UDC 574.58:639.3(282.247.32)
DOI https://doi.org/10.32782/wba.2025.1.17

BIOLOGICAL PRODUCTIVITY AND ECOLOGICAL OPTIMIZATION OF FISHERIES USE OF LAKE KAGUL

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This article presents a comprehensive study of the biological productivity of Lake Kagul (Odesa Region) as an object of fisheries utilization within the framework of a natural eutrophic ecosystem. The relevance of the issue lies in the need to optimize fisheries activities under conditions of increasing anthropogenic pressure and climatic fluctuations, which significantly affect the structural and functional state of the aquatic ecosystem. The research evaluates the natural food base (phyto- and zooplankton), analyzes the species composition of commercial fish, examines catch dynamics, stocking efficiency, and the influence of both natural and anthropogenic factors on the productivity of the lake. Particular attention is paid to the practical experience of local fisheries, including the dynamics of post-stocking commercial return, the results of applied biotechnological measures, and the organizational models of management.

Modern approaches to fisheries intensification are discussed, taking into account ecological risks such as eutrophication, the spread of invasive species, and the degradation of natural spawning habitats. A list of technical, biotechnical, and organizational solutions is provided, aimed at increasing fish productivity while preserving biodiversity. Conceptual foundations for sustainable aquatic resource management are proposed based on ecosystem and adaptive approaches. The prospects for the development of fisheries on Lake Kagul are outlined, with emphasis on the implementation of systematic ecological monitoring, improvement of stocking schemes, and the formation of a coordinated management model involving scientists, resource users, and regional authorities.

Keywords: Lake Kagul, fisheries use, biological productivity, fish stocking, ecological risks, sustainable development, biodiversity, hydroecological monitoring.

Problem statement. Lake Kagul is a strategically important component of the Lower Danube aquatic system. Under conditions of increasing anthropogenic load, climate change, and unstable hydrological regimes, there arises the urgent need to optimize fisheries use without disrupting the ecological balance of the lake.

Analysis of recent research and publications. Issues of fish productivity in deltaic water bodies are covered in the works of both Ukrainian and international researchers [1, 2, 5, 8]. However, most of the literature focuses on specific aspects of hydroecology or biotechnological regulation, lacking an integrated assessment of water bodies as fisheries systems within a sustainable management framework.

Objective. The aim of the study is to justify approaches to optimizing the fisheries use of Lake Kagul by evaluating its biological productivity, ecological status, and the effectiveness of applied management practices. The main objectives include analyzing the natural food base, assessing the structure of the ichthyofauna, studying stocking and harvesting practices, identifying ecological risks, and formulating recommendations for sustainable management.

Research results. Lake Kagul is part of the Danube-connected lake system and is located in the southern part of the Odesa Region, near the national border with Romania. It is a freshwater lake of natural origin, relatively shallow (average depth ranges from 2.5 to 3.5 meters), and covers an area of approximately 8,500 hectares. The hydrological regime of the lake is formed primarily through inflow from the Danube River, atmospheric precipitation, and limited surface runoff (Table 1).

A distinctive feature of Lake Kagul is the seasonal variability of the water level, which significantly affects the structure of biocenoses, the intensity of trophic interactions, and the overall biological productivity. According to its trophic status, the lake is classified as meso- or mesoeutrophic, with zooplankton dominating the trophic base, creating favorable conditions for the development of filter-feeding fish species, particularly silver carp (*Hypophthalmichthys molitrix*).

Table 1. **Main Hydrological and Physico-Chemical Characteristics of Lake Kagul (average values over the past 5 years)**

Indicator	Value
Surface area, ha	8 500
Average depth, m	2,8
Mineralization, mg/L	400–500
Dissolved oxygen, mg/L	5,2–9,8
Water transparency, cm	30–50
Trophic type	Mesoeutrophic

The ichthyofauna of the lake is represented mainly by species adapted to low-flow or stagnant water bodies. The dominant commercial species include silver carp (*Hypophthalmichthys molitrix*), common carp (*Cyprinus carpio*), crucian carp (*Carassius gibelio*), and bream (*Abramis brama*) (Table 2).

Historically, Lake Kagul was used by local fishing cooperatives for commercial fishing, but in recent decades the emphasis has shifted toward controlled stocking and integrated fisheries use with elements of aquaculture. Current approaches to lake exploitation take into account both economic feasibility and the ecological vulnerability of the water body.

