Investigation of 1998-2012 Africana survey data

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Background on survey design

Demersal surveys cover the same geographical range each year, viz: from the coast out to the 500 metre isobath and from the international border between South Africa and Namibia to Cape Agulhas (20° E longitude). Stations are selected using a pseudo-random stratified sampling design. The area is divided into depth strata and each stratum was further subdivided into 1° latitude substrata on the West Coast (Table 1a) and 1° longitude substrata on the South Coast (Table 1b). Stations within each substratum were selected at random, and the number of target stations per substratum was proportional to the area of the substratum.

Table 1a: Area (nm^2) of depth and latitude strata used on the West coast of South Africa for Demersal Surveys

Lat\Depth	000-100	101-200	201-300	301-400	401-500
28°30-29	239.27	312.53	0	0	0
29-30	345.3	4098.38	447.49	173.26	252.3
30-31	687.55	2301.22	3150.3	627.42	404.82
31-32		2080.96	1535.9	1121.03	1016.07
32-33	814.69	1302.36	1306.45	1585.85	824.19
33-34	678.16	860.71	550.25		
34-35	1244.8	1366.69	641.22	709.32	521.71
35-36°20	62.41	1820.77	896.65		
TOTAL	4072.18	14143.62	8528.26	4216.88	3019.09

Table 1b: Area (nm^2) of depth and longitude strata used on the South coast of South Africa for Demersal Surveys

Long\Depth	000-050	051-100	101-200	201-500
20-21	303.57	1804.2	3750.72	454.22
21-22	138.06	1930.39	3804.62	839.05
22-23	230.39	2080.29	3389.52	1206.37
23-24	100.36	651.68	1783.61	533.91
24-25	183.39	231.76	1419.01	347.78
25-26	330.65	385.01	978.24	281.79
26-27	206.79	512.61	899.12	164.97
TOTAL	**1493.21**	**7595.94**	**16024.84**	**3828.09**

Table 2: Hake length (cm) – weight (g) relationships calculated by Singh (2013)

M. capensis	Length- Weight Relationship	N	R^2		*M. paradoxus*	Length- Weight Relationship	N	R^2
All	$y = 0.006x^{3.073}$	18312	0.9916		All	$y = 0.0064x^{3.0346}$	12272	0.9925
SC	$y = 0.0062x^{3.0672}$	10053	0.992		SC	$y = 0.0055x^{3.0795}$	3018	0.9852
WC	$y = 0.0058x^{3.0799}$	8256	0.9912		WC	$y = 0.0065x^{3.0275}$	9254	0.9935
SC females	$y = 0.0061x^{3.0724}$	4937	0.9918		SC females	$y = 0.005x^{3.1065}$	1083	0.9862
SC males	$y = 0.0076x^{3.0124}$	4165	0.9868		SC males	$y = 0.0079x^{2.9712}$	1893	0.9565
WC females	$y = 0.0058x^{3.0783}$	4795	0.9896		WC females	$y = 0.0064x^{3.0355}$	5550	0.9932
WC males	$y = 0.0059x^{3.0746}$	3035	0.991		WC males	$y = 0.0076x^{2.9825}$	3477	0.9898

Singh L (2013) Length weight relationship of both hake species. *FISHERIES/2013/OCT/SWG-DEM/58*, 3pp.

Starting Point: MARAM IWS/DEC13/Ecofish/P7 (& P6)

"To obtain growth rates independent of otoliths-based age data, we integrated a length-frequency analysis (LFA) in the model complex. The LFA estimates the age distribution of a given length class by following the cohort-peaks in the length frequencies as they grow."

Table 3: Age distribution of length classes derived by Jansen et al (MARAM IWS/DEC13/Ecofish/P6 & P7); assumed to be for *Merluccius capensis* but was used for *M. paradoxus*, as no alternative available in the Jansen papers.

age_0_5	**age_1_5**	**age_2_5**	**age_3_5**	**age_4_5**	**age_5_5**	**age_6_5**	**age_7_5**	***age_plus***
*[5-]*16cm	27cm	36cm	45cm	53cm	60cm	67cm	73cm	*105cm*

The data presented here is exclusively from valid trawls during abundance estimate surveys completed on the *Africana* between 1999 and 2012. No survey was completed in 1998 and the *Dr Fridtjof Nansen* was used on the west coast for 2001 & 2001 and the south coast for 2000 but these were excluded for simplicity. The total sample size is 3031 trawls, during which 6 452 260 Merluccius paradoxus (>5cm) and 2 812 102 Merluccius capensis (>5cm) were measured. In comparison with the GeoPop dataset which *"consisted of 7.1 million measures M. paradoxus in 7,000 trawl hauls from 1998 to 2011. 324 of the hauls were especially informative in relation to gear inter-calibration, because they were taken with different gears, less than 3 hours apart and at a maximum distance of 18 nautical miles (nm)…Gisund trawl gear was used most frequently."*

Density per year and grid block was calculated as follows:

1. A total weight of W_t^L of large fish L is taken in trawl t.

   A total weight of W_t^S of small fish S is taken in trawl t.

   A total weight of W_t^A of all (i.e. not sorted by size) fish A is taken in trawl t.

   A random subsample of weight w_t^L of large fish is taken and the length distribution of the fish measured yielding $n_{t,l}^L$ fish of length group l; w_t^S of small fish yields $n_{t,l}^S$ fish of length group l and w_t^A of all fish yields $n_{t,l}^A$ fish of length group l.

   The estimated number of fish of length group l in the whole trawl is then given by:

$$N_{t,l} = n_{t,l}^L \frac{W_t^L}{w_t^L} + n_{t,l}^S \frac{W_t^S}{w_t^S} + n_{t,l}^A \frac{W_t^A}{w_t^A}$$

2. The estimated number of fish of length group l were converted to a catch weight (kg) using the length-weight relationship for "all" (Table 2)

3. The area swept (nm^2) a_j for each trawl: where s_j is the towing speed (knots, nm/hr), t_j is the duration (minutes) and w_j is the horizontal mouth width (m) i.e. the width of the trawl track in the *j*-th trawl;

$$a_j = s_j \times \frac{t_j}{60} \times \frac{w_j}{1852}$$

4. The observed density (kg/nm^2) d_j in the *j*-th trawl for each trawl where C_j is the observed catch weight (kg) of the species and a_j is the area swept (nm^2);

$$d_j = \frac{C_j}{a_j}$$

5. The observed density (kg/nm^2) were aggregated by age group (Table 3) and averaged per year and grid.

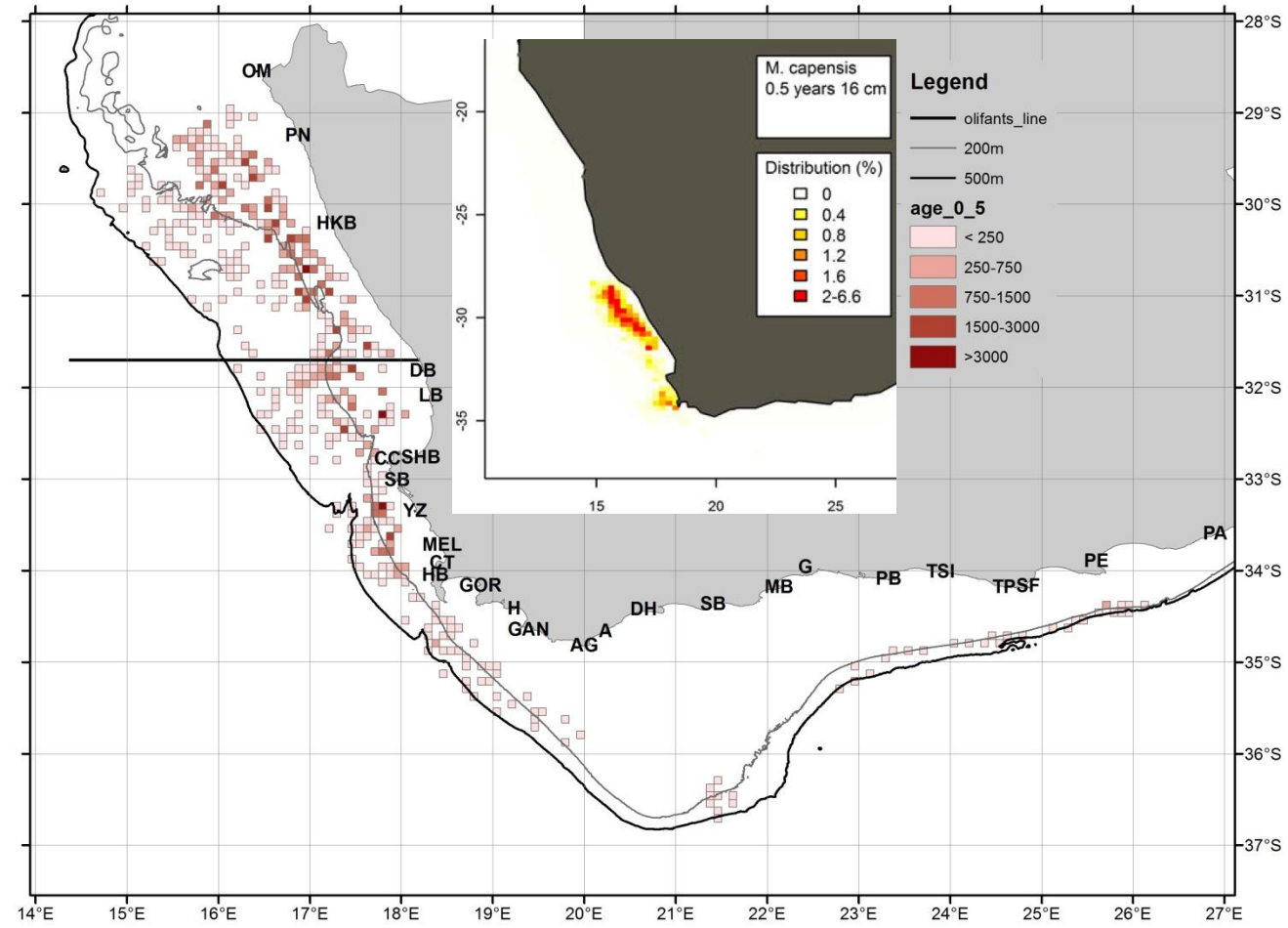
Interpreting the results given in Figures 1 and 2

