Hungarian Association of Agricultural Informatics
European Federation for Information Technology in Agriculture, Food and the Environment

Journal of Agricultural Informatics. Vol. 8, No. 3
journal.magisz.org

Multimedia database development for innovative application about fish fauna for inland water ecosystem management

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INFO
Received 25 Sept 2017
Accepted 4 Nov 2017
Available on-line 21 Nov 2017
Responsible Editor: M. Herdon

Keywords:
Databases, Multimedia system, Decision support system, Fresh water fish fauna, Inland water, Wetlands management, Inland water ecosystem

ABSTRACT

This paper describes the development of an innovative application with a multimedia database, concerning the management of fresh water fish fauna in the inland water ecosystems of Greece. This database is a baseline for keeping descriptive information of fresh water fish fauna and bibliographic spread reports. The database has provision for both descriptive and geographic mapping (GIS). The sources of the data used for the database population were from a) The Red Book of Endangered Animals of Greece b) IUCN (International Union for Conservation of Nature and c) Ministry of Environment & Energy (Study 6: Supervision and Evaluation of the Conservation status of fish species of Community interest in Greece). A detailed description will be made for the development of the stages of the database (Conceptual - Logical - Physical Design). The database management system was developed in Microsoft Access and in pgAdmin, which is an open source administration and development platform for PostgreSQL. In addition, we will mention the filling of the database and the Entity - Relationship Model. The database due to its structure and data it will be able to provide answers to hypothetical scenarios to the application that will use it. Furthermore, the aim of this project is to construct a database that will provide ichthyologic and environmental data. The main advantage is the compatibility with various software platforms and that it can be easily expanded.

1. Introduction

Inland fish fauna, like all taxonomic groups of fauna, directly related to the environment in which they live and are part of its history. Their study (recognition, recording, spreading, morphology, anatomy, biochemistry, ecology etc.) is a key task for specialists, but the state of their environment, the threats they face and their management in general requires the involvement of state actors, as well as every sensitive citizen and civil society (Legakis & Maragou 2009). Water is an important natural resource, necessary for the human survival as well as for all living organisms. Ecosystems provide major functions to humans. However, in the 21st century the health of freshwater system is in crisis caused by excessive human development, which has led to a global environmental degradation. The inland waters ecosystems have been characterized as systems of high biodiversity, because they include 2.4% of all known species, although they occupy 0.8% of the land area and represent 0.3% of all water planet. The inland water crisis seems to be the most important problem and must be solved (McAllister et al. 1997). E-governance deals with sensitive information, such as social services and environmental scientific data as the fishery data that should not be available to third party private for-

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profit businesses. Within that framework, the governance and management of inland waters ecosystems constitute an important factor towards an “environmentally aware” society. Inland waters have always been acknowledge as a key nutrition resource for people living around lakes, rivers and other inshore water bodies. Additionally, the intense necessity for fresh water in inlands is constantly growing and imposes more pressure to relative practiced activities, usually in conflict uses (Kokkinakis & Andreopoulou 2011; Andreopoulou et al. 2011). The development of computer science, in recent years, has made information one of the most important assets. Particularly in organizing and handling large amounts of environmental information, databases are effective tools in the wider context of environmental governance (Andreopoulou 2000; Andreopoulou 2007). Furthermore, the aim of this project is to construct an RDBMS database that will provide multiple and various ichthyology and environmental data.

1.1. RedBook

The goal of the Red Data Book of Endangered Animals in Greece was to record the conservation status of species of Greek fauna, to distinguish endangered species and to identify, as far as possible, the main threats and the most necessary measures for protection and conservation of these species. The species evaluation and development for the animals of Greece based on the system established by IUCN (International Union for Conservation of Nature). It is a process of assessing and documenting the status of species, ending in their hierarchical classification, in order to identify those species that are most at risk of extinction in their natural environment and to promote the need to protect them. However, Red Books is more than just a list of names and related risk categories, it is a rich source of data for the species being evaluated (Legakis & Maragou 2009).

