Supplementary material

Otolith microchemistry: a useful tool for investigating stock structure of yellowfin tuna (*Thunnus albacares*) in the Indian Ocean

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Table S1. Summary of element : Ca precision and accuracy for standards analysed in this study; MACS3, NIST610

Measurement precision are shown as percentage relative standard deviation (RSD) and accuracy percentage. The last was calculated by dividing the averages to preferred 2011 values from the GEOREM website (http://georem.mpch-mainz.gwdg.de/; Jochum *et al.* 2005)

Standard	Measure	^{7}Li	^{25}Mg	^{55}Mn	^{57}Fe	^{59}Co	^{60}Ni	^{63}Cu	^{66}Zn	^{88}Sr	^{138}Ba
MACS3	RSD (%)	4	4	3	14	5	7	3	6	4	3
	Accuracy (%)	107	116	106	49	103	117	101	100	105	103
NIST610	RSD (%)	1	1	1	13	1	1	2	2	1	1
	Accuracy (%)	103	124	104	54	105	104	98	101	100	101

Table S2.   In order to ascertain the level of interannual variability in the studied area, spatial structure similarity was examined for the periods of interest; 2008 and 2009 summer monsoons (i.e. May–Oct), estimated period at which YOY fish were born

For that EU Copernicus Marine Service Information on sea surface salinity (SSS), sea surface temperature (SST), mixed layer thickness (MLD), mass concentration of chlorophyll-*a* in seawater (CHL) and dissolved molecular oxygen concentration (DO_2) were explored in the 20°N-30°S and 30°E-70°E area at a spatial resolution of $0.25 \times 0.25°$ grid. Daily data of SSS (PSU), SST (K) and MLD (m) was obtained from the '*GLOBAL_REANALYSIS_PHY_001_025*' dataset. Daily