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Analysis of the factors promoting of effective organic aquaculture in the semiarid climates of Russia, China and Kazakhstan

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Abstract. This overview report provides insights intothe internal reserves of aquaculture production in Russia, China and Kazakhstan, highlighting their potential in ensuring sustainable production of environmentally friendly commercial fish products. China, for instance, currently produces 72 million tons of hydrobionts annually, accounting for 56.7% of the global aquaculture production in 2022. On the other hand, Russia's current production level remains modest, representing only 0.53% of China's output. The report emphasizes the importance of implementing a conservation strategy that promotes organic aquaculture practices within inland waters. This approach aims to ensure compliance with environmental regulations while transitioning towards fish production. It emphasizes the need for common approaches and self-regulating technologies in balanced and sustainable aquaculture, prioritizing the conservation and restoration of natural resources. Furthermore, the report delves into the specific challenges and prospects of semiarid aquaculture in southeastern China, as well as the Caspian regions of Russia and Kazakhstan. These are as share similar agro-climatic conditions f for inland reservoirs. The report underscores the potential of utilizing agricultural lands for the development of organic aquaculture, emphasizing environmentally friendly production practices and high fish productivity. Organic aquaculture is portrayed as an adaptive and sustainable form of nature management. It aims to enhance agricultural production, increase productivity, and preserve the ecological balance of water resources in semiarid territories. Moreover, it highlights the economic feasibility of organic aquaculture, making it accessible to fish farmers and fisheries industry professionals alike.

Keywords: aquaculture, fish, potential of productivity, China, Russia, Kazakhstan, organic aquaculture

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Научная статья

Анализ факторов продвижения эффективной органической аквакультуры семиаридного климата России, Китая и Казахстана

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Аннотация. В настоящем обзорном сообщении раскрываются внутренние резервы аквакультурного производства стран России, Китая и Казахстана, которые способны обеспечить должный уровень производства экологичной товарной рыбной продукции. Раскрываются позиции Китайской Народной Республики, которая к настоящему времени ежегодно производит 72 млн т гидробионтов, что составляет 56,7 % общего объема аквакультурной продукции, произведенной в мире в 2022 г. Текущий уровень производства российских производителей гораздо скромнее, поскольку составляет 0,53 % от китайского. Раскрывается форсайт сберегающей стратегии природопользования с переходом к производству рыбной продукции во внутренних водоемах, ориентированному на соблюдение правил органической аквакультуры. Обосновывается необходимость разработки общих подходов к реализации особой стратегии с приоритетом сохранения и восстановления природных ресурсов, в том числе за счет применения самовосстанавливающих технологий сбалансированной и устойчивой аквакультуры. Вопросы семиаридной аквакультуры юго-восточных территорий Китая и Прикаспийских областей России и Казахстана, характеризующихся сходными агроклиматическими условиями функционирования внутренних водоемов, рассматриваются в контексте общего состояния сельскохозяйственных угодий и перспектив их дальнейшего использования в целях развития органической аквакультуры с соблюдением норм экологически чистого производства и с высокими показателями рыбопродуктивности. Отмечается, что органическая аквакультура может рассматриваться в качестве адаптивной формы рационального природопользования, применяемой в целях экологизации сельскохозяйственного производства и повышения продуктивности при сохранении водного аутэкологического оптимума при решении проблем природопользования семиаридных территорий, а также как экономически обоснованный способ ведения аквакультурного производства, доступного для фермера-рыбовода и специалистов рыбохозяйственной отрасли.

Ключевые слова: аквакультура, рыба, потенциал внутренних водоемов, Китай, Россия, Казахстан, органическая аквакультура

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The relevance of aquaculture

The geographical proximity of China, Russia and Kazakhstan has determined the presence in these countries the regions with a high degree of similarity of climatic conditions. We are talking about the vast territories of the south-east of China and the Caspian regions of Russia and Kazakhstan with a semiarid climate which is characterized by a significant predominance of the evaporation process over precipitation, significant fluctuations in daily and seasonal air temperatures. The specificity of semiarid territories is manifested in a certain similarity of approaches to the involvement in economic turnover and the use of land and water resources, including fish farming practices, which in this context can be considered not only as a form of agricultural production, but also, more broadly, as an element stabilizing the regional ecological system.

