A FUZZY LOGIC RULE-BASED MODEL TO EXAMINE THE SPATIO-TEMPORAL RELATION OF DEMERSAL RESOURCES WITH ENVIRONMENTAL CONDITIONS

G. Sylaios *, M. Torre , A. Khayati , R. Fageot , A. Kallianiotis
Fisheries Research Institute, National Agricultural Foundation, 64007, Nea Peramos, Greece - fri@otenet.gr

Abstract
A fuzzy rule-based model was developed and applied on the fishery dataset derived from North Aegean Sea MEDITS Survey, during 1998-2001. The model provides a non-linear relationship between total fish biomass and four fish biomass dependent environmental variables (bottom temperature, bottom salinity, water depth and crustaceans biomass), which improves multiple linear regression approaches, and could be utilised for future fish biomass descriptive and predictive purposes.
Keywords : Demersal, Fishes, Models, Biomass, Aegean Sea.

Introduction
Understanding the spatial and temporal variability of demersal resources, and its links to the deep sea environment, appears as an important task for trawl fisheries management. Fuzzy logic techniques have recently been applied in fisheries research [1], improving classical fish landings analysis. Data on the distribution of demersal resources biomass in the North Aegean Sea were collected during MEDITS Surveys (1998-2001), and analysed for species assemblages, patterns in spatio-temporal changes related to environmental factors and ecological species interactions [2]. In this work, a fuzzy logic, rule-based model was developed aiming to provide a non-linear relationship between total fish biomass and environmental variables, as station water depth, bottom temperature, bottom salinity and crustaceans biomass.

Materials and methods
Fishery and oceanography data were collected and processed according to standard MEDITS protocol [3], at 64 stations throughout the North Aegean Sea during 1998-2001 (n = 165). Biological variables as total fish biomass (kg/km^2) and total crustaceans biomass (kg/km^2), along with environmental variables (sea bottom temperature and salinity) were extracted from the above database. The software DECISIA SPAD 5.5 for Windows was utilized for multiple linear regression analysis and a fuzzy logic model was developed on a simple MS-Excel spreadsheet following Sylaios et al. [4], to derive a complex relation between total fish biomass and the above described environmental factors.

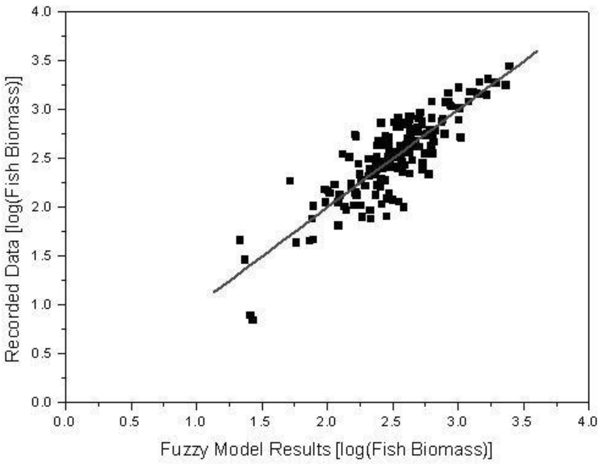

Fig. 1. Scattergram of modeled versus observed Log(Fish Biomass) values.

Results and Discussion
The multiple regression model derived from the data considered was highly significant (p<0.01) but with a poor predictive capability (R^2=0.33).
Figure 1 illustrates the scattergrams of fuzzy estimated fish biomass versus the observed fish biomass values imported in the model. A linear regression equation formed as:
Recorded Data [log(Fish Biomass)] = 1.00103 * Fuzzy Model Results [log(Fish Biomass)] - 0.0026
produced a line which coincides with the best-fit line (1:1 slope), as shown in Figure 1. Fish biomass values produced by the model were slightly overestimated with the slope γ obtaining a value of 1.009. The squared correlation coefficient of modelled and observed data obtained adequately high values (R^2 = 0.751), while the Sum of Squared Errors was 7.77 and the Root Mean Squared Error was 0.217. Figure 2 compares the observed and predicted fish biomass values time series, for the different data points considered, showing good agreement.

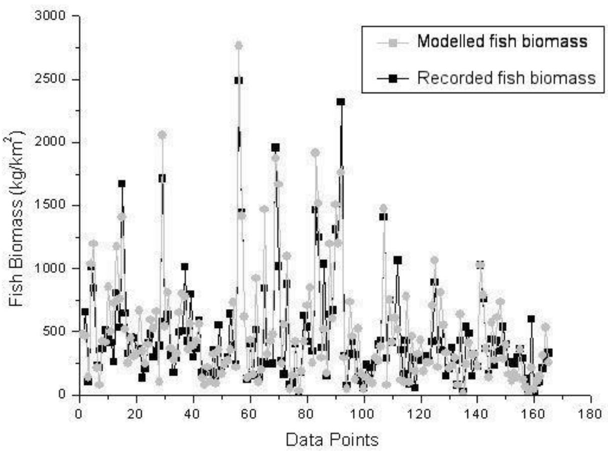

Fig. 2. Comparison between recorded and modelled fish biomass (in kg/km^2).

According to our results fuzzy modelling improved the multiple linear regression approach in describing the variation of fish biomass according with the variables considered. Biologically, bottom temperature, bottom salinity and water depth should be considered as principal constrains in the biomass carrying capacity of demersal environment. Furthermore, fish and crustaceans dependence may be explained either in terms of predator-prey relationships or in terms of environmental niche siilarities.
Fuzzy modelling shows potential for the fisheries domain, but its predictability must be demonstrated with further studies.

References
1 - Koutroumanidis Th., Iliadis, L. & G. Sylaios, 2006. Time-series modeling of anchovy landings using ARIMA and Fuzzy Expected Intervals Software. *Env. Model. Softw*., 21: 1711-1721.
2 - Kallianiotis, A., Vidoris, P. & G. Sylaios, 2004. Fish species assemblages and geographical sub-areas in the North Aegean Sea, Greece. *Fish. Res*., 68:171-187.
3 - Bertrand J., 1994. Campagnes internationales de chalutage démersal en Méditerranée (MEDITS). Campagne 1994. Manuel des protocoles. Contrat MED 93/020, 018, 006, 004.
4 - Sylaios, G., Koutroumanidis, T. & V. Tsihrintzis, 2006. CHLfuzzy: A simulation tool for lagoon eutrophication. *Proc.8th Panhell. Congr. Ocean. Fish*., Thessaloniki, 4-8/6/2006.