

Assessing the non-stationary spatial effects of environmental conditions on *Illex argentinus* in the Patagonian region



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Introduce

- Spatial relationships between species distribution and the environment can be non-stationary.
- Complex topography and heterogeneous marine environments characterize the Patagonian Shelf and adjacent waters, fostering high productivity.
- The spatial distribution pattern of *Illex argentinus* exhibits significant heterogeneity, with its abundance also showing pronounced unevenness.
- Local models are more effective in unraveling the spatially non-stationary relationship between *Illex argentinus* and environment.

Method

1) Multicollinearity analysis

2) Generalized additive model (GAM)

- Species-environment non-linearity
- Key factor identification

$$y = \beta_0 + s(x_j) + \varepsilon$$

where y is the response variable, β_0 is the intercept, s is the smoothing function, x_j represents the j -th covariate.

3) Multi-scale geographically weighted regression (MGWR) model

- Spatially Varying Relationships
- Capturing Multi-scale Processes

$$y_i = \beta_0(u_i, v_i) + \sum_{j=1}^k \beta_{bwj}(u_i, v_i) x_{ij} + \varepsilon_i$$

where (u_i, v_i) are the coordinates of sample point i , $\beta_j(u_i, v_i)$ represents the local regression, the bw represents the bandwidth.

Result

1) Identification of key environmental factors

Table 1. GAM results for *I. argentinus* CPUE and environmental variables.

Factor	AIC Value	Variance Explained%	R ²	p
SSH	12186.63	14.9	0.147	0.000
T50m	12460.47	6.74	0.065	0.000
Chl- a	12412.77	8.22	0.080	0.000
SSH+T50m+Chl- a +SSS	11944.20	23.0	0.221	—
SSH+T50m+Chl- a +SSS+SST	11940.97	23.2	0.223	—

2) Spatial patterns of key environmental factors

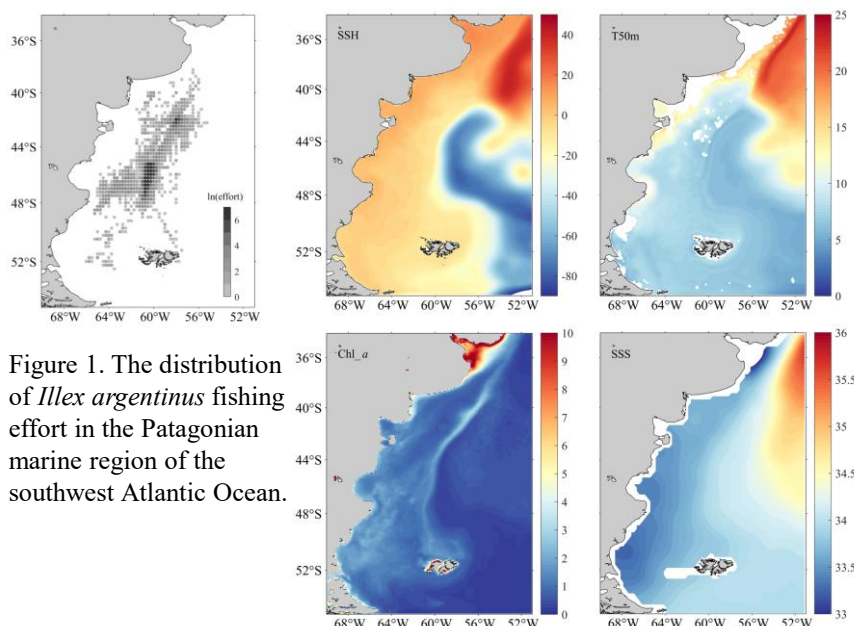


Figure 1. The distribution of *Illex argentinus* fishing effort in the Patagonian marine region of the southwest Atlantic Ocean.

Figure 2. Mean spatial distribution of selected environmental variables in the southwest Atlantic Ocean from 2013-2019.

Result

3) Model performance comparison

Table 3. Statistical results of the GAM and the MGWR model.

