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Trawling impacts on the distribution of *Funiculina quadrangularis* fields on the Cantabrian Sea and Galicia

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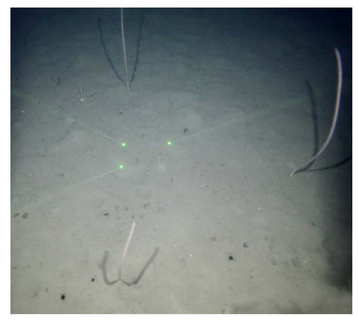
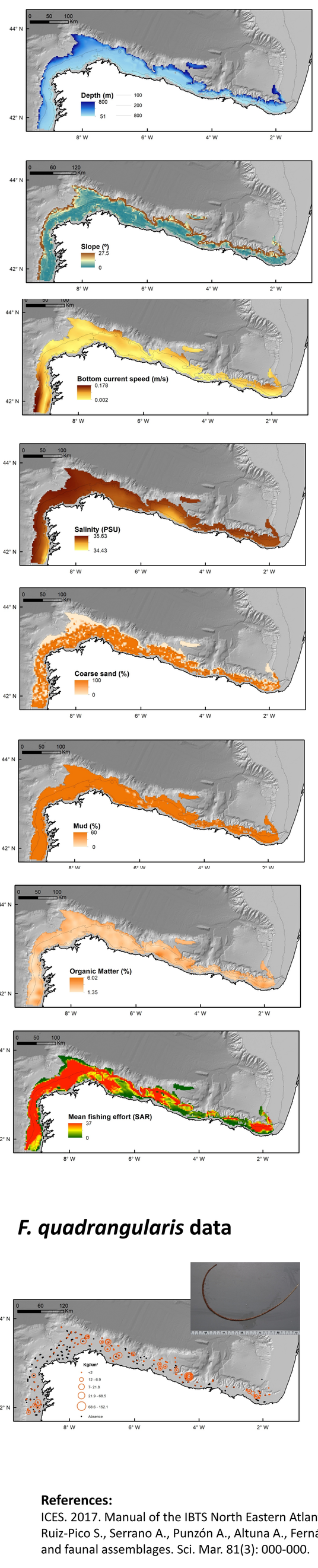
The sea pen *Funiculina quadrangularis* is the most abundant characteristic species of Pennatulacean presented in the trawlable grounds of the study area. These communities have been described as vulnerable marine ecosystems (VMEs, Seapen fields) and are currently being protected by international resolutions promoted by organizations like the FAO or OSPAR. In any case, low densities of *F. quadrangularis* were observed may be due to the high trawling intensity, highlighting the importance of spatially characterize these communities in the region and better understanding the impact of trawling on them. Thus, the aim of this study was to applied Generalized Additive Models (GAM) in a two steps approach to show the *F. quadrangularis* density distribution and the relationship with trawling effort.

First, the probability of the presence of F. *quadrangularis* was modelled using a binomial model. Second, the abundance of the species was modelled after removing the zeros from the data. Both models were finally combined to provide a final output showing the density distribution of *F. quadrangularis* in the area. Along with different environmental variables (depth, slope, sedimentological characteristics, and oceanographical information), trawling was included as an explanatory variable in the models. Furthermore, a hypothetical scenario without trawling was also applied to show how the suitable distribution of *F.quadrangularis* may be in the absence of pressure. The distribution data for the species studied were obtained from otter trawl in the DEMERSALES surveys between 2013 and 2021 carried out in this area.



