Modeling the spatial distribution of the invasive ctenophore Mnemiopsis leidyi in NW Mediterranean Sea

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Modeling the spatial distribution of the invasive ctenophore *Mnemiopsis leidyi* in NW Mediterranean Sea.

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Introduction

The American comb jelly *Mnemiopsis leidyi* A. Agassiz, 1865 is native to the western Atlantic Ocean [1]. In the early 1980s, *M. leidyi* was introduced into the Black Sea and progressively has expanded its distribution to almost all Eurasian seas (i.e., Sea of Azov, Sea of Marmara, Aegean Sea, Caspian Sea, North Sea, Baltic Sea and the Mediterranean Sea) [2-6].

Due to its strong invasive potential (high physiological elasticity and reproductive rates) [7], now this ctenophore is considered one of the "100 World's Worst Invaders" (IUCN) [8].

Efforts to understand its spread potential over the Mediterranean Sea have been assessed using locally restricted data and based on a singular statistical approach (GAM model) [6].

The environmental niche modeling of a species as a tool for predicts suitable areas, entails to gather all the environmental restriction of this species and to assume niche conservatism [9]. Also, uncertainty associated with the modeling process allows the Ensemble Modeling be an useful tool when invasive species are studied [10].

Aim

1° study the distribution and the environmental restrictions of *M. leidyi* in a recent invaded area, the Ebro river delta (NW Mediterranean)
2° use the published occurrence data through the Mediterranean Sea to develop an Ensemble modeling approach in order to predict the potential areas for the establishment of *M. leidyi* in the Mediterranean Sea, particularly in NW Mediterranean waters.

Methods

Obj. 1°:

• Field sampling were conducted in the Alfacs bay (Fig.1 A), where individuals of *M. leidyi* and some environmental variables were collected since 2010 to 2012.

• Association between environmental variables (fig.1 B) and Abundance of *M. leidyi* was assessed using GAM models. The (log) filtered volume of seawater was used as an offset inside the model. A log-link was used to model a Poisson distribution (count data), following:

$$Abundance_i = \alpha + Offset(LogVol.filt) + f1(Temperature_i) + f2(Salinity_i) + f3(Chla_i) + f4(Dissolved\ O_{2i}) + f5(Nitrate_i) + f6(Phosphate_i) + \epsilon_i *$$

***fn (X)** are smoothing functions of the explanatory variables / ϵ_i is the error term (residuals of the model) with mean 0 and Variance σ^2 / , sub-index= Sampling station*

Obj. 2°:

• Reported data on *M. leidyi* occurrence, covering the whole Mediterranean Sea, were used as input data for the Model predictions (Fig.1 B - upper panel).

• Climatic oceanographic data: Sea surface temperature (°C), Salinity, Chlorophyll-a (µmol L^{-1}), Dissolved Oxygen (%), Nitrate (µmol L^{-1}) and Phosphate (µmol L^{-1}) were used as explanatory variables at Mediterranean Scale. Data was obtained from the free on-line database (Bio-Oracle) with a resolution of 9 km.(Fig.1 B – Lower panel) [11].

• The models and ensemble forecasting were run using the Package "Biomod2" [12] for the free statistical software R (version 3.0.1) [13]. Models used were: Generalized linear and additive models (GLM and GAM), Multivariate adaptive regression splines (MARS) and Random Forest (RF).

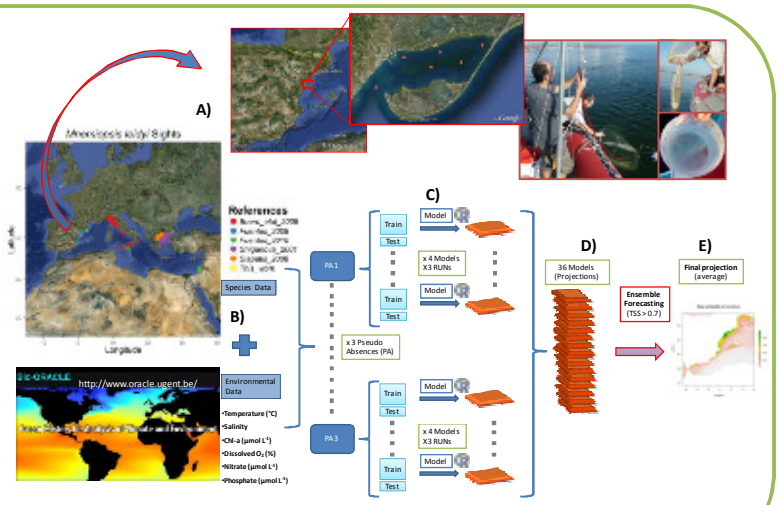

Figure 1. Flow chart of the modeling and projection process. **A)** Sampling stations at Ebro river delta; **B)** input data for the models (upper panel = *M. leidyi* occurrence; lower panel = Environmental data) ; **C)** modeling framework; **D)** ensemble forecasting and **E)** final projection

Results

Obj. 1°:

• All life stages of *Mnemiopsis leidyi* have been found at the Ebro river delta. Models showed no differences in environmental restrictions between developmental stages.
• GAMs model showed that the abundance of *M. leidyi* was significantly affected by the six environmental variables; partial effects are shown in Figure 2.