Model	RSS	AIC	Adjusted R ²	Moran's I	p
GAM	9739.52	11944.20	0.221	0.141	0.000
MGWR	1620.32	6990.37	0.410	-0.003	0.729

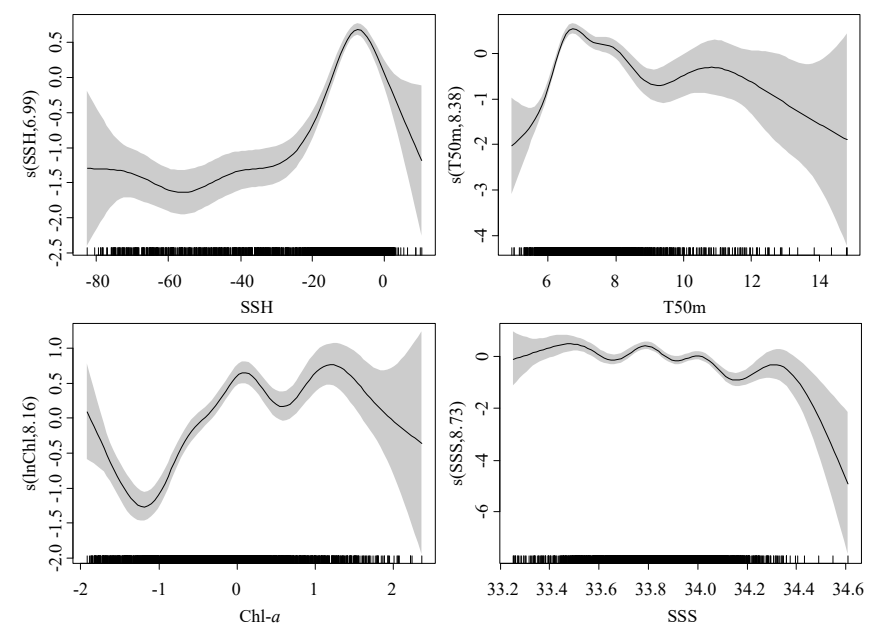


Figure 2. GAM results showing the effects of the selected environmental variables on *Illex argentinus* CPUE.

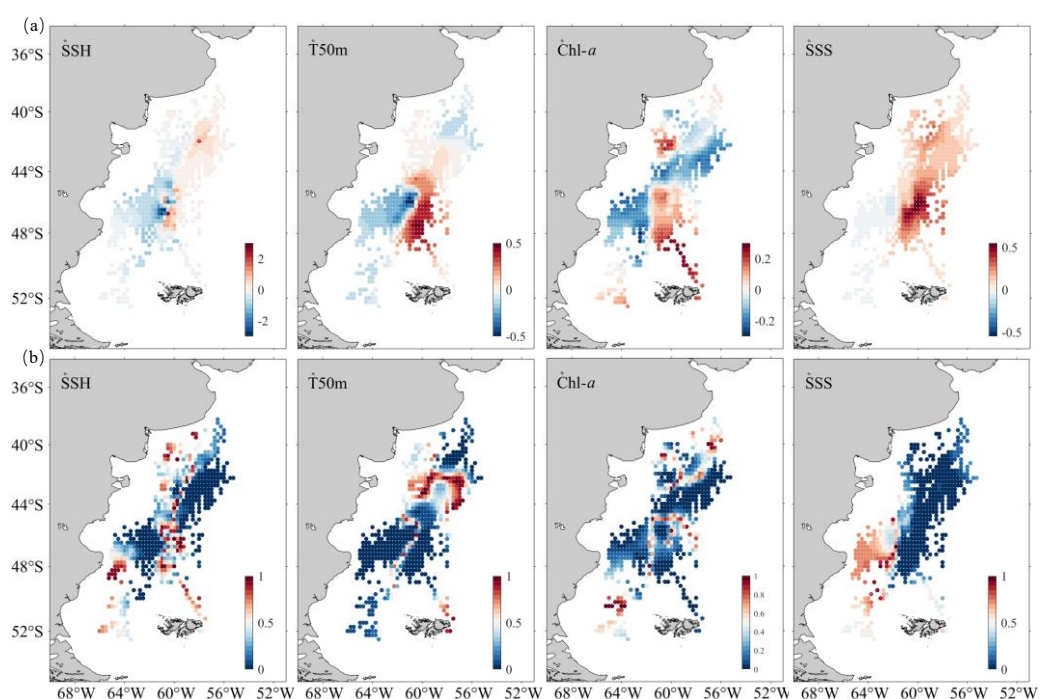


Figure 4. Spatial distribution of local regression coefficients (a) and significance (b) for each environmental factor in the MGWR model.

Conclusion

- In this study, the MGWR model demonstrated superior performance over GAM, effectively addressing the issue of spatial heterogeneity.
- The influence of environmental variables on *Illex argentinus* CPUE exhibits significant spatial non-stationarity, with the effects of different variables also demonstrating spatial variation.
- Marine environmental conditions are key factors influencing the distribution of *Illex argentinus*. Specifically, fronts generated by the interaction of ocean currents with shelf break topography deliver abundant nutrients, thereby providing a suitable habitat environment for the squid.

Acknowledgments

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