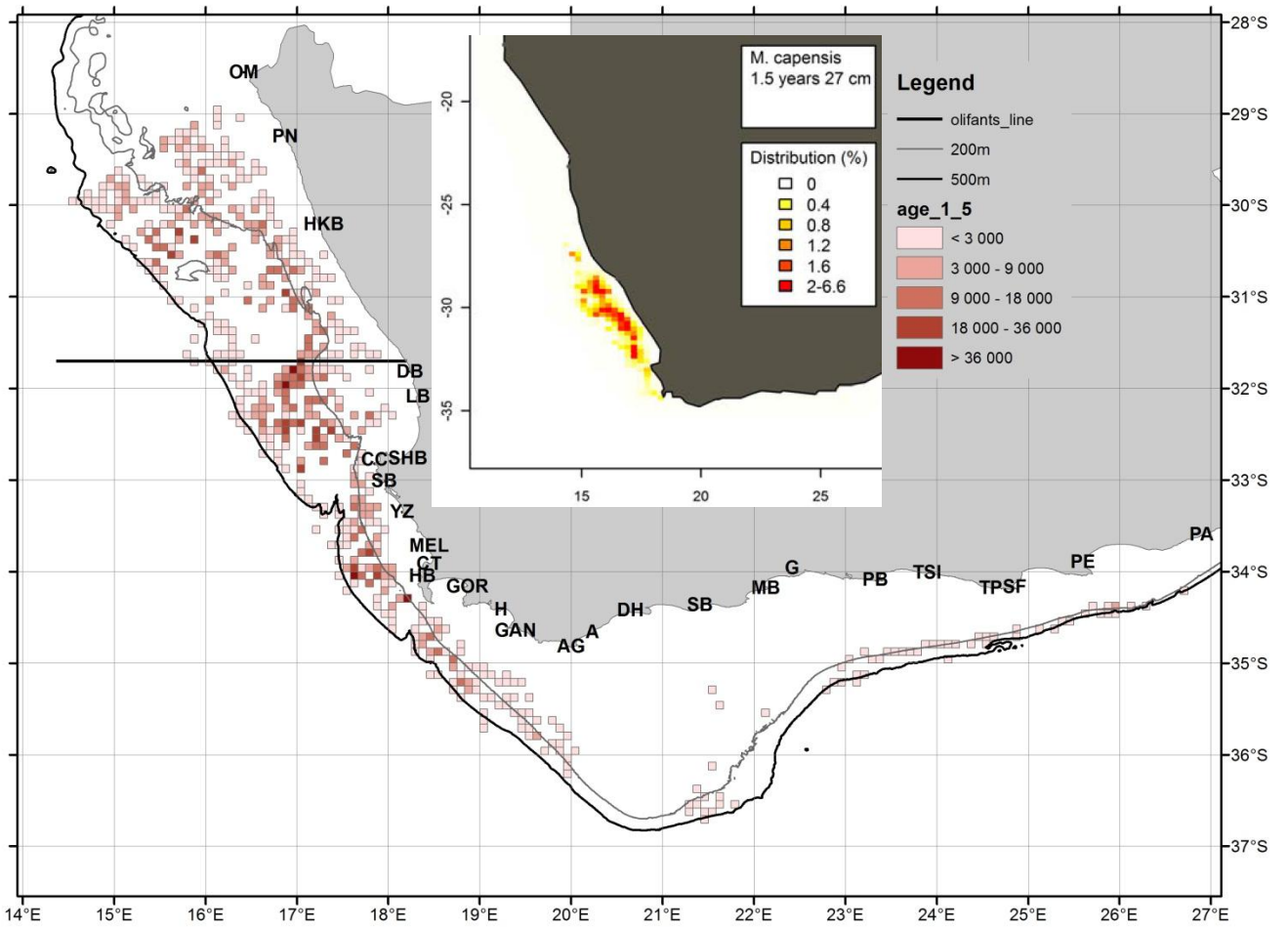
As discussed above the age distribution for M. paradoxus is possibly incorrect but time constraints and a need for "comparability" required the analysis continue despite the potential error. Rademeyer (pers comm) suggested it was unlikely to have a major effect.

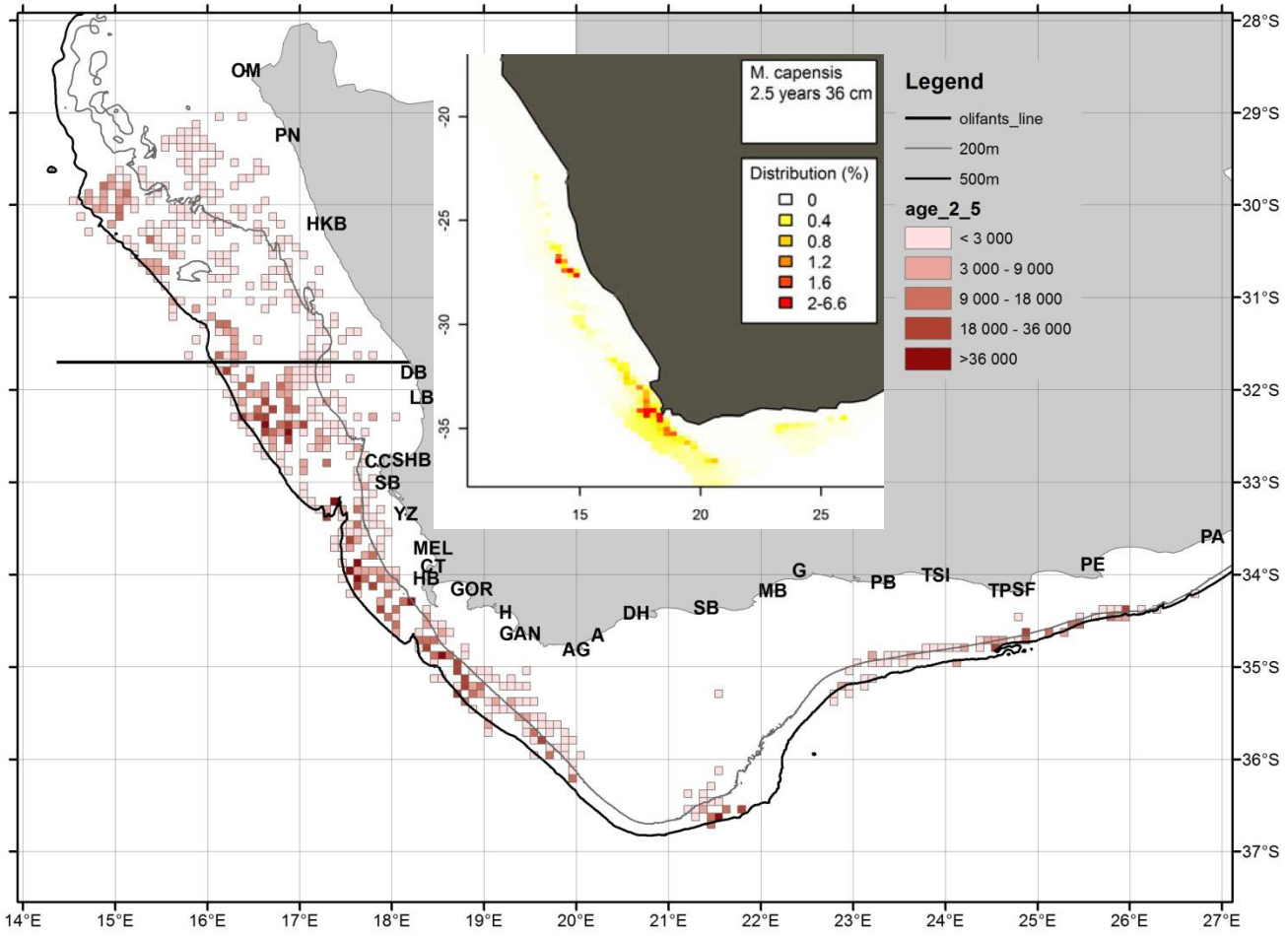
The map inserts from Jansen et al (P6 & P7) include Namibia whereas the main maps do not.

