

Environmental Data Base of the Lakes of West Macedonia (Greece) for Their Sustainable Management[#]

Andreopoulou S. Zacharoula^{1,*}, Kokkinakis K. Antonis²

1. Laboratory of Forest Informatics, Faculty of Forestry and Natural Environment, Aristotle University of Thessaloniki, Box 247, 54124 Thessaloniki, Greece; 2. Laboratory of Wild Life and Freshwater Fisheries, Faculty of Forestry and Natural Environment, Aristotle University of Thessaloniki, Box 241, 54124 Thessaloniki, Greece.

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Abstract: Lakes are sensitive ecosystems, critical for natural equilibrium and local economies. Irrational and excessive human interventions have a major impact in biodiversity and productivity. This paper describes the design and the implementation of a database for the lakes in West Macedonia, Greece aiming to their monitoring within sustainable development. Data were collected from scientific references, studies and research programs about lakes of Small (Micro) Prespa, Big (Macro) Prespa, Zazari, Chimadits, Petron, Vegoritis, Kastoria and Polyfyto. In the database are included qualitative and quantitative information of the lakes such as hydrological, geomorphologic information, physico-chemical characteristics of the lakes, the flora and fauna, avifauna, fish fauna, the protection legal status, land and water uses, economic activities, information on fishery production and infrastructure, human interventions and also information on the active management plan and measures for the protection, rehabilitation and sustainable development of the lakes. To help users effectively handle the stored data, a Graphical User Interface (GUI) was designed to customize the system to the users' demands and needs and support information flow. The integration of ecological, biological and socio-economic data for the lakes in a user-friendly database is important for many disciplines and supporting while planning of local projects.

Key words: database, lake ecosystems, data management, sustainable exploitation, West Macedonia.

Introduction

Lake wetlands constitute sensitive and vulnerable ecosystems with critical worth for the natural stability and for people because their protection, preservation and management are vital for local and regional development. Extreme human interventions, not well adjusted have usually a major impact in their two focal characteristics, biodiversity and productivity.

Even if a lot of environmental studies and scientific projects have been carried out concerning the wild life and the biodiversity for the lakes in the region of West Macedonia in Greece (Pyrovetsi *et al.*, 1984; Koutsoubidis, 1988; Hollis & Stevenson, 1997; Papoutsi-Psychoudaki & Psychoudakis, 2000) only a few of them were occupied directly with human activities in the above ecosystems as the fishery (Crivelli *et al.*, 1997; Kilikidis *et al.*, 1984; Economidis *et al.*, 2001, Kokkinakis *et al.*, 2003, Kokkinakis & Andreopoulou, 2008a,b,c,d, 2009). The majority of the relevant scientific references deal with environmental problems, conservation of wild life and general environmental management and only a few negotiate directly with the existing management of the natural biological resources in the lake ecosystems.

All of the above ecosystems constitute traditionally inland water fishery areas, not only for this mountainous region of Greece, but also for the neighbouring countries. Unfortunately during the last decades, and mainly since the decade of 70's, their fishery production has decreased significantly, at least in their Greek part. This is mainly accrued from the contemporary problems of the intensive exploitation of their natural biological resources, the environmental pollution, as also from the conflict functions and uses of their waters (Economidis *et al.*, 2001; Kokkinakis *et al.*, 2003; Kokkinakis *et al.*, 2004; Kokkinakis & Arabatzis, 2004).

Although many research attempts have been successfully carried out locally, at often considerable cost, their use remained limited either geographically, as the results were not shared

*Corresponding; E-mail: randreop@for.auth.gr; Tel.: ++30.2310.992714; Fax: ++30.2310.99217.