Table 2. **Estimated Dynamics of Commercial Fish Catches in Lake Kagul (2019–2023)**

Fish Species	2019	2020	2021	2022	2023
Silver carp	1 200	1 350	1 600	1 800	2 050
Common carp	450	500	620	700	820
Crucian carp	300	370	410	460	510
Grass carp	90	130	160	200	230
Bream	280	290	310	330	360

Note: data are presented in metric tons; source – fisheries user reports and State Fisheries Agency monitoring.

Lake Kagul, located in the southwestern part of Odesa Region, is a transformed deltaic lake of the liman type. It is characterized by a complex hydrological structure, shallow depths, and high productivity under favorable ecological conditions. The biological productivity of the lake is determined primarily by the state of the natural food base, the species composition of commercial fish, and a combination of natural and anthropogenic factors.

The functioning of the trophic chain in Lake Kagul largely depends on the state of the plankton communities (Table 3, 4), which form the fundamental food base for the juveniles of commercial fish species [4, 9].

Table 3. **Dominant Phytoplankton Species in Lake Kagul (Based on Summer Monitoring Data, 2022–2023)**

Taxonomic Group	Dominant Species	Mean Biomass, mg/L	Share in Structure, %
Cyanophyta	Microcystis aeruginosa	1.35	32
Bacillariophyta	Aulacoseira granulata	1.10	26
Chlorophyta	Scenedesmus quadricauda	0.95	23
Euglenophyta	Euglena acus	0.45	11
Others	–	0.35	8
Total	–	4.20	100

Table 4. **Composition and Biomass of Main Zooplankton Groups in Lake Kagul**

Taxonomic Group	Representative Species	Mean Biomass, g/m³	Biomass Share, %
Cladocera	Daphnia magna, Bosmina longirostris	3.0	43
Copepoda	Cyclops vicinus, Eudiaptomus gracilis	2.2	32
Rotifera	Brachionus calyciflorus	1.4	20
Others	–	0.3	5
Total	–	6.9	100

The ichthyofauna of Lake Kagul includes 25 species, of which 8 are of commercial significance (Table 5).

Table 5. **Dynamics of Commercial Fish Catches in Lake Kagul (2019–2023), t/year**

Species	2019	2020	2021	2022	2023	Trend
Bream (Abramis brama)	64.2	59.5	52.8	48.3	42.6	Decreasing
Common carp (Cyprinus carpio)	38.5	41.3	45.2	47.9	49.1	Stable growth
Pike (Esox lucius)	17.8	15.2	13.5	12.0	11.4	Decreasing
Crucian carp (Carassius gibelio)	22.3	28.9	34.7	39.2	44.8	Increasing
Roach (Rutilus rutilus)	31.0	27.6	25.3	22.9	20.5	Decreasing

The commercial value of common carp and bream remains high; however, increasing competition from crucian carp necessitates the implementation of biotechnical measures to regulate its population size.

The biological productivity of Lake Kagul is influenced by a range of factors of both natural and anthropogenic origin (Table 6).

Table 6. **Key Factors Influencing the Fish Productivity of Lake Kagul**

Factor Group	Specific Factor	Impact on Biological Productivity
Natural	Water level fluctuations (dependence on the Danube River)	Alters the area of spawning and feeding habitats
	Temperature regime	Determines plankton activity and juvenile fish growth
	Water transparency	Influences phytoplankton photosynthetic activity
Anthropogenic	Overfishing	Leads to population degradation of pike and bream
	Pollution by agrochemicals	Causes eutrophication and cyanobacterial blooms
	Lack of monitoring	Hinders effective regulation of harvesting and fishery management

Enhancing the ecological and fishery efficiency of Lake Kagul requires the implementation of adaptive water use regulation models, support for the natural food base, and biotechnical restoration of native fish species.

The practical fisheries utilization of Lake Kagul is carried out by specialized enterprises that conduct regulated commercial fishing, stocking activities, and monitoring of aquatic biological resources. Over the past decade, targeted management efforts have been implemented within the water body, with the integration of productivity optimization technologies, enabling an assessment of their effectiveness from the perspective of sustainable resource use.

Several enterprises are involved in the fishery exploitation of the lake, notably LLC “Pivdenrybgosp” and other water users licensed for commercial catch. In 2023, the total commercial harvest of fish species amounted to 170.2 tonnes, representing a 12 % decrease compared to 2021 (Table 7). The primary components of the catch traditionally include bream, common carp, roach, and crucian carp.