Please note, there is definitely survey information well past Port Elizabeth which is the "end point" in the Figure 8 of P7.

Figure 1: Average density (kg/nm2) of *Merluccius paradoxus* for 1999-2012 per grid block and age group, inserts copied from Jansen *et al* (MARAM IWS/DEC13/Ecofish/P7) **NOTE** the "M.capensis" text in the legend is an editing error by Jansen et al.






M. capensis
2.5 years 36 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-6.6
Legend
olifants_line
200m
500m
age_2_5
< 3 000
3 000 - 9 000
9 000 - 18 000
18 000 - 36 000
>36 000
OM
PN
HKB
DB
LB
CCSHB
SB
YZ
MEL
CT
HB
GOR
H
GAN
AG
A
DH
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MB
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PB
TSI
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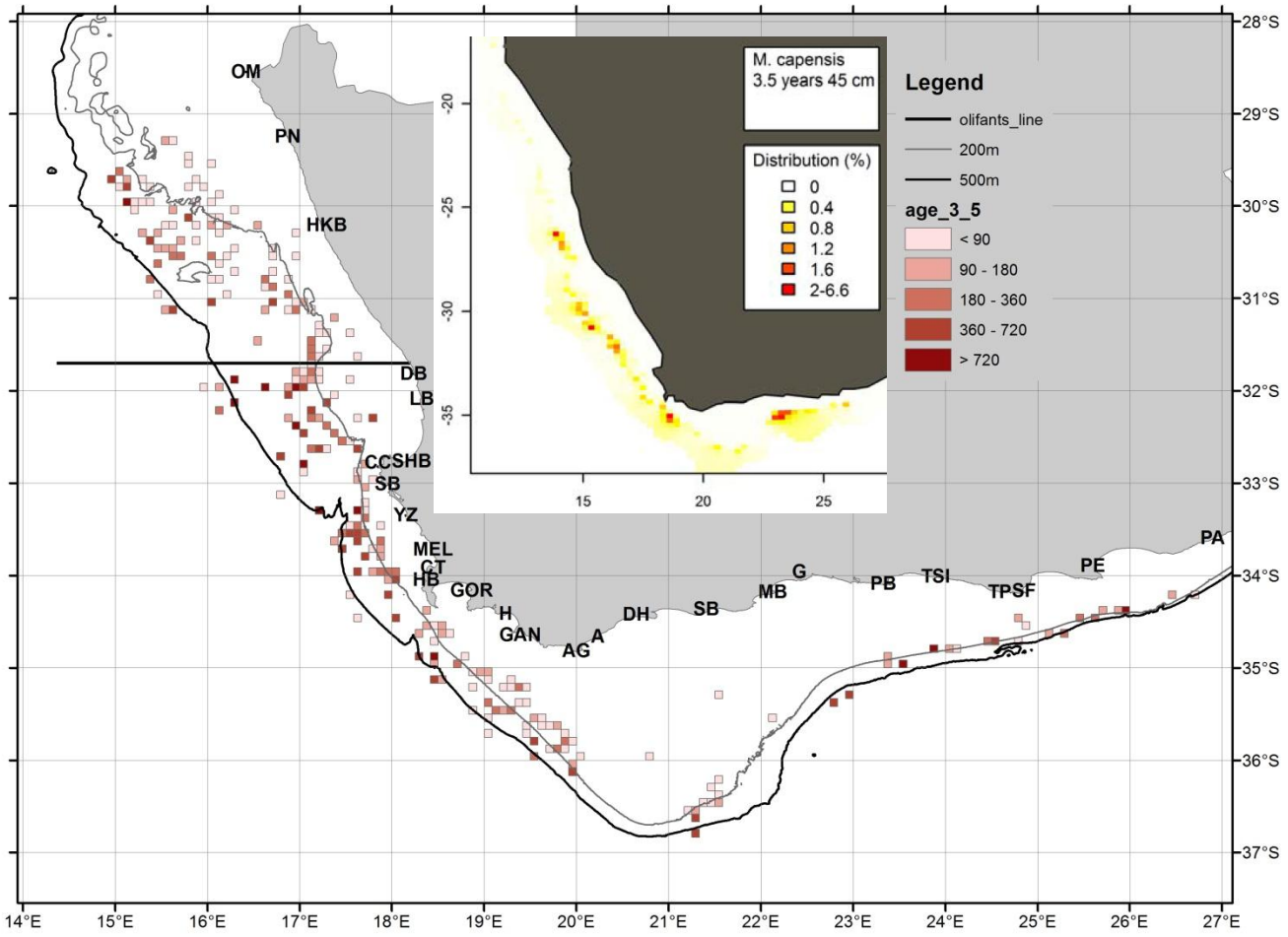
PE
PA