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outside the institute that conducted the project, or timely, as the results were of immediate interest to a particular project but did not remain available for future wider use (Andreopoulou *et al.*, 2007). Effective organization, access and management of all-available information on the sensitive lake ecosystems constitute an important factor within decision-making process, especially when it concerns decisions on sustainable development. Databases allow data redundancy, improved data consistency, program data independence, improved data sharing, increased productivity, improved data accessibility and responsiveness and reduced program maintenance, particularly when a powerful, full-functioned DB Management System (DBMS) is used (Mc Fadden, 1999)

Relative scientific efforts have been in the development of environmental databases for the Greek aquatic ecosystems as an environmental database for the status of freshwater in Greece (Tsouni *et al.*, 2002), a pilot database for the organization and exploitation of environmental data on river ecosystems (Andreopoulou *et al.*, 2004, 2007), for Natura 2000 ecosystems in Northern Greece (Kokkinakis *et al.*, 2005) for coastal lake ecosystems (Andreopoulou & Kokkinakis, 2006) and finally about the aquaculture activities in Greece (Kentouri *et al.*, 1995).

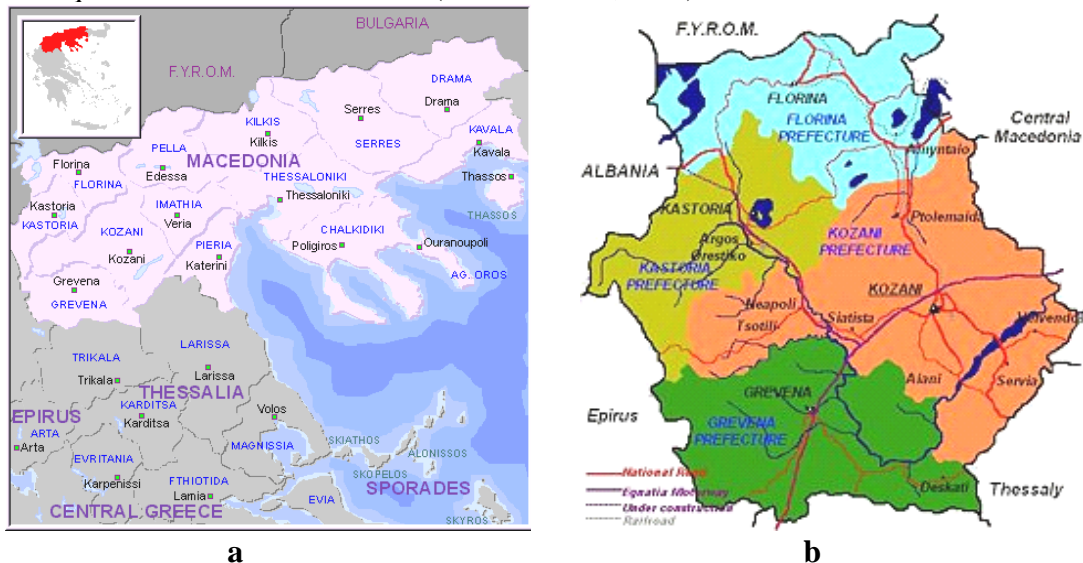


Figure 1. a) The area of Macedonia in Northern Greece and **b)** the region of West Macedonia in Greece

This paper describes the design and the implementation of a database for the transboundary and Greek lake ecosystems in the region of West Macedonia (Greece) within sustainable development and environmental monitoring. For the pilot version of the project, scientific registrations were used concerning the region of West Macedonia in North Greece, as the lake systems of Small (Micro) and Big (Macro) Prespa, Zazari, Chimaditis, Petron, Vegorit, Kastoria, and Polyfytyou (Fig. 1).

Materials and Methods

Data concerning only the lakes were collected from scientific references (Kilikidis *et al.*, 1984; Crivelli *et al.*, 1997; Hollis & Stevenson, 1997; Kokkinakis *et al.* 2003, 2004; Papoutsis-Psychoudaki & Psychoudakis, 2000; Pavlides, 1997; Petridis & Sinis, 1997; Kokkinakis & Andreopoulou, 2006, Kokkinakis & Andreopoulou, 2008a,b,c,d,2009), relative studies and recent research programs to implement the pilot database (Pyrovetsi *et al.*, 1984; Koutsoubidis, 1988; Florina's Prefecture, 1998; Economidis *et al.*, 2001), and from the relative governmental offices of the Greek "Fisheries Departments" for each lake ecosystem.

