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FISH RESOURCES OF KYZYLORDA REGION, THEIR USE AND POSSIBLE METHODS OF FORMATION

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Abstract. This paper examines fish resources in the Kyzylorda region, including the Small Aral Sea, lower Syr Darya River, and local water bodies. The area is home to 16 commercial fish species, with about 21% classified as invasive. Bream, roach, and pike perch are the main species caught, making up approximately 90% of the total catch.

Fish catches have remained steady between 6,000 and 7,500 tons annually since 2015, but local processing plants have a much greater capacity—up to 45,000 tons per year. This mismatch leads to increased illegal, unreported, and unregulated fishing. To address this issue, aquaculture should become a focal point for industry development. Since 2022, annual commercial fish production has surpassed 1,000 tons, largely from carp/sazan and herbivorous species.

The sustainable future of the fishing sector depends on adopting lake and cage farming technologies, boosting water body productivity, and enhancing regulation. Efficient resource management and expanding aquaculture through intensive methods will help utilize processing facilities fully, support regional food security and economic growth, and curb illegal fishing activities.

Keywords: fish resources, Syr Darya River, local water bodies, Small Aral Sea, processing, aquaculture

Introduction.

The Kyzylorda region occupies a special position in the hydrogeographical and fisheries system of the Republic of Kazakhstan: the region is in the lower reaches of the Syr Darya River and includes the Small Aral Sea and part of the Great Aral Sea. The natural and climatic conditions of the region are characterized by a sharp continental climate, snowless winters, hot and dry summers, as well as the peculiarities of the water regime of the river and adjacent lakes and reservoirs. Under these conditions, the region's fisheries and aquaculture are of great importance both in terms of food security and the sustainable use of aquatic biological resources.

After the filling of the Small Aral Sea, this region has once again become one of the centers of Kazakhstan's fisheries, and issues related to the development and regulation of the fishing industry are becoming particularly acute, especially in a period of understanding the need for rational use of water resources. One way to use resources rationally is to combine different activities in the same water bodies – exploiting natural fish stocks and creating new sources of resources in the form of fish farms.

In a situation where fishing has reached a stable phase and no increase in commercial fishing volumes is expected, the development of aquaculture in the region should be viewed as a systemic process requiring a comprehensive approach: assessment of the state of fish resources and ichthyofauna, development of technological schemes for intensive farming, creation of infrastructure adapted to arid and variable conditions, as well as legislative and organizational support. Given the unique natural conditions of the Kyzylorda region and the high potential of local water bodies, investment in aquaculture could become one of the vital areas of sustainable development in the region. However, “spontaneous” investment without sufficient biological justification could lead to uneven development of individual parts of the fish production chain.

The purpose of this article is to summarize scientific data on the use of fish resources in the water bodies of the Kyzylorda region and to analyze the prospects for the development of aquaculture in the region, including an assessment of resource potential, technological and organizational solutions.

Data and methods.

This study is based on data published in the public domain by the National Statistics Bureau of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. Data analysis was conducted using the standard Office 365 suite.

Taxon names follow the classification provided by Froese R. and Pauly D. [1]. Commercial species are defined as those listed in the Order of the Minister of Agriculture [2].

The compilation of water bodies of both republican and international significance adheres to the order issued by the Minister of Agriculture of the Republic of Kazakhstan [3], while the inventory of fish farming water bodies of local significance follows the decree of the akim of the Kyzylorda region [4].

For the purposes of this article, the portion of the Aral Sea situated within Kazakhstan and segmented from the remaining section by the Kokaral Dam is referred to as the Small Aral Sea (SAS), consistent with its designation in the fisheries documentation of the Republic of Kazakhstan.

Results and discussion.

The fish stocks in the Kyzylorda region come from several sources: internationally significant bodies of water like the Small Aral Sea and the Syr Darya River, local fish farming sites, and commercial aquaculture.

