

## CREATION OF FISH DATABASES FOR ELECTRONIC INTERACTIVE MAP: TABLES AND KEYS

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**Purpose.** Purpose of the work is to create fish databases using rainbow trout data and basing on new methods of theoretical analysis of fish data and their ordering in hierarchical structures with elements represented as relation tables linked through a system with primary keys with specific codes.

**Methodology.** The methods of object-oriented system analysis, ER-diagram design, and the methods of computer databases construction were used in process of present work.

**Findings.** Some well-known fish databases (seafood, aquaculture samples) were reviewed and some of their peculiarities are analyzed from the point of view of professional construction of relational databases within modern electronic information systems. The ways of the construction of such databases for domestic use in connection with the Internet were proposed. A number of algorithm stages for fish database design was described on the example of the information on rainbow trout and locations of its occurrence (catches) in Ukraine; ER-diagram, logical diagram of such database with its elements that can be presented in tables are suggested as well. Such tables should be unmistakably interconnected through the key system, and this procedure is described in detail in the article, as well as the creation of specific key codes, their formation and use to form links between the tables. The implementation of described works can be considered as one of the first stages in the development of interactive map with information of the fish species distribution (and locations of their catches) in Ukraine.

**Originality.** Such important modern project as an interactive map with the information on the distribution of fish species (and locations of their catches) based on modern information and computer technologies using biological databases has not been implemented yet in Ukraine. The work described in this article is the first step in creating of such a map that will facilitate further intensive introduction of modern information technologies and the development of domestic fishery industry.

**Practical value.** Rainbow trout is an important object for fishery industry of the country; and development of interactive electronic map with the information on the spread of the rainbow trout and other fish species (and places of their catches) in Ukraine is an important step for the transformation of fishery industry in our country to the contemporary level of the world technologies and for the provision of food safety. Using of contemporary computer technologies suggested in the this article, would make this branch more effective in Ukraine and in the whole world.

**Keywords:** fish, fishery economy, trout, databases, electronic information systems object-oriented system analysis, key, primary key.



**СТВОРЕННЯ БАЗ ДАНИХ РИБ ДЛЯ ЕЛЕКТРОННОЇ ІНТЕРАКТИВНОЇ  
КАРТИ: ТАБЛИЦІ ТА КЛЮЧІ**

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**Мета.** Виконати розробку баз даних риб, використовуючи дані про райдужну форель та базуючись на новітніх методах теоретичного аналізу даних про риб, а також їх упорядкуванні у ієрархічні структури, елементи яких можуть бути представлені у вигляді реляційних таблиць, які пов'язані через систему з первинними ключами зі специфічним кодуванням.

**Методика.** У процесі виконання робіт використано методи об'єктно-орієнтованого системного аналізу, проектування ER-діаграм, методи конструювання комп'ютерних баз даних.

**Результати.** Розглянуто деякі відомі у світі бази даних риб (зразків морепродуктів, об'єктів аквакультури) та проаналізовані окремі їх особливості з точки зору професійного конструювання реляційних баз даних у складі сучасних електронних інформаційних систем. Запропоновані шляхи конструювання таких баз даних для вітчизняного застосування у зв'язках із всесвітньою мережею Інтернет. Описано ряд етапів алгоритму конструювання баз даних про риб на прикладі інформації про райдужну форель та місця її існування (вилову) в Україні, наведено ER-діаграму та логічну схему такої бази даних, елементи якої можуть бути представлені у вигляді таблиць. Такі таблиці мають бути безпомилково пов'язані між собою через систему ключів і ця процедура детально розглянута у статті, як і створення специфічних кодів-ключів, їх формування і застосування для утворення зв'язків між таблицями. Виконання описаних робіт може розглядатись, як один з перших етапів при розробці інтерактивної мапи з інформацією про поширення видів риби (та локацій її вилову) в Україні.

**Наукова новизна.** В Україні ще не реалізовано такий сучасний важливий проект, як інтерактивна мапа з інформацією про поширення видів риби (та локацій її вилову) в країні на основі сучасних інформаційно-комп'ютерних технологій із застосуванням біологічних баз даних. Виконувана розробка, описана у даній статті, є першим етапом створення такої мапи, що сприятиме подальшому інтенсивному впровадженню сучасних інформаційних технологій та розвитку вітчизняної рибної промисловості.

