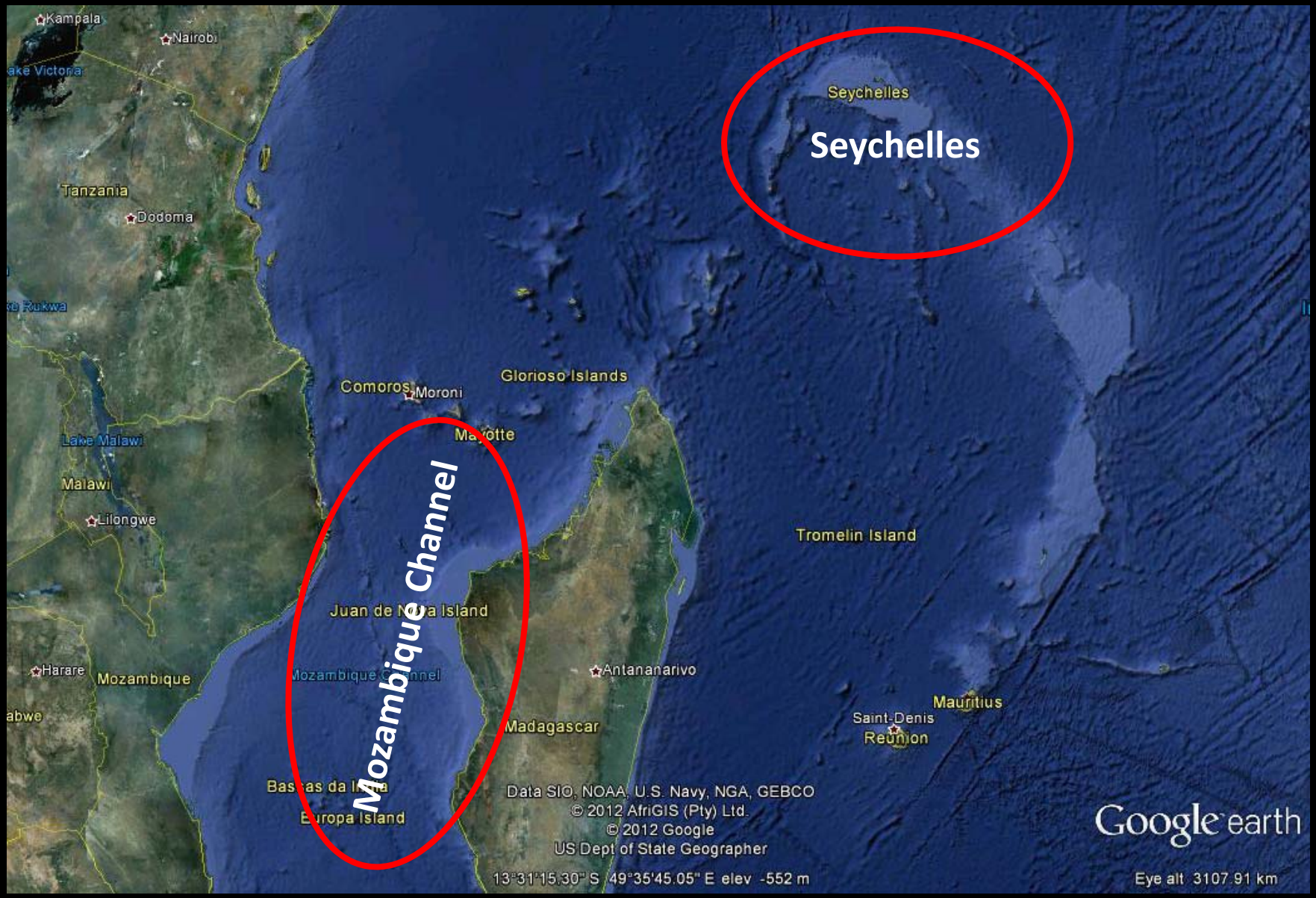
- **Still do not understand why tuna associate with FADs**
- Understanding the associative behaviour of tunas
- How much time tuna spends around FADs
- Document the short excursions made by tunas
- Describe the vertical behaviour
- How does these behaviour differ between regions

Method

- Tagged tunas around DFADs during 4 research cruises in two regions
  - Mozambique Channel
  - Seychelles
- Surgically implanted coded V13P tags
- DFADs equipped with VR4s

Method

Study sites



Method

Tagging summary

DFAD	Location	No. of SKJ-YFT-BET tagged	No. of SKJ-YFT-BET detected
31	Mozambique Channel	6-6-2	5-5-0
34	Mozambique Channel	7-6-2	6-6-2
41	Mayotte	0-3-0	0-2-0
42	Mayotte	0-1-0	0-1-0
43	Seychelles	3-3-1	1-0-0
30	Seychelles	0-2-0	VR4 did not work
37	Seychelles	2-6-0	1-5-0
28	Torre Guilia	0-5-0	0-4-0
32	Torre Guilia	2-4-5	1-4-4

- Total number of fish detected (tagged): SKJ = **14** **(20)**
  YFT = **27** **(36)**
  BET = **6** **(10)**

Data Analysis

How much time tuna spends around FAD

- Continuous residency times (CRT) 24hrs

Document the short excursions made by tunas

- Fine-scale continuous residency times (FCRT) 1hr
- Absence time (AT)

How does these behaviour differ between regions

- Survival curves
- Cox proportional hazards regression model (Wald statistics)

Data Analysis

Vertical distribution

- Grouped by 10 cm size classes
- Frequency of depth distributions during day and night

