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Data model for an intelligent fish farm management system

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Abstract. The article defines the importance of artificial cultivation of hydrobionts. The article analyzes the state of fish farming in Russia. The main trend of the industry is the need for digital transformation of processes that provide management, control and monitoring of hydrobiont farming processes. This requires the development and implementation of "smart" digital solutions based on data. The analysis of the subject area has shown that there is a large amount of heterogeneous data related to, for example, the microclimate of water bodies, the state of hydrobionts, the works performed, the sanitary condition, and so on. All this requires the creation of a unified data model that meets the requirements of integrity, consistency, redundancy and normalization. This defines the purpose of the work to be performed. The application of methods that allow to obtain a description of the key aspects of the subject area, provided the opportunity to use the methodology of relational database design. With its help, key entities, their key and non-key attributes, as well as relationships between them are developed. The developed data model provides the principles of data storage and management, scalability of the model and its integration with other specialized software solutions.

1 Introduction

One of the global problems is the depletion of natural resources, including hydrobionts [1]. This problem is aggravated by the unsatisfactory ecological state of the global ocean, obliging to seek new solutions for sustainable development of fisheries [2]. One of the options for solving such a problem is the breeding of hydrobionts artificially in ponds, pools and installations with water recirculation. It makes it possible to create a habitat for hydrobionts, providing maximum yield of marketable products in a shortened period of time while maintaining its quality [1].

Hydrobionts have high nutritional and biological value, therefore, their finished products are strategically important foodstuffs [3]. Its consumption improves human health and quality of life. Satisfying the needs of the population with such products is impossible without stable development of the whole industry, which includes management of activities and modernization of production processes [4, 5].

One of the ways to ensure effective management of a fishery enterprise is the introduction of complex hardware and software solutions. The modern market of software products makes

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it possible to solve a huge range of objectives in different industries: to monitor the state of objects and processes, process data arrays, determine effective control actions, manage processes, etc. [6-8]. The need for digitalization and integration of information technologies in the fishery industry is noted in the order of the Russian Government "Strategic direction in the field of digital transformation of industries of agro-industrial and fishery complexes of the Russian Federation for the period up to 2030", approved in 2023.

The content of this strategy notes the need for participation in the digital transformation of all economic entities of the fishery complex, addressing, first of all, the objectives of reducing shadow turnover of products and ensuring the completeness and reliability of industry data of the Ministry of Agriculture and Rosrybolovstvo. The next stage in the implementation of the strategy, the regulator determined the mandatory introduction of information technology in production processes.

Fish farming enterprises highlight as the main areas for digitalization the possibility of automation of monitoring and data collection processes, equipment management and robotization, management of technological processes based on data and results analysis, ensuring the safety of processes and the enterprise as a whole, organization of interaction between different systems. Indeed, to ensure high quality of products requires compliance with numerous requirements and conditions, which can be monitored and managed by intelligent systems with possible, if necessary, human participation.

In order to create effective intelligent systems capable of providing decision support, it is required to create conditions for effective integration and unification of the data required for analysis [9, 10]. Thus, the purpose of the work is to create data models for an intelligent system of technological processes management of fish farming enterprises. For this purpose, it is necessary to determine the key characteristics of objects and processes relevant to the artificial cultivation of hydrobionts, establish links between them and formalize the obtained results.

Theoretical significance is determined by the possibility of systematization and structuring of knowledge in the field of aquaculture. The data obtained data models can be used in research in the field of aquaculture, ecology and sustainable development, as well as a basis for the development of algorithms and methods for predicting the impact of changes in the characteristics of the environment for growing hydrobionts. Practical significance of the obtained results makes it possible to develop a comprehensive system of control and monitoring of fish farming enterprises processes, capable of making decisions on effective management of technological processes on the basis of processed heterogeneous data.

2 Methods

The key characteristics of objects and processes of the subject area are obtained through the integrated use of the methods of systematization, abstraction, observation, analysis, step-by-step refinement, comparison and synthesis. The listed methods are general scientific, and the methodological approach of their use does not change from the characterization of the subject area [11-13]. The objects to which the above methods were applied were legal documents regulating technological processes of fish farming enterprises and specialists involved in their support or management.