There are descriptive, qualitative and quantitative data organized in thematic units such as hydrological, geomorphologic information, physico-chemical characteristics, the flora and fauna, avifauna, fish fauna, the protection legal status, the current land and water uses, economic activities, information on fishery production and infrastructure, human interventions and also the suggested protection measures for the protection and sustainable development of these ecosystems.

The collected raw data were formatted in pre-defined Ms-Excel files to be used in automatic import procedures to the system database. It was then designed the framework for the total bilateral database, supported with the database management system of Ms Access software.

A Graphical User Interface (GUI) was designed to customize the database system to the users' demands and needs and also to support information flow. To help users effectively handle the huge amount of data stored in the database, a form-based GUI was designed with successive button selections till the final presentation of the data drawn from the database (Post & Kagan, 2001, Elmasri & Navathe, 2004). The data in question appear in the same stable design throughout the application, in report printable style. The experienced user can also have access to the main database window which can also serve as a data management interface; hence they can design even more complicated queries, reports or forms, to serve potential needs and to support decision making process (Figure 2).

Results

The application automatically starts in an introductory window where the title of the application appears and two active buttons in order to "enter" and "exit" from the DB. Figure 3.a shows a picture of the GUI developed for the starting window.

With the activation of the "enter" command button, the user is forward in a new window for ecosystem selection (Fig. 3.b), to choose from a list of active buttons labeled with the formal names of the lake systems. Once an ecosystem is selected the user is taken in the main management window that serves as the key DB management window.

Figure 4.a shows a picture of the GUI developed for the main management window. That consists of a set of active buttons that lead in the major partial thematic issues that are covered in the database of the selected area. Active buttons act as control elements to enhance the data flow within the database and they concern: general information about the ecosystem, meteorological information, hydrological information, geomorphologic information, physico-chemical information, biological and ecological data, the land and water uses, fishery information, protection status and finally the active management plan of the ecosystem. In parallel, there are active buttons for the selection of the relative bibliography used and finally a button to exit the application.

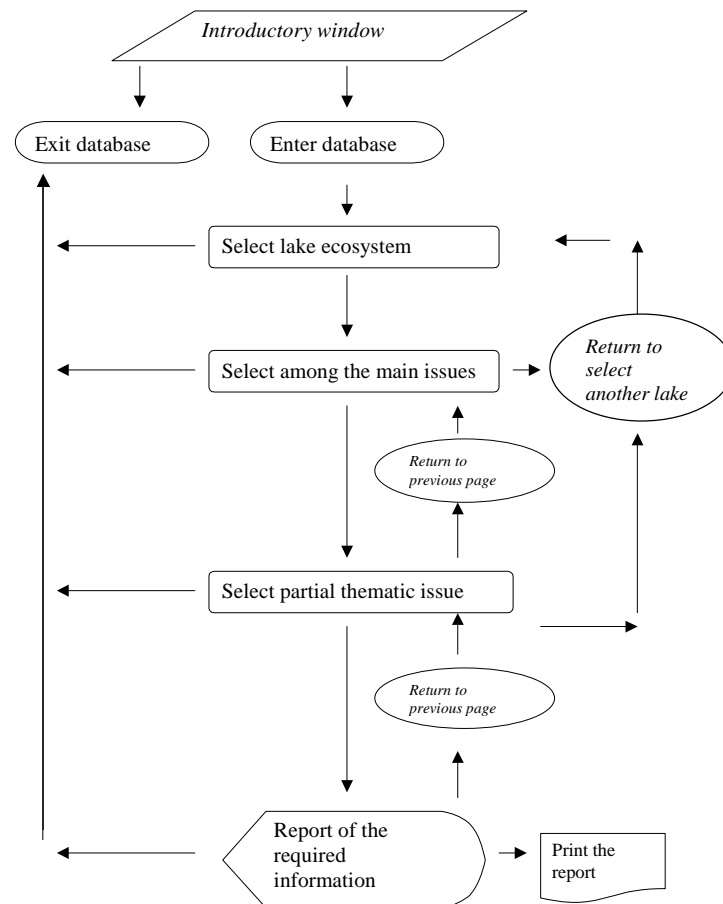


Figure 2. Information flow in the database

The selection of one of the above main thematic units in the application activates another window where the user can select from a list of the available relative partial thematic. In detail, the thematic unit “general information” consists of a list of partial choices that concern the historical evolution of the lake ecosystem, data on the hydrological basin and relative historical data.