1.2. IUCN

The IUCN Red List of Threatened Species (also known as the IUCN Red List or Red Data List), founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species. The International Union for Conservation of Nature (IUCN) is the world's main authority on the conservation status of species. A series of Regional Red Lists produced by countries or organizations, which assess the risk of extinction to species within a political management unit. The IUCN Red List is set upon precise criteria to evaluate the extinction risk of thousands of species and subspecies.

These criteria are relevant to all species and all regions of the world. The aim is to convey the urgency of conservation issues to the public and policy makers, as well as help the international community to try to reduce species extinction. The IUCN Red List of Threatened Species does not just focus on threatened species, it considers the status of all species across an increasing number of taxonomic groups. In the past, there has unfortunately been no formal reporting process to capture all the Least Concern assessments; hence the list of Least Concern species on the IUCN Red List is not comprehensive (IUCN 2017).

1.3. Monitoring of the habitat types and species of Community interest in Greece

The monitoring of the habitat types and species of Community interest in Greece (NATURA 2000 and national area) takes place in response to the obligations arising from Directives 92/43 / EEC and 2009/147 / EC (known today 79/409 / EEC) The monitoring program is implemented on two main axes. In the areas of the NATURA 2000 network, outside the competence of existing Protected Areas Management Bodies (FACS) and in the areas of the national area outside the NATURA 2000 network, outside the competence of existing FABs. The conservation and assessment program for conservation status is also relevant for these areas, but at a different (coarser) level than Natura 2000 sites (Sites of Community Importance and Special Protection Areas).

Surveillance and assessment of conservation status are implement for species and types of habitats throughout the national area, as the assessment of the conservation status of species and habitats at national level and the preparation of the National Reports for the 2007-2012 season requires supervision not only within, but also outside the Natura 2000 sites (Ministry of Environment, Energy and Climate Change 2017).

1.4. Databases

Database is a collection of data organized to serve multiple applications at the same time as logically or verbally logged in a single storage medium allowing them to handle efficiently and managed by one or more users at the same time (Andreopoulou 2008; Andreopoulou 2009). It is easy to understand that the larger the volume data is the use of the database is necessary. As a result, there is an increase in productivity and a reduction in waiting time (Andreopoulou 2000; Andreopoulou 2009). Each user can access and use the same data for different purposes even at the same time (Andreopoulou et al. 2004; Andreopoulou 2008). The organization of data in a database gives the program data independence, prevents redundancy, has greater data coherence, improves data sharing, increases productivity, improves data accessibility and reduces maintenance and management of the program, especially when a DBMS database is used (Andreopoulou & Kokkinakis 2009).

2. Methodology

The initial stage of the effort to create the multimedia database started with a reasonable sequence of steps - stages that had the expected outcome. Those steps were data collection, use of internet material, digitalization, image processing, text translations, and geographic data processing. The sources of the data used for the database population were from a) The Red Book of Endangered Animals of Greece b) IUCN - International Union for Conservation of Nature c) Ministry of Environment & Energy, Study 6: Supervision and Evaluation of the Conservation status of fish species of Community interest in Greece and d) Fishbase.