Relational modeling methodology was used to create a conceptual and logical data model. It was used to create a logical data model representing a set of relations and a declarative description of data integrity constraints. Crow's Foot notation was used to display the results obtained.

3 Results

The activities of fish farms in Russia are regulated by legislation, including the laws "On Veterinary Medicine" and "On sanitary and epidemiological welfare of the population". These laws also include the rules and regulations for environmental protection, as well as sanitary and hygiene requirements for food safety and quality. Fish farms must comply with these regulations, and managers and specialists are responsible for ensuring compliance. Fish farms in Russia belong to closed facilities, where the epizootic and sanitary well-being of fish populations must be maintained. This includes maintaining a resilient population and preventing the spread of diseases.

Fish growth requires the provision of optimal conditions for their maintenance in a water body. The main criterion is proper water quality, which must meet both hydrochemical and bacteriological indicators depending on the fish group. These indicators include temperature; odors and flavors; color; transparency; presence of suspended solids; levels of hydrogen, dissolved oxygen, dissolved carbon dioxide, dissolved hydrogen sulfide, and dissolved ammonia; permanganate oxidizability; bichromate oxidizability; total microbial abundance; prophytes; total and ferrous iron; phosphate; nitrite; nitrate; and ammonium. All of these can be stored in the “Indicators” attribute as a structured file.

Water withdrawal should be carried out in accordance with the established schedule using specialized instruments. It should be noted that the instruments can be installed directly in the water body for continuous monitoring of certain indicators, as well as lowered into it by an appropriate specialist. If a specialist is involved to take a water sample, the indicators can be measured in laboratories. Based on this, the data model requires an “INDICATOR” entity that will store the characteristic values of all sensors, analyzers, sensors and other devices that are installed in the water body or used in the farm to obtain indicators of water and other objects. The characteristics of the entity shall be its operational features, schedule of use and the responsible persons for its maintenance and operation.

Compliance with housing conditions is aimed at effective growth environment for hydrobionts. For this purpose, each group of fish is kept in specific ponds, with adult females being housed separately from males. Based on this, the creation of the entity “RESERVOIR” is required, providing information about its current state (location, reared individuals, key dates, characterizing both works to maintain a favorable growth environment for fish and actions with these hydrobionts). In addition to the description of the habitat, it is required to store information about the reared group (entity “GROUP”) and the feed introduced into the water body (entity “NUTRITION”).

Fig. 1 shows a fragment of the developed data model based on studying fish farm objects and processes.