The overall efficiency of inland water bodies aquaculture directly depends on the chosen method of their operation. Agricultural method used in a semiarid climate in order to achieve efficiency should take into account the genesis of water bodies. Taking into account the combined effect of climatic, biotic and abiotic factors the indiscriminate use of even the most modern intensification measures to increase the productivity of a pond may not bring the expected result, and the effect may be far from the optimal for the cultivation of aquatic organisms. This leads to the necessity to search for the most effective way to uncover the ecological and biological potential of inland water bodies suitable for fish farming in semi-arid territories, to test these methods, their development and scaling in economic activities. As one of such schemes, biotechnology for organic aquaculture production can be proposed for consideration.

From a social economic point of view organic aquaculture can be considered as a way of organizing management that corresponds to a number of significant trends including the growing importance of innovation-intensive production areas (which can rightfully include aquaculture, in particular, such areas as recirculating systems, breeding, genetics, etc.); the greening process of agricultural production with increased transparency and traceability of the production chain at all stages of the production process and consumption (“from farm to fork”, including the final stage of waste disposal or recycling); updating issues related to achieving “carbon neutrality”; expansion of organic forms of management and production in accordance with approved international and (or) national standards and regulatory procedures for quality assurance.

Scientific research related to the development of organic production is becoming increasingly relevant for the agricultural sector in general and for the fishing industry in particular [1]. The range of practice-oriented areas of organic aquaculture may include the elaboration of technological regulations that ensure the transition to aquaculture production based on organic principles (i. e. corresponding to the general parameters of standards of organic products and environmental safety) and industry (aquaculture) additions to existing standards, as well as for developing, piloting and scaling more effective methods, techniques, biotechnologies for the organic aquaculture production, taking into account the specifics of the climatic and environmental conditions of the regions for economic activities. Scientifically based use of the advantages of natural and climatic conditions, increasing the level of environmental friendliness of production and resource conservation are a reserve for increasing the aquaculture potential of the territories and increasing the level of regional food security.

Current state of aquaculture

Aquatic biological resources (fish and other aquatic organisms) are one of the most important groups of food products, a key source of valuable animal protein.

According to the Food and Agriculture Organization of the United Nations (FAO), in the period 1961-2019, global consumption of food from aquatic biological resources grew at a rate almost twice faster than the world population growth rate (3.0% per year and 1.6% per year, respectively). Consumption of aquatic animal products per capita over the same period increased in absolute terms from 9.0 kg (live weight equivalent) to 20.5 kg [2].

In fact, the total annual volume of capture and production of aquatic biological resources in the period 1961-2019 in absolute terms increased 5.7 times – from 37.27 to 212.84 million tons, including: in fisheries – 2.6 times (from 35.32 to 93.03 million tons), in aquaculture – 61.1 times (with 1.96 to 119.81 million tons) [3, 4].

Aquaculture is an important growth driver of global food production. The active involvement of water resources in economic turnover, multiplied by the introduction of high-tech technologies, has allowed the aquaculture industry to demonstrate high growth rates in recent decades. Thus, over the period 2000-2020, the total annual volume of aquaculture production increased 2.9 times – from 43.01 to 122.71 million tons (in 2021−126.04 million tons). For comparison, over the same period, world grain production increased only 1.5 times (from 2.06 to 3.01 billion tons), meat (including livestock, pig farming, poultry farming) – 1.4 times (from 233 to 334 million tons), and traditional fisheries showed a reduction of 5% at all (from 94.44 to 90.59 million tons).