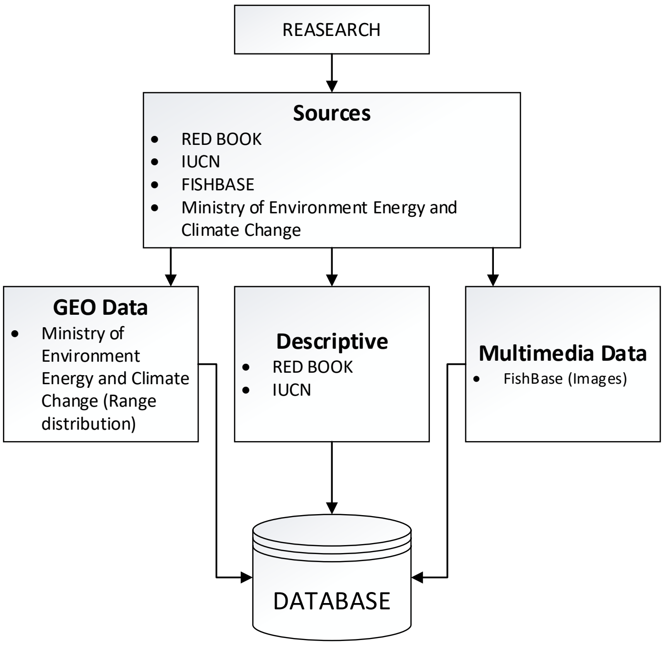

Figure 1. Database data types

The main goal in designing database is to store the data in such way that it can be used for a wide range of applications while at the same time it is possible for users to achieve interactive process in the form of queries between the "user" and the "computer" (Andreopoulou 2006; Andreopoulou et al. 2007; Andreopoulou 2008; Andreopoulou & Kokkinakis 2009). Furthermore, we aim for various users to have the opportunity to use the data avoiding the development of complicated programs. Microsoft Access is one of the most popular and powerful programs for designing, creating, editing and managing relational databases. Other similar applications are dBase, FoxPro and Paradox (Goultidis 2004).

The entity-relationship model (ERM) that is currently used to design the database, was proposed by Peter Chen (1976). The method was used in the first stage of database design to map terms and relationships to one area of interest. The outcome was an entity - relationship diagram (ERD) that is containing a standardized and symbolic way of the entire information that is stored in the database, and the way that the portions of the information is linked together.

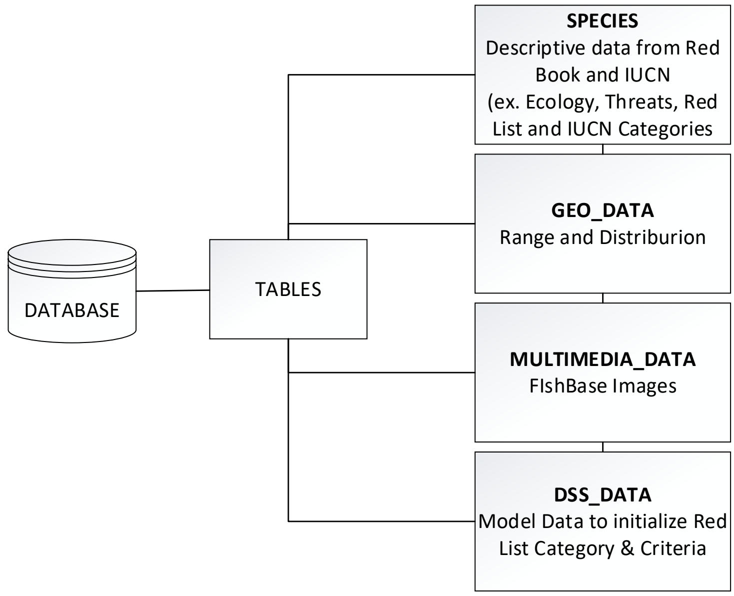

Figure 2. Database organization

The above actions included the following tasks: a) the conceptual schema of the multimedia database according to the object-oriented data model, as supported by the class diagram and b) the logical design of the database, based on conceptual schema, according to the relational data model. The database management system was developed in Microsoft Access and in pgAdmin, which is an open source administration and development platform for PostgreSQL.

2.1. Conceptual Schema

According to the entity - relationship model (ERM), at this stage, each type of the descriptive data are represented as one entity. At the conceptual schema design, identify candidate keys and primary keys for each entity or association. In a second phase, we determined the relationships between entities. Relationships are a conceptual link between two or more types of entities.