The thematic unit “meteorological information” leads in a new window with relevant data. The thematic unit “geomorphologic information” when selected, leads in a new window with a list of 4 choices in button type, that concern morphological data, geomorphologic data, the morphology of the bottom sediment and the geological type of the bottom sediment.

The thematic unit “hydrological information” leads in a new window with a list of partial choices concerning the water inflow and outflow of the lake system, the total water volume and the hydrological water balance of the ecosystem.

The thematic unit “physico-chemical information” leads in a new window with a list of partial choices concerning recorded physicochemical data about the water and of the lake system. Figure 4.b shows physicochemical data in Lake Vegoritis.

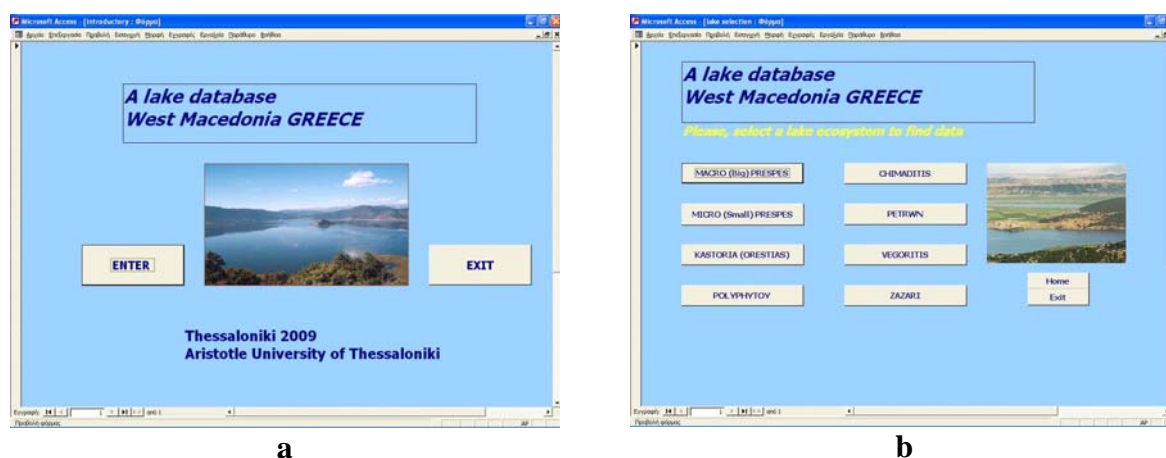


Figure 3. a) The introductory form, b) The ‘Lake selection’ form

The thematic unit “ecological information” (Figure 5.a), consists of a window with a list of partial choices concerning the phytoplankton, zooplankton and benthos populations, the surrounding the lake system phyto-societies, the local avifauna and the fish fauna of the ecosystem (Fig. 5.b).