As of 2022, it is aquaculture (including mariculture), and not traditional fisheries, that provides about 80% of the production of diadromous fish, 74% of shellfish, 65% of crustaceans, 65% of various aquatic animals, as well as more than 80% of the world's freshwater fish production and more than 95% of the production of algae used for commercial (including food) purposes.

It is also important that aquaculture finds the same development both in marine coastal territories (mariculture) and in inland (continental) water bodies. Thus, according to FAO, in 2020, the global volume of aquaculture production in inland waters amounted to 54.4 million tons, or 44.4% of the global volume of animals and algae grown in aquaculture. And it is the aquaculture of inland water bodies, and not mariculture, that provides the production of most aquatic organisms (animals) – 62.2% of the total volume of aquaculture production.

The totality of the production capabilities of the fisheries industry, as well as the country–specific behavior of the population affects the volume of consumption of fish products, which in the world averages about 20.5 kg per capita, in China – 40.1 kg, in Russia – 21.9 kg (with the recommended norm of 22 kg by the Ministry of Health of Russia), in Kazakhstan – 14.1 kg.

China is undisputedly the world leader in aquaculture. Annually, China produces about 72 million tons of aquatic animals and algae, i. e. 56.7% of the total volume of global aquaculture products produced in 2022. Aquaculture amounted to more than 80% of the total volume of aquatic organisms produced in China (excluding algae).

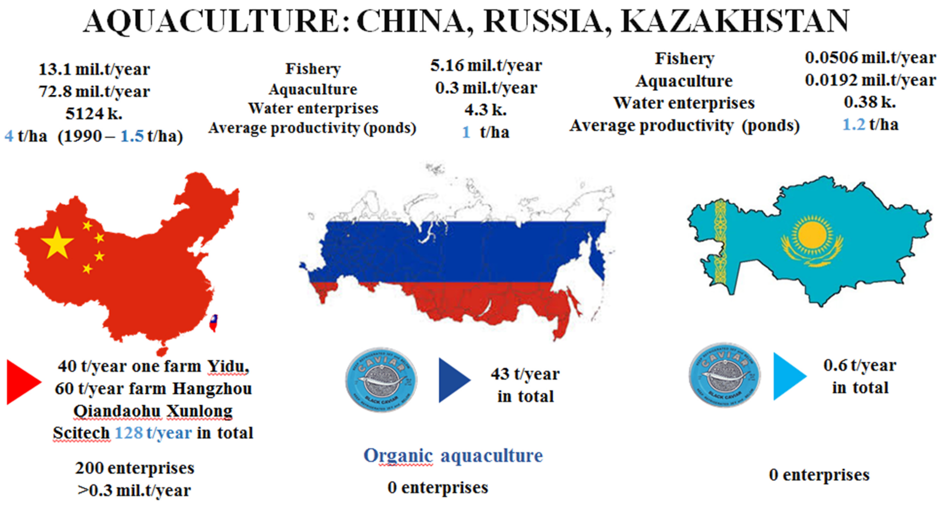
Against the background of the global leader's indicators, the current level of aquaculture development in Russia looks disproportionately more modest. So, in 2022, the aquaculture production amounted to only 383.5 thousand tons (an annual growth of 7%), which, taking into account the existing natural and climatic potential, allows us to judge the insufficient development of this production area.

In the Republic of Kazakhstan according to official statistics in 2022 the volume of aquaculture products produced amounted to only 13.2 thousand tons (7.3 thousand tons in 2021). And although the Ministry Natural Resources and Environment of the Republic of Kazakhstan calls higher figures – 19.2 thousand tons in 2022 (14.9 thousand tons in 2021), but these figures also indicate, rather, insufficient disclosure of the potential of aquaculture in the country.

The development of aquaculture is supported by the state, which, in particular, is reflected in state strategies and programs for the development of research activities. At the same time, it should be noted that the focus of the policy in China (in particular, within the framework of the thirteenth five-year plan for 2016-2020) is on improving the environmental friendliness of aquaculture, especially in the interior of the country, including within the framework of mitigation programs of economic activity, as a result of which by 2021 fenced areas of reservoirs were dismantled, and cage aquaculture was actually curtailed in favor of other forms of agricultural and aquaculture production.