data of CHL (mg m^{-3}) and DO_2 (mmol m^{-3}) was obtained from '*GLOBAL_REANALYSIS_BIO_001_029*' dataset. The value of each parameter at each grid was then averaged for each corresponding period of interest. Resultant matrixes were converted into a raster object using '*rasterFromXYZ*' function from '*raster*' package (R. J. Hijmans *et al.*; see https://CRAN.R-project.org/package=raster, accessed January 2019). Two measures of spatial similarity Schoener's *D* (Schoener 1968) and Warren's *I* (Warren *et al*. 2008), were calculated using '*nicheOverlap*' function of the '*dismo*' package (R. J. Hijmans, S. Phillips, J. Leathwick, and J. Elith; see https://cran.r-project.org/web/packages/dismo/dismo.pdf, accessed January 2019). In addition, the overall correlation between raster layers was assessed using Pearson's (*r*) and Spearman' (*ρ*) correlation coefficients

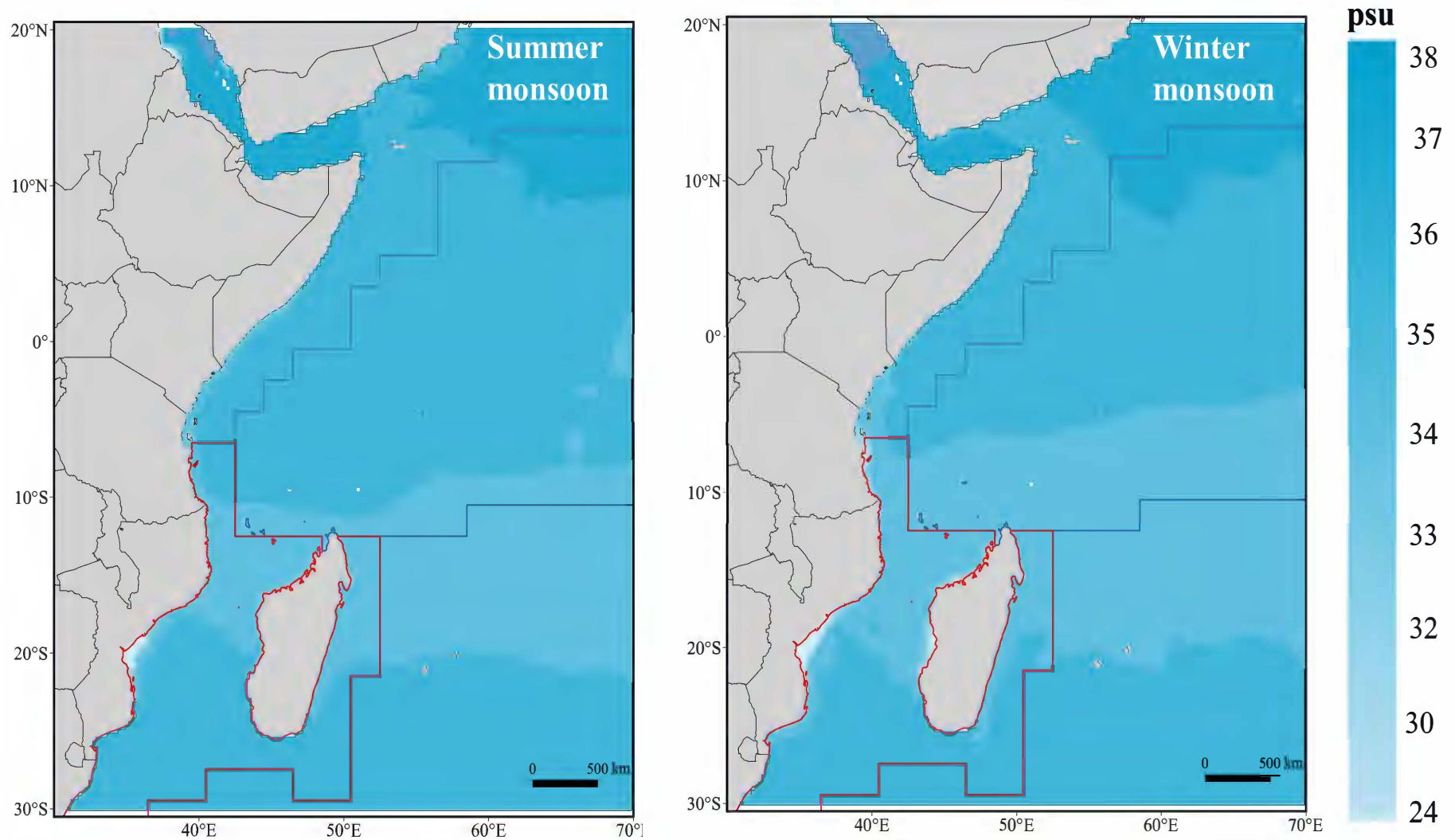| Parameter	Unit	Schoener's *D*	Warren's *I*	Pearson *r*	Spearman *ρ*
SSS	PSU	0.998	1.000	0.957	0.917
SST	K	1.000	1.000	0.987	0.985
MLD	m	0.936	0.996	0.850	0.849
CHL	mg m^{-3}	0.890	0.990	0.930	0.909
DO_2	mmol m^{-3}	1.000	1.000	0.987	0.977

Fig. S1. Mean sea surface salinity (SSS) in the western Indian Ocean within the studied period. Maps are differentiated for summer monsoon (May–Oct 2008 and May–Oct 2009) and winter monsoon (Nov–Apr 2008–09 and Nov–Apr 2009–10). Daily data of SSS (PSU) was obtained from the '*GLOBAL_REANALYSIS_PHY_001_025*' dataset available in the EU Copernicus Marine Service Information.