Table 7. **Annual Commercial Fish Catch in Lake Kagul, t/year**

Year	Bream	Common Carp	Crucian Carp	Roach	Other Species	Total Catch
2019	64.2	38.5	22.3	31.0	14.5	170.5
2020	59.5	41.3	28.9	27.6	13.8	171.1
2021	52.8	45.2	34.7	25.3	11.5	169.5
2022	48.3	47.9	39.2	22.9	10.2	168.5
2023	42.6	49.1	44.8	20.5	13.2	170.2

Source: compiled data from LLC "Pivdenrybgosp" and the 2023 annual fisheries report of the Odesa Regional Department of the State Fisheries Agency of Ukraine.

To support fish productivity, annual restocking of Lake Kagul is conducted using juveniles of valuable fish species, primarily common carp, silver carp, and grass carp. The volumes of stocking and assessments of commercial return are presented in Tables 8 and 9.

Table 8. **Fish Stocking Volumes in Lake Kagul, 2021–2023**

Year	Common Carp (thousand ind.)	Silver Carp (thousand ind.)	Grass Carp (thousand ind.)	Total (thousand ind.)	Year
2021	680	240	130	1050	2021
2022	720	260	145	1125	2022
2023	750	280	170	1200	2023

Source: data from stocking reports for Lake Kagul, provided by the Odesa State Environmental Inspectorate and approved by the State Fisheries Agency of Ukraine (2023).

Table 9. **Assessment of Commercial Return from Stocked Fish (2021–2023)**

Fish Species	Avg. Mass of Stocked Juveniles, g	Commercial Return Coefficient, %	Avg. Weight Gain to Harvest, g
Common Carp	25	13.8	1100
Silver Carp	30	10.2	1500
Grass Carp	28	8.5	1250

Source: calculations based on field observations from water resource users and laboratory analysis (Odesa Research Institute of Aquatic Bioresources, 2023).

As part of the fishery management regime on Lake Kagul, a series of practices have been implemented to promote rational resource use and reduce pressure on native populations. These include:

− seasonal fishing restrictions during spawning periods (particularly April–May);

− the use of selective fishing gear (nets with mesh size ≥ 40 mm);

− localized restocking in zones with optimal hydrochemical conditions;

− biotechnical monitoring of catch structure and juvenile fish development.

According to expert assessments, these measures have maintained total fish productivity at the level of 165-170 tonnes per year, with a relatively stable catch composition. However, further improvements in efficiency are contingent upon comprehensive modernization of management approaches – including the introduction of a unified electronic catch tracking system, adaptive restocking planning, and integration with environmental monitoring of the lake ecosystem.

Ways to optimize the productivity of Lake Kagul. Based on a comprehensive assessment of the lake's biological productivity, industrial use dynamics, and environmental impact factors, optimizing the fisheries efficiency of Lake Kagul requires the implementation of a balanced set of technical, biotechnical, and organizational measures. The main objective is to achieve stable productivity while maintaining ecosystem equilibrium and ensuring the sustainable use of aquatic biological resources.

In the context of integrated water resource management, it is advisable to implement a set of technical solutions aimed at improving the habitat conditions for native fish species and maintaining the ecological stability of the aquatic ecosystem. In particular, these measures include the reconstruction and improvement of littoral spawning areas, involving the mechanical removal of excess silt and the installation of artificial substrates serving as spawning grounds for pike (*Esox lucius*), common carp (*Cyprinus carpio*), and roach (*Rutilus rutilus*).

Additionally, it is necessary to introduce systems for regulating water exchange with the Danube River, which will help maintain a stable water level regime in the lake, reduce hydrological stress, and mitigate the adverse effects of extreme fluctuations. Another important technical solution is the spatial optimization of commercial fishing zones, taking into account seasonal feeding activity areas and the migratory behavior of key commercial fish species.

At the biotechnical level, effective measures include the active regulation of populations of low-value or invasive species, particularly the silver crucian carp (*Carassius gibelio*), which negatively affects the lake's trophic structure. It is essential to maintain an optimal balance in the ichthyofaunal composition by prioritizing the restoration and support of high-yield species populations, such as common carp, silver carp (*Hypophthalmichthys molitrix*), and bream (*Abramis brama*). Regular bioremediative stocking with filter-feeding species – silver carp and grass carp (*Ctenopharyngodon idella*) – is also recommended to reduce nutrient loading and improve water quality.