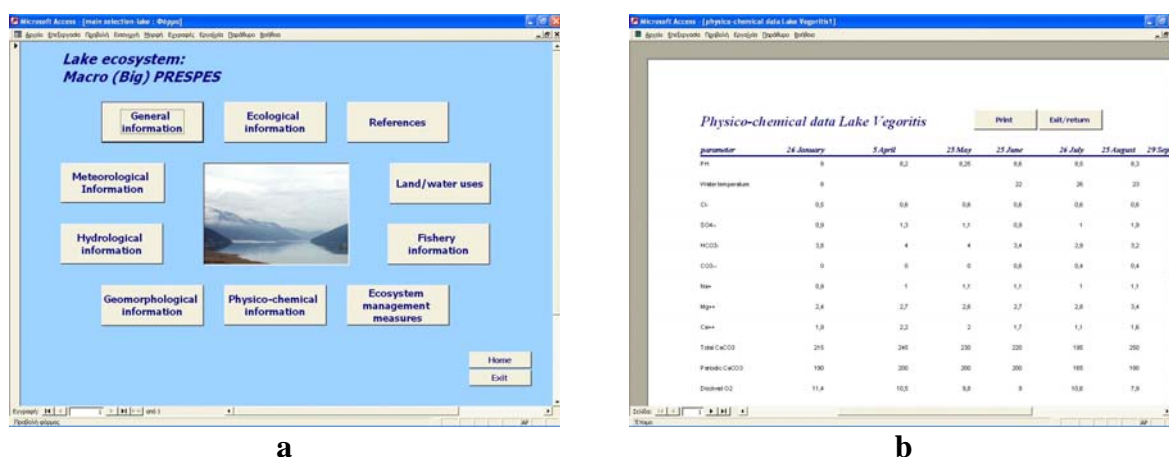


Figure 4. a) The ‘Main data management’ form from Macro Prespa, b) Physico-chemical data for Lake Vegoritis

The thematic unit “land and water uses” consist of a window with a list of partial choices concerning the status of the manager of the ecosystem, its public exploitation carriers, its water usages, the around land uses, the economic activities and the impact of human usages in the total lake system. The thematic unit “fishery information” includes a window with a list of partial choices concerning the number of fishing boats, the types and the methods of fishing, the number of fishermen, the situation of amateurish fishing, the existing aquaculture units, the fishermen’s partnerships, the fishery data and the fish enrichment activities in each system.

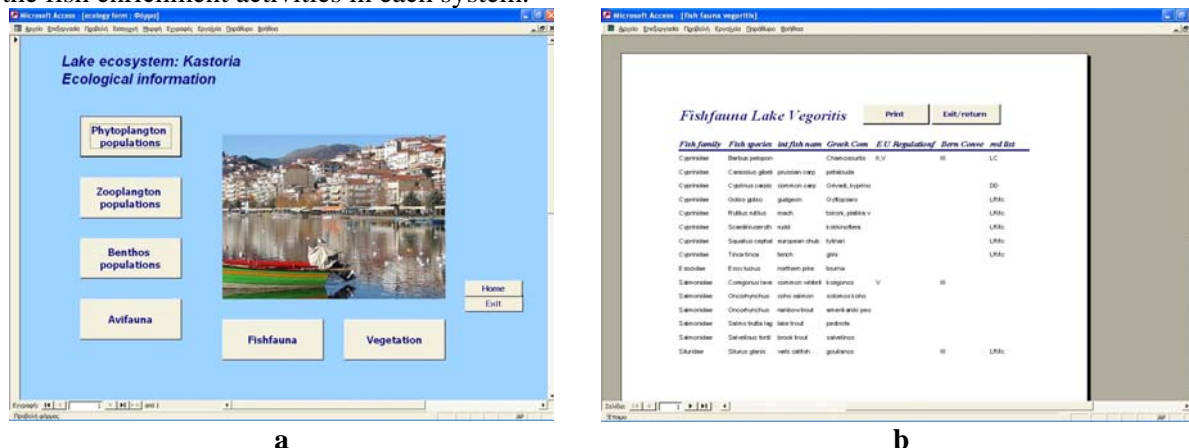


Figure 5. a) The ‘Ecological’ selection form for Lake Kastoria, **b)** The ‘Fish fauna’ report for Lake Vegoritis.

The thematic unit “protection status” guides to a window with a list of partial choices concerning the relative scientific projects have completed and they was relating with the ecosystem, the governmental and privet organizations which are responsible or working in the ecosystem, the scientific institutes or other organizations connected to the ecosystem etc. The thematic unit “active management plan” consists of the already planed activities aiming in the protection, the rehabilitation and the sustainable development of the lake ecosystem.

Discussion and Conclusions

The integration of all the available ecological, biological and socio-economic data for water resources, such as lakes, still-water bodies, water reservoirs, rivers and wetlands in a functional data base can be of a great importance for many scientific disciplines (Lehner & Doll, 2004). The structured registration of all the available information within a user-friendly interface enables the study of the lake ecosystems from any user, researchers, students, conservation organizations, resource managers, environmental research or education projects, computer literate or not, regarding the strengthening of the scientific co-operation within countries and the establishment of cross border scientific partnership in the field of natural lakes management and sustainable development.