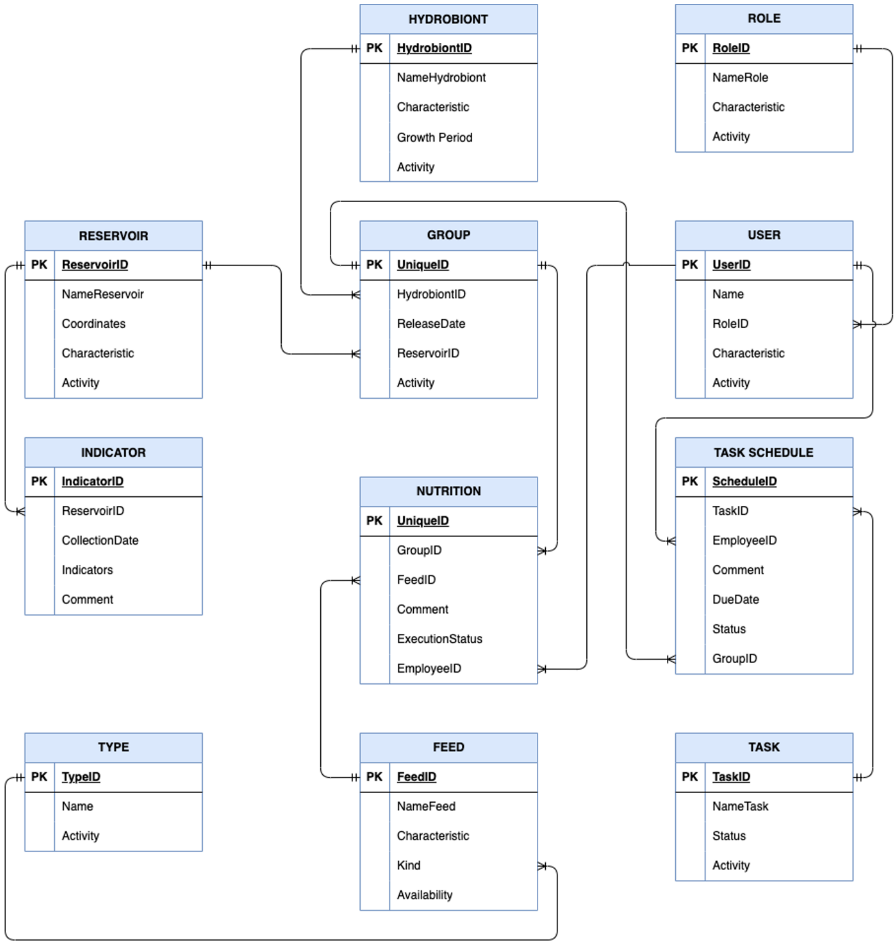

Fig. 1. A fragment of the developed data model

This data model makes it possible to control user access to the system (attribute "Activity"). Each user is assigned a list of objectives to be performed. The model provides the formation of a list of objectives ("TASK SCHEDULE") from the available ones (entity "TASK") and determine their executors and deadlines. This can be done automatically on the basis of the used knowledge base [14] or manually by a manager. Fixation of objective fulfillment is carried out manually by the responsible user (attribute "Status"), if it is impossible to carry out automatic control (for instance, changes in water body indicators can be determined by instrument readings). In addition, the user has the possibility to leave comments, which will be stored in the system and will become available for the report preparation or for the accomplishment of the next in the chain technological objective.

4 Discussion

The results obtained can be classified according to the following features:

1. Data integrity assurance. The analysis of the problem domain with the allocation of relations between objects made it possible to create a model that complies with the basic principles of database creation: consistency, consistency, non- redundancy and normalization. This means that the data are always in a topical state and when making any changes there

will be no anomalies that will cause unforeseen distortion of unrelated data. As noted in works with automated data processing, adherence to these principles ensures that linked data is automatically updated when any parts of the data change [6, 7, 15].

2. Data governance assurance. The smooth operation of any software product requires the availability of tools in which structured data is stored, constantly updated and provided in accordance with user requests [10, 16]. The developed data model makes it possible to receive data both from users in manual mode and from sensors in automatic mode, to systematize and keep them in topical state, as well as to provide answers to queries in accordance with the established conditions.

3. Provide scalability and integration. Over time, processes or objects in the subject area change, which affects the operation of any software solutions, requiring their modernization [8, 9]. The use of a database created using relational data design methodology provides the possibility of modifying it depending on conditions [6, 17]. Such conditions may include both changes in the subject area and the introduction of additional software solutions that require access to the stored data. In addition, the developed structure provides the possibility of obtaining data for analytics or predicting the results of changes in the subject area depending on the realized management decisions [18, 19].

Thus, the results obtained do not contradict the basic principles of designing and modeling digital software solutions.

5 Conclusions

The main trend in the development of Russia's economy is the digitalization of as many industry activities as possible. Introduction of modern digital technologies makes it possible to solve numerous different objectives: from ridding employees of routine tasks to “transparent operations” before the state regulator. The use of software solutions in their activities ensures transparency and understandability of management, as well as high speed of data processing for accurate and objective decision-making in the dynamically changing conditions of the fisheries sector.

The introduction of “smart farm” technologies, making it possible to automate the processes of fish keeping and breeding, ensures increased profitability of the farm. Such a solution requires consolidation of numerous heterogeneous data, based on the results of processing of which, objective management decisions are determined. This requires the creation of accurate data models corresponding to the qualitative and quantitative characteristics of the problem area.

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