On the organizational level, it is advisable to establish a permanent coordination council or interagency commission for managing the fisheries use of Lake Kagul. This advisory body should include representatives from scientific institutions, resource users, local government authorities, and environmental organizations. Its activities will ensure effective planning, transparent decision-making, and adaptive responses to ecological changes in the lake.

To improve the efficiency of stocking efforts, a transition from extensive practices to a programmed approach is necessary. This approach should be based on ecosystem monitoring and take into account the trophic status of the water body, hydrometeorological features, and biotic interactions. Key priorities for improvement include the development of an annual scientifically grounded stocking program based on data on the biomass of the natural food base, previous years' catch structure, and projected climate variability.

Adjustments to the species composition of stocked fish are recommended, with a focus on yearling carp as an economically viable species and juvenile silver carp as a natural biofilter to reduce nutrient loads. The implementation of a “controlled return” model is a promising strategy, involving the tracking of the proportion of artificially stocked individuals in commercial catches, which enhances the effectiveness of biotechnical interventions.

To reduce dependence on external sources of stocking material, the development of local broodstock and hatchery infrastructure must be supported, ensuring genetic adaptation of fish populations to local environmental conditions. Concurrently, the application of bioindicative zonation in stocking is recommended – selecting sites with optimal hydrochemical parameters such as transparency, temperature, dissolved oxygen levels, and the presence of natural shelter for juvenile fish.

Effective management of the fish productivity of Lake Kagul is impossible without systematic hydroecological monitoring (Table 10). To enable timely responses to ecosystem changes and support evidence-based decision-making, it is advisable to establish a permanent hydroecological observation station in partnership with relevant scientific institutions. This station should conduct quarterly sampling of water, phyto- and zooplankton, bottom sediments, and perform hydrochemical analysis of key indicators.

In addition, it is essential to implement automated sensor systems for continuous measurement of water environment parameters, including temperature, water level, dissolved oxygen, and pH levels. For spatial assessment of the ecological condition, the development and implementation of a GIS-based biotope mapping system for Lake Kagul is recommended. This would enable the identification of eutrophication zones, localized sources of pollution, hypoxic areas, and other ecological stressors.

Table 10. **Comprehensive Measures for Optimizing Fish Productivity in Lake Kagul**

Area of Intervention	Specific Measure	Expected Effect	Conditions for Implementation
Technical	Reconstruction of littoral spawning areas (dredging, artificial substrates)	Increased survival of eggs and fry of native species	Funding from local budgets or special funds; approval from environmental authorities
	Regulation of water exchange with the Danube River	Stabilization of water level regime, reduced risk of fish kills	Cooperation with water management authorities (e.g., Basin Water Resources Management)
	Selective placement of commercial fishing zones	Reduction of by-catch, protection of juvenile fish	Updating of lake zoning schemes
Biotechnical	Bioremediative stocking with filter-feeding species (silver carp, grass carp)	Reduction of eutrophication, improved water quality	Seasonal stocking, coordination with plankton analysis data
	Population control of silver crucian carp via regulated catch	Decreased competition for food and spawning grounds	Establishment of quotas/ regulations; informational outreach to fishers
	Stocking of juveniles in ecologically optimal lake zones	Improved survival of stocked fish	Preliminary monitoring of hydrochemical conditions in shallow areas
Organizational	Establishment of a lake management coordination council	Alignment of interests between users and management bodies	Regional or administrative order; inclusion of scientists, users, and environmental groups
	Development of annual stocking programs in consultation with scientific bodies	Adaptive fish population management	Contracts with research institutes; annual adjustment of species and stocking volumes
	Maintenance of electronic records of catch and stocking	Transparency, timely planning, analytical support	Use of a registration database accessible to control authorities
Monitoring	Establishment of a permanent hydroecological monitoring station at a university or R&D institute	Timely detection of changes in ecological status	Funding via grants, Horizon Europe, or the Ministry of Environmental Protection
	Installation of automated sensors (O_2, pH, temperature, water level)	Real-time data collection, support in critical conditions	Technical support from international programs or local budgets
	Development and maintenance of GIS-based biotope mapping	Spatial analysis of ecosystem, zoning	Collaboration with geoinformatics experts; integration with Ukraine's water monitoring platform

Source: synthesized from scientific and technical recommendations of the Odesa Research Institute of Aquatic Bioresources, project materials of UkrNDIEcoproject (2021–2024), and the authors' own findings.