Comparisons

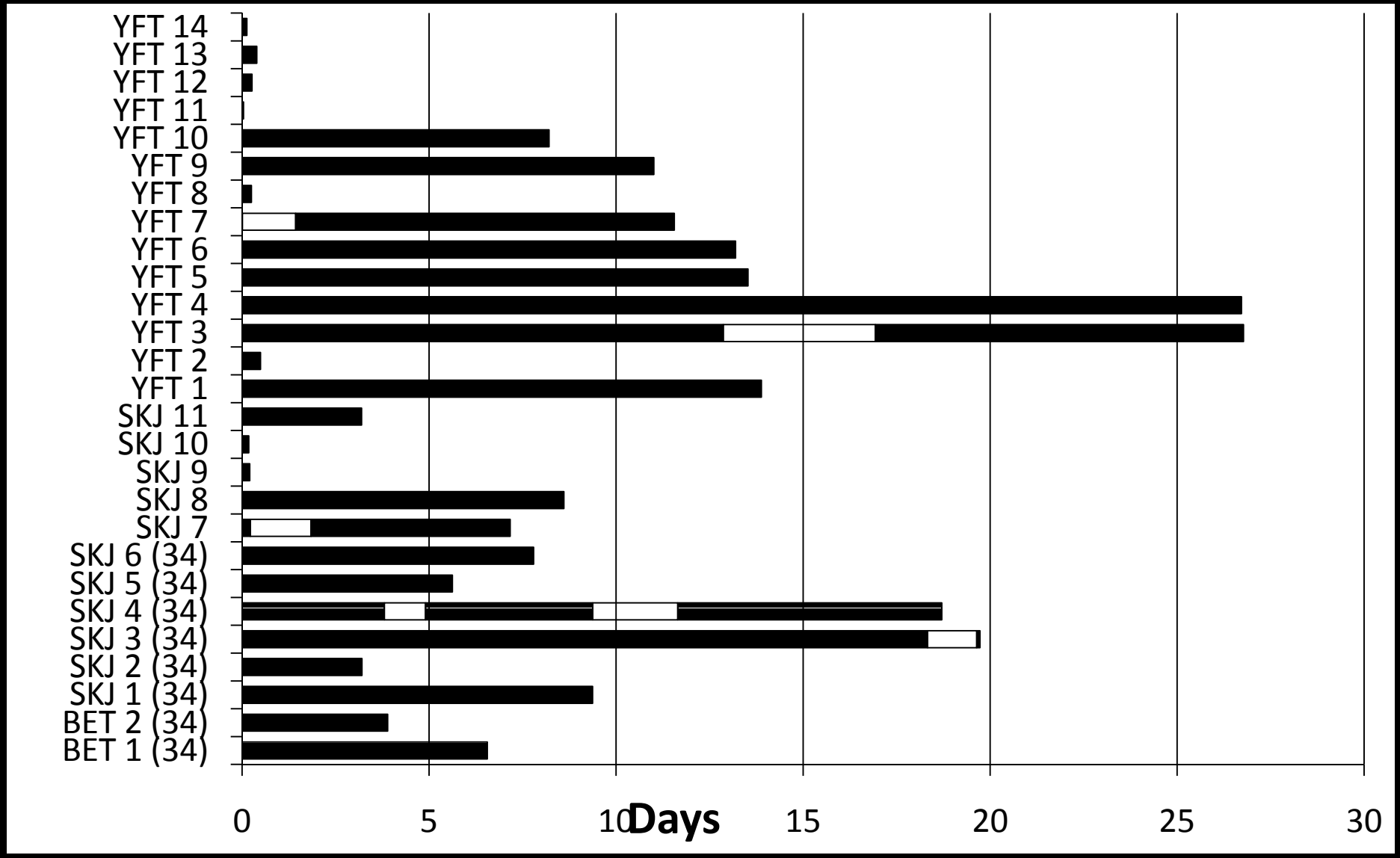
- Day and night distribution
- Between same species of different size classes at each region
- Between same species of the same size class by region
- Between different species of the same size at same regions

- Mann Whitney U test

Results

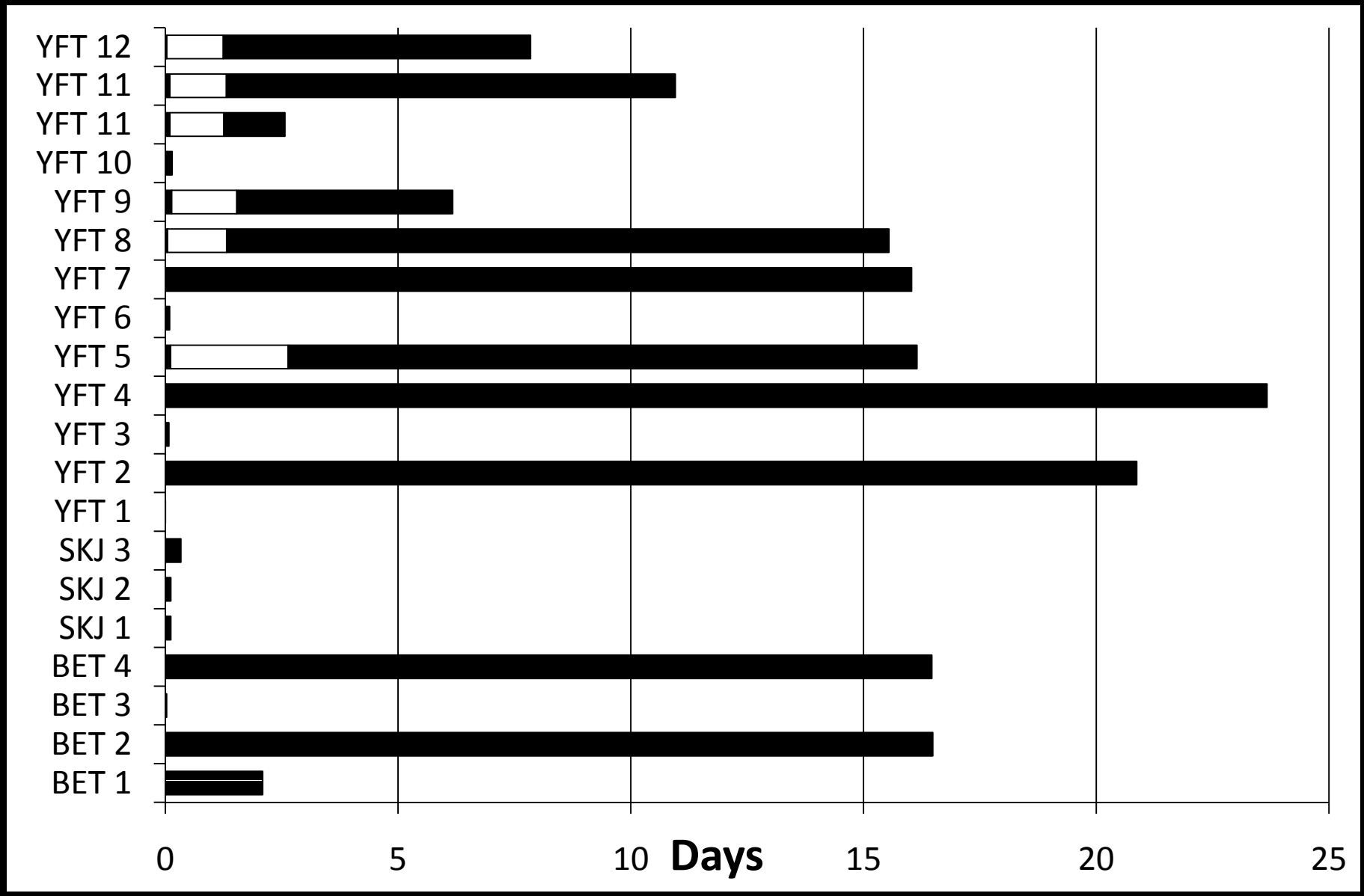
How much time does tunas spend around FADs