There are 16 commercially important fish species in the region, representing 8 families, and 21% of these species are invasive (see Table 1).

Table 1 – Composition of commercial fish fauna in the water bodies of the Kyzylorda region [5–8]

No.	Species name		Species status
	Scientific	Common	
Family Esocidae – Pike			
1.	*Esox lucius* Linnaeus, 1758	Northern pike	native
Family Leuciscidae – Smelt			
2.	*Abramis brama* (Linnaeus, 1758)	Freshwater bream	native
3.	*Alburnus chalcoides* (Guldenstadt, 1772)	Danube bleak	native
4.	*Ballerus sapa* (Pallas, 1814)	White-eye bream	native
5.	*Leuciscus aspius* (Linnaeus, 1758)	Asp	native
6.	*Pelecus cultratus* (Linnaeus, 1758)	Sichel	native
7.	*Rutilus rutilus* (Linnaeus, 1758)	Roach	native
8.	*Scardinius erythrophthalmus* (Linnaeus, 1758)	Rudd	native
Family Cyprinidae – Carp			
9.	*Carassius gibelio* (Bloch, 1782)	Prussian carp	native
10.	*Cyprinus carpio* Linnaeus, 1758	Common carp	native
Family Xenocyprididae – East Asian minnows			
11.	*Ctenopharyngodon idella* (Valenciennes, 1844)	Grass carp	invasive

No.	Species name		Species status
	Scientific	Common	
12.	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	Silver carp	invasive
Family Siluridae – Catfish			
13.	*Silurus glanis* Linnaeus, 1758	Wels catfish	native
Family Percidae – Perch			
14.	*Sander lucioperca* (Linnaeus, 1758)	Pikeperch	native
Family Channidae – Snakeheads			
15.	*Channa argus* (Cantor, 1842)	snakehead	invasive
Family Pleuronectidae – Flatfish			
16.	*Platichthys flesus* (Linnaeus, 1758)	European flounder	invasive

The Kyzylorda region ranks third in Kazakhstan in terms of fish catch volume, contributing 15.65% to the national total, following East Kazakhstan (18.54%) and Atyrau (21.06%). Collectively, all other regions account for less than 45% of the overall catch. Over 80% of the fish harvested originates from the Small Aral Sea, with the remainder sourced from local fishing areas. Fishing activities on the Syr Darya River represent a negligible portion, comprising less than 0.2% of the annual quota allocated for the waters of Kyzylorda Region (Table 2).

Table 2 – Fish catch in the Kyzylorda region by type of reservoir, tons

Water body	2020	2021	2022	2023	2024
SAS	3,821.6	4,063.7	7,804.4	4,700.9	6,063.7
Local water bodies	2,918.4	3,286.5	1,085.4	587.9	981.2
Rivers	1.6	0	0	3	0
Total for the region	**6,741.6**	**7,350.2**	**8,889.8**	**5,291.8**	**7,044.9**

The total area of local fishing reservoirs amounts to 44,567.5 hectares, with over half situated in the Aral district (Table 3), primarily comprising the delta lakes of the Syr Darya River. The majority of these lakes support commercial fishing activities, while certain reservoirs are allocated for lake-based commercial fish farming (Table 4). Generally, water bodies of local significance serve a single purpose; however, Lake Kamystybas—the region's largest lake—features designated zones for multiple uses: three areas for commercial fishing, seven for cage aquaculture operations, and one area reserved for recreational angling.

Table 3 – Area of local fishery water bodies in the Kyzylorda region

Administrative district	Area, ha	Share
Aral	27,063.5	60.7
Zhalagash	1,520.0	3.4
Zhanakorgan	2,064.0	4.6
Kazalinsky	4,253.0	9.5
Karmakshinsky	2,616.0	5.9
Kyzylorda	1,091.0	2.4
Syrdarya	2,133.0	4.8
Shiyeli	3,827.0	8.6
Total	**44,567.5**	**100.0**

Table 4 – Distribution of local fishery water bodies in the Kyzylorda region by intended use

Indicator	Fish farms	Cage farms	Recreational	Fishing
Number of lakes/areas, units.	113	7	2	79
Area of water bodies/plots, hectares	13,943.5	5,695.0	501.0	24,428.0

Since 2015, fish catches in the region's reservoirs have stabilized at 6,000–7,500 tons per year (Figure 1).