To ensure public transparency and foster civic engagement in aquatic ecosystem protection, it is advisable to create an open-access electronic database of monitoring results. Such a resource would support the development of an integrated environmental control system and improve the quality of decision-making in fisheries governance.

With regard to the ecological aspects of fisheries intensification, it should be noted that the development of fishery activities in the context of a natural ecosystem such as Lake Kagul requires that environmental considerations be an integral part of management decisions. The intensification of commercial use without an ecosystem-based approach risks disrupting aquatic biotic balance, degrading natural habitats, and reducing biodiversity.

Among the main ecological risks accompanying the intensification of fisheries in Lake Kagul, the following stand out:

− Eutrophication of the lake due to the influx of agrochemicals from adjacent agricultural lands [6, 12], leading to massive cyanobacterial blooms, a decline in dissolved oxygen levels, and summer fish kills.

− Depletion of native fish populations as a result of unregulated fishing during the spawning season and the destruction of natural spawning habitats.

− The spread of invasive or low-value species (e.g., silver crucian carp, bleak), which displace autochthonous species and reduce the trophic quality of the biocenosis.

− Physical degradation of littoral zones caused by reed overgrowth, shallowing, and siltation of shallow areas.

Collectively, these factors not only reduce the productivity of the water body but also limit the potential for long-term sustainable fisheries development.

Within the scope of fishery activities, it is advisable to implement a set of conservation measures aimed at maintaining and preserving biodiversity:

− Development and implementation of protection zone schemes around key biotopes (spawning grounds, overwintering pits, and riparian wetlands).

− Annual ichthyofauna inventories, with emphasis on the status of native species and key ecological indicators.

− Restrictions on fishing during the spawning season, enforced through compliance monitoring by local environmental inspections.

− Use of bioindicators (zooplankton, benthic invertebrates, macrophytes) to assess ecosystem health.

− Support for predator fish populations as natural regulators of small fish abundance and as a means of maintaining trophic balance.

Preservation of both structural and functional diversity in the lake is a prerequisite for its ecological stability and capacity for recovery following environmental stressors.

The sustainable development of fisheries in Lake Kagul necessitates the integration of ecological, economic, and social dimensions into management decision-making. The core principles of this concept include:

− An ecosystem-based approach that considers not only fish as a resource but the entire aquatic ecosystem – from phytoplankton to birds and aquatic vegetation.

− Adaptive management, which entails flexible decision-making based on the results of ongoing monitoring.

− A balance between use and conservation: optimal exploitation rates for fish populations, prevention of overfishing, and the implementation of rational quotas and accounting systems.

− Inclusive governance: involvement of local communities, scientists, and stakeholders in the planning and implementation of fisheries programs.

− Transboundary cooperation within the Danube River Basin, particularly in the exchange of hydroecological data and harmonization of management approaches for deltaic lakes.

The implementation of a sustainable management framework will ensure the ecological integrity of Lake Kagul and support the long-term economic viability of the region's fishery sector.

Conclusions. This study has provided a comprehensive analysis of the biological productivity of Lake Kagul as a fisheries resource. The status of the natural food base was assessed, the species composition of commercial fish was characterized, and practical aspects of harvesting and stocking were examined. In addition, the main ecological risks associated with the intensification of fisheries activities were identified. The key findings are as follows:

1. Lake Kagul is characterized as a mesoeutrophic water body with high natural productivity, underpinned by a well-developed trophic base formed by phyto- and zooplankton communities. Under stable hydroecological conditions and rational use of aquatic resources, the lake's fish productivity can be sustainably maintained at 160–180 tonnes per year.

2. The ichthyofauna of the lake comprises 25 fish species, with the primary components of commercial catches being bream (Abramis brama), common carp (Cyprinus carpio), roach (Rutilus rutilus), pike (Esox lucius), and silver crucian carp (Carassius gibelio). A negative trend is observed in the declining proportion of native species, coinciding with the proliferation of ecologically plastic but economically less valuable taxa.

3. The practice of fish stocking has proven effective when scientifically grounded biotechnical standards are met. In particular, the average commercial return coefficient for common carp ranges from 12–14 %, indicating the value of continuing such measures with further optimization of species composition and stocking volumes.