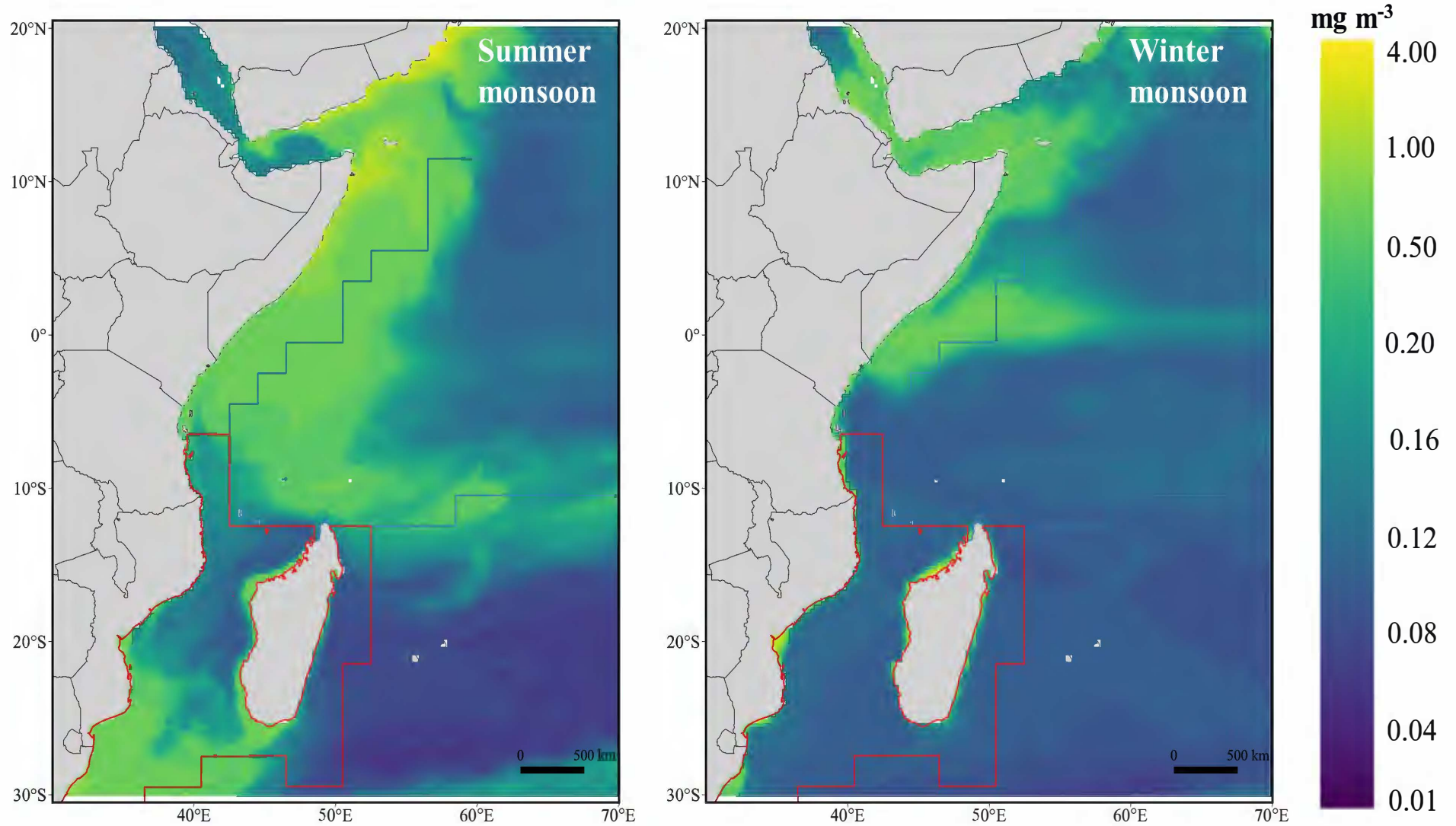
Fig. S2. Mean sea surface chlorophyll (Chl-*a*) in the western Indian Ocean within the studied period. Maps are differentiated for summer monsoon (May–Oct 2008 and 2009) and winter monsoon (Nov–Apr 2008–09 and Nov–Apr 2009–10). Daily data of Chl-*a* (mg m^{-3}) was obtained from the '*GLOBAL_REANALYSIS_BIO_001_029*' dataset available in the EU Copernicus Marine Service Information.