Mozambique Channel



Results

Seychelles



Results

Continuous residency times (CRT) (days)

		Mozambique channel	Seychelles
BET	Average	**5.2**	**8.8**
	SD	1.9	8.9
	Max.	6.6	16.5
	n	2	4
SKJ	Average	**5.2**	**0.2**
	SD	4.8	0.1
	Max.	18.3	0.3
	n	15	3
YFT	Average	**7.6**	**5.9**
	SD	7.8	8.0
	Max.	26.7	23.7
	n	16	19

Results

CRT comparison between region

- Comparison only possible for YFT
- No significant difference (Wald test, p=0.58)

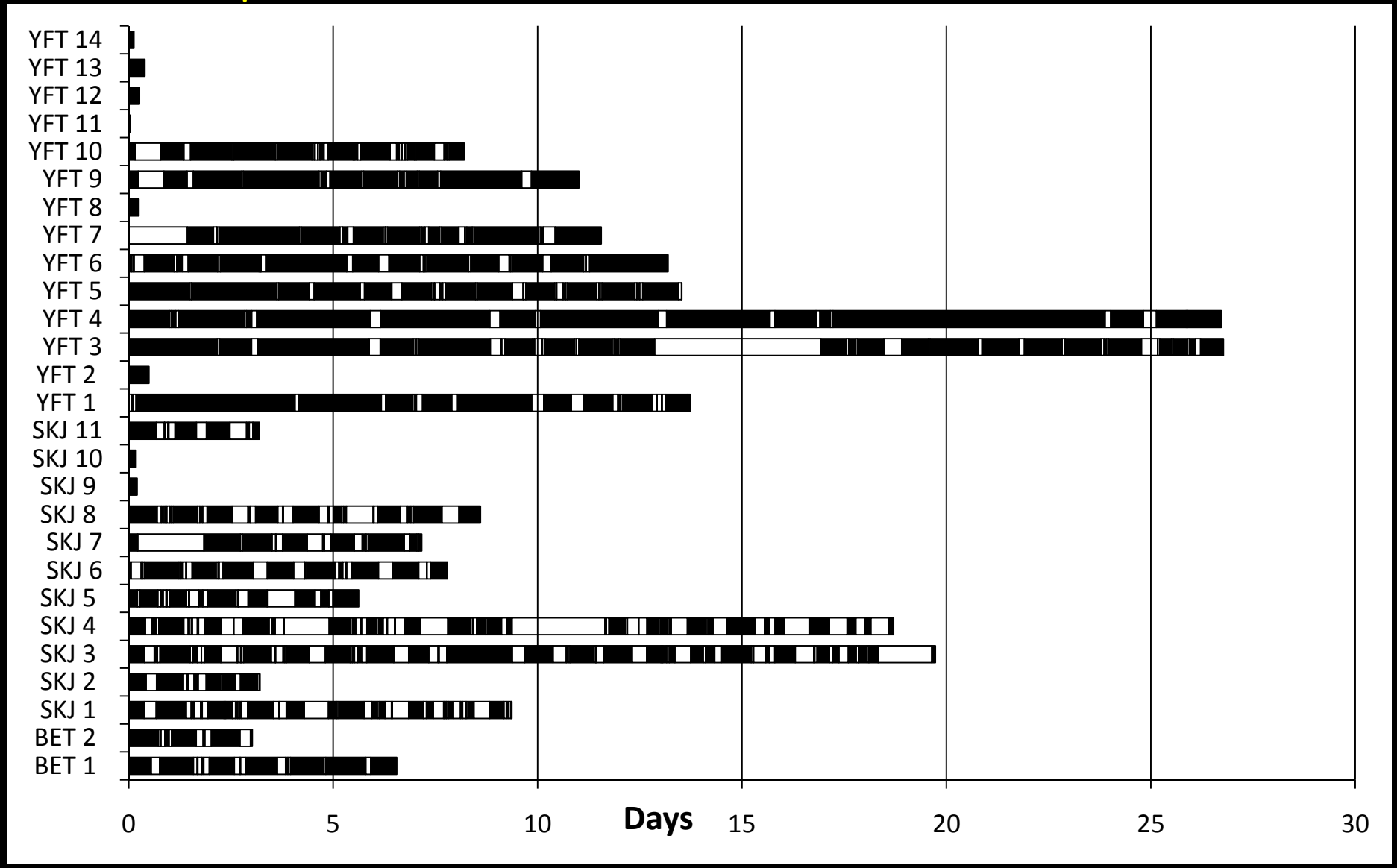
CRT comparison within region

- SKJ and YFT in Mozambique Channel
- No significant difference (Wald test, p=0.181)