At the same time, the scientific and expert environment actualizes the problem of the need for the transition of aquaculture production to the model of "ecological" aquaculture, ensuring the achievement of sustainable development goals; to aquaculture as a set of "ecosystem services" (processes and conditions that directly or indirectly lead not only to production benefits, but also to environmental, cultural, etc.), which should be based on various integrated and resource saving approaches to economic activities [5].

Such approaches include organic aquaculture, which is already considered one of the driving factor for the development of Chinese aquaculture which, in particular, is presented in such indicators as the number of aquaculture enterprises certified according to national standards (Fig.).



Aquaculture production of China, Russian and Kazazhstan

The development of organic aquaculture in Russia as an entirely new area of fish farming is in its infancy [6]. During the period of 2020-2021small and medium-sized aquaculture enterprises in the Russian Federation were given the opportunity to certify their products according to organic production standards (AUSS – all-Union State Standard) free of charge. Although a few schemes for the transition of aquaculture to the production of organic aquatic and agricultural products were developed in order to instruct licensed certification services providers to carry out the certification procedures in compliance with the national standard of organic aquaculture, Russia has not registered any certified aquaculture production according to the national organic standard.

Among other things, in the existing regulatory framework which governing the processes of production and processing of organic products (the law on organic products, standards for the production of organic products), organic aquaculture is mentioned nominally, as one of the areas with defining concepts and described general requirements for production. However, their incompleteness is quite obvious, which requires the addition and updating of the underlying principles, partially inherited from the first editions of the European standards of 2007-2008. In the Russian Federation, the largest national certification providers still do not distinguish certification of organic aquaculture as a separate area.

In Kazakhstan, despite the existence of a legislative framework on organic agriculture and the implementation of the Fisheries Development Program for 2021-2030, there are currently no enterprises engaged in organic aquaculture. The reasons for this situation lie in the absence of certification bodies, the problem of infrastructure, the insufficient level of culture of consumption of organic products, including organic aquaculture products.

Semiarid aquaculture development trends

In recent decades, the role of the main source of production of fish products for human consumption has shifted from traditional fishing towards aquaculture.

In 2022 53% of the world's fish consumed is produced by aquaculture enterprises and this share is expected to increase over time against the backdrop of increased adoption of the concepts of greening and food security, aimed at ensuring the high quality of produced products in accordance with the physiological norms of health of aquaculture facilities and biotechnical requirements of the production process [7].

In recent years, with a shift in priorities towards achieving sustainable development (and later carbon neutrality), aquaculture, among other production areas, has faced criticism for its negative impact on the environment [8]. Thus, the pressing forward maximizing the volume of fish products obtained in aquaculture using inland fishery water bodies leads to an imbalance in the sustainability of the ecological system, with an increase in eutrophicity, the ratio of productive and destructive processes changes sharply towards the former. With an increase in the load of biogens formed in the water bodies of allochthonous (brought into the reservoir as a result of intensive feeding, fertilization) and other autochthonous organic substances, the intensity of the oxygen regime increases, the mineralization of organic substances and the trophic index decrease, which leads to an increase in the population of blue-green algae and additional deterioration of the process of growing hydrobionts due to the appearance of cyanotoxins.

The development of intensive aquaculture in *semiarid climate* is widely associated with a high risk of a negative environmental factor due to Cyanobacterial blooms (blue-green algae) in water bodies during the growing season, which creates serious environmental problems. This climate type provides favorable thermal regime for *Cyanophyta* (*Cyanobacteria*) in the microbiocenosis of water bodies.

Moreover, aquaculture is also responsible for the eutrophication of aquatic ecosystems due to the release of nutrients from aquafeed for hydrobions, for example, nitrogen (N), phosphorus (P) [9], which are the main triggers for the growth of cyanophytes.