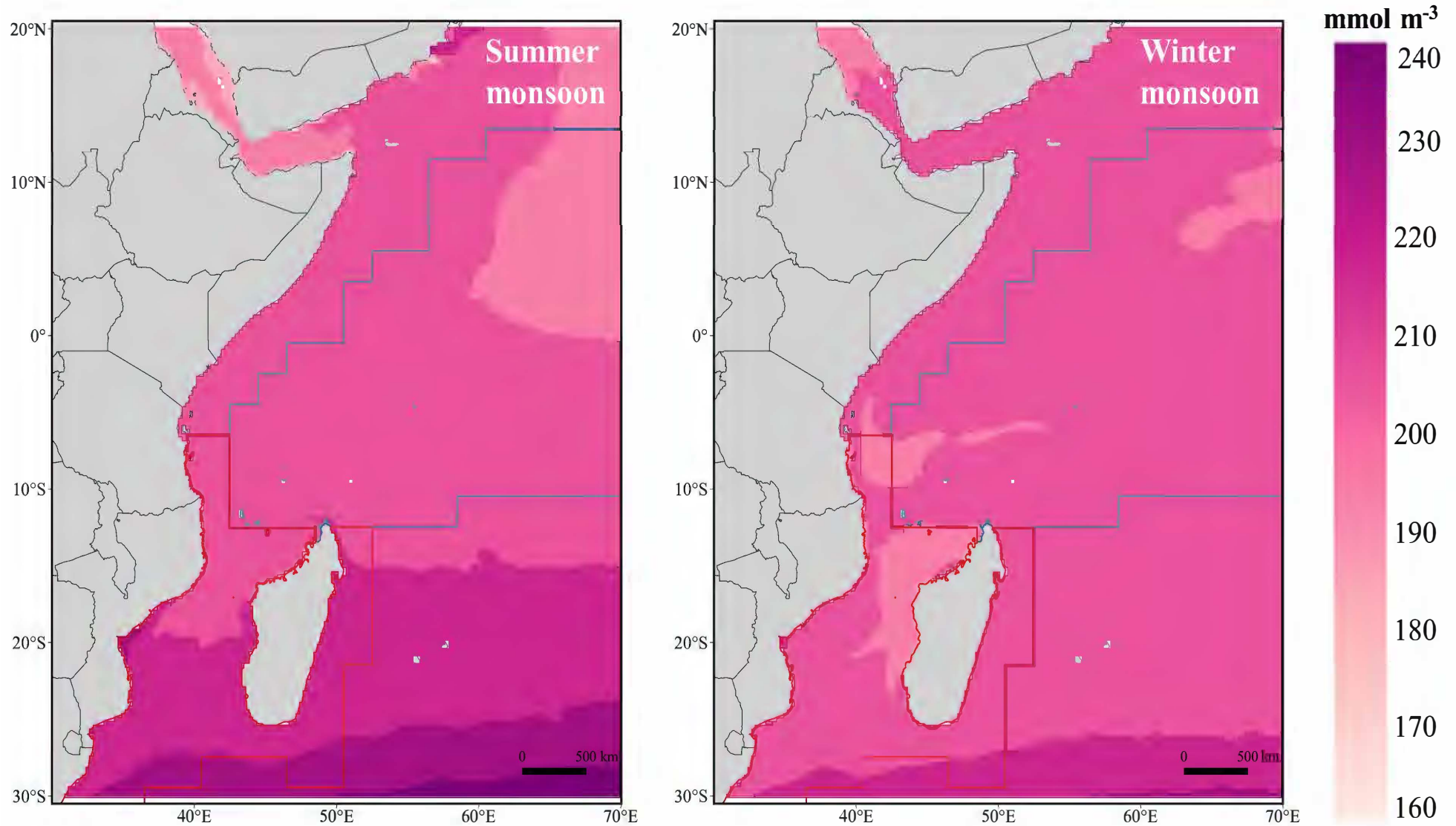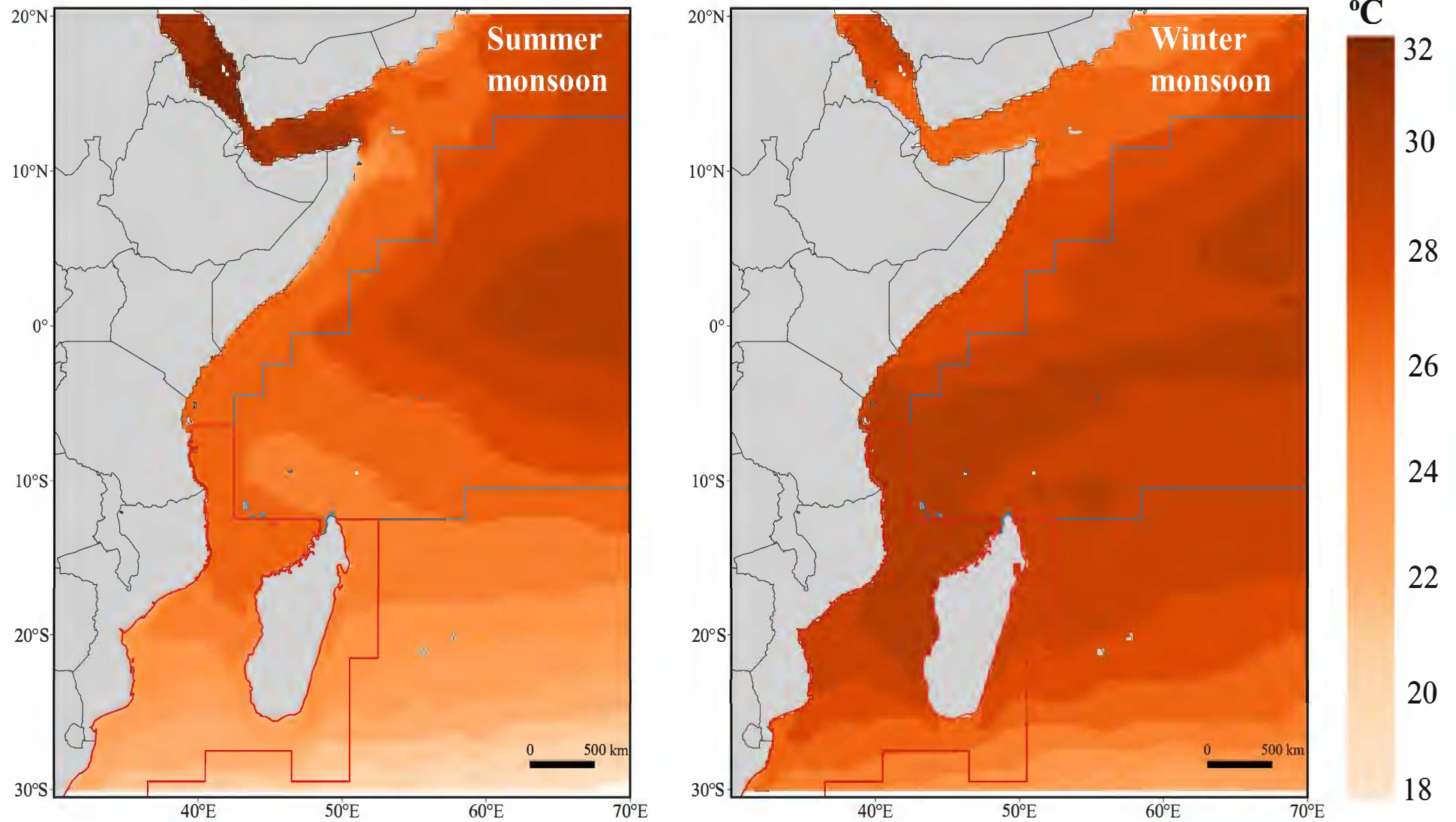
Fig. S3. Mean sea surface dissolved molecular oxygen concentration (DO_2) in the western Indian Ocean within the studied period. Maps are differentiated for summer monsoon (May–Oct 2008 and 2009) and winter monsoon (Nov–Apr 2008–09 and Nov–Apr 2009–10). Daily data of DO_2 (mmol m^{-3}) was obtained from the '*GLOBAL_REANALYSIS_BIO_001_029*' dataset available in the EU Copernicus Marine Service Information.

Fig. S4. Mean sea surface temperature (SST) in the western Indian Ocean within the studied period. Maps are differentiated for summer monsoon (May–Oct 2008 and 2009) and winter monsoon (Nov–Apr 2008–09 and Nov–Apr 2009–10). Daily data of SST (°C) was obtained from the '*GLOBAL_REANALYSIS_PHY_001_025*' dataset available in the EU Copernicus Marine Service Information.