**Практична значимість.** Райдужна форель є цінним об'єктом для рибного господарства країни; розробка інтерактивної електронної мапи з інформацією про поширення вказаного та інших видів риби (і локацій її вилову) в Україні є важливим кроком для переведення рибного господарства нашої країни на сучасний рівень світових технологій та для забезпечення продовольчої безпеки. Застосування інформаційних комп'ютерних технологій, розглянутих у даній роботі, зробить рибну галузь в Україні та світі більш ефективною.

**Ключові слова:** риба, рибне господарство, форель, бази даних, електронно-інформаційні системи, об'єктно-орієнтований системний аналіз, ключі, первинний ключ.



## СОЗДАНИЕ БАЗ ДАННЫХ РЫБ ДЛЯ ЭЛЕКТРОННОЙ ИНТЕРАКТИВНОЙ КАРТЫ: ТАБЛИЦЫ И КЛЮЧИ

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**Цель.** Выполнить разработку баз данных рыб, используя данные о радужной форели и базируясь на новейших методах теоретического анализа данных о рыбах, а также их упорядочении в иерархические структуры, элементы которых могут быть представлены в виде реляционных таблиц, которые связаны посредством системы с первичными ключами со специфическим кодированием.

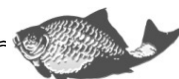
**Методика.** В процессе выполнения работы использованы методы объектно-ориентированного системного анализа, проектирование ER-диаграмм, методы конструирования компьютерных баз данных.

**Результаты.** Рассмотрены некоторые известные в мире базы данных рыб (образцов морепродуктов, объектов аквакультуры) и проанализированы некоторые их особенности с точки зрения профессионального конструирования реляционных баз данных в составе современных электронных информационных систем. Предложены пути конструирования таких баз данных для отечественного использования в связях с всемирной сетью Интернет. Описаны некоторые этапы алгоритма конструирования баз данных о рыбах на примере информации о радужной форели и мест ее обитания (вылова) в Украине, приведены ER-диаграмма и логическая схема такой базы данных, элементы которой могут быть представлены в виде таблиц. Такие таблицы должны быть безошибочно связаны между собой посредством системы ключей, и эта процедура детально рассмотрена в статье, так же, как и создание специфических кодов-ключей, их формирование и использование для образования связей между таблицами. Выполнение описанных работ может рассматриваться как один из первых этапов при разработке интерактивной карты с информацией о распространении видов рыбы (и мест ее вылова) в Украине.

**Научная новизна.** В Украине еще не реализован такой важный современный проект, как интерактивная карта с информацией о распространении видов рыбы (и мест ее вылова) в стране на основе современных информационно-компьютерных технологий с использованием биологических баз данных. Исполняемая разработка, описанная в данной статье, является первым этапом создания такой карты, что будет способствовать дальнейшему интенсивному внедрению современных информационных технологий для развития отечественной рыбной промышленности.

**Практическое значение.** Радужная форель является ценным объектом для рыбного хозяйства страны; разработка интерактивной электронной карты с информацией о распространении радужной форели и других видов рыбы (и мест ее вылова) в Украине является важным шагом для перевода рыбного хозяйства нашей страны на современный уровень мировых технологий и для обеспечения продовольственной безопасности. Использование информационных компьютерных технологий, рассмотренных в данной работе, сделает рыбную отрасль в Украине и мире более эффективной.

**Ключевые слова:** рыба, рыбное хозяйство, форель, базы данных, электронно-информационные системы, объектно-ориентированный системный анализ, ключ, первичный ключ.



## PROBLEM STATEMENT AND ANALYSIS OF THE LAST STUDIES AND PUBLICATIONS

During the last decades the people become to understand that the increasing number of population of the Earth needs more and more food products, including fish products [1]. The aquaculture is the most rapidly growing product sector of the World – today it supply approximately one half of all consumed fish, or 17 kg per one person [1]. The novel methods of biotechnology provide the great impulse to the development of aquaculture, as well as contemporary information computer technologies (ICT) [2, 3, 24]. At the same time, the last world experience in studying and controlling of the situation with biodiversity proves the necessity of intensive use of ICT in biological industries. Thus, at the beginning of the rapid expansion of network Internet technologies in biology, on June 2000, the First International Conference in programming was held, which was devoted to the problems of creation of information systems (IS) and databases (databases) in biology [24]. The conference was titled "Very Large DataBase 2000 Conference" (VLDB) and featured a wide range of top-level specialists: biologists, ICT engineers, administrative staff from leading countries around the world, and others. A number of topical issues of the development of IS from the database in biology were observed, a number of generalizations were done. The decisions were made that determined development of works in this field; they are relevant today still. Of the final important provisions adopted at this conference, let us list only two: i) computer science / information technology (CN / IT) professionals play a fundamental role in the creation of technological infrastructure, which should also include sciences about environment and its changes; ii) the next generation of CN / IT software must take into account complex, hierarchically organized processes in ecosystems and the environment to address environmental issues.