Currently, during high temperatures during the growing season cyanotoxins annually cause outbreaks of various diseases in aquaculture objects associated with their toxic effect around the world, and as a result, the course and exacerbation of chronic diseases and an increase in mortality, these phenomena force the removal of fishery water bodies from the fish breeding process, which reduces the profitability of the pond-, cage-based and pastoral fish farms.

Chinese scientists pay special attention to the study of the problem associated with the effect of various feeds for hydrobionts on the dynamics of the concentration of nutrients released into the water bodies environment, which becomes a stimulating factor for the development of blue-green algae. Scientific research in this area has established a direct relationship between the influence of various feed components on fish growth and changes in the composition of nutrients introduced into the water bodies when using different types of feed. It is confirmed that the used aquaculture feeds, including the recently developed ecological ones, directly proportionally affect the growth of algae and the kinetics of their nutrients, which leads to a deterioration in water quality. Also, the effectiveness of various aquafeeds used in China in the conditions of growing aquaculture objects in inland waters [10] and their impact on the ecosystem using the test factor Microcystis aeruginosa was also estimated. These studies made it possible to evaluate the effects of minimizing the impact on the ecosystem of nutrients released into the environment – phosphorus and nitrogen-containing organic compounds, using the unique method of modified functions Logistic and Monod [11, 12]. Thus, the interest in this problem is not accidental, traditional feed application schemes that use raw cereals and mixed feeds not in the form of food pellets contribute to the emergence of additional sources and energy subsidies for the artificial ecosystem, which is fully used by the population of *Cyanophyta* (*Cyanobacteria*) for its growth. The latter is often accompanied by the release of cyanotoxins into the environment of the world's most common species of toxic algae *Microcystis aeruginosa* (registered in 108 countries, and the release of toxins in 79 of them [13], creating a toxic load on the aquatic organisms, causing a violation of the intestinal microflora and the dysfunctioning of the gastrointestinal tract, liver, disruption of the nervous system, as well as deterioration of the external integument due to the action of dermatotoxins. In addition, one of the consequences of the growth of populations of *Cyanophyta* (*Cyanobacteria*) is a decrease in the content of dissolved oxygen in water, which leads to the risk of cardio loads in aquatic organisms due to for asphyxia. Also being an allergenic factor for immune reactions of an immediate type, entering the body and accumulating, cyanotoxins can lead to adverse immune-related effects. The cumulative effect of the mentioned class of biological toxins is of particular concern as a result of prolonged exposure. Moreover, their accumulation leads to inflammatory and allergic reactions. As the substance has accumulated in the body, it causes processes aggravating the physiological state of aquaculture species. Such a process is inadmissible in commercial aquaculture, where the technological processes of cultivation should be aimed at the production of high-quality food products that meet consumer requirements [6].

Substances released in the process of cultivation, containing biogenic elements in their composition (feed residues, waste products of aquaculture objects) function as potential pollution factors. Their accumulation determines the positive dynamics of the content of phosphorus and nitrogen in the water and affects the increase in the growth rate of *Cyanophyta* (*Cyanobacteria*) during the growing season. At present, theoretical analysis and experimental studies have confirmed that the amount of phosphorus released from feed increases with a decrease in the active reaction of the environment (pH), while the level of ammonium nitrogen increases with increasing pH.

In this regard, it is necessary to monitor the quality of the feeds, their impact on the functioning of the internal systems of the grown organism and monitor the kinetics of dissolved non-mineralized forms of biogenic elements in the water bodies, which form a nutrient medium for macro- and microbiota.

It is obvious that the expected increase in the volume of organic aquaculture products makes it necessary to solve the problem associated with an increase in the production of aquaculture feeds with a high level of involvement in the circulation of environmentally friendly biocomponents, protectors, modulators, etc. from raw materials that meet organic requirements.