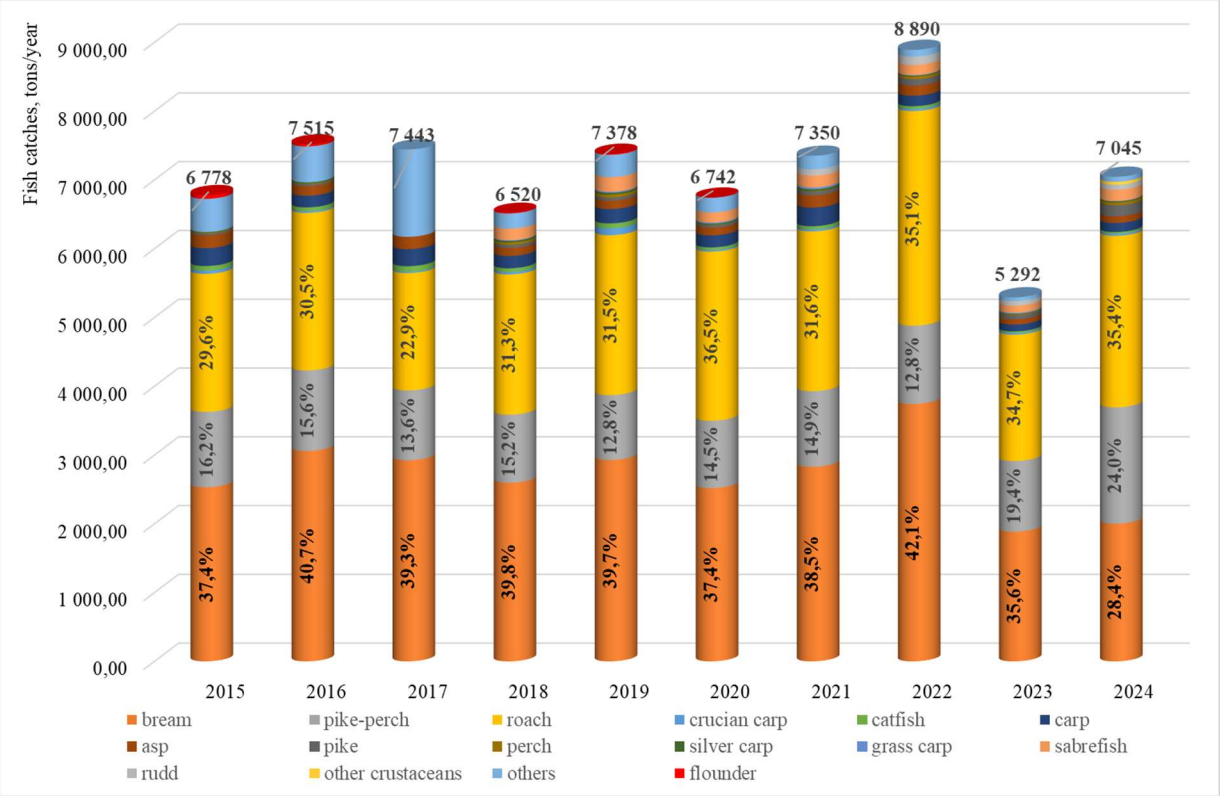

Figure 1 – Fish catches in the water bodies of the Kyzylorda region, tons

The primary commercial fish species in the region are bream (representing 38–41% of total catches from 2017 to 2020), roach (30–33%), and pike perch (13.4–14.7%). Collectively, these species constitute approximately 75–90% of the regional catch.