A further extension would also be a GIS application that creates customized maps with the data stored in the DBS. A future development can be web-based management of the database supporting a multidisciplinary lake information portal in the WWW that would also contribute in the research field as a reference in environmental studies about the lake ecosystems, for local comparative studies and in general environmental or water resource management projects.

Therefore, the database framework discussed is a helpful tool within the evaluation of alternative scenarios and towards the development of a common trans-boundary environmental planning from authorities and designation of a sound policy towards protection and sustainability.

References

- Andreopoulou ZS, Kokkinakis AK, (2006) The development of a database for the littoral lakes in Northern Greece aiming to their rational and environmental friendly fishery management. *Proc. of 2nd Intern. Conf. of Balkan Water Observ. & Inform. Syst. - BALWOIS*, May 2006, FYROM, 340, (Abs & Cd-Rom), Ohrid

- Andreopoulou ZS, Kokkinakis AK, Pavlidis T, (2004) Development of a pilot database for the organization and exploitation of environmental data on river ecosystems. *Proc. of the 1st Environmental Conf.*, 7-9 May, pp:805-816, Orestiada, Greece.
- Andreopoulou ZS, Kokkinakis AK, Pavlidis T, (2007) Sustainable environmental management of running waters ecosystems with a database application. *Proc. of the 10th International Conference of Global Nest-CEST*, 5-7 September 2007, B: 36-43, Kos Island, Greece.
- Crivelli AJ, Catsadorakis G, Malakou M, Rosecchi E, (1997) Fish and fisheries of the Prespa lakes. *Hydrobiologia*, **351**, 107-125.
- Economidis PS, Bobori D, Michaloudi E, Artemiadou B, Spaneli B, (2001) *Lakes, rivers and springs of the area of West and Central Macedonia. Developmental Project "Pesca"*, Final Report, Ministry of Agriculture, Department of Fisheries, In CD-Rom. Athens, Greece.
- Elmasri R, Navathe SB, (2004) *Fundamentals of Database Systems*. 4th ed, Addison-Wesley.
- Florina's Prefecture (1998) Specific environmental study of Prespes lakes in the area of Florina's Prefecture. Special Edition of Florina's Prefecture. 130 pp. Florina, Greece.
- Hollis, G.E. & Stevenson, A.C. (1997). The physical basis of the lake Mikri Prespa systems: geology, climate, hydrology and water quality. *Hydrobiologia*, **351**, 1-19.
- Kentouri M, Papandroulakis N, Divanach P, (1995) Aqua bank. A database for the Greek aquaculture. *Options Mediterraneennes*, **14**, 257-263.
- Kilikidis S, Kamarianos A, Fotis G, Koussouris Th., Karamanlis X, Ouzounis K, (1984) Ecological search in the lakes of Northern Greece, (lakes S. Basil, Doirani, Vistonida). Necessary requirements for the establishment of a fish hatchery, *Vet. Sc. Ann. AUTH*. 269-439.
- Kokkinakis AK, Andreopoulou ZS, (2006) Sustainable fisheries as a key factor for the environmental conservation of the Balkan trans-frontier lakes. *Proc. of 2nd Intern. Conf. of Balkan Water Observation & Information Systems - BALWOIS*, May 2006, FYROM, 271-272, (Abs. & Cd-Rom), Ohrid.
- Kokkinakis AK, Andreopoulou ZS, (2008a) Management and environmental problems affecting the fish and the fisheries of lakes Vegoritis and Petron in W. Macedonia, Greece. *Proc. Intern. BENA Conf. on "Balkan Collaboration: The Must for Better Life and Environment in S.E. Europe"*, 6-9/11/2008, Florina, Greece.
- Kokkinakis AK, Andreopoulou ZS, (2008b) Environmental impacts concerning the fish and the fisheries of lakes Chimaditis and Zazari in W. Macedonia, Greece. *Proc. Intern. BENA Conf. on "Balkan Collaboration: The Must for Better Life and Environment in S.E. Europe"*, 6-9/11/2008, Florina, Greece.
- Kokkinakis AK, Andreopoulou ZS, (2008c) Evaluation of the fishery production through classification in the two trans-boundary Prespa lakes. *Proc. 4th Intern. Conf. Aquaculture, Fisheries Tech. & Environ. Manag.* (AQUAMEDIT 2008), 21-22/11/2008, In Cdrom, Athens, Greece.
- Kokkinakis AK, Andreopoulou ZS, (2008d) Changes in the fishery composition of Greek part of trans-boundary Prespa (Micro and Macro) lake ecosystem. *Proc. 3^d Conf. BALWOIS 2008*, FYROM, 27-30/5/ 2008. pp:320-321, Ohrid.
- Kokkinakis AK, Andreopoulou ZS, (2009) Modeling the fisheries of Kastoria Lake (West Macedonia, Greece). *Proc. 4th Intern. Env. BENA Conf. on "Life Quality and Capacity Building in the frame of a Safe Environment"*, 17-20/3/2009, pp:57-58. Katerini, Greece.
- Kokkinakis AK, Arabatzis G, (2004) Typology of the lakes of Northern Greece according their environmental characteristics and fisheries production. *Proc. 2nd Intern. Conf. of HAICTA*, 18-20/3/ 2004, 2: 47-54. Thessaloniki, Greece.
- Kokkinakis, A.K., Andreopoulou, Z.S. & Pavlidis, T. (2005). Development of a pilot database for the organization and exploitation of environmental data on Natura 2000 ecosystems. *Proc. of the 9th Intern. Conf. of Global Nest-CEST*, 1-3 September 2005, Rhodes. 400-405 (& Cd-Rom).
- Kokkinakis AK, Andreopoulou ZS, Mixafentis N, Papageorgiou N, (2004) Human activities impacts on fish fauna and fisheries in northeastern Greek lake ecosystems. *Proc. of the 10th Intern. Conf. MEDECOS- Mediterranean Climate Ecosystems*, April 25 - May 1, 2004, Rhodes, Greece, Arianoutsou & Papanastasis (eds), MILLPRESS, 168 (& Cd-Rom), Rotterdam.