The key task is to find new methods to make aquaculture production more environmentally friendly [14]. Feeds have a significant impact on how aquaculture production affect the environmental, due to the release of nitrogen and phosphorus. Recently, concerns about both the quality of fish feed and the impact of fish feed on the aquaculture aquatic environment have risen to new levels, and controlling the environmental impact of cage-based farms is considered to be an essential part of sustainable aquaculture [15]. Another challenge facing the organic aquaculture industry is optimizing ish feed addition scheme. Single and multiple exposures to pollutants are common mainly in pharmacological studies [16]. However, only few studies have investigated the effect of single and repeated exposure to feed on fish and aquatic biota.

The effect of different feed components on fish growth and nutrient composition changes can also differ, feeds with different composition of components in the formula affect the concentration of nutrients released into the environment and stimulate the development of algae in different ways.

The above facts lead to the conclusion that it is necessary to develop compound feeds for pond aquaculture in accordance with the need to solve the above problem and conduct further research on the growth of algae, fish and the kinetics of their nutrients, and water quality.

Attempts have been made by Chinese scientists to investigate the causes and consequences of nutrient excretion in fish food and its effect on stimulating algae growth. There is also evidence of experimental work on the effectiveness of food for commercial fish, taking into account the growth of algae in order to comprehensively and simultaneously assess the feed used for growth rates in relation to water quality [17-19].

The abovementioned highlights the importance of project objectives, which consists in a comprehensive study of the influence of ecosystem factors, including the growth of *Microcystis aeruginosa*, causing environmental stress in hydrobionts during cultivation under conditions of intensive and semi-intensive aquaculture, and the development of approaches to prevent the corresponding deterioration, indicators of homeostasis by creating new green/organic feed formulas based on natural components of plant and animal origin and monitoring macro and microbiota of inland waters according to the model of modified Logistic and Monod functions. This also integrates principles of aquaculture greening process and the requirements of organic standards. These three components of the study, are to be applied to the methodology of farming process, promising to increase its efficiency and to reduce the impact of negative factors.

Russian scientists have taken efforts in the development of theoretical substantiation and practical recommendations for the development of compound feeds for commercially important aquaculture species, including feeds with specific actions. Widely cited publications that correspond to the general strategy for the development of aquaculture in the Russian Federation and the state program for the short term prospect are presented in open access. Studies of new compound feeds are carried out on the main indicator of growth using a two-way analysis of variance, variance with corrections for multiple comparisons of samples using the Bonferroni a posteriori test for the separate and combined effects of several factors. At the same time, environmental conditions are assessed in dynamics by analyzing the indicators of the state of individuals – bioindicators of fish blood, histological studies of the status of the internal organs of fish. Based on the observed dynamics of indicators, further recommendations are formed regarding the technological process of growing aquaculture species, using them for the prevention and/or treatment of alimentary diseases of fish and non-fish species in conditions of artificial cultivation, as well as growth stimulants [20-23] and biofeeds that increase resistance of the organism. The later can avoid the use of antibiotics in accordance with the requirements for organic aquaculture [24].

A new and relevant direction for assessing the compensatory effect of compound feeds will reduce both the effect of environmental factors deviating from the optimum on the organism of cultivated species, and the biogenic load on fishery water bodies in the semi-arid climate zone, by preventing the growth of the *Microcystis* population, will be timely.

A new and relevant approach to assessing the compensatory effect of compound feeds will be able to reduce both the effect of environmental factors deviating from the optimum on farmed organisms, and the biogenic load on fisheries water bodies in the semiarid areas, by preventing the growth of the *Microcystis* population.

At the moment, to reduce the negative effects of *Cyanophyta* fertilization treatment is used, as well as a longer process involving the involving the introduction of biological additives (for example, a suspension of microalgae of the genus *Chlorella*) for biological treatment [25] or aquacrop rotation, which possesses the ability of “natural” self-recovery biotope [7, 26]. Many researchers have dealt with the issues of the ecological status of water bodies and the “greening” of fishery production over the past years, among the main areas it is necessary to study the biochemical activity of water and soil microorganisms, as well as ammonifying bacteria involved in the process of denitrification of ponds.