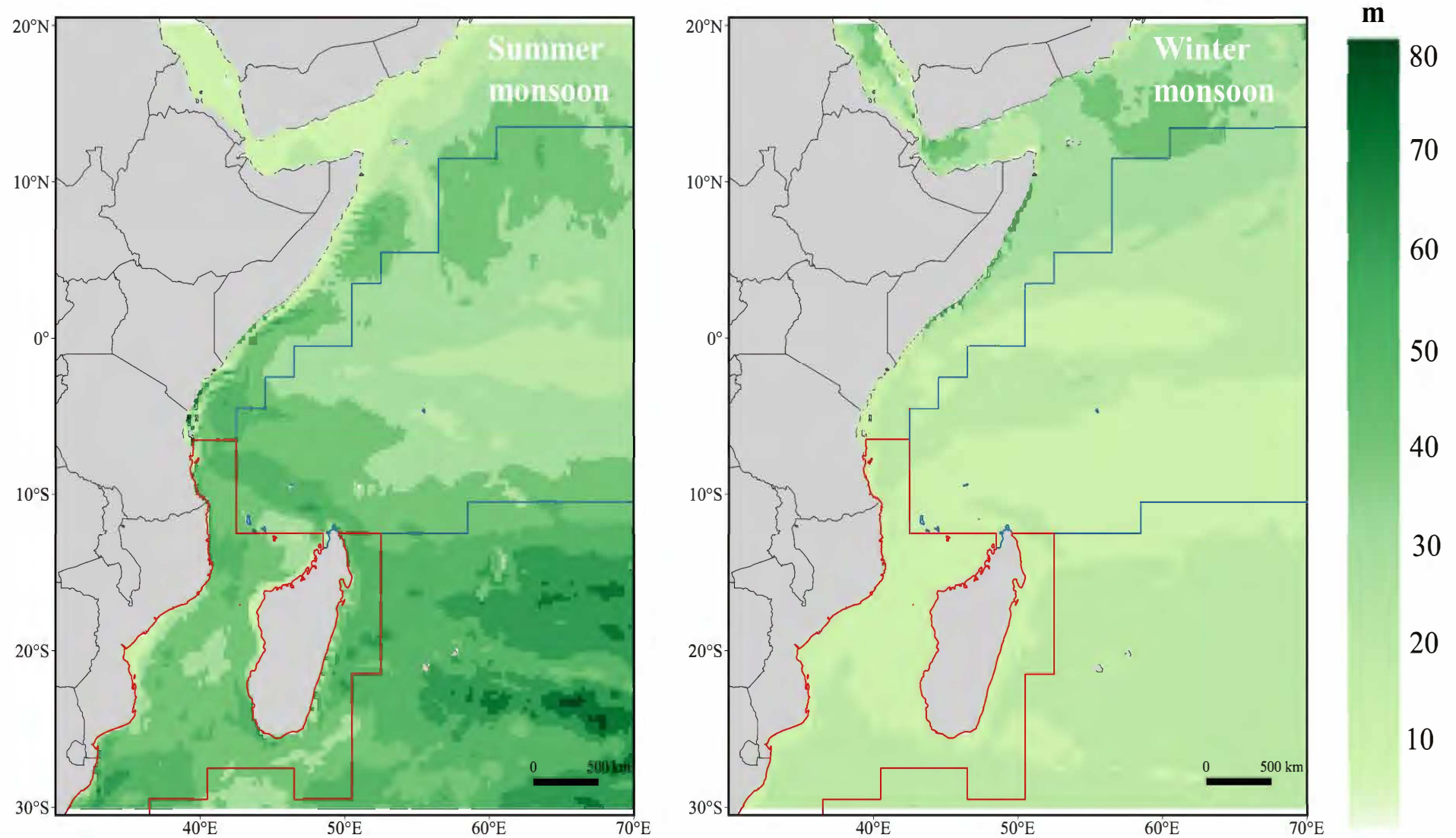
Fig. S5. Mean mixed layer depth (MLD) in the western Indian Ocean within the studied period. Maps are differentiated for summer monsoon (May–Oct 2008 and 2009) and winter monsoon (Nov–Apr 2008–09 and Nov–Apr 2009–10). Daily data of MLD (m) was obtained from the '*GLOBAL_REANALYSIS_PHY_001_025*' dataset available in the EU Copernicus Marine Service Information.