So, with ICT development appears the possibility of development of new tools, new methods of science-intensive fishery economy organization, its control, the account of biological organisms, and etc. In these frameworks the development of databases (DB) of fishes, other aquaculture organisms with further DB links to electronic information systems (ICs) become really necessary. In previous publications the authors have already written about the necessity of such ICs with DB creation in Ukraine [1, 24] for fishes [2, 3], other living organisms [4, 5, 24]. Few foreign IS with DB were observed in present publication [6-8] that may be taken as prototypes for DB creating by the authors. Materials about the development of IS with DB of living organisms (including fishes) were described before by different authors [2-24], and we suppose that biological DBs and ISs created by citizens of each country who knows local fauna and the most interested in such ISs have the greatest value [3, 24]. That is why for our work we used, first of all, the data of fish research of contemporary scientists in Ukraine [1-3, 25-41, 52]. Our previous publications demonstrate our experience in biological DBs construction [2-5, 42-51] as well as the achievements of other professionals in DBs development [55-60].

*Foreign fish databases construction experience.* Below we would like to suggest information about some fish databases created in different countries of the World that may be seen as prototypes to our developed DB.

1) *A Map and Database of Westslope Cutthroat Trout Hybridization Throughout Idaho and Montana Streams (USA).* The authors of this publication [6] had written that



among the many threats posed by invasions of nonnative species is introgressive hybridization, which can lead to the genomic extinction of native taxa. This phenomenon is regarded as common and perhaps inevitable among native cutthroat trout and introduced rainbow trout in western North America, despite that these taxa have naturally co-occurred for thousands of years in some locations. The scientists have conducted a synthetic analysis of 13,315 genotyped fish from 558 sites in Idaho and Montana by building logistic regression models using data from geospatial stream databases and from 12 published studies of hybridization to assess whether environmental covariates could explain levels of introgression between westslope cutthroat trout and rainbow trout. A consensus model performed well (AUC, 0.78–0.86; classification success, 72–82%; 10-fold cross validation, 70–82%) and predicted that rainbow trout introgression was positively associated with warmer water temperatures, larger streams, proximity to warmer habitats, to recent sources of rainbow trout propagates, and presence within the historical range of rainbow trout. The databases for the 558 sites, as well as user-friendly digital maps and ArcGIS shapefiles showing hybridization probabilities for three thresholds (1%, 10%, and 20%) associated with six climate change and rainbow trout invasion scenarios are available at the project website to assist managers in conservation planning [6].

2) *The CRCT GIS-based database (USA)*. In other publication [7] was written that Colorado River Cutthroat Trout (CRCT) conservation team identified a need to further develop a long-term approach to updating and maintaining the CRCT GIS-based database that was created using the Inland Cutthroat Trout Protocol (ICP). The University of Wyoming Geographic Information Science Center was contracted to develop a multi-state, web-based database and a web-based application for viewing and editing the data to aid in conservation activities. Previously, Colorado, Utah and Wyoming all used separate, desktop databases that could not be shared with partnering agencies nor updated for all users simultaneously. The database and application is for CRCT as well as other cutthroat species (Greenback cutthroat trout and Rio Grande cutthroat trout).

The developed web application is composed of a data viewer and a password protected editor. Base layers include: topographic raster, aerial images and NHD streams and water bodies. Cutthroat spatial data includes: historic distribution, barriers, current distribution, and conservation populations. The viewer includes a query tool to view database attributes associated with barriers, current distribution and conservation population. The editor has stream reach editing tools that allow addition, deletion and adjusting of stream reaches and barriers and an online form to add, delete and modify attributes. Any edits conducted through the web tool will not be permanent until reviewed and validated by the database manager and Geographical Management Unit leaders on an annual basis [7].