Obj. 2°:

• For all the models the six explanatory variables were significantly correlated with the presence of *M. leidyi*.
• Different predictions were obtained from different model techniques (Figure 3 – upper panel).
• The ensemble forecasting revealed as high probability areas for the NW Mediterranean the Tyrrhenian and Ligurian Sea, along the west coast of Italy. A small area at the southern end of the Gulf of Lion (France). Along the Spanish coast, high suitable areas are found mostly all along the north and central coast, with lesser suitable values in the south Spain.

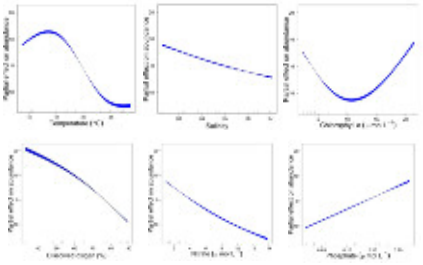

Figure 2. Smoothed fits of covariates modeling the Abundance of *M. leidyi*. The y-axis represent the partial effect of each covariate (the spline function)

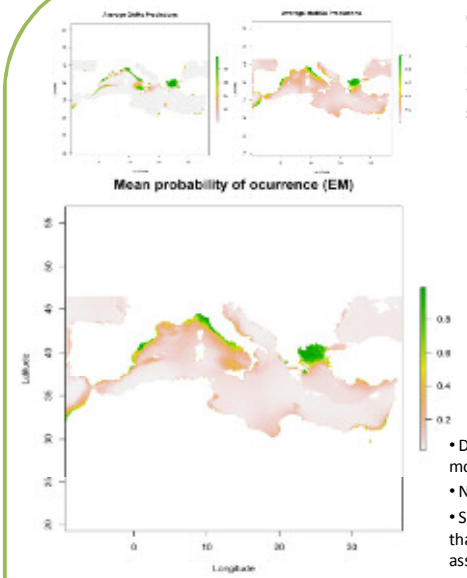

Figure 3. Suitable habitats for *Mnemiopsis leidyi*. Upper panels shows average prediction from GAM (left) and MARS models (right). Lower panel shows the ensemble forecasting for the potential distribution of *M. leidyi* in the Mediterranean Sea.

Discussion and Conclusions

• Differences in prediction were found to be associated to the modeling techniques. Highlighting the importance of the ensemble models for an agreed-upon forecasting of habitat suitability.
• Northwestern Mediterranean, showed a high probability of occurrence for *M. leidyi*; particularly along the North-Central Spanish coast.
• Spatial predictions for Mediterranean Sea differed from those already published [6]. The western basin showed lower probabilities than this results (principally the Italian coast) , whereas the eastern basin had higher probabilities than our work. This differences may be associated with the income data (climatology versus in-situ[6]) and (as mentioned above) differences associated to the models uncertainty.
• Interestingly, the Black Sea showed low probability values even when it´s known to be an invaded area for *M. leidyi*. In contrast the north Aegean Sea (closely related with the oceanographic characteristic of the Black Sea [6]) had higher probability. This results shown the importance of "niche conservatism" in species distribution modeling and the need to incorporate data from this place in order to represent properly the niche of the species

References

[1] Mianzan. In South Atlantic Zooplankton. Backhuys Publ.1999.
[2] Boero F, et al. Aquatic Invasions 4: 675–680. 2009.
[3] Shiganova TA, et al. Mar. Bio. 139: 431–445. 2001.
[4] Fuentes VL, et al. Aquatic Invasions 4: 671–674. 2009.
[5] Fuentes VL, et al. Hydrobiologia 645(1): 23-37. 2010.
[6] Siapatis A, et al. Hydrobiologia 612:281–295. 2008.
[7] Costello JH, et al. Hydrobiologia 690(1): 21-46. 2012.
[8] Lowe S, et al. The Invasive Species Specialist Group (ISSG)-IUCN. 2000.
[9] Pearman PB, et al. Ecography, 33, 990-1003. 2010.
[10] Helen MP, et al. Aquatic Invasions 7 (1): 59–72. 2012.
[11] Tyberghein L, et al. Global Ecol. Biogeogr. 21, 272–281. 2012.
[12] Thuiller W, et al. Ecography, 32: 369-373. 2009.
[13] R Core Team. R Found. Stat. Comp. http://www.R-project.org/. 2013.

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