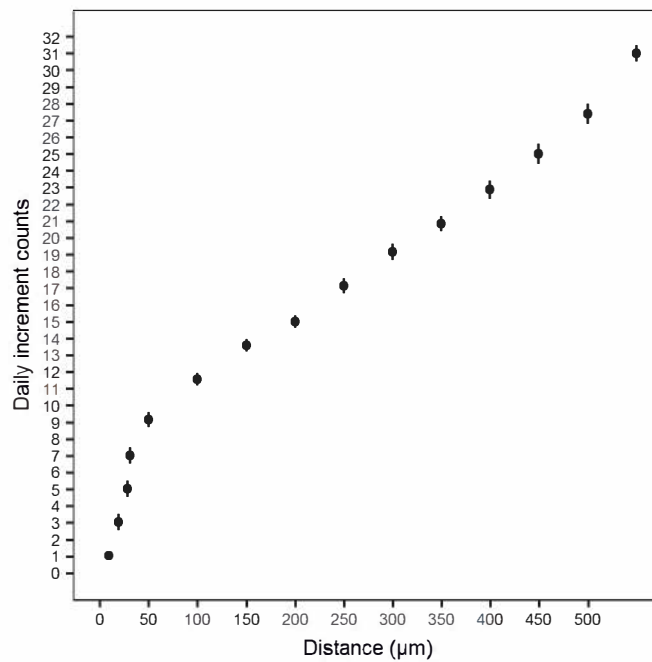
Fig. S6. The relationship between the micro-increment counts and the distance from the primordium (μm) measured along the growth axis of the otolith in young-of-the-year (YOY) yellowfin tuna (*Thunnus albacares*, n = 8). Points represent mean count estimates, and bars standard errors.
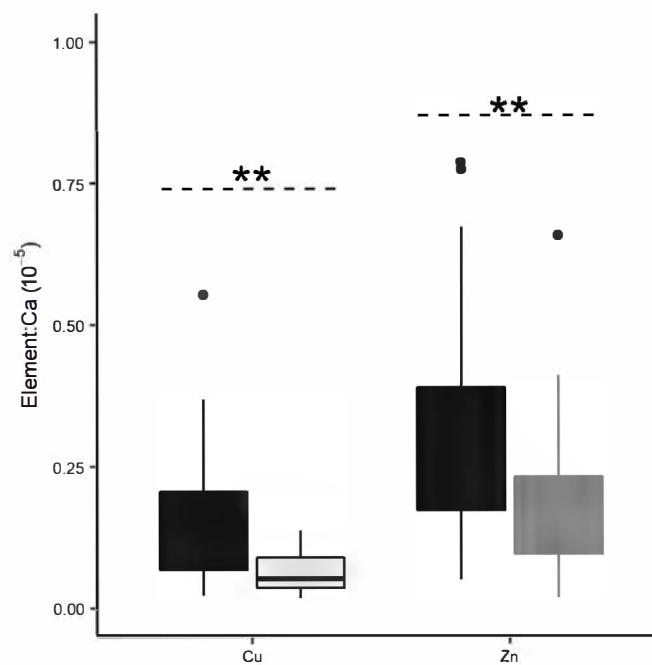

Fig. S7. Otolith core (black) and near-core (grey) Cu:Ca and Zn:Ca ratios for young-of-the-year (YOY) yellowfin tuna (*Thunnus albacares*) collected in the western Indian Ocean. Boxes, interquartile range (25th and 75th percentiles); midline, median; error bars, range (excluding outliers, dots). Asterisks indicate the significance differences between otolith portions according to bootstrapped Yuen *t*-tests (*, $P < 0.05$; **, $P < 0.01$).

References

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