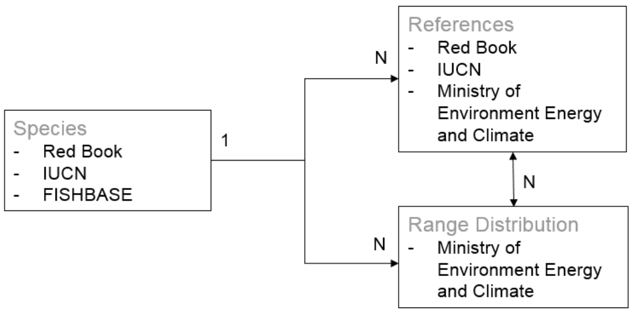

Figure 3. Conceptual Schema

- 1-1 (one-to-one). Assigns an entity of a type with at most or just an entity of another type.
- 1-N (one-to-many). An entity of one type is associated with none, one or more snapshots of another type.
- N-N (many-to-many). Matching one instance of one type with one, no or multiple snapshots of the other type.

2.2. Logical design

Logical design concerns the process of rationally designing the structure of the base panels in a way that is flexible and efficient in its use. In the relational database model, the basic principle of designing is to group the fields of entity types, and to create tables for entity and correlation types as defined in the relationship entity model. The logical design stage includes the following steps:

a) Conversion of the conceptual model into a logical model

b) Transformation of the data structure into a different type so that it is easier to be managed by the Database Management System (DBMS).

- Creating tables - relations
- Normalization of the tables.
- Definition of the integrity constraints.

2.3. Physical design

At this stage, the data storage structures in database files that are designed to support optimal data access. In the physical design, databases were adjusted to the database management system (DBMS) to improve performance. Databases are dynamic and they are able to upgrade and integrate new data. Finally, at physical design, we define that portion of the base that will be visible to each user. This mainly applies to extended databases with complex design and large number of users.

3. Results

Although this paper describes the process of the database construction, it was a necessity to contribute a research in order to evaluate which data are appropriate for the researchers in order to draw useful conclusion for inland water management. The results of the above process were the creation of a multimedia database about fish fauna in inland water of Greece consisting of a descriptive data segment and comprising data entities and their attributes. The multimedia database has 42 Tables, 66 Geographical files, 127 Species, 509 References, and 3367 Range Distribution Records. These species, due to their limited geographical spread, are vulnerable and as a result some natural populations have disappeared while others are in threat directly or indirectly (Economidis 1991).

Field Name	Data Type	Description (Optional)
ID	AutoNumber	
Family	Short Text	
Class	Short Text	
ScientificName	Short Text	
SpeciesAuthority	Short Text	
CommonName	Short Text	
Summary	Long Text	
RedListCategoryIUCN	Short Text	
RedListCriteriaIUCN	Short Text	
RedListCategoryGR	Short Text	
RedListCriteriaGR	Short Text	
YearPublishedIUCN	Short Text	
DateAssessedIUCN	Short Text	
JustificationIUCN	Long Text	
PreviusCategoryIUCN	Short Text	
RangeDescriptionIUCN	Long Text	
PopulationIUCN	Long Text	
CurrentPopulationTrendIUCN	Long Text	
HabitatAndEcologyIUCN	Long Text	
ThreatsIUCN	Long Text	
ConcervationActionsIUCN	Short Text	
PopulationRangeGR	Long Text	
PopulationPerGR	Long Text	
EcologyGR	Long Text	
ThreatsGr	Long Text	
ConcervationActionsGR	Long Text	
ConcervationActionsNeedGR	Long Text	
Region	Short Text	
ImageFile	Hyperlink	
MapFileShp	Hyperlink	
PointFileKml	Hyperlink	
MapFileKml	Hyperlink	