3) *The database “Fischdatenbank” (Austria, Germany)*. This fish database [8] has been created since the beginning of the “EU Water Framework Directive” on 2000. The information about the fish contained there was collected since 1980s. All fish data collected in this database under the monitoring rules required by EU-WRR1 have to be managed, estimated and evaluated. The original database ATFI-BASE was adapted to the changed requirements and developed further to the Fischdatenbank Austria (FDA). The term FDA now contains several specialized scientific databases and comprehensive software framework. Results from this database were subsequently available in the



Water Information System Austria (WISA), and they were incorporated in the National Water Management Plan (NGP). All data collected within the framework of the program “Fish on running waters” (GZÜV (Gewässerzustandsüberwachungsverordnung) for water status monitoring regulation, implementation of the Water Framework Directive) in Austria are stored and evaluated in the FDA also. The total number of the data (GZÜV data and projects) includes 6755 surveys at more than 5000 water objects throughout Germany until October 2017 [8].

### **DEFINING OF PARTS OF THE PROBLEM THAT WERE NOT SOLVED BEFORE. THE PURPOSE OF THE WORK**

This publication is a continuation of previous ones about fish databases (DBs) construction [2, 3] with demonstration of the next steps of construction algorithm. In our previous works there were some first parts of this problem; there are the next ones that were not solved before/ So, there were not revealed some details about the tables formation from the objects on ER-diagrams, as well as some important details of keys formation and usage. So, there we would like to demonstrate some engineering and programming tools that provide through the keys one of the main principles of DBs construction: the principle of data integrity, that provides the reliability and prevents data losses during DB functioning. This principle is important indeed because it prevents losses of great volumes of information from different “sub-elements” of DB, or different DBs sectors. Sure, the method that will be demonstrated below is usable for the construction of DBs of living organisms (fishes) in Ukraine, and these DBs are network based and can be linked with ISs that visualized DB in the Internet. As our “distant goal” we would like to see further development of interactive electronic map with the information about the spreading of rainbow trout and/or other fish species (together with linked necessary information about the each fish specie) in Ukraine. Such electronic map has to be based on DBs, construction of which we would like to present in this article. Such works fulfillment we see as important step for the transformation of fishery industry in our country to the contemporary level of world technologies and for providing of food safety.

Purpose of this work was to create fish database using the data about rainbow trout, basing on the new methods of theoretical analysis of the data about fishes and their ordering in hierarchical structures with elements represented as relation tables linked through the system of codes-keys with primary keys with specific codes. Detailed information about such keys role, their formation and functioning will be given below.

### **MATERIALS AND METHODS**

The methods of object-oriented system analysis for databases application, ER-diagram design, the methods of computer databases construction including the methods of keys formation and functioning were used in process of the work fulfillment.

### **RESULTS OF THE STUDIES AND THEIR DISCUSSION**

Designing a relational database with fish information is based on the algorithm we described earlier for different species of living organisms [2-4, 24]. Let us describe briefly the first stages of this algorithm (since each task is impossible to do without it realization), and then lets move on to the extended presentation of the essence of this problem solution within this article. First, for the species of rainbow trout (Fig. 1), we



create the object model shown at Fig. 2. Logical model of DB for this task is demonstrated at Fig. 3.

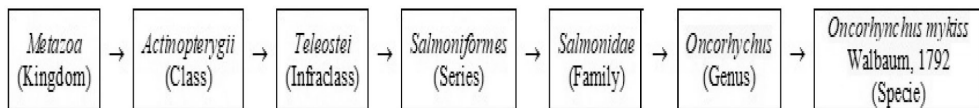


Fig. 1. Hierarchic classification of *Oncorhynchus mykiss* (Walbaum, 1792) [3].

