SPATIOTEMPORAL PREDICTION MODEL OF FIN WHALES DISTRIBUTION IN THE LIGURIAN SEA

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INTRODUCTION

Fin whale *(Balaenoptera physalus)* are known to be common in the Ligurian Sea, a Marine Protected Area since 1999. Geographic information systems and remote sensing represent useful tools to determine the relationships between environmental parameters and cetaceans. The objective of our study is to infer fin whale preferential distribution between Corsica and French mainland, to better interpret our seasonal density variation observed on a single axe (Antibes-Calvi). Physical parameters have been considered as determinant for fin whale distribution in the world (Gregr & Trites, 2001 ; Hamazaki, 2002) and in the Mediterranean sea (Azzelino *et al.,* 2001). We also considerer temperature and biomass as possible predictors, as mentioned by Littaye *et al.* (2004).

MATERIAL AND METHODS

The study area was divided into 14 x 12 km cells, representing on a total surface of 43,500 km² (Figure 1). Environmental parameters used include topographic, oceanographic and biological variables, measured simultaneously (using existing database and remote sensing).

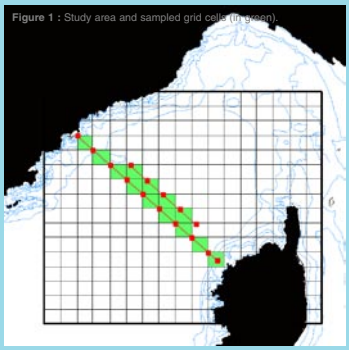


Figure 1 : Study area and sampled grid cells (in green).

DATA SOURCES

- Fin whale sightings were collected monthly between Antibes (French mainland) and Calvi (North Corsica) using line transect methodology (Buckland *et al.,* 2001). From February 2001 to February 2004, 30 dedicated surveys were conducted along two parallel transect lines at an average speed of 20.5 km/h (11 kn). Three experienced observers were searching with naked eyes, 4 m above the water surface. Fin whale sightings were computed as a binary variable (presence or absence), for each grid cell including between 14 to 18 km of effort, in good meteorological conditions (*i.e.* wind less or equal to 3 Beaufort).

- Topography— Sea bottom depth was retrieved from the digital database GEBCO© (2003) and distance to the shore was computed with ARCGIS® 8.3 (ESRI, 2002).

- Sea surface temperature (SST) averaged on 8-day periods, was imported from Pathfinder (PODAAC NASA/NOA).

- Net primary production (NPP) was computed using WIMSOFT® 6.13 (Kharu, 2003). Inputs parameters were SST, PAR (Photosynthetically Active Radiation) and Chlorophyll from SeaWIFS sensor (NASA).

Remote sensing parameters (SST, NPP), nominally referred on 9 x 9 km (at the equator), were computed on the study grid with MATLAB® 7 (2004) and simple or relative difference, compared to the entire grid, were compiled for each cell. Two temporal scales were tested for oceanographic parameters: in addition of 8-day compilation, variables were also averaged on monthly scale.

MODEL CONSTRUCTION

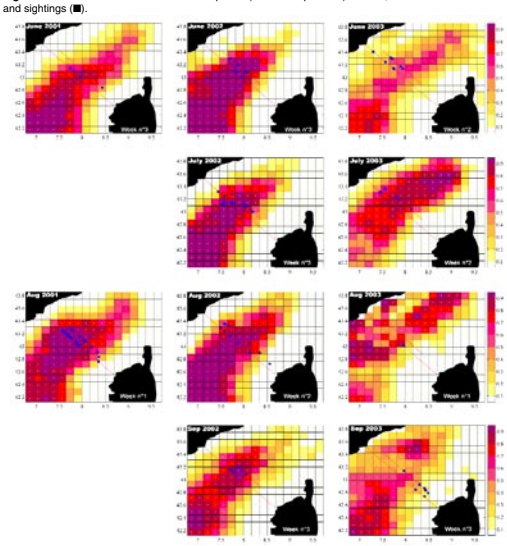
Fin whale prediction models were generated on SYSTAT® 11 (SPSS, 2004) using a multiple logistic regression with forward- backward stepwise selection. Input and output parameters were fixed to 0.05 and 0.10.

CROSS VALIDATION

Models were tested by cross-validating probability of presence obtained for each cell with an independent survey conducted by the GREC (Groupe de REcherche sur les Cétacés) and the CRC (Centre de Recherche sur les Cétacés) in July 2001. This survey was conducted in the Marine Protected Area with the same plateform and a similar protocol; only speed was slightly inferior with 18 km/h (10 kn). A total of 64 cells, including a minimum effort of 12 km, were sampled and 15 of them included fin whales sightings.

RESULTS AND DISCUSSION

Figure 2 : Predicted distribution for summer period (June to September) in 2001, 2002 and 2003 and sightings (■).



Between June and September of 2001 to 2003, 110 grid cells were visually sampled with the same protocol and 50 denoted fin whale presence.

Monthly scale provided a correct classification rate of 63% using difference of primary production (with the entire grid) and distance to the coast as predictor (Table 1). Most significant predictor variables for 8-day temporal resolution were relative difference of primary production compared to the entire grid, SST difference (with the entire grid) and distance to the coast. This model predicted correctly 68% of the sampled cells (Table 1). The expected spreading of whales between June and August was consistent with our sightings. The model also predicted successfully the spatial shift of fin whale distribution in August 2003, in comparison with previous years (Figure 2). Indeed, we recorded a single whale during August 2003 sampling, despite an effort of 175 km (see Laran *et al.,* 2004 for details). However, the model failed to predict the South East displacement of whales in September 2003, and the temporal shift that occurred in 2003, with the earlier occurrence of whale in the area (maximum observed in April) compared to previous years.

Table 1 : Models for fin whale *(Balaenoptera physalus).*

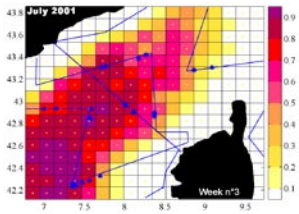
Temporal scale	Predictor variables	Mac Faden ρ^2	Correct prediction	- of presence	- of absence
8 days	- Primary production relative difference * - Temperature difference - Distance to the coast	0.279	67.9%	61.6%	72.4%
1month	- Primary production difference - Distance to the coast	0.192	63.3%	55.8%	68.6%

* compared to the entire grid

With the independent data set, used for validation, 8-day model predicted correctly 73.3% of the presence and 79.6% of the absence of whales (Figure 3). The monthly scale model predicted correctly 46.7% of whale sighting cells and 79.6% of absence. This result confirms that temporal resolution of 8 days seems more suitable than 1 month for fin whale habitat prediction.

Our results confirm that primary production and sea surface temperature are good predictors of fin whale summer distribution, in consistence with Littaye *et al.* (2004) study. The same analysis conducted on a year basis (under construction) produces promising prediction in term of spatio-temporal distribution.

Figure 3 : Predicted distribution for July 20 to 27 period, with independent sightings.



CONCLUSION

With a model of three predictor variables, we obtained a correct classification of 78% on an independent data set. This project contributes to understand fin whales distribution in the Marine Protected Area and potential relationships with environmental parameters.

A possible application of this study is a conservation tool in management of the Sanctuary to prevent interaction with human activity, such as collision between ship and whales.

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