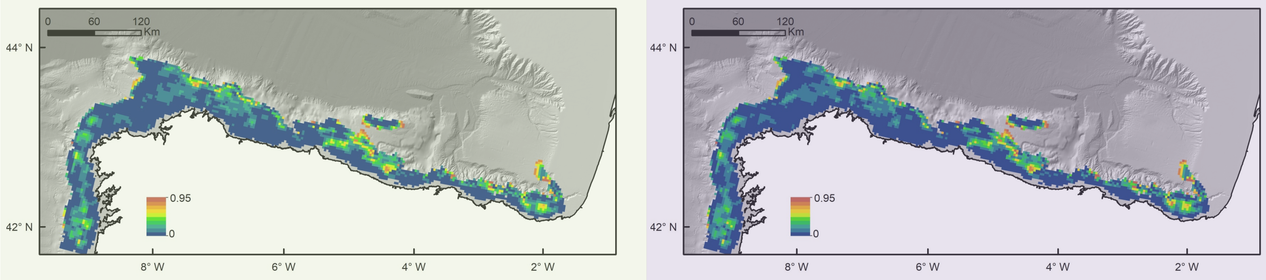
Environmental variables (EVs)



Real scenario

Hypothetical scenario without trawling

Model 1: Probability of presence

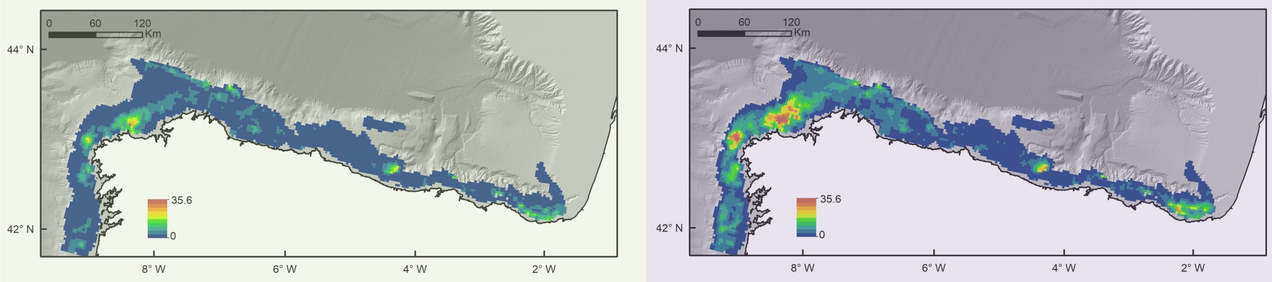


binomial model (15.4 % desviance explained; p-val < 0.001)

Statistical Significance EVs	P-value
Depth	<0.001
Organic matter	<0.001
Salinity	<0.001
Bottom current speed	<0.001
Coarse sand	0.001
Mud	0.001
Mean fishing effort	0.01

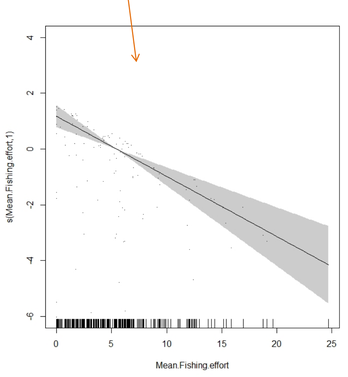
pres ~ s(Coarsesand, k = 4) + s(Current.Intensity, k = 4) + s(Depth, k = 4) + s(Mean.Fishing.effort, k = 4) + s(Mud, k = 4) + s(OrganicMatter, k = 4) + s(Salinity, k = 4) + 1

Model 2: Abundance in presence areas



Negative binomial model (32.8 desvianced explained; p-val <0.001)

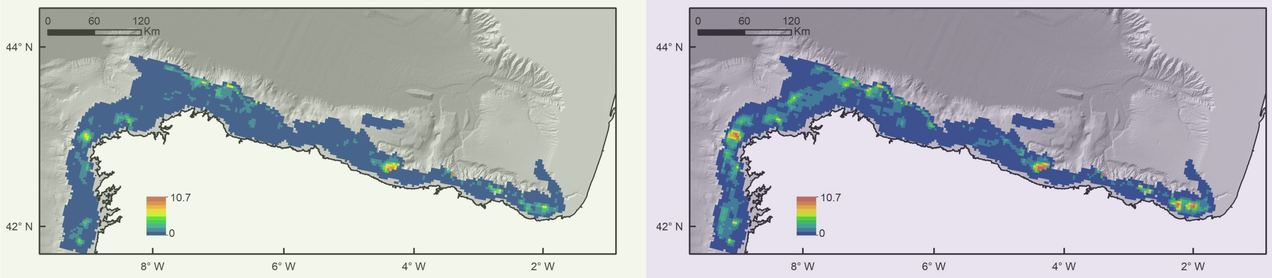
Statistical Significance EVs	P-value
Depth	<0.001
Mean fishing effort	<0.001
Salinity	<0.001
Mud	0.001
Coarse sand	0.01
Organic matter	0.01