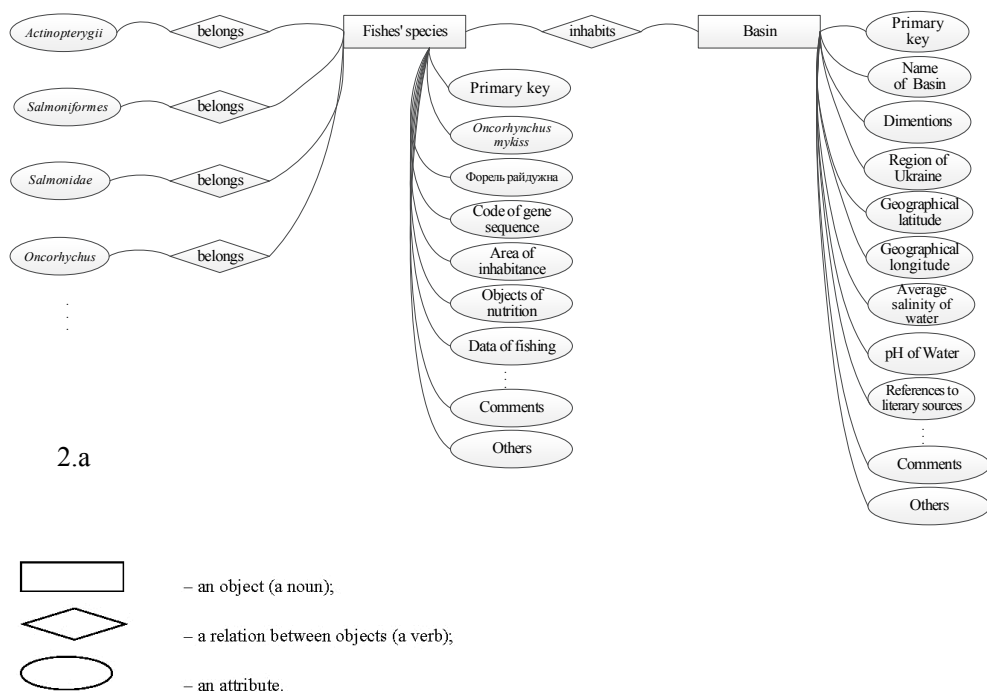


Fig. 2. Fragment of ER-diagram «Fishes and Basins of Their Inhabitation» on example of Rainbow Trout (*Oncorhynchus mykiss* Walbaum, 1792): 2.a. Fragment of ER-diagram (explanations see in text), 2.b. Symbolic denotation of objects, relations and attributes at the scheme [2, 3].

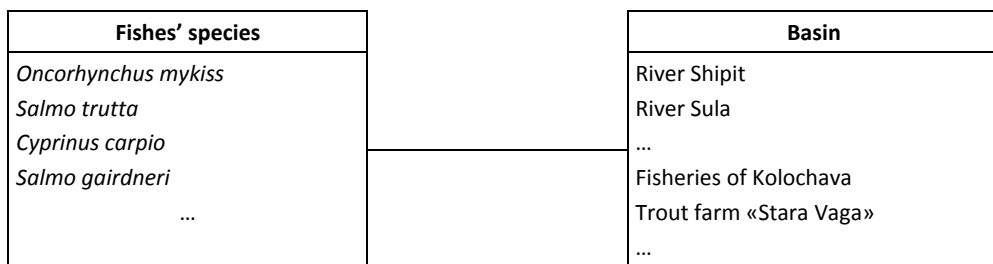
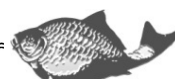


Fig. 3. Logical model of DB with information about the fishes and locations of their inhabitation (catching).



The database we are currently developing is planning to be laid in base of creation of an interactive map of rainbow trout spread across Ukraine (and later for other fishes species). At the beginning two main objects logically have to be chosen: "Fishes' species" and "Basin" (explanations to this stage of algorithm see in [2, 3]). Some attributes to the object "Fishes' species" we left the same as we select them earlier in [3], but some important attributes we added later. For the second object "Basin", it would be logical to choose the following attributes (for natural reservoirs): "Name" (if any), "Dimentions", "Geographical latitude", "Geographical longitude", "Average salinity of water", and etc. (see below). Therefore, the objects in the proposed logical model are characterized by the attributes:

**Object "Fish"**

*Attributes:*

Primary key

The name of the fish (in Latin, Ukrainian and Russian).

Class

Subclass

Series

Family

Genus

Species

Area of inhabitanсe.

Biotopes of inhabitanсe.

Objects of nutrition.

Data of fishing.

Code of gene sequence (if it is known)

References to literary sources.

.....

Comments.

Other.

**Object "Basin"**

*Attributes:*

Primary key

The name of the Basin (in English and in languages of local population).

Dimentions

Geographical latitude

Geographical longitude

Average salinity of water

References to literary sources.

.....

Comments.

Other.