Need to understand fine-scale movement of tunas

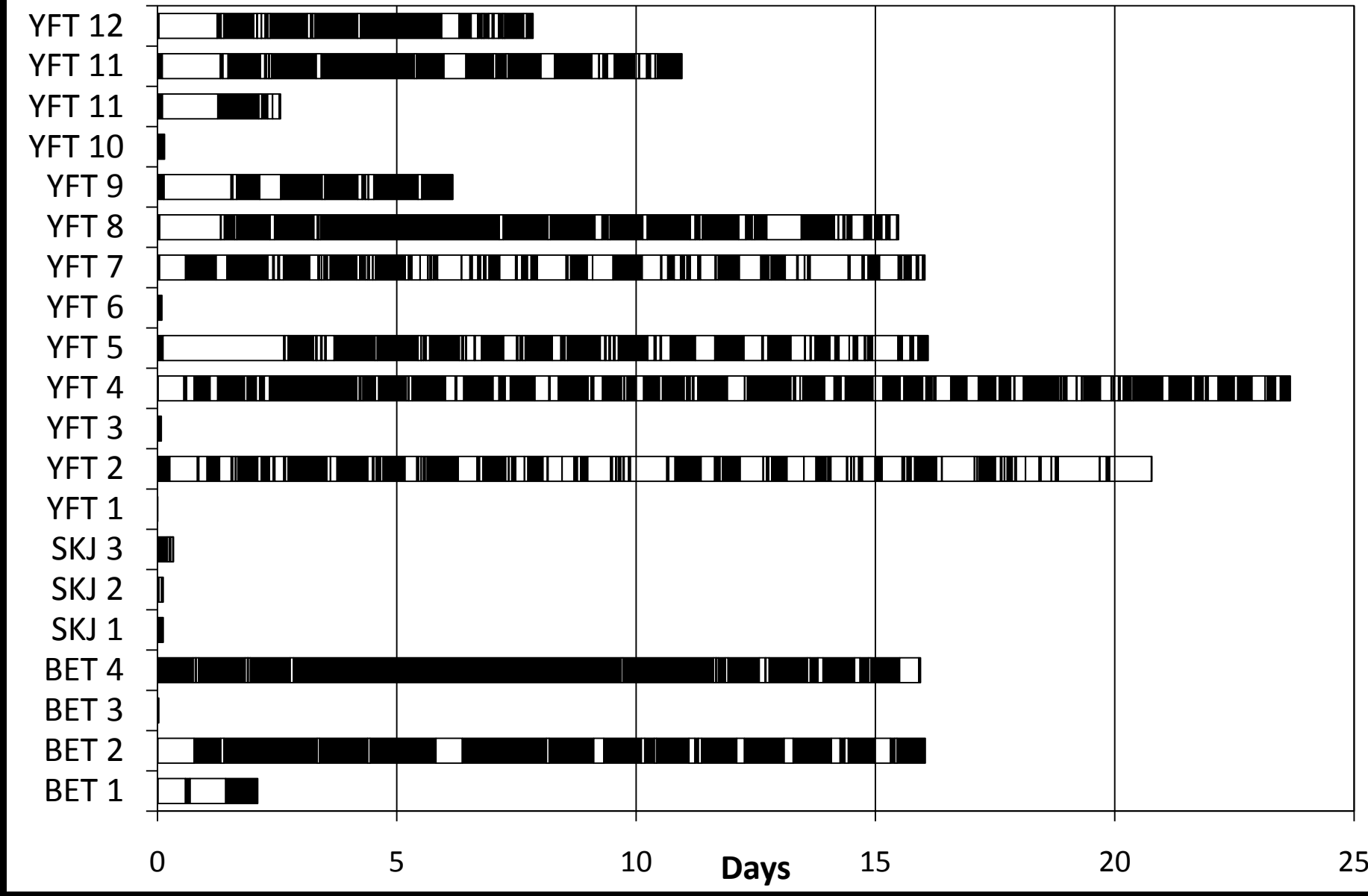
Results

Short-scale movements of tuna at FADs Mozambique Channel



Results

Seychelles



Results

Fine-scale continuous residency times (FCRT)

		Mozambique channel	Seychelles
BET	Average	**0.4**	**0.7**
	SD	0.4	1.1
	Max.	1.0	6.8
	n	18	39
SKJ	Average	**0.3**	**0.1**
	SD	0.3	0.1
	Max.	1.6	0.2
	n	185	6
YFT	Average	**0.7**	**0.2**
	SD	0.9	0.4
	Max.	6.7	3.7
	n	152	297

Results

FCRT comparisons between regions

		Mozambique channel	Seychelles
BET	Average	0.4	0.7
	Median	0.6	0.6
	Max.	1.0	6.8
	n	18	39

- No significant difference (Wald test, p=0.149)

Results

FCRT comparisons between regions

		Mozambique channel	Seychelles
YFT	Average	**0.7**	**0.2**
	Median	0.6	0.1
	Max.	6.7	3.7
	n	152	297

- Significant difference (Wald test, p= <0.0001)
- Comparison not possible for SKJ

Results

FCRT comparisons within regions

		BET	SKJ	YFT
Mozambique channel	Average	0.4	0.3	0.7
	Median	0.6	0.2	0.6
	Max.	1.0	1.6	6.7
	n	18	185	152

- BET vs SKJ = Significant difference (Wald test, p= 0.0209)
- BET vs YFT = No significant difference (Wald test, p= 0.0681)
- SKJ vs YFT = Significant difference (Wald test, p=<0.0001)

Results

FCRT comparisons within regions

		BET	SKJ	YFT
Seychelles	Average	**0.7**	0.1	**0.2**
	Median	0.6	0.03	0.1
	Max.	6.8	0.2	3.7
	n	39	6	297

- BET vs YFT = Significant difference (Wald test, p= <0.0001)
- How does these compare to the amount of time spent away from the FAD

Results

How much time tuna spends away from FAD
Absence time (AT)

		Mozambique channel	Seychelles
BET	Average	**0.13**	**0.16**
	SD	0.06	0.20
	Max.	0.26	0.76
	n	16	35
SKJ	Average	**0.20**	**0.05**
	SD	0.26	0.01
	Max.	2.27	0.06
	n	174	3
YFT	Average	**0.15**	**0.17**
	SD	0.37	0.25
	Max.	4.07	2.53
	n	138	284

Results

Absence time (AT) comparisons between regions

		Mozambique channel	Seychelles
YFT	Average	**0.15**	**0.17**
	SD	0.37	0.25
	Max.	4.07	2.53
	n	138	284

- Significant difference (Wald test, p=0.016)