Figure 4. Table example

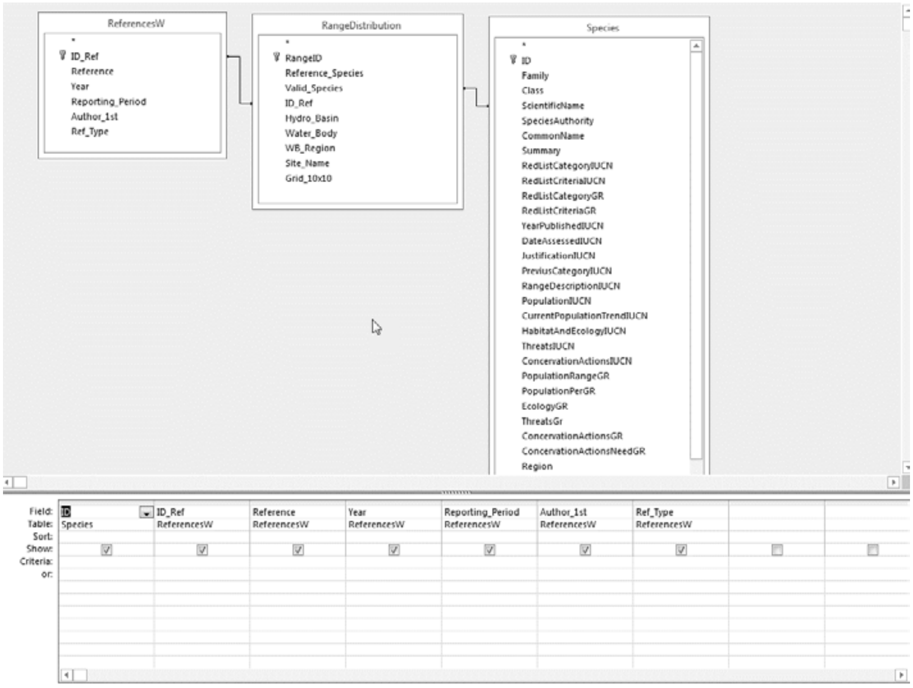

Figure 5. Query example

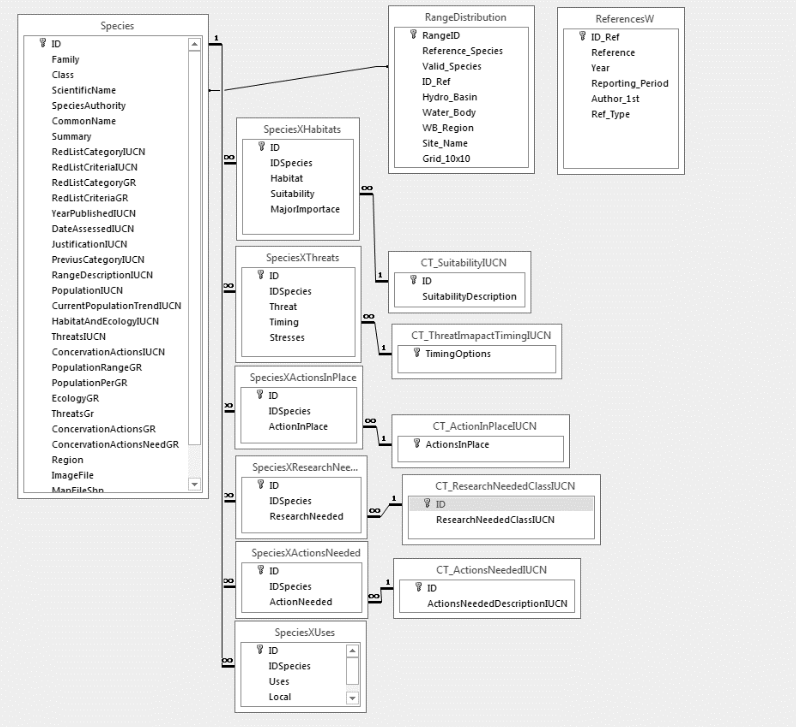

Figure 6. Database relationships

The data, which fulfill the multimedia database, and they mentioned above in the previous section, are organized in tables so they are manageable in order to create multi-criteria queries about:

- Descriptive ichthyology data according to both Red Book and IUCN (Figure 7)
- References of species (Figure 8)
- Range distribution of species (Figure 9)

Species

ID	Class	ScientificName	SpeciesAuthority	CommonName	Re(	Re	RedListCriteriaGR	Year	DateAsses
1	Actinopterygii	Alburnus macedonicus	Karaman 1928	Σίρκο Δοϊράνης	CR	CR	A3c;B1ab(i,ii,iii)+ 2ab(i,ii,iii)	2008	2008-01-01
2	Actinopterygii	Alburnus vistonicus	Freyhof & Kottelat, 2007	Αλάια	CR	CR	B2ab(ii,iii)	2008	2008-01-01
5	Cephalaspidomorphi	Petromyzon marinus	Linnaeus, 1758	Πετρόμυζον	LC	LC			
9	Actinopterygii	Aphanius almiriensis	Kottelat, Barbieri & Stoumboudi, 2007	Ζαχαριάς	CR	CR	B1ab(I,ii,ii,iv,v)+2ab(I,ii,iii,iv,	2008	2008-01-01
10	Actinopterygii	Barbus euboicus	Stephanidis, 1950	Ευβοϊκή Μπριάνα	CR	CR	B1ab(i,ii)c(ii)+2ab(i,ii)c(ii)	2006	2006-01-31
11	Actinopterygii	Barbus pergamonensis	Karaman, 1971	Μπριάνα Λέσβου	LC	CR	B1ab(iii)+2ab(iii)	2008	2008-01-01
12	Actinopterygii	Cobitis stephanidisi	Economidis, 1992	Φεροβελονίτσα	CR	CR	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	2006	2006-01-31
13	Cephalaspidomorphi	Eudontomyzon hellenicus	Vladykov, Renaud, Kott & Economidis,	Γκαβόχελο	CR	CR	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv	2006	2006-01-31
14	Actinopterygii	Knipowitschia goerneri	Ahnelt, 1991	Κερκυρογωβιός	DD	CR	B1ab(i,ii)+2ab(i,ii)	2006	2006-01-31
15	Actinopterygii	Oxynoemacheilus theophili	Stoumboudi, Kottelat & Barbieri, 2006	Λεσβοβίνος	LC	CR	B1ab(iii)+2ab(iii)	2008	2008-01-01
16	Actinopterygii	Pelasgus epiroticus	(Steindachner, 1895)	Ηπειρώτικη τσίμα	CR	CR	A2ce+B1ab(iii,v)	2006	2006-01-31
17	Actinopterygii	Pelasgus laconicus	(Kottelat & Barbieri, 2004)	Λακωνικός πελασγ	CR	CR	B2ab(ii,iii,iv,v)	2006	2006-01-31
18	Actinopterygii	Pungitius hellenicus	Stephanidis, 1971	Ελληνοπυγόστεος	CR	CR	B2ab(i,ii,iii,iv,v)	2015	2013-02-11
19	Actinopterygii	Valencia letourneuxi	(Sauvage, 1880)	Ζουρνάς	CR	CR	A3ce;B2ab(i,ii,iii,iv,v)	2006	2006-01-31
20	Actinopterygii	Alburnus volviticus	Freyhof & Kottelat, 2007	Γελάρτζα	EN	EN	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv	2008	2008-01-01
21	Actinopterygii	Cobitis arachthosensis	Economidis & Nalbant, 1996	Αραχθοβελονίτσα	EN	EN	B1ab(iii)	2006	2006-01-31