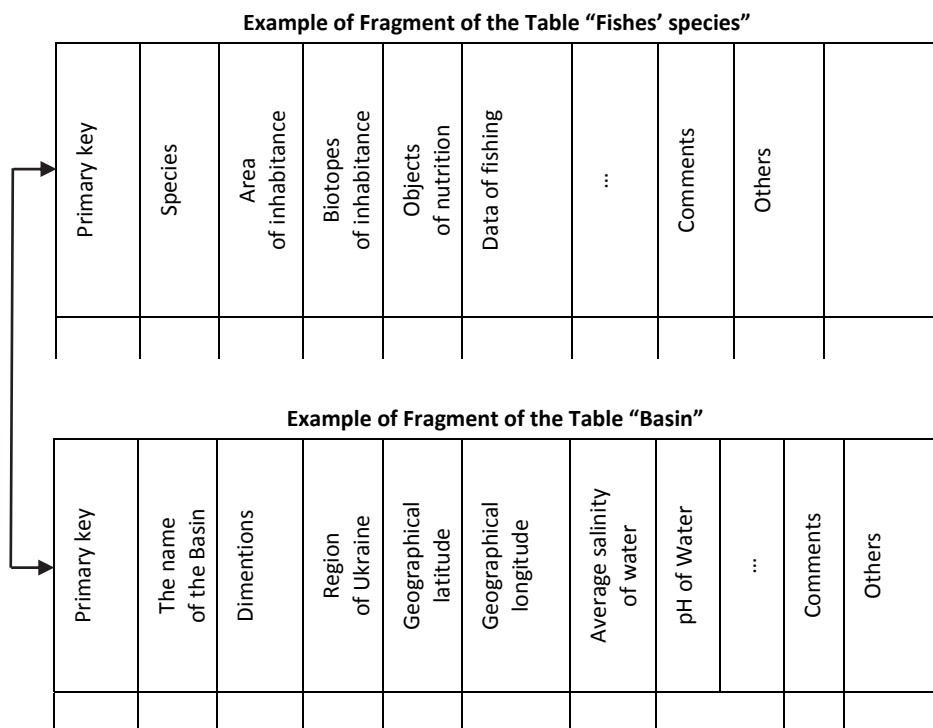
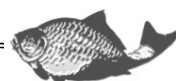


Fig. 4. Objects and relative tables

In process of further DB development the Object 1 “Fishes’ species” and Object 2 “Basin” are transformed in tables 1, 2. Attributes of these objects become the columns of these tables.

Using this database in working mode, a biological scientist can find out easily what species of fishes live in a particular basin. Using such databases, such specialist can easily perform all those operations with the data that were impossible for him previously: sorting, searching for a particular record, data filtering, data outputting in the desired format, and etc. These opportunities are very important in day-to-day professional work because the person who works in the field almost every day or adds to the previous material new information (data input into the table), or lists the species alphabetically (sorting of the data), or lists all species from one genus (filtration procedure), or perform other operations like these. ones.

*ER-diagram analysis and brief description.* ER-diagram is an abstraction that has to represent in whole all *objects* from the database with all their *relations* and with all characteristics of the objects that are called “*attributes*”. Those characteristics are important from the point of view of DB construction. For such DB are too important the data (attributes) as gene sequences, specie, family, genus and other similar. For the representation of these 3 main notions of ER-diagram the special symbols are used that we described in details before [2, 3]. Such diagram helps to analyze better all entities



that we would like to include into the database and to represent them in their entirety. Without such analysis the construction of DB of a high quality is not possible.

*Development of the database with information about fishes' on the base of "ER-diagram".* The scheme "ER-diagram" we need for further development of the database with information about fishes on its basis. Let's study the representation of such database in the form of tables 1, 2. It is easy to see that [3]:

1. Objects of "ER-diagram" were transformed into separate tables;
2. Attributes were transformed into the fields of these tables (in our case - in the columns);
3. The relations between the objects were transformed into the relations between separate tables.

At the same time, the power of relations reflects the number of tables that need to be linked with the object; and the developer decides what number have to be. If the power of relation is 1, then the link is formed with one table, if "M" – with "M" numbers of tables [2, 3].

Objects in our model can be characterized by the number of attributes (see above, also the Tables 1, 2).

*"Keys" are the tools for the ensuring of the data integrity.* In order not to lose the information that is ordered into the biological DB, the technique of "keys" is used [2].

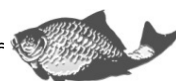
"Keys" are necessary "tools" for the relations establishing between the objects [2]; they guarantee that the information from the database is accessible and it always may be obtained from there. Indeed, there is no sense to write thousands of data records into a structure if these data can not be used, if they are not accessible! Consequently, the "keys" are the elements of each table; they are related to each other through programmed links. By obtaining the information from one table, it is possible to obtain the information from another table associated with it through a link that unites their keys. Usually, as a "key" serves a certain code (numbers or other symbols), and the links between such codes from individual tables in many modern software environments, even a young developer can make by themselves [2].