Response curve of the mean fishing effort EV in the negative binomial model, showing an inverse relationship between trawling and the *F.quadrangularis* abundance.

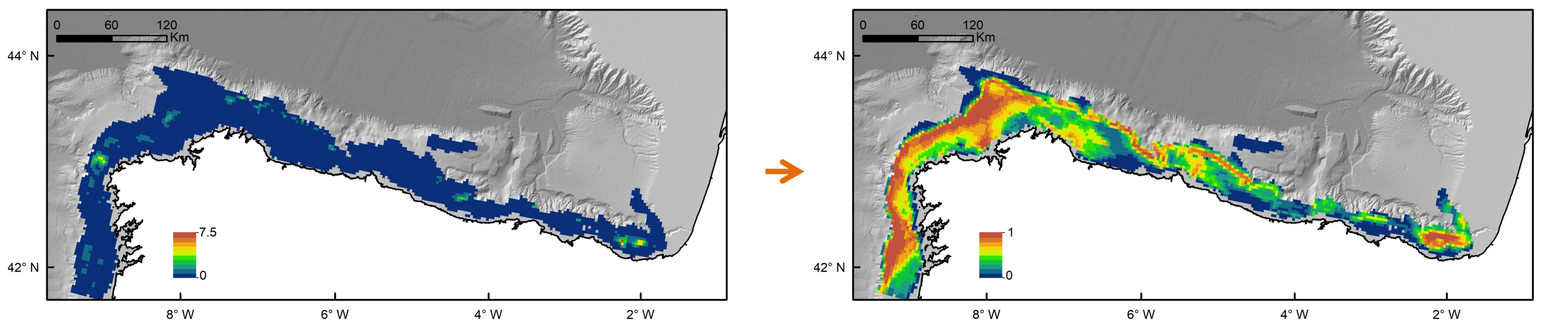
Weight ~ s(Coarsesand, k = 4) + s(Depth, k = 4) + s(Mean.Fishing.effort, k = 4) + s(Mud, k = 4) + s(OrganicMatter, k = 4) + s(Salinity, k = 4) + 1

Delta models: Model 1 x Model 2



Difference

The results maps of subtracting from the hypothetical scenario without trawling the real scenario serve us to predict how the abundance of *Funiculina quadrangularis* would be increase in areas were currently there is a high trawling effort and how trawling effort is influencing the model.



Delta no trawling – Delta real

(Delta no trawling- Delta real)/ Delta no trawling

F. quadrangularis data

Conclusions

The study identified depth, organic matter, coarse sand, mud, and mean trawling effort as important drivers for predicting the presence and the abundance of *F.quadrangularis*. Salinity and bottom current speed were also recognized as statistically significant for the binomial models.

Trawling effort shows a higher and a lineal inverse influence in the abundance model. In addition, the scenario without trawling shows areas with higher values of biomass even in areas currently unsuitable for this specie because of the high levels of trawling.

These potential suitability areas of *F.quadrangularis* found in this study can be useful for management purposes as areas to preserve in the future implementation of the different directives related to the protection of the sea.

References:
ICES. 2017. Manual of the IBTS North Eastern Atlantic Surveys. 92 pp. http://doi.org/10.17895/ices.pub.3519
Ruiz-Pico S., Serrano A., Punzón A., Altuna A., Fernández-Zapico O., Velasco F. 2017. Sea pen (Pennatulacea) aggregations on the northern Spanish shelf: distribution and faunal assemblages. Sci. Mar. 81(3): 000-000.

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