M. capensis
3.5 years 45 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-6.6
Legend
olifants_line
200m
500m
age_3_5
< 90
90 - 180
180 - 360
360 - 720
> 720
OM
PN
HKB
DB
LB
CCSHB
SB
YZ
MEL
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HB
GOR
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TSI
TPSF
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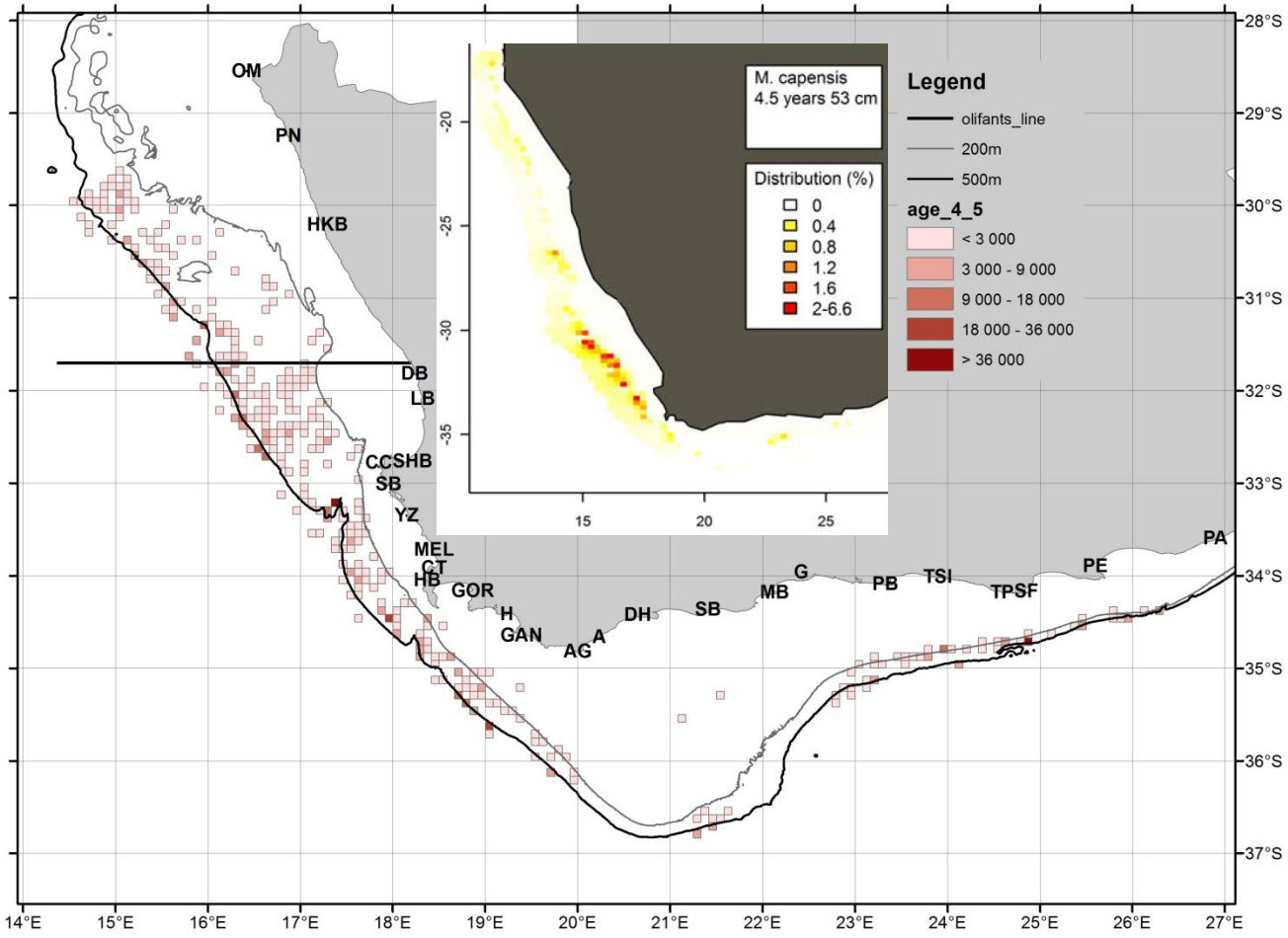
M. capensis
4.5 years 53 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-6.6
Legend
olifants_line
200m
500m
age_4_5
< 3 000
3 000 - 9 000
9 000 - 18 000
18 000 - 36 000
> 36 000
OM
PN
HKB
DB
LB
CCSHB
SB
YZ
MEL
CT
HB
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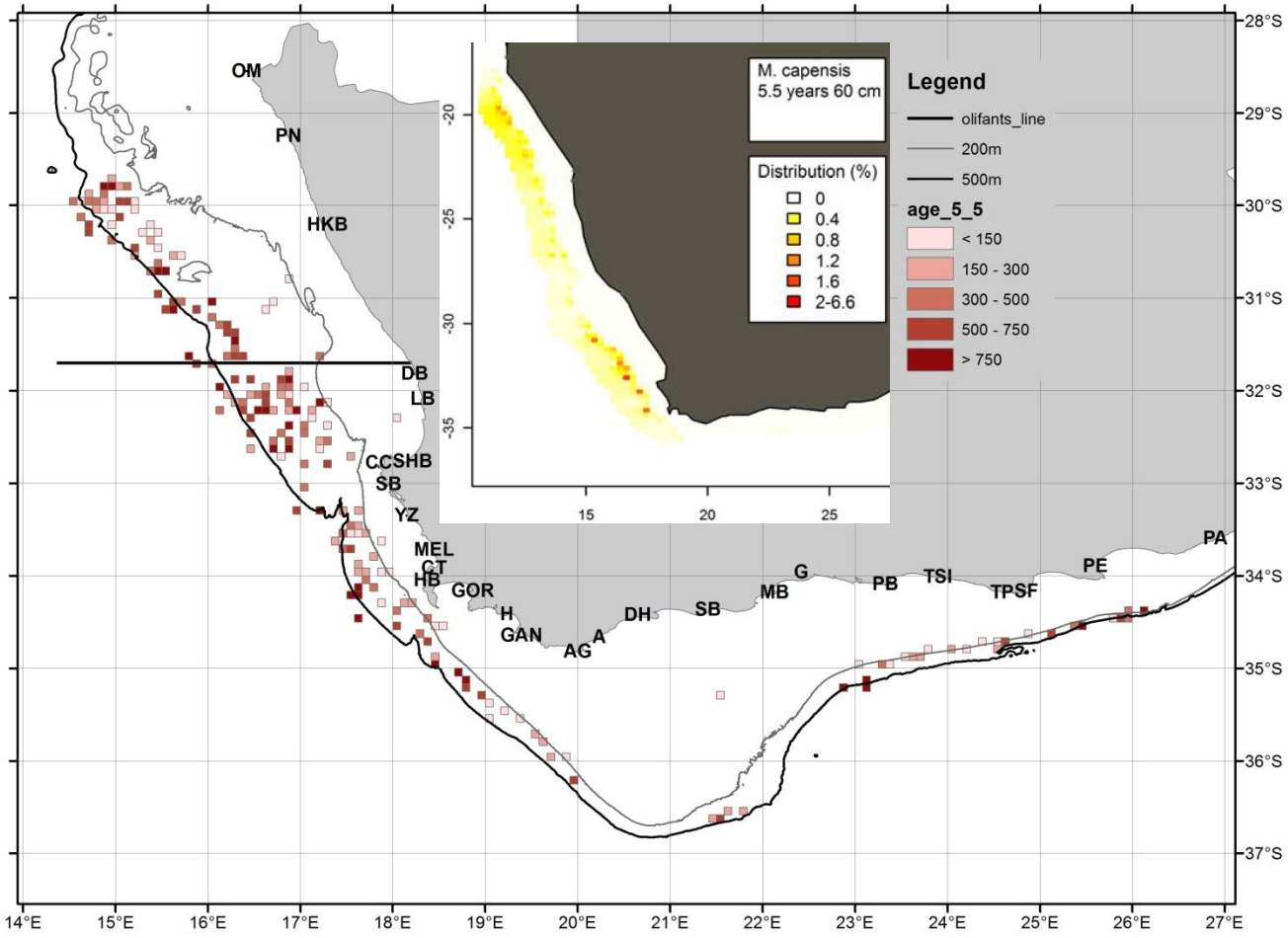
M. capensis
5.5 years 60 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-6.6
Legend