Results

Absence time (AT) comparisons within regions

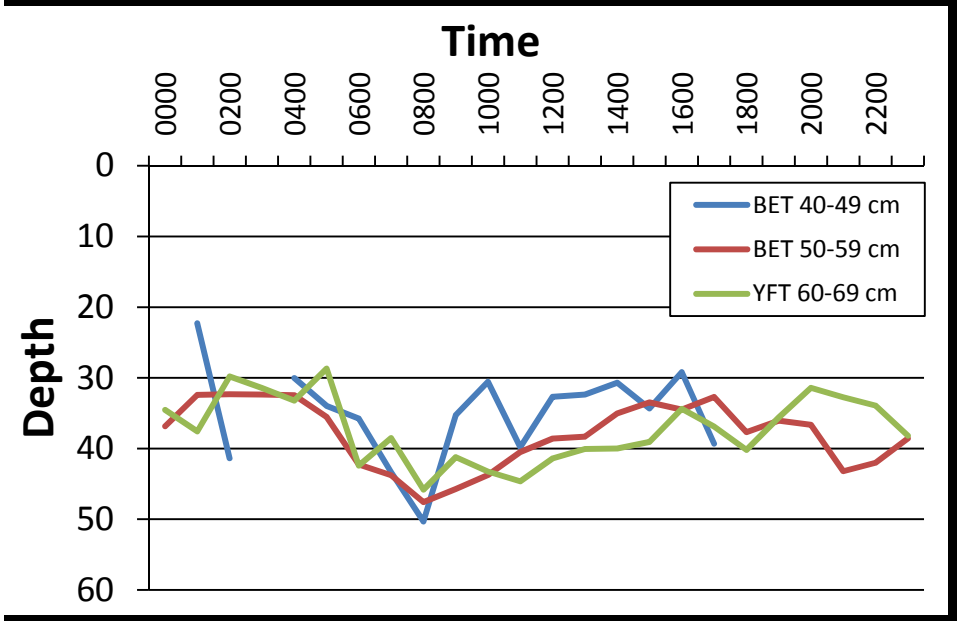
		BET	SKJ	YFT
Mozambique channel	Average	0.13	**0.20**	**0.15**
	SD	0.06	0.26	0.37
	Max.	0.26	2.27	4.07
	n	16	174	138

- SKJ vs YFT = Significant difference (Wald test, p=0.0007)

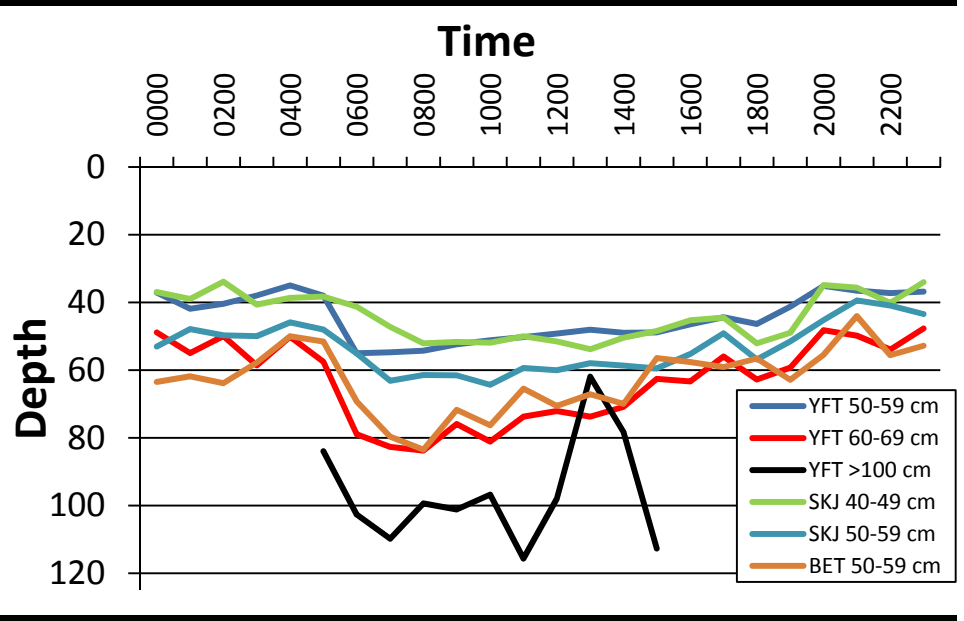
Results

Vertical distribution

Seychelles



Mozambique Channel



		Day				Night			
Species	Size classes	Average	SD	Min.	Max	Average	SD	Min.	Max
BET	40-49 cm	**36**	12	11	97	**34**	12	2	54
	50-59 cm	**40**	19	2	242	**36**	14	1	85
YFT	60-69 cm	**41**	23	0	286	**33**	17	0	87

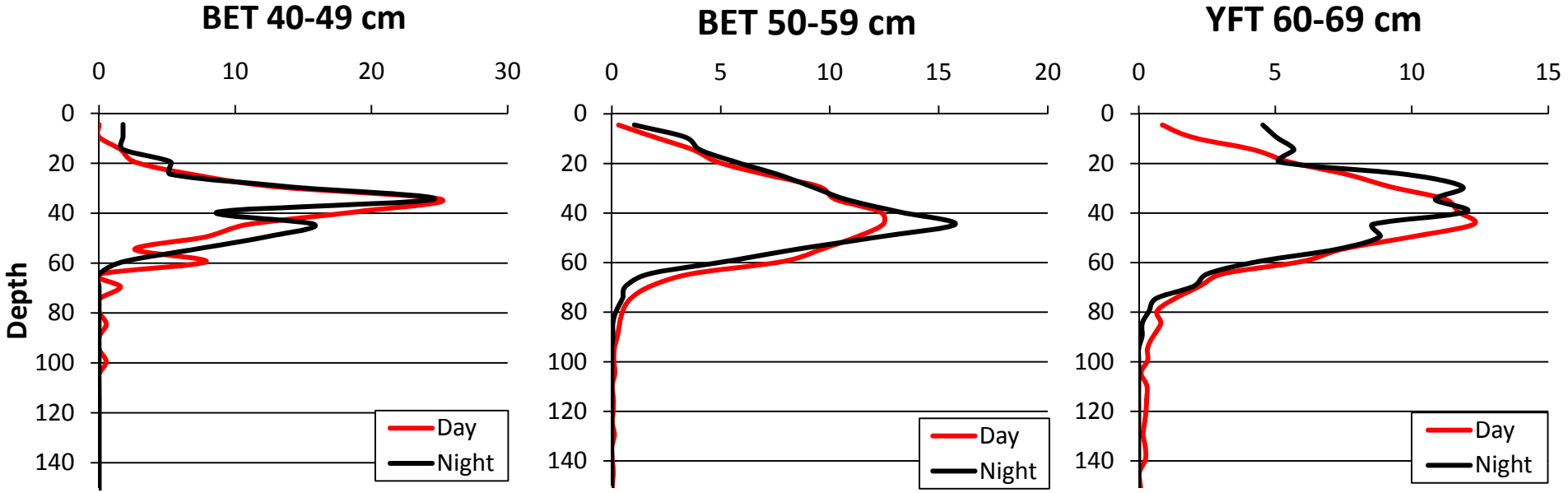
		Day				Night			
Species	Size classes	Average	SD	Min.	Max	Average	SD	Min.	Max
BET	50-59 cm	**67**	26	11	258	**56**	25	6	105
SKJ	40-49 cm	**49**	26	0	201	**38**	18	0	97
	50-59 cm	**59**	23	4	235	**46**	20	1	105
YFT	50-59 cm	**50**	27	0	311	**38**	19	0	108
	60-69 cm	**72**	22	4	151	**52**	21	1	102
	>100cm	**100**	24	42	188	**NA**	NA	NA	NA