As one could see from Fig. 5 the "keys" serve to make connections between fields of the tables that logically have to be linked. For example, the user would like to find from the database where he can find the fish specie *Oncorhynchus mykiss*. Programmer knows that it lives in trout farm «Stara Vaga». So, in program the key "181\*" from the table "Fishes' species" have to be linked with the key "335\*" from the table "Basin". In other case, the user would like to find where he can catch the fish *Cyprinus carpio* L. In the same way, in program the key "344\*" from the table "Fishes' species" have to be linked with the key "864" (river Sula) from the table "Basin". Keys on Fig. 5 may be coded also in other symbols, their number may differs also. Such key usage permits to realize the effect of "data integrity" in the database. In table field "Photo" we gave hyperlinks to the real photos of mentioned fish species in Internet, for *Oncorhynchus mykiss* the length of this hyperlink have been cut because of limited table dimensions.



Table "Fishes' species"

Primary key	Name of species (Latin)	Name of species (national)	Photo	Area of inhabitation	Biotopes of inhabitation	Objects of nutrition	Data of fishing	Comments	Others
181*	<i>Oncorhynchus mykiss</i>	форель райдужна	<a href="https://upload.wikimedia.org/wikipedia/commons/a/a1/Truite_arc-en-ciel.jpg">https://upload.wikimedia.org/wikipedia/commons/a/a1/Truite_arc-en-ciel.jpg</a>	Western Pacific: the Kamchatka Peninsula, and has been recorded from the Commander Islands East of Kamchatka, sporadically in the Sea of Okhotsk, as far south as the mouth of the Amur River, also in upper streams of rivers Prut, Cheremosh, Seret, Stryi, Dniester, its tributaries Svich, Limnitsa, in rivers Tisa, Teresva, Terebl, Ritz, in mountain rivers of Crimea	Coldwater specie. Optimal water temperature is 14–20 ° C, the O <sub>2</sub> content is 7–8 mg/l. Specie prefers clean, clear ponds and mountain rivers	Predator. Minnow, frogs, little birds, mollusks, larvae, insects, etc.	June-November		
263*	<i>Salmo trutta</i> L.	Лосось струмковий (форель струмкова)	<a href="https://ih1.redbubble.net/image.65006165.3846/flat,800x800,070,f.u2.jpg">https://ih1.redbubble.net/image.65006165.3846/flat,800x800,070,f.u2.jpg</a>	in upper streams of rivers Prut, Cheremosh, Seret, Stryi, Dniester, its tributaries Svich, Limnitsa, in rivers Tisa, Teresva, Terebl, Ritz, in mountain rivers of Crimea	Mountainous parts of rivers, streams. Specie reaches altitudes 800-1000 m a. s.l. Prefers areas with flow 1–3 m/sec with water temperature not higher than 16 °, O <sub>2</sub> saturation more than 10 mg/l. Does not like water contamination with substances that absorb O <sub>2</sub> (oil, petroleum products, phenols, resins, dyes, alkalis, acids, municipal sewage, mineral fertilizers, poison chemicals)	Mostly insects that fly over water surfaces as well as leafhoppers, spiders, dragonflies, other insects that get into the water, mollusks, fish, frogs, etc.	June-November		



Continuation of the Table "Fishes' species"

Primary key	Name of species (Latin)	Name of species (national)	Photo	Area of inhabitation	Biotopes of inhabitation	Objects of nutrition	Data of fishing	Comments	Others
344*	<i>Cyprinus carpio</i> L.	Короп звичайний	<a href="http://www2.dnr.cornell.edu/cek7/nyfish/Cyprinidae/common_carp.jpg">http://www2.dnr.cornell.edu/cek7/nyfish/Cyprinidae/common_carp.jpg</a>	Species-cosmopolitan that has been introduced to many regions of the world and has successfully naturalized in European basins	water pH=7-8. pH 5.5 and below inhibits its life, metabolic disorders are developed in fish organism. pH increasing over 9 is detrimental. Optimal water temperature is + 20-30° C, O <sub>2</sub> content is not less than 4-5 mg/l (optimal O <sub>2</sub> values are 6-8 mg/l). O <sub>2</sub> concentration reduction to 2 mg/l and below is dangerous, and to 0,5 mg/l is detrimental	At early stages of development it feeds on zooplankton. At early days the fry consumed small forms (moins), later consumed <i>Daphne</i> , <i>Ceriodaph</i> , <i>Cyclops</i> , etc) Later at the first life year consumed zoobenthos, and at older age groups in the diet predominate larvae of chironomids, oligochaetes, mollusks). During food deficiency consumes larger aquatic organisms (large forms of zooplankton, macrophytes, and detritus). Species is well adapted to eating compound feed and cereal grains			
...									