4. Key environmental challenges for the lake's ecosystem include intensifying eutrophication, declining water levels due to hydrological instability, degradation of natural spawning areas, and the spread of invasive species. This

combination of factors necessitates the implementation of both preventive and compensatory management mechanisms.

5. A comprehensive set of measures has been substantiated to optimize the lake's productivity, encompassing technical (spawning ground restoration, hydrological regulation), biotechnical (bioremediation, selective stocking), and organizational (creation of a coordinating council, electronic harvest accounting) tools.

6. Biodiversity conservation is regarded as a system-forming factor essential for ensuring both long-term ecological balance and the economic sustainability of the fishery. Effective management of fisheries should be grounded in ecosystem-based principles, adaptive planning, and interdisciplinary coordination.

The future development of the fishery sector in Lake Kagul is closely tied to the integration of scientific knowledge into water resource management practices, the enhanced involvement of local communities, and the mobilization of external investment and technical support. If a comprehensive governance model based on sustainable development principles is successfully implemented, Lake Kagul may serve as a pilot site for the effective adaptation of Ukrainian deltaic lakes to the challenges of the modern bioeconomy.

БІОЛОГІЧНА ПРОДУКТИВНІСТЬ ТА ЕКОЛОГІЧНА ОПТИМІЗАЦІЯ РИБОГОСПОДАРСЬКОГО ВИКОРИСТАННЯ ОЗЕРА КАГУЛ

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У статті представлено комплексне дослідження біологічної продуктивності озера Кагул (Одеська область) як об'єкта рибогосподарського використання в умовах природної евтрофної екосистеми. Актуальність проблеми обумовлена необхідністю оптимізації рибогосподарської діяльності в умовах антропогенного навантаження та кліматичних коливань, які значною мірою впливають на структурно-функціональний стан водойми. В роботі здійснено оцінку кормової бази (фіто- та зоопланктону), проаналізовано видовий склад промислових риб, тенденції вилову, ефективність зариблення, а також вплив природних та антропогенних факторів на продуктивність водойми. Особливу увагу приділено практичному досвіду місцевих рибогосподарств, зокрема динаміці промислового повернення зарибку, результатам впроваджених біотехнічних заходів та організаційним моделям управління.

Розглянуто сучасні підходи до інтенсифікації рибного господарства з урахуванням екологічних ризиків, таких як евтрофікація, поширення інвазійних видів та деградація природних нерестовищ. Наведено перелік технічних, біотехнічних та організаційних рішень, спрямованих на підвищення рибопродуктивності за умови збереження біорізноманіття. Запропоновано концептуальні засади сталого управління водними біоресурсами на основі екосистемного та адаптивного підходів. Окреслено перспективи розвитку рибного господарства на озері Кагул з урахуванням впровадження системного екологічного моніторингу, удосконалення схем зариблення та формування координаційної моделі управління з участю науковців, користувачів ресурсу і регіональних органів влади.

Ключові слова: озеро Кагул, рибогосподарське використання, біологічна продуктивність, зариблення, екологічні ризики, сталий розвиток, біорізноманіття, гідроекологічний моніторинг.

ЛІТЕРАТУРА

1. Бекетова В. М. Екологічні основи рибогосподарської меліорації внутрішніх водойм. К.: Урожай, 2015. 368 с.
2. Дубина А. І., Коваленко В. В. Сучасні проблеми інтенсифікації рибництва в дельтових водоймах України. *Вісник аграрної науки Причорномор'я*. 2020. № 3(114). С. 45-52.
3. Кириченко М. М., Роговська Н. В. Іхтіофауна південних водойм України: видова структура та динаміка. Херсон: Олді-плюс, 2018. 224 с.
4. Ткаченко І. Г. Основи управління водними біоресурсами: екосистемний підхід. К.: Академперіодика, 2016. 310 с.
5. Шеремет А. І., Бичкова В. С. Біологічні засади відновлення аборигенних видів риб у прісноводних екосистемах. *Наукові записки ТНУ ім. В.І. Вернадського. Біологія*. 2019. № 1(77). С. 93-100.
6. FAO (2022). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome: Food and Agriculture Organization of the United Nations. DOI: https://doi.org/10.4060/cc0461en
7. Schiemer, F., Zalewski, M. The Importance of Riparian Ecotones for Diversity and Productivity of Riverine Fish Communities. *Netherlands Journal of Zoology*. 1992. no. 42(2-3):323-335.
8. Bayley, P. B. Aquatic environments in the Amazon Basin, with an analysis of carbon sources, fish production, and yield. In: Dodge, D.P. (Ed.), Proceedings of the International Large River Symposium (LARS). *Canadian Special Publication of Fisheries and Aquatic Sciences*. 1989. no. 106:399-408.
9. Wetzel, R. G. Limnology: Lake and River Ecosystems (3rd ed.). San Diego: Academic Press. 2001. 1006 p.
10. Cowx, I. G., Welcomme, R. L. Rehabilitation of Rivers for Fish: A Study Undertaken by the European Inland Fisheries Advisory Commission. *FAO Fisheries Technical Paper*. 1998. no. 384. Rome: FAO.
11. Ковальчук Н. А., Андрющенко А. М. Сучасні підходи до зариблення природних водойм. *Рибне господарство України*. 2021. № 1. С. 12-18.
12. Environmental Agency of Ukraine. Report on the Ecological Status of Surface Waters in the Danube Basin. Kyiv: State Water Resources Agency of Ukraine. 2020.