olifants_line
200m
500m
age_5_5
< 150
150 - 300
300 - 500
500 - 750
> 750
OM
PN
HKB
DB
LB
CCSHB
SB
YZ
MEL
CT
HB
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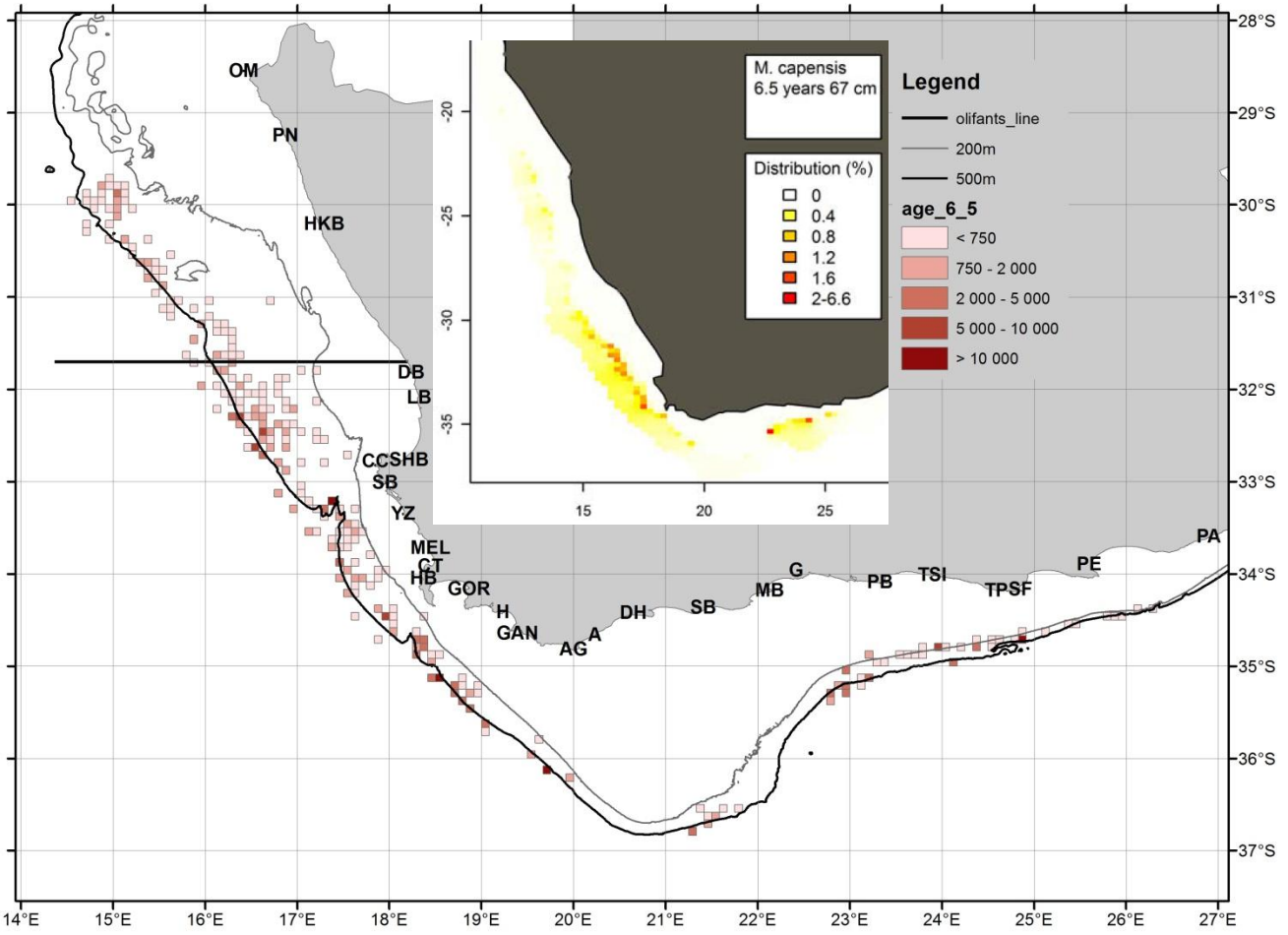
M. capensis
6.5 years 67 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-6.6
Legend
olifants_line
200m
500m
age_6_5
< 750
750 - 2 000
2 000 - 5 000
5 000 - 10 000
> 10 000
OM
PN
HKB
DB
LB
CCSHB
SB
YZ
MEL
CT
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GOR
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28°S
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30°S
31°S
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33°S
34°S
35°S
36°S
37°S
14°E
15°E
16°E
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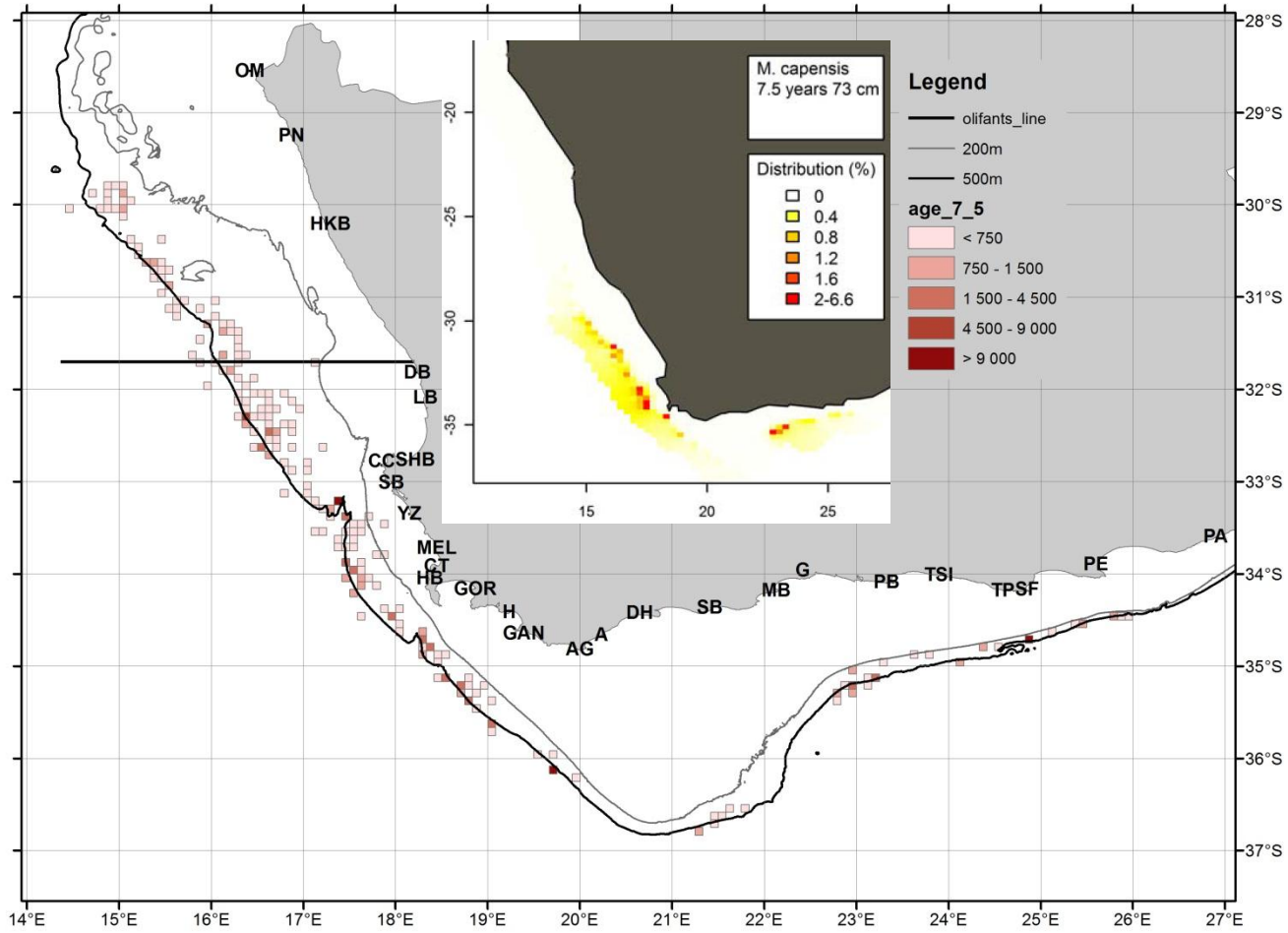
23°E
24°E
25°E
26°E
27°E