5, a



Table "Basin"

Primary key	The name of the Basin	Dimensions	Region of Ukraine	Geographical latitude	Geographical longitude	Average salinity of water	pH of Water	...	Comments	Others
341	Shipit river	Length 20 km, basin square 127 km <sup>2</sup>	Sources of r.Shipit – several mountain streams that originate at the Northeastern regions of mountain massif Polonina Rivna and Southern slopes of Hostry Mountain. River flows mainly to the South and Southwest. It flows through the vil. Turia Polyana. From the village to the confluence of r.Uzh the river is called Turya	48°44'03" North latitude	22°29'49" East longitude	n/d	n/d			
864	River Sula	River length 363 km, basin square 19 600 km <sup>2</sup> .	Sula source is on the Southwestern slopes of the Middle Russian Highlands, then flows through Dnieper lowland. It flows first to the West, then gradually turns to the Southwest and South. In the interval from the estuary of Lochwitz to the town Zavodskoye the river flows to the East, after which it turns sharply to the Southwest; in the lowest part it flows to the South. It flows into r. Dnieper (Kremenchuk reservoir)	River source: 50°50'49" North latitude, estuary: 49°33'19" North latitude	River source: 34°28'59" East longitude, estuary: 32°45'16" East longitude	Water mineralization changes throughout the year: spring flood - 659 mg/dm <sup>3</sup> ; summer-autumn limit - 812 mg/dm <sup>3</sup> ; winter limit - 871 mg/dm <sup>3</sup> .	Annual average value 7.51			
121	Fisheries of Kolochava	n/d	Transcarpathian region, Mizhhirsky district, vil. Kolochava, Voloshina str.	48°27'27.96" North latitude	23°43'11.68" East longitude	n/d	n/d			
335	Trout farm «Stara Vaga»	n/d	Transcarpathian region, Irshava district, vil. Bronka, tract "Bronnitska River"	48° 24' 21.04" North latitude	23° 19' 19.77" East longitude	n/d	n/d			
::										

5, b

Fig. 5. Tables of developed database with information about fishes [2]. (5, a), (5, b) - the attributes became the fields of the tables. "Primary keys" are the tools for the formation of the relationships between the tables. Cyrillic words are in tables for domestic use in Ukraine. n/d – means "no data" for today (but these data may be added in future)



In addition, it is easy to follow in the diagram whether all entities are linked together. In this case it makes possible to access all records, so, the information from the database becomes fully available for everybody (the condition of the data integrity ensuring). Alternatively, if this condition is violated, the user will not be able to obtain the information from those parts of the database that are not connected by such links. However, using the methods described above, the programmer can easily recover connections based on the ER-diagram and linking the objects using keys. In the application of the abovedescribed methods, there are no differences between biological and technical databases and anybody for such purpose can study this technique using appropriate manual.

### CONCLUSIONS AND PROSPECTS OF FURTHER DEVELOPMENT

In present article according to the purpose of the work was demonstrated that the methods for relation electronic databases construction, that were developed earlier for physics, engineering, etc. can be applied in biological branches. The following set of methods was used to develop databases with biological content: the methods of object-oriented system analysis, ER-diagram design, and the methods of computer databases construction were used in process of present work fulfillment.

At the beginning of present article, a number of examples of electronic fish databases that were developed in different countries of the world were given. On the basis of theoretical generalizations an ER-diagram for two types of objects was developed: fish species (on the example of rainbow trout) and basin of its inhabitance. At the end of the publication it was shown how relational tables of biological databases were formed, and how they are interconnected with the “keys”.

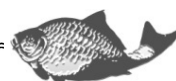
Using above described approach of the biological DB construction it is possible to develop interactive map with fish species of Ukraine in future. The authors tried to demonstrate the first results of their works in this direction on the example of rainbow trout. This specie is an important object for fishery industry of the state; and development of interactive electronic map with the information about the spreading of rainbow trout and other fish species (and places of catching) in Ukraine is an important step for the transformation of fishery industry in our country to the contemporary level of the world technologies and for the providing of food safety. Using of contemporary computer technologies suggested in present article, would make this branch more effective in Ukraine and in the whole world.

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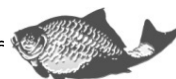
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