REFERENCES

1. Beketova V. M. (2015). *Ekolohichni osnovy rybohospodarskoi melioratsii vnutrishnikh vodoim* [Ecological foundations of fishery melioration of inland water bodies]. Kyiv: Urozhay. [in Ukrainian].
2. Dubyna A. I., Kovalenko V. V. (2020). *Suchasni problemy intensyfikatsii rybnytstva v deltovykh vodoimakh Ukrainy* [Modern problems of fish farming intensification in the delta waters of Ukraine]. *Visnyk ahrarnoi nauky Prychornomoria* [Bulletin of agricultural science of the Black Sea region]. no. 3(114), 45-52. [in Ukrainian].
3. Kyrychenko M. M., Rohovska N. V. (2018). *Ikhtiofauna pivdennykh vodoim Ukrainy: vydova struktura ta dynamika* [Ichthyofauna of southern Ukrainian reservoirs: species structure and dynamics]. Kherson: Oldi-plius. [in Ukrainian].
4. Tkachenko I. H. (2016). *Osnovy upravlinnia vodnymy bioresursamy: ekosystemnyi pidkhid* [Fundamentals of aquatic bioresources management: an ecosystem approach]. Kyiv: Akademperiodyka. [in Ukrainian].
5. Sheremet A. I., Bychkova V. S. (2019). *Biolohichni zasady vidnovlennia aboryhennykh vydiv ryb u prisnovodnykh ekosystemakh* [Biological principles of restoration of native fish species in freshwater ecosystems]. *Naukovi zapysky TNU im. V.I. Vernadskoho. Biolohiia* [Scientific notes of the V.I. Vernadsky TNU. Biology]. no. 1(77), 93-100. [in Ukrainian].
6. FAO (2022). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome: Food and Agriculture Organization of the United Nations. DOI: https://doi.org/10.4060/cc0461en
7. Schiemer, F., Zalewski, M. (1992). The Importance of Riparian Ecotones for Diversity and Productivity of Riverine Fish Communities. *Netherlands Journal of Zoology*, no. 42(2-3):323-335.
8. Bayley, P. B. (1989). Aquatic environments in the Amazon Basin, with an analysis of carbon sources, fish production, and yield. In: Dodge, D.P. (Ed.), Proceedings of the International Large River Symposium (LARS). *Canadian Special Publication of Fisheries and Aquatic Sciences*, no. 106:399-408.
9. Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems (3rd ed.). San Diego: Academic Press.
10. Cowx, I. G., Welcomme, R. L. (1998). Rehabilitation of Rivers for Fish: A Study Undertaken by the European Inland Fisheries Advisory Commission. *FAO Fisheries Technical Paper*, no. 384. Rome: FAO.
11. Kovalchuk N. A., Andriushchenko A. M. (2021). *Suchasni pidkhody do zaryblennia pryrodnykh vodoim* [Modern approaches to stocking natural water bodies]. *Rybne hospodarstvo Ukrainy* [Fisheries of Ukraine]. no. 1:12-18. [in Ukrainian].
12. Environmental Agency of Ukraine (2020). Report on the Ecological Status of Surface Waters in the Danube Basin. Kyiv: State Water Resources Agency of Ukraine.