M. capensis
7.5 years 73 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-6.6
Legend
olifants_line
200m
500m
age_7_5
< 750
750 - 1 500
1 500 - 4 500
4 500 - 9 000
> 9 000
OM
PN
HKB
DB
LB
CCSHB
SB
YZ
MEL
CT
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GOR
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GAN
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TSI
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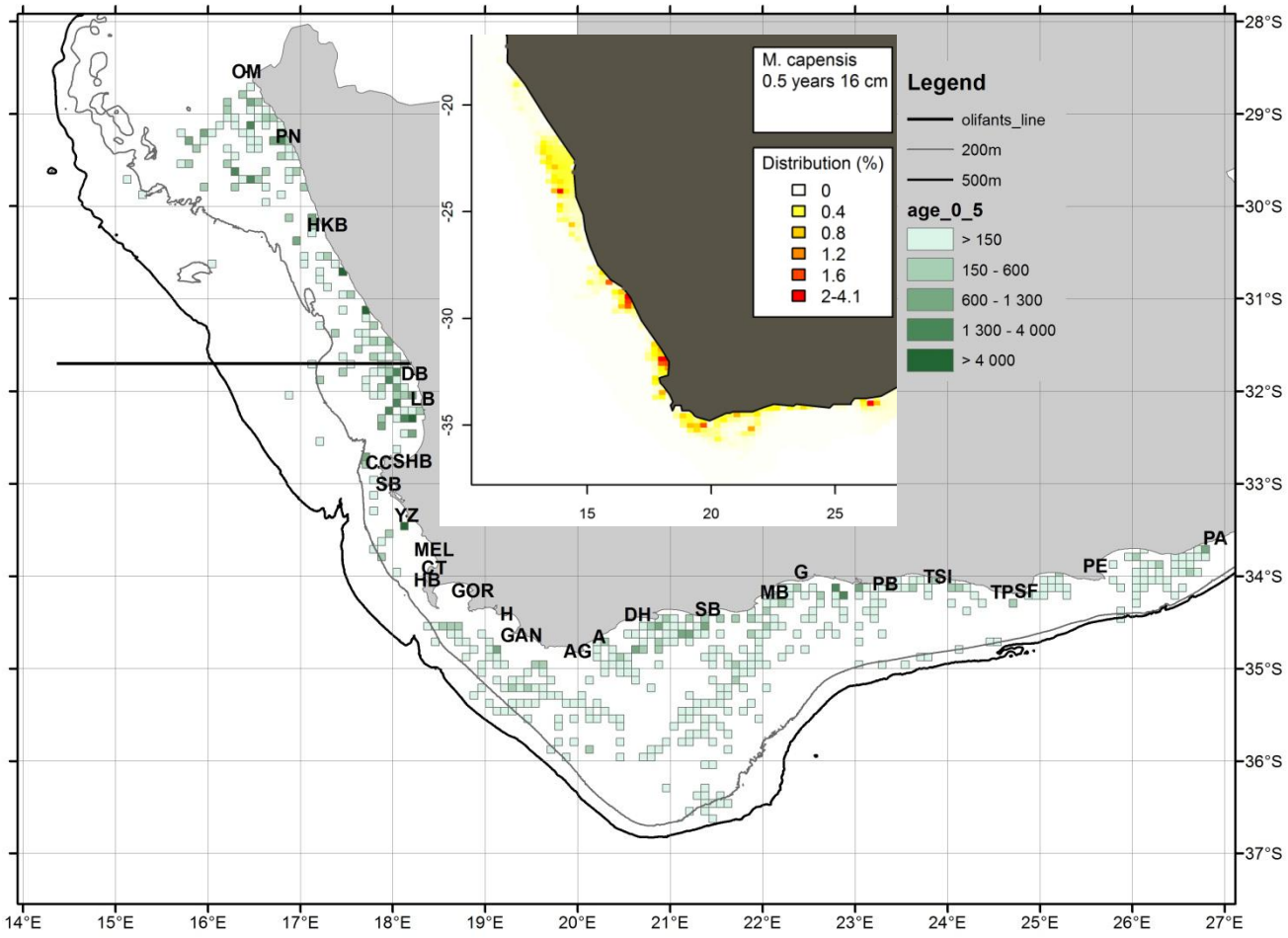
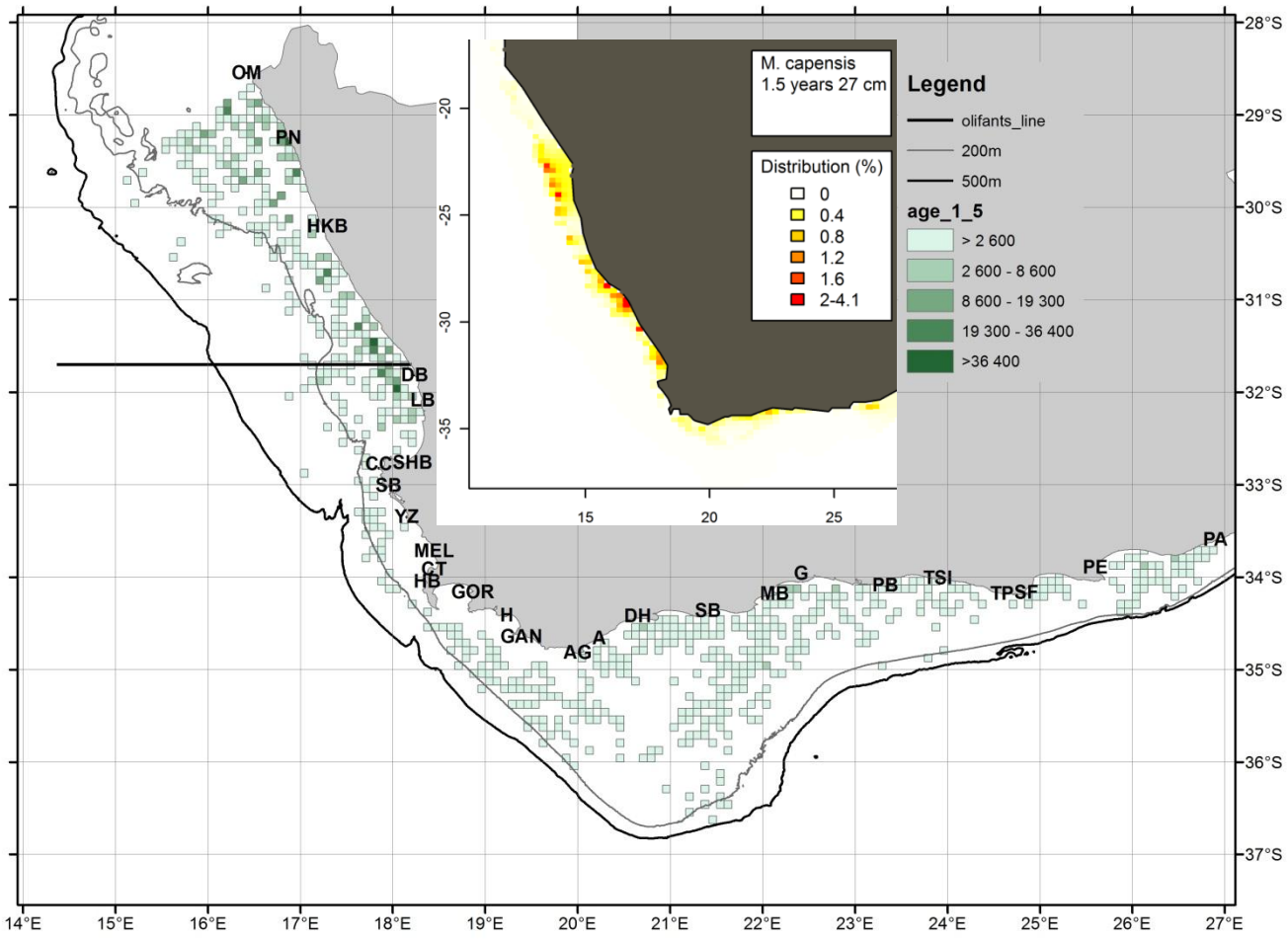
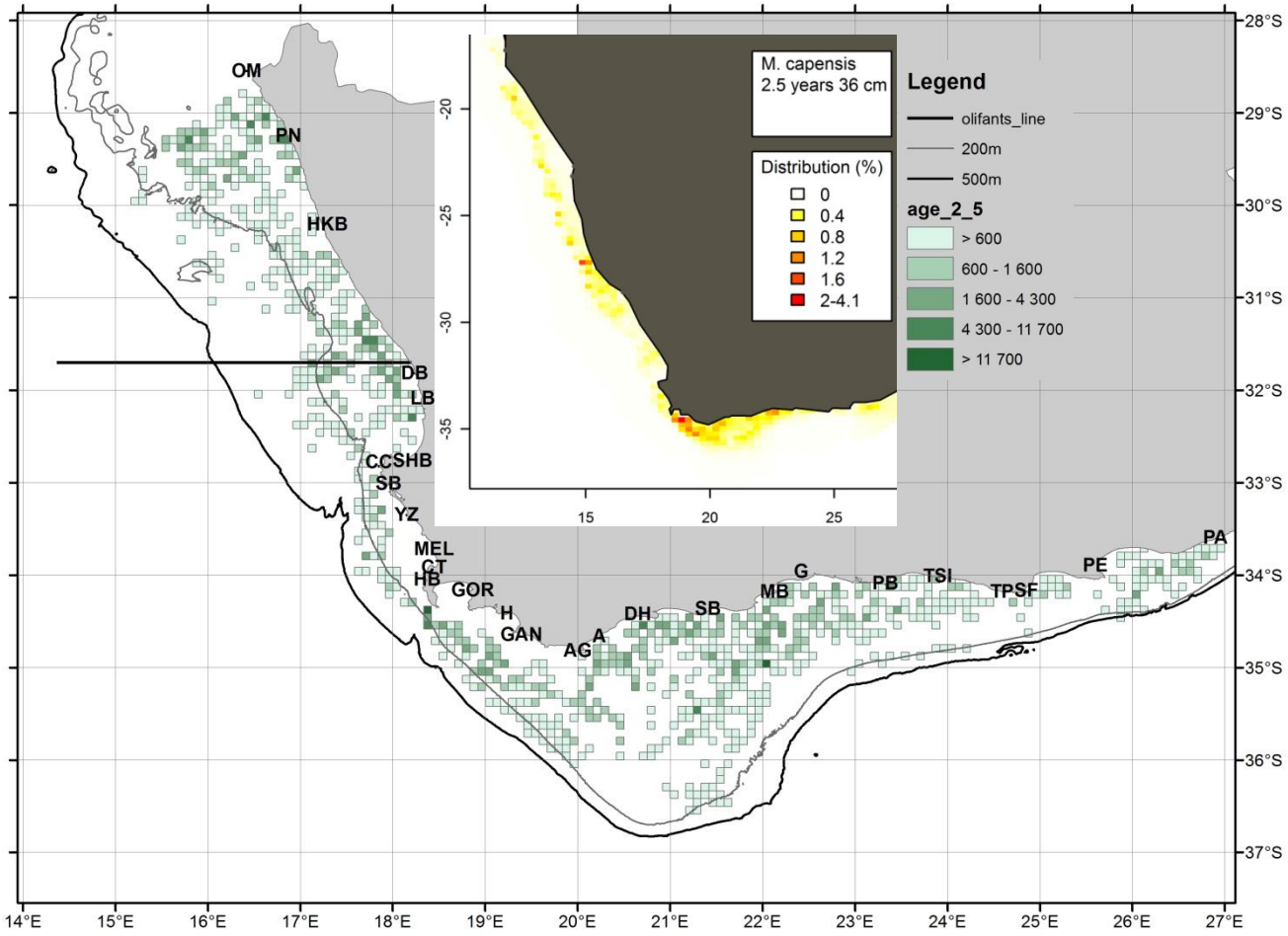
PE
PA
28°S
29°S
30°S
31°S
32°S
33°S
34°S
35°S
36°S
37°S
14°E
15°E
16°E
17°E
18°E
19°E
20°E
21°E
22°E
23°E
24°E
25°E
26°E
27°E