In turn, international scientific cooperation will enrich the studies by supplementing them with empirical data with the regional specifics of aquaculture production in semiarid climates. Thus, the main directions of aquaculture scientific research in the Republic of Kazakhstan are aimed at developing a technology for the artificial reproduction of rare and endangered fish species, as well as biotechnology for the commercial cultivation of valuable fish species (for example, the creation of a “cryobank” of reproductive cells of valuable fish species in Kazakhstan). In particular, this addresses such tasks: the development and implementation of effective biotechnical methods for conducting lake-commodity fish farming in various regions of Kazakhstan, the development and implementation of effective technologies for the formation of broodstock sources of rare endemic fish species in Kazakhstan in order to preserve biodiversity and develop aquaculture, the development and implementation of industrial technologies cultivation of promising fish and invertebrate hydrobiotic species in the conditions of fish-breeding farms of Kazakhstan, genetic certification of broodstock sources of valuable, endemic fish and invertebrate hydrobiotic species – potential species of aquaculture of the Republic of Kazakhstan, the formation and effective use of sturgeon brood stocks, taking into account their genetic diversity in the conditions of sturgeon fish-breeding farms of the Republic of Kazakhstan, development and implementation of technologies for the production of domestic competitive artificial feeds and adaptation of technologies for cultivating promising live foods for valuable and endemic fish species at fish farms of the Republic of Kazakhstan, development of evidence-based recommendations for increasing the fish productivity of fishery water bodies through the introduction and reintroduction of fish and hydrobionts as forage bases. Aquaculture research also involves the development of biotechnical techniques for the artificial reproduction of zander, the cultivation of Australian redclaw crayfish, tilapia, catfish and other fish species. The issues of the natural forage base are considered, for example, "Study of an export-oriented bioresource – *Artemia franciscana* to develop a biological substantiation for their introduction, in order to increase the productivity of saltwater bodies of the Republic of Kazakhstan".

The logical continuation of work in this scientific direction at the moment is the development of a comprehensive technology for obtaining safe fish products, based on the study of the biological potential of ponds to achieve ecosystem sustainability and implementation of aquacrop rotation using organic technology.

The strategy for the development of organic production until 2030, approved by Order of the Government of the Russian Federation dated July 4, 2023 No. 1788-p, which mentions the law "Organic products", came into force on January 1, 2020, has given a new impetus to the development of organic aquaculture, as a key factor in providing the population with safe, high-quality fish products through the greening of technological processes.

Organic aquaculture shows the potential for high flexibility in terms of the possibility of its implementation not only in conditions close to natural ones, but also the ability to expand and complement, for example, in the form of integrated systems.

Russian scientists have defined a theoretical basis and also developed biotechnological standards for the transition of modern pond fish farming in inland waters in relation to the natural and climatic conditions in semi-arid regions to organic aquaculture cultivation.

The proposed technology for the transition to organic production is based on using pond areas after the cultivation of aquaculture species to grow grain or melon crops every 1, 2 or 3 years; the cyclical use of pond areas after a certain period of time depends on the quality of the soil, in particular on the humus content.

Soil improvement and costs (such as features of soil composition and structure) are minimized by increasing the fertility of soils involved in the form of aqua-crop rotation, which makes it possible to avoid chemical fertilizers in favor of compliance with the principles of organic production [7, 26].

The achieved environmental and economic effect of the approach includes: reducing the volume of applied fertilizers and feed consumption, increasing the yield of grains and melons in place of drained ponds, increasing fish and crayfish productivity, ensuring a high level of readiness for certification for compliance with the requirements of organic production.

Melons and grains grown organically in drained ponds possess a number of distinctive characteristics − high quality and yield exceeding 20-30% of those grown on the field. The calculations contributed to the development and implementation of technological aspects of organic aquaculture, which makes it possible to increase the volume of environmentally friendly products by 20%, ensuring an increase in profits of up to 40%.