Results

Vertical behaviour

Day and night comparisons

Seychelles

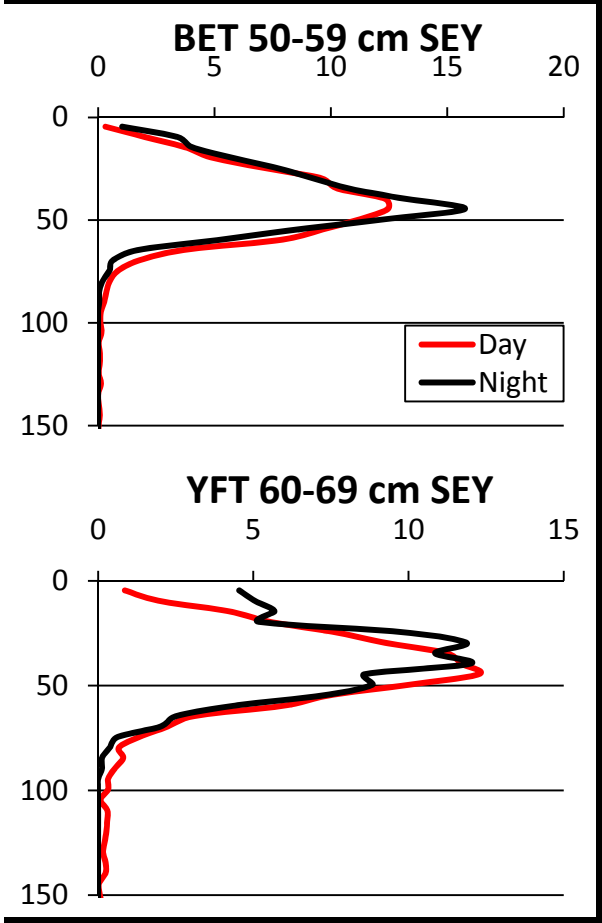


- Significant differences in day and night depth distributions
- Except BET 40-49 cm (Mann-Whitney U test, p=0.502)

Results

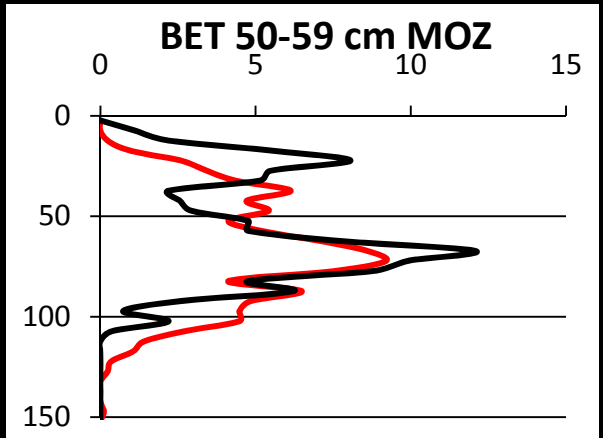
Vertical behaviour

Comparison between same species of the same size class by region

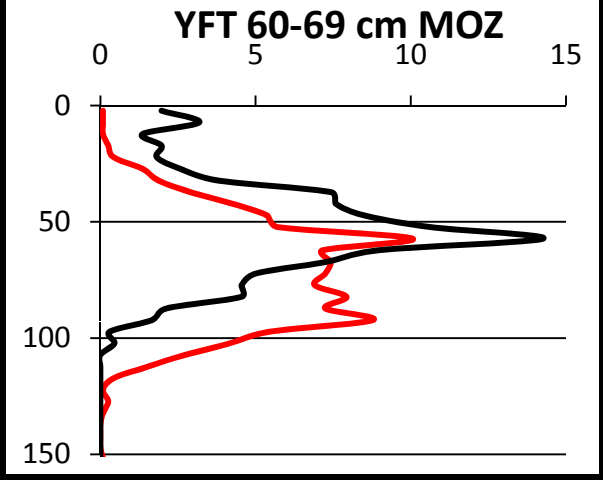


Average Depth
Day = **40m**
Night = **36m**

Average Depth
Day = **41m**
Night = **33m**



Average Depth
Day = **67m**
Night = **56m**



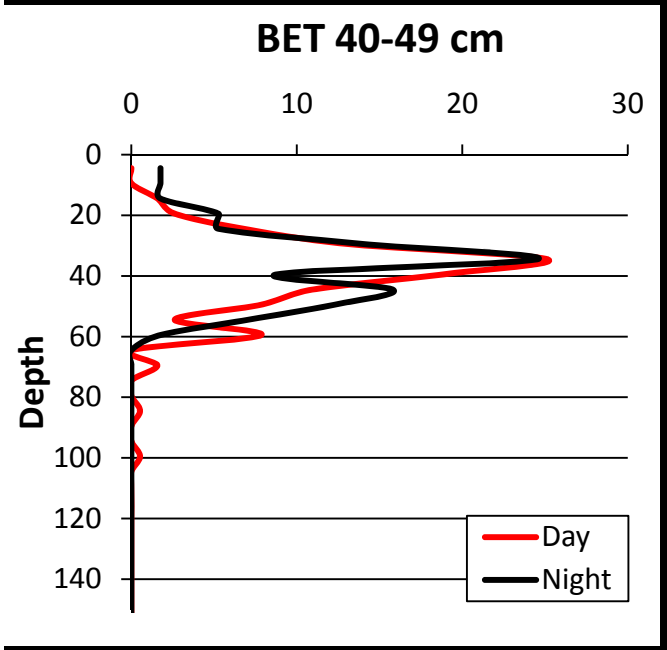
Average Depth
Day = **72m**
Night = **52m**

- Significant differences in day and night depth distributions
- BET and YFT deeper in Mozambique Channel