Figure 7. Result of descriptive organized Species Data

SpeciesXReferences_Distinct

ID	ID_Ref	Reference
1	605	Bobori, D.C., D.K. Moutopoulos, M. Bekri, I. Salvarina, A.I. Perandones Muñoz. (2010). Length-weight relationships of freshwater fish species caught in three Greek lakes. Jo
1	606	Bobori, D.C., I. Salvarina. (2010). Seasonal variability of fish abundance and biomass in gillnet catches from an E Mediterranean lake. Journal of Environmental Biology 31(6)
1	609	Triantafyllidis, A., D.C. Bobori, C. Koliamitra, E. Gbandi, M. Bandi, O. Petriki, N. Karaiskou. (2011). DNA barcoding analysis of fish species diversity in four North Greek lakes.
2	71	Bobori, D.C., Koutrakis, E. T. & Economidis P.S. (2001). Shad species in Greek waters - An historical overview and present status. Bull. Fr. Peche: Piscic., 363 : 1-8, In press
2	72	Bobori, DC., Economidis, PS. & Maurakis, EG. (2001). Freshwater Fish Habitat Science and Management in Greece. Aquatic Ecosystem Health & Management, 4 (4) : 381-391.
2	74	Bobori, D.C. & Economidis, P.S. (2003). Fish biodiversity in the main Greek rivers and lakes. In review.
2	87	Crivelli, A.J. (1990). Fisheries decline in the freshwater lakes of northern Greece with special attention for lake Mikri Prespa. In: W.L.T. van Denden, B. B. Steinmetz & R.H. H
2	127	Economidis, P.S. & Sinis, A.I. (1986). Situation taxinomique et comparaisons des Aloses (Pisces, Clupeidae) provenant des lacs Volvi et Vistonis (Grece). Description d'une n
2	135	Economidis, P.S. (1995). Endangered freshwater fishes of Greece. In: Endemic Freshwater Fishes of N. Mediterranean region. Biol. Conserv., 72 (2) : 201-211.
2	137	Economidis, P.S., Vogiatzis, V.P. & Bobori, D. (1996). Freshwater fishes. In: NATURA 2000, pp. 604-635. Directive 92/43/EEC "The Greek Habitat Project NATURA 2000: An over
2	141	Economidis, P.S. (1999). Conservation of Greek freshwater fish. Historical overview and perspectives. Workshop on "Mediterranean Stream Fish Ecology and Conservation"
2	176	Hadjibiros, K., Economidis, P.S. & Koussouris, T. (1997). The ecological condition of major Greek rivers and lakes in relation to environmental pressures. Fourth Euraqua Tecl
2	424	Οικονομίδης, Π.Σ. (1974). Μορφολογική, συστηματική και ζωογεωγραφική μελέτη των ιχθύων των γλυκέων υδάτων της Α. Μακεδονίας και Δ. Θράκης. Διδακτορική Διατριβ
2	496	Οδηγία Πλαίσιο περί Υδάτων 2000/60/ΕΕ - Ανάπτυξη δικτύων και παρακολούθηση ποιότητας των επιφανειακών, εσωτερικών, μεταβατικών και των παράκτιων υδάτων της
2	498	Hellenic Center for Marine Research unpublished data
2	702	Μπρόντερζεν, Οικονομίδης, Σιμελιάδου 2011. Οικολογική ποιότητα υδάτων σε επίπεδο λεκάνης απορροήςΠερίπτωση λεκάνης ποταμού Κομψάτου
9	501	Hellenic Center for Marine Research unpublished data