- Kokkinakis AK, Mixafentis N, Papageorgiou N, (2003) Environmental impacts in the fisheries of the west Macedonian lakes (Greece). Proc. 11th Pan-Hellenic Forestry Conf., 1-3/10/03. pp:447-460, Olympia, Greece.
- Koutsoubidis E, (1988) Ecological search for the lakes and rivers of Florina's prefecture. Final report, Prefecture of Florina, p. 190. Greece.
- Lehner B, Doll P, (2004) Development and validation of a global database for lakes, reservoirs and wetlands. *Journal of Hydrology*, **296**, 1-22.
- McFadden FR, Hoffer JA, Prescott MB, (1999) Modern Database Management. Addison-Wesley Publishing, Inc. Reading, MA.
- Papoutsis-Psychoudaki S, Psychoudakis A, (2000) Agricultural externalities and policy for sustainable agriculture in the Greek part of Prespa. *Proc. of the Intern. Symp. "Sustainable development of Prespa region"*, FYROM, 23-25/6/2000. 179-189. Ochrid.
- Pavlidis G, (1997) Aquatic and terrestrial vegetation of the Prespa area. *Hydrobiologia*, **351**, 41-60.
- Petridis D, Sinis AI, (1997) The benthic fauna of Lake Mikri Prespa. *Hydrobiologia*, **351**, 95-105.
- Post G, Kagan A, (2001) Database management systems: Design considerations and attribute facilities. *The Journal of Systems and Software*, **56**, 183-193.
- Pyrovetsi MD, Crivelli AJ, Gerakis PA, Karteris MA, Kastro ED, Komninos N, (1984) Integrated environmental study of Prespa national park, Greece, Final Report of the E.E. Project. pp:205-215. Thessaloniki.
- Tsouni, A., Zervos, N., Hadjibiros, K. & Andreadakis, A. (2002). An environmental database for the status of fresh water in Greece. *Global Nest: the International Journal*, **4**, 1-14.