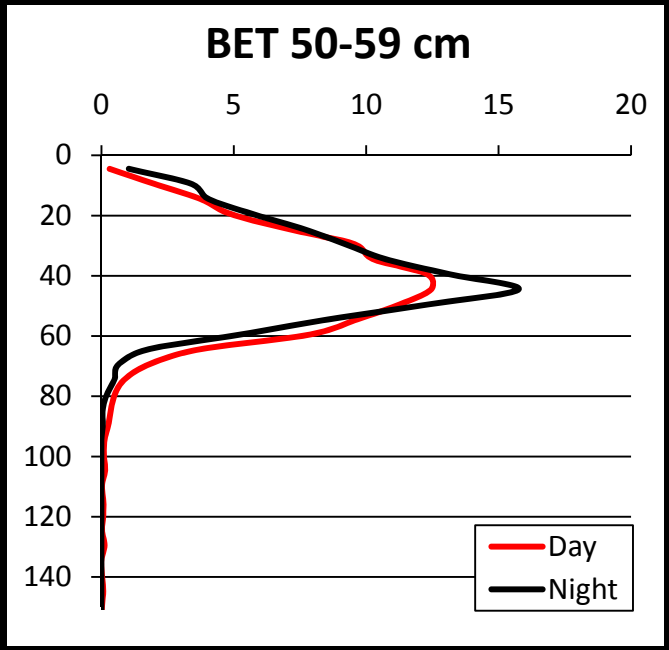
Results

Comparisons between same species of different size classes

Seychelles



Average Depth
Day = **36m**
Night = **34m**



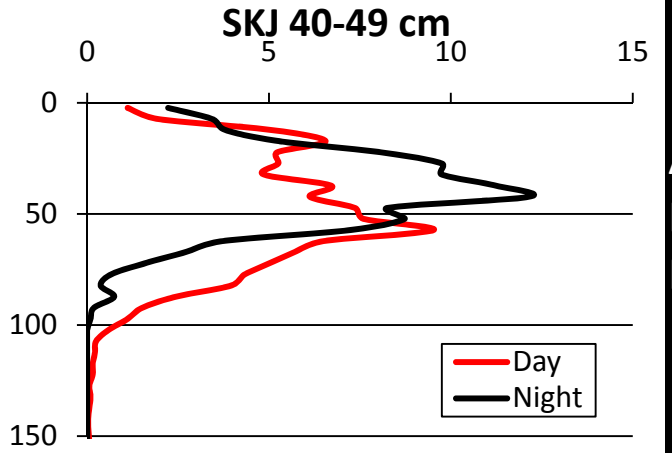
Average Depth
Day = **40m**
Night = **36m**

- Significant difference during day (Mann-Whitney U test, p=0.003)
- No difference during night (Mann-Whitney U test, p=0.34)

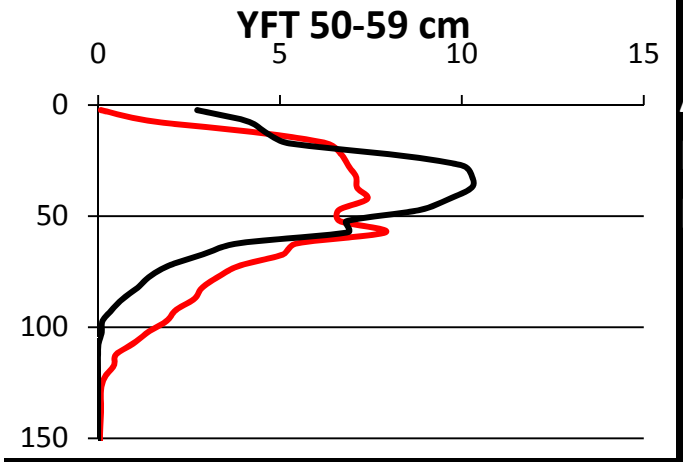
Results

Comparisons between same species of different size classes

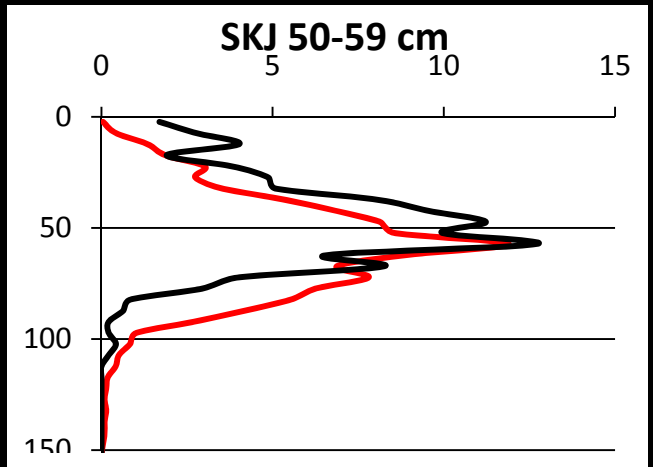
Mozambique



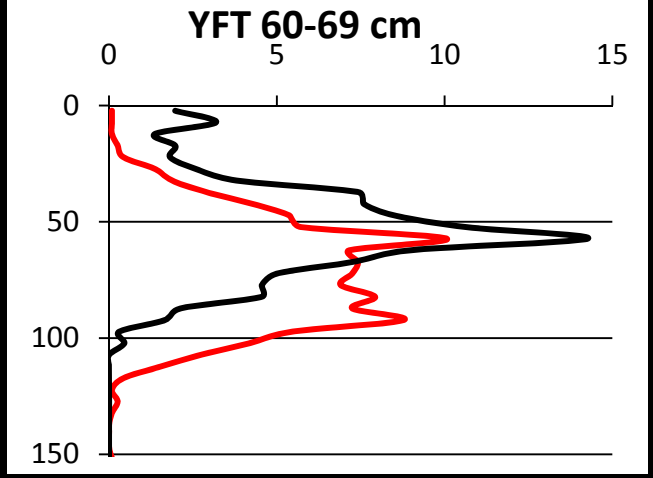
Average Depth
Day = **49m**
Night = **38m**