Figure 8. Result Species X Reference

SpeciesXRange

ID	RangeID	Reference_Species	Valid_Species	ID_Ref	Hydro_Basir	Water_Body	WB_Region	Site_Name	Grid_10x10
2	1	Alburnus vistonicus	Alburnus vistonicus	496	BOSPOS		Θράκη	VOZVOZ	10kmE560N212
2	2	Alburnus vistonicus	Alburnus vistonicus	498	KOMSATOS	KOMPSATOS P	Θράκη	LAKEWATER	10kmE558N212
2	3	Alburnus vistonicus	Alburnus vistonicus	498	KOMSATOS	KOMPSATOS P	Θράκη	PSARADES	10kmE558N213
2	4	Alburnus vistonicus	Alburnus vistonicus	498	KOMSATOS	KOMPSATOS P	Θράκη	POTAMOCHOR	10kmE557N214
2	5	Alburnus vistonicus	Alburnus vistonicus	498	FILIOURIS		Θράκη	FIL_LOFARI	10kmE562N212
2	6	Alburnus vistonicus	Alburnus vistonicus	498	VISTONIDA (LA	Kossynthos r.	Θράκη	POLISITO	10kmE558N212
2	7	Alburnus vistonicus	Alburnus vistonicus	498	KOMSATOS	KOMPSATOS P	Θράκη	TSALAPETEINC	10kmE558N214
2	8	Alburnus vistonicus	Alburnus vistonicus	498	KOMSATOS	KOMPSATOS P	Θράκη	MOSAIKO	10kmE559N212
9	11	Aphanius fasciatus	Aphanius almiriensis	501	Moustou Lake	Moustou Lake	Ανατολική Πελοπόννησος	MOUSTOU_DW	10kmE545N168
21	435	Cobitis arachthosensis	Cobitis arachthosensis	500	ARACHTHOS	ARACHTHOS P.	Ηπειρος	AKROPOTAMI	10kmE527N184
21	436	Cobitis arachthosensis	Cobitis arachthosensis	496	ARACHTHOS	ARACHTHOS P.	Ηπειρος	ARTA	10kmE527N185
22	557	Knipowitschia thessala	Knipowitschia thessala	500	PINIOS	Trikala West C	Θεσσαλία	KIT_TRIK	10kmE533N190
22	558	Knipowitschia thessala	Knipowitschia thessala	500	PINIOS	7T can.	Θεσσαλία	MELISSA	10kmE540N192
22	559	Knipowitschia thessala	Knipowitschia thessala	496	PINIOS	Pinios r.	Θεσσαλία	P088	10kmE538N194
22	560	Knipowitschia thessala	Knipowitschia thessala	496	PINIOS	Pinios r.	Θεσσαλία	P266	10kmE535N191
22	561	Knipowitschia thessala	Knipowitschia thessala	496	PINIOS	Pamisos r.	Θεσσαλία	PAMISOS	10kmE533N189
22	562	Knipowitschia thessala	Knipowitschia thessala	500	PINIOS	Pamisos r.	Θεσσαλία	PAMISOS	10kmE533N189
22	563	Knipowitschia thessala	Knipowitschia thessala	496	PINIOS	Lithaios r.	Θεσσαλία	LITHAION	10kmE533N190
22	564	Knipowitschia thessala	Knipowitschia thessala	496	PINIOS	Pinios r.	Θεσσαλία	P300_US	10kmE534N190

Figure 9. Result Species X Range

4. Discussion

The structure of the organized data can effectively assist in decision making on rational environmental management when based on secure, correct and reliable data (Andreopoulou et al. 2004; Andreopoulou et al. 2007; Andreopoulou 2009; Andreopoulou & Kokkinakis 2014). This multimedia database is a multi-user database, i.e. many users can use the same data for the same or for different applications at the same time (data sharing) and this is particularly successful in the environmental and biological sciences with data logging flora and fauna (Andreopoulou et al. 2004; Andreopoulou, et al. 2007; Andreopoulou & Kokkinakis 2009; Andreopoulou & Kokkinakis 2014). Moreover, this database can operate as a repository of the effective organization, promotion and utilization of environmental data, particularly in the area of sensitive inland water ecosystems (Kirkenidis et al. 2011). The database due to its structure and data it will be able to provide answers to hypothetical scenarios to the application that will use it in order to achieve the best form of intervention. The main advantages of the database are the compatibility with various software platforms and that it can be easily expanded in the future. Finally, the database will work as data organized repository in a user-friendly decision support system tool for environmental projects and reference for research institutes, authorities and organizations dealing with environmental issues and fishery management on similar wetlands or inland water ecosystems

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