Aquaculture in organic aquatic and agricultural production can be economically more profitable based on the following grounds: firstly, in this case, the reduction of applied fertilizers and feeds, secondly, the yield and fish productivity increase and thirdly, the high safety of food products. In addition, as part of the transition to an "green" aquaculture model that includes a range of "ecosystem services":

– building human and social capital (knowledge, skills, trust, cooperation, etc.);

– strengthening social links between rural and urban areas;

– creation of supporting institutional capacity: for research, education, knowledge dissemination, training, demonstrations, innovation, outreach, etc. information and demonstration programs on agricultural practices and agritourism;

– increasing food security at the level of the family, region, and country as a whole;

– creation of new jobs at the local community.

The biotechnology of growing aquaculture species using the method of alternating aquacrop rotation meets the high requirements of organic aquaculture, the environmental safety of the work carried out, and ensures readiness for organic certification of the products produced.

Organic technology for aquaculture and agricultural production has shown high efficiency in conditions suitable for pond cultivation. The obtained results indicate the possibility of scaling organic technology for aquaculture and agricultural production in fishery water bodies of semiarid regions [7].

The results of searching for effective technologies for semiarid climate are a timely response to current challenges in the development of the agricultural sector of many economies and represent undoubted practical value.

Conclusion

The specifics of aquaculture production in pond conditions under semiarid climate call for the search for a balance between the intensity of the use of compound feeds and the compensatory capabilities of pond ecosystems. One of the possible ways to achieve such a balance is the transition to organic forms of management. The relevance of organic aquaculture as a promising direction for the development of the agro-industrial complex is based on the increased attention of states to issues of sustainable development, environmental wellness, and food security.

The potential of organic aquaculture can be revealed through a combination of positive economic, social and environmental effects for the local community, region, and country as a whole. The benefits of enterprises that have switched to organic forms of management include higher profitability due to premium prices, preserve biodiversity in the locations of their farms, solve employment problems, but are not exhausted by them.

The immediate tasks at the present stage of the development of aquaculture in semiarid regions are: development of methodological approaches and practical recommendations for the implementation of biotechnology with the release of fishing enterprises for certification according to the standard of organic production in inland waters adapted to the natural and climatic conditions of semiarid territories of Russia, Kazakhstan, China; development of key standards for the use of aquacrop rotation as a method aquaculture production corresponding organic standard; the organization for the production of compound feeds with compensatory action, which will not require a significant restructuring of production lines, but will contribute, on the one hand, to the highly productive work of aquatic farms by optimizing the growing process through the use of more effective compensatory feed formulations and improving the indicators of the growing process and, on the other hand, the application and development of an approach consistent with the principles of environmentally friendly nature conservation techniques for safe commercial aquaculture production, since the required compensatory components in the composition of green/organic compound feeds and their implementation will comply with modern principles of organic agriculture.

Based on the aforesaid the contours of promising cooperation for mutual interaction in related studies of the aspect of optimizing processes and increasing the efficiency of aquaculture, which responds to the challenges of the environment and food security of Russia, Kazakhstan and China, have also been identified: development and application of an integrated approach to the study of the health of aquaculture species during thermal eutrophication caused by climatic conditions, together with the intensive growth of blue-green algae and the introduction of feeding technologies, providing for the prevention of ecostress impact using the method of organic aquaculture. Scientific work in this direction will promote joint activities within the framework of training courses, joint research (for example, learning guides) or mutual support in research on organic production, as well as contribute to national exchange within the framework of organic legislation. The organization of mutually beneficial events also include among other things gradually cooperation building in promising sales markets for the country and the geographical proximity of this market can serve as an advantage when Russian exporters enter the market. Moreover through such interaction we can achieve the set indicator (the Strategy for the organic Production Development in the Russian Federation until 2030 issued in 2023) to increase the involvement of specialists, including farmers, technologists, veterinarians and other agricultural specialists in the organic production.

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