Figure 2: Average density (kg/nm2) of *Merluccius capensis* for 1999-2012 per grid block and age group, inserts copied from Jansen *et al* (MARAM IWS/DEC13/Ecofish/P6).






M. capensis
2.5 years 36 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-4.1
Legend
olifants_line
200m
500m
age_2_5
> 600
600 - 1 600
1 600 - 4 300
4 300 - 11 700
> 11 700
OM
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CCSHB
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30°S
31°S
32°S
33°S
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37°S
14°E
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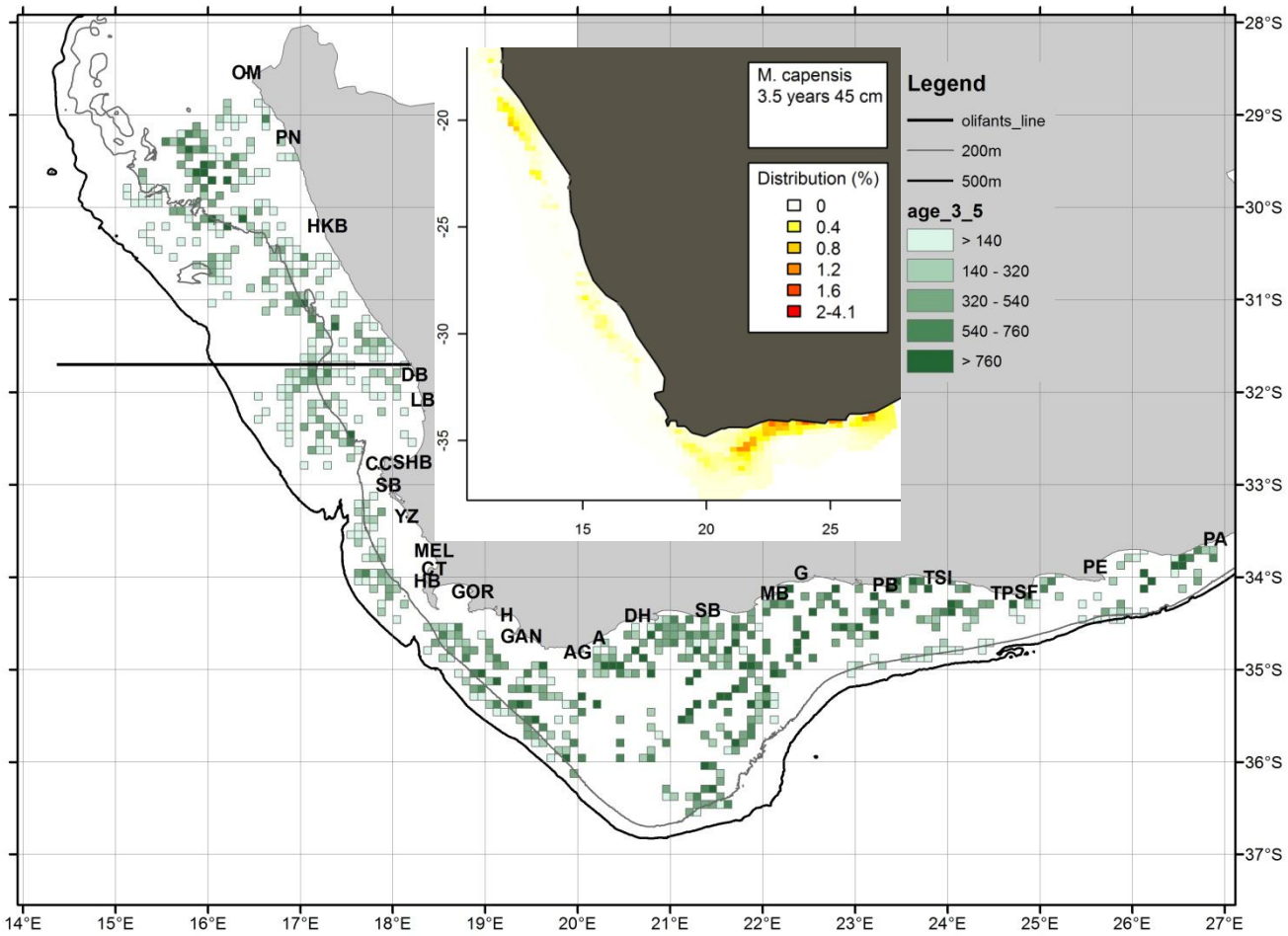
25°E
26°E
27°E