Average Depth
Day = **50m**
Night = **38m**



Average Depth
Day = **59m**
Night = **46m**



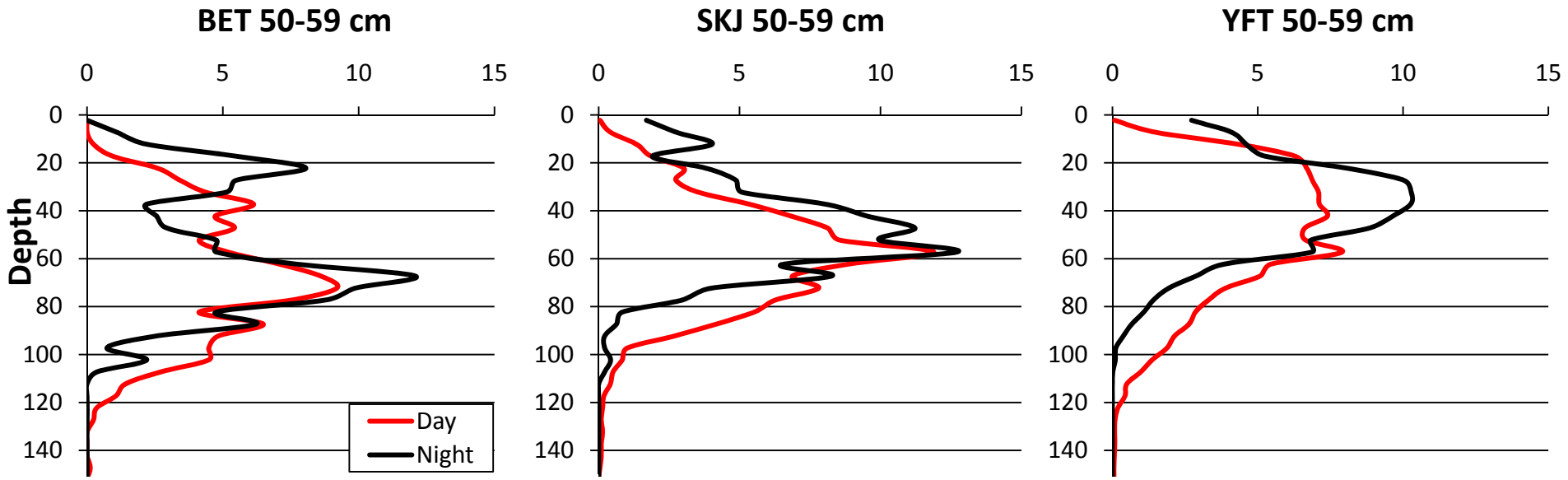
Average Depth
Day = **72m**
Night = **52m**

- Significant difference between day and night distributions
- Larger SKJ and YFT deeper in Mozambique Channel

Results

Comparisons between different species of the same size

Mozambique Channel



Average Depth
Day = **67m**
Night = **56m**

Average Depth
Day = **59m**
Night = **46m**

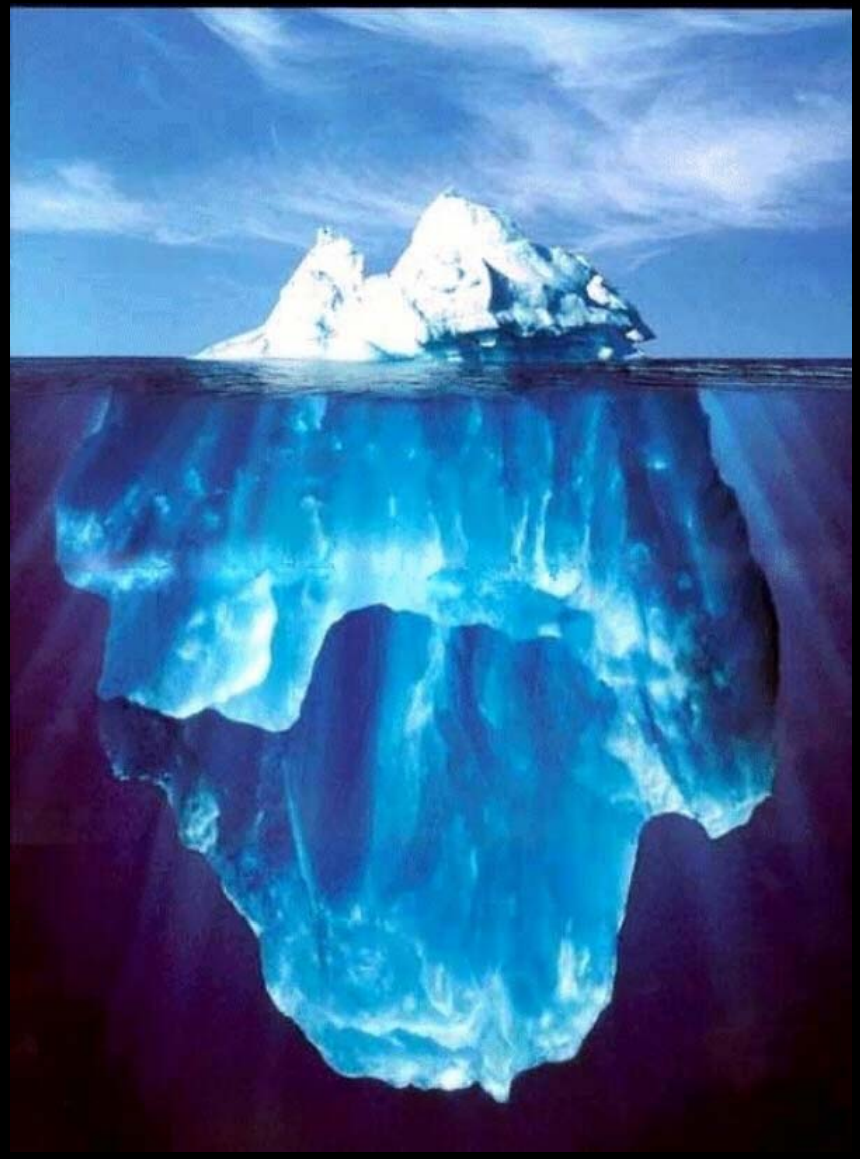
Average Depth
Day = **50m**
Night = **38m**

- Significant difference during day and night distributions (Mann-Whitney U test, p=<0.0001)
- Depth = BET > SKJ > YFT

Conclusion

- Variability in the associative behaviour between and among regions
- YFT in Mozambique Channel more associated to FADs
- Diel pattern in depth distributions
- Variations in the depth distribution between sites
- Size differences in depth distributions
- Larger size classes were deeper

THE END



Questions??