M. capensis
3.5 years 45 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-4.1
Legend
olifants_line
200m
500m
age_3_5
> 140
140 - 320
320 - 540
540 - 760
> 760
OM
PN
HKB
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LB
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33°S
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35°S
36°S
37°S
14°E
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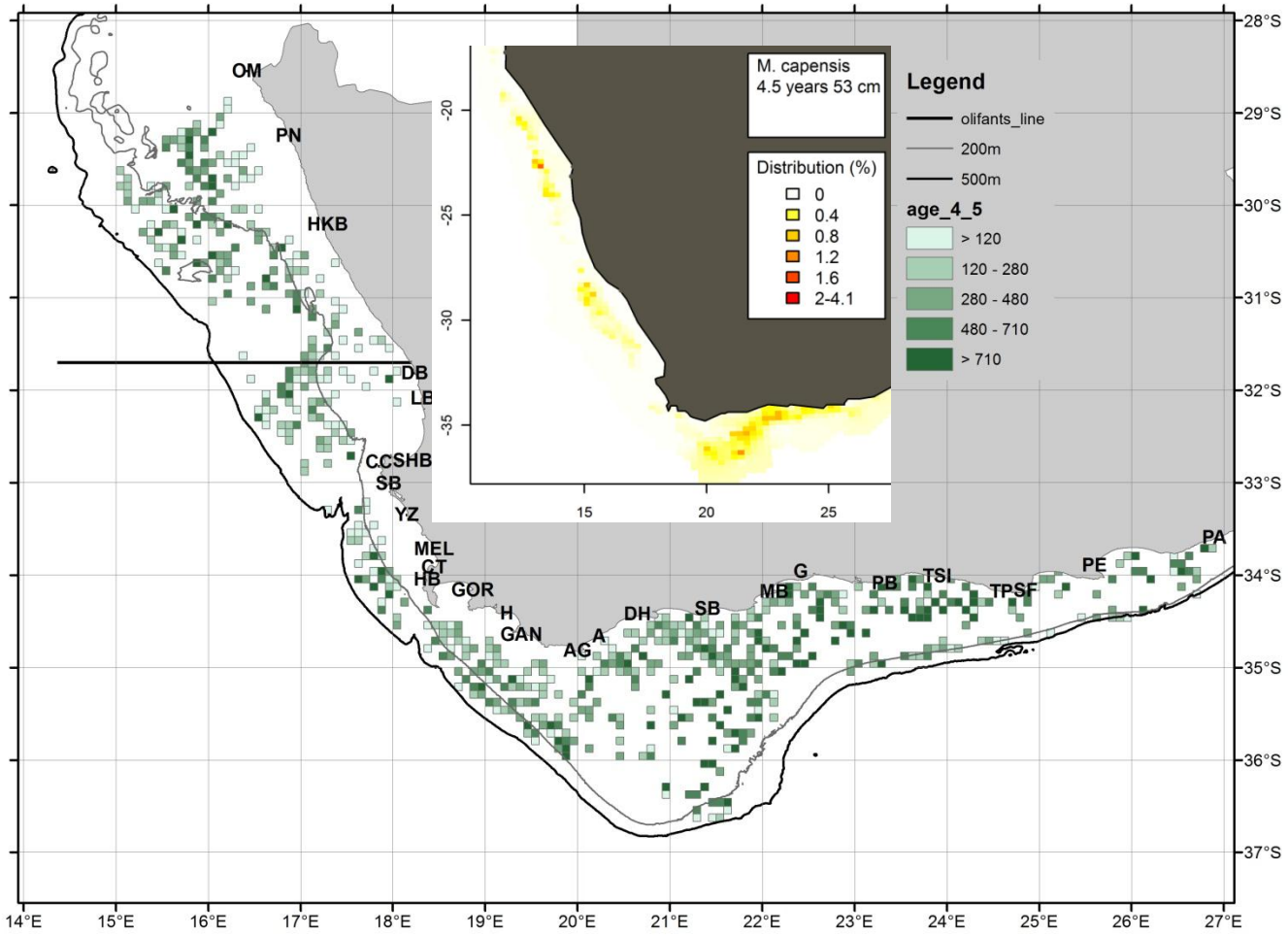
M. capensis
4.5 years 53 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-4.1
Legend
olifants_line
200m
500m
age_4_5
> 120
120 - 280
280 - 480
480 - 710
> 710
OM
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24°E
25°E
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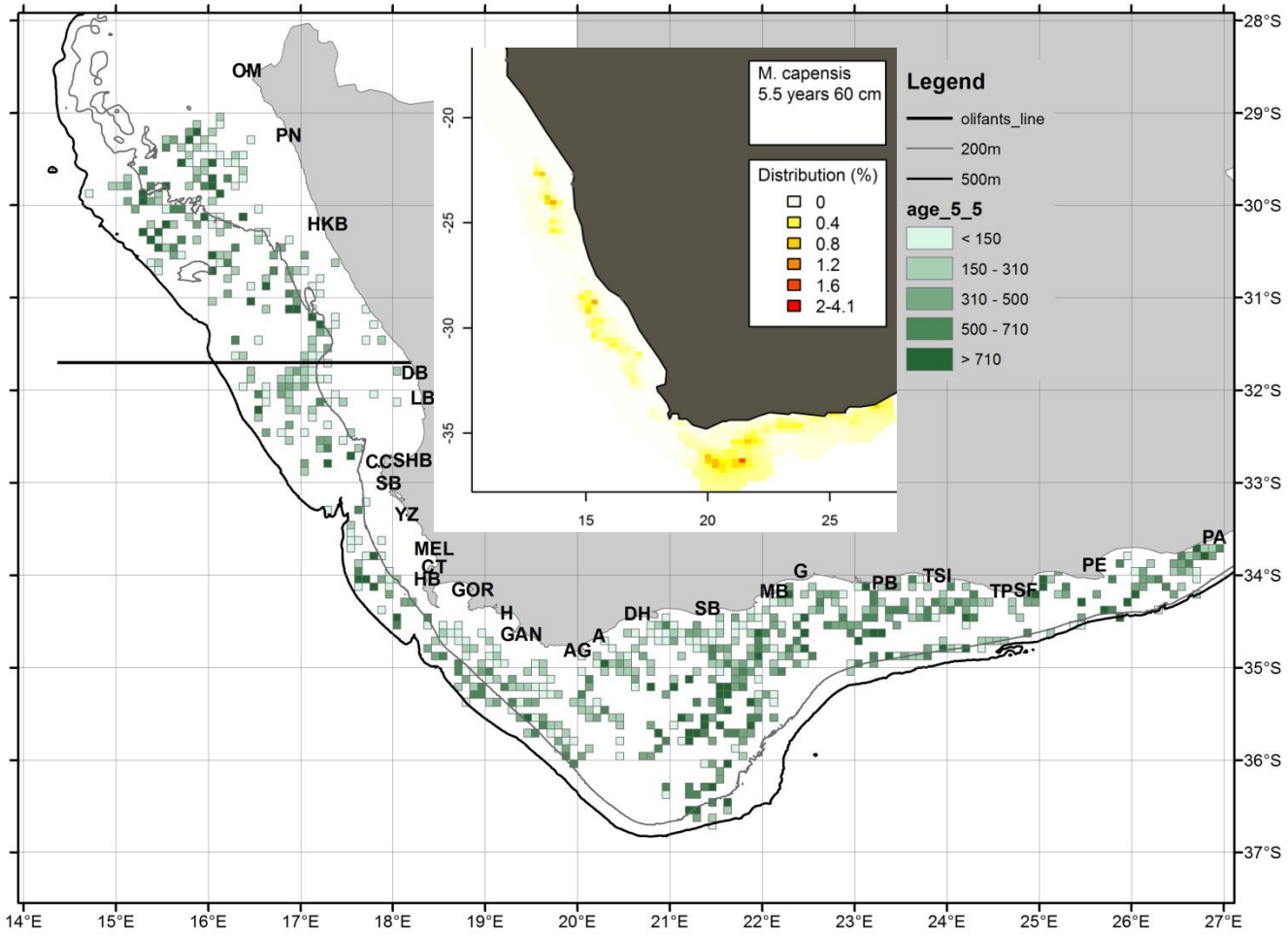
M. capensis
5.5 years 60 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-4.1
Legend
olifants_line
200m
500m
age_5_5
< 150
150 - 310
310 - 500
500 - 710
> 710
OM
PN
HKB
DB
LB
CCSHB
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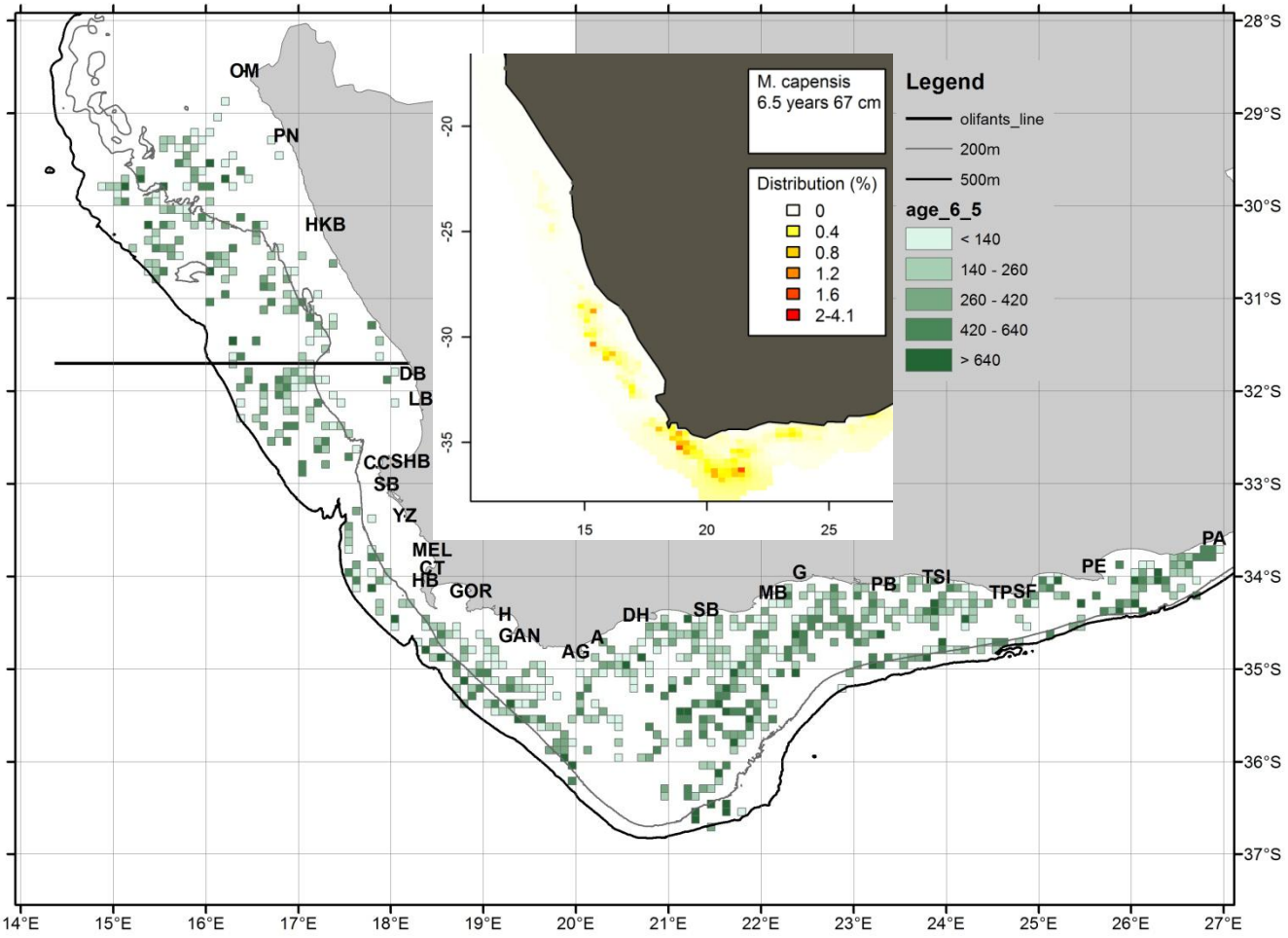
M. capensis
6.5 years 67 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-4.1
Legend
olifants_line
200m
500m
age_6_5
< 140
140 - 260
260 - 420
420 - 640
> 640
OM
PN
HKB
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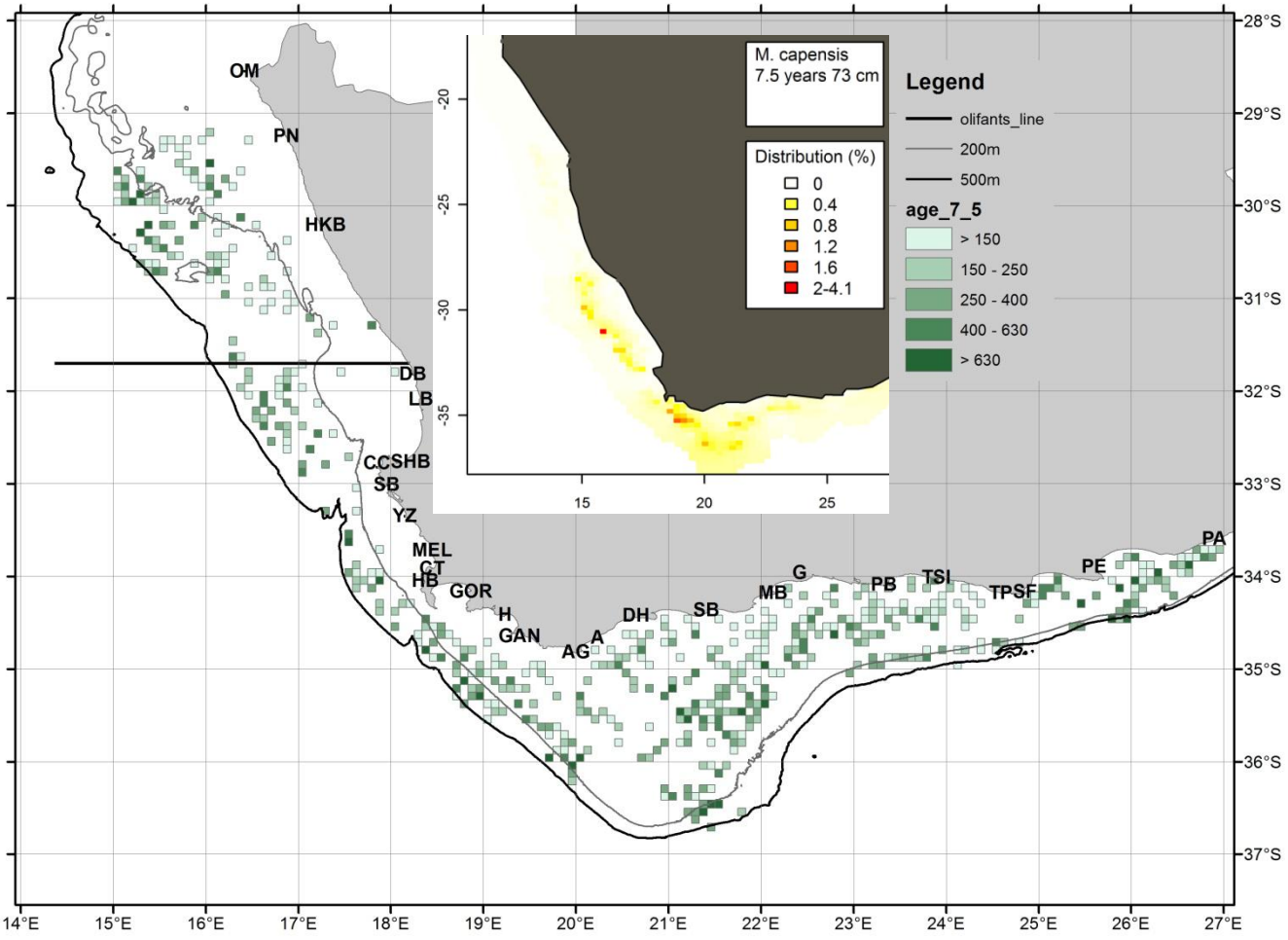
M. capensis
7.5 years 73 cm
Distribution (%)
0
0.4
0.8
1.2
1.6
2-4.1
Legend
olifants_line
200m
500m
age_7_5
> 150
150 - 250
250 - 400
400 - 630
> 630
OM
PN
HKB
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27°E