As a result of the desalination of the Small Aral Sea, flounder populations have declined significantly, with annual catches dropping from 1,100 tons in 2005 to just 24 tons in 2019. In recent years, flounder has only been observed in isolated instances and is no longer targeted commercially; current catches serve scientific purposes exclusively. If prevailing hydrological conditions persist, the extinction of flounder is probable, a process that may accelerate should sea levels rise and salinity decrease further.

Commercial fish farming in the area is conducted through lake farms. There are currently 73 registered entities, encompassing various forms of ownership, engaged in "Freshwater fish farming" and "Marine fish farming."

No commercial aquaculture entitles were recorded in the Kyzylorda region prior to 2021. From 2022 to 2024, aquaculture output doubled, surpassing 1,000 tons annually. The principal farmed species include carp/sazan and herbivorous fish such as white amur and white silver carp, which together comprise over 86% of total commercial fish production (see Table 5).

Table 5 – Volume of commercial fish farmed in the reservoirs of the Kyzylorda region, tons/year

Year	Total	Carp	Sazan	Silver carp	White amur	Pike perch	Catfish	Other species
2022	526.5	35.2	162.3	101.4	82.5	107.0		38.0
2023	875.0	156.9	254.2	204.1	128.1	120.0		11.8
2024	1,001.2	197.1	326.6	195.9	149.1	120.0	10.0	2.5

Thus, officially, up to 8–10 thousand tons of fish are produced in the Kyzylorda region.

Processing.

In the Kyzylorda region, nearly all fish processing facilities are concentrated within the Aral district, positioned close to primary raw material sources. The region hosts 22 operational fish processing enterprises: two located in Kyzylorda, one in Zhanakorgan district, one in Kazalinsk district, and the remaining eighteen registered in the Aral district.

The development of fish processing capacity in the region has occurred across four distinct stages:

1) Prior to 2009;
2) 2009–2016;
3) 2016–2018;
4) 2018 to the present (Figure 2).

The principal outputs of the region's fish processing enterprises are frozen fish and fish fillets. In 2018, these products accounted for approximately 95 to 100% of total processed volume. From 2019 onward, the product range expanded slightly; however, the share of these main products decreased to between 87% and 95%. Newly introduced product types do not represent a significant portion of production (Figure 3).

While frozen whole fish remains the predominant product by volume, pike perch fillets and other fish species intended for export constitute the primary source of revenue, accounting for over 70% of regional fish exports annually (Figure 4), driven by strong demand and high prices within European Union markets.

It is evident that the region’s fish processing capacity exceeds available supply of raw fish materials by a factor of 5.6 (Figure 2).

As of 2024, the region’s accessible raw material resources amounted to 8,000 tons —7,000 tons from fishing and 1,000 tons from aquaculture. On one hand, this capacity suggests potential for increased fish processing volumes; on the other, the substantial excess forces producers to seek additional sources of raw materials to maximize utilization rates. The installed processing capacity stands at 45,000 tons per year. Achieving an 80% utilization rate would require 36,000 tons of raw material annually. After accounting for existing resources, there remains an unmet demand for 28,000 tons of raw fish.

It is not feasible to consistently increase fish catches while simultaneously utilizing resources sustainably and maintaining stable hydrological and habitat conditions. Annual fish yields fluctuate due to changing habitat circumstances. According to the Ministry of Water Resources and Irrigation of Kazakhstan [9], fish catches in the Small Aral Sea are expected to rise once the sea level reaches 44 meters BS following the completion of the Kokaral dam reconstruction. However, this increase is projected to remain below 2,000 tons per year.

Other potential sources are commercial aquaculture products, fish brought in from other areas of Kazakhstan, and international imports.

There are several methods for commercial fish farming that can be used in natural bodies of water, such as lake fish farms, cage systems, and coastal fish farms with different levels of intensity. At present, only lake fish farms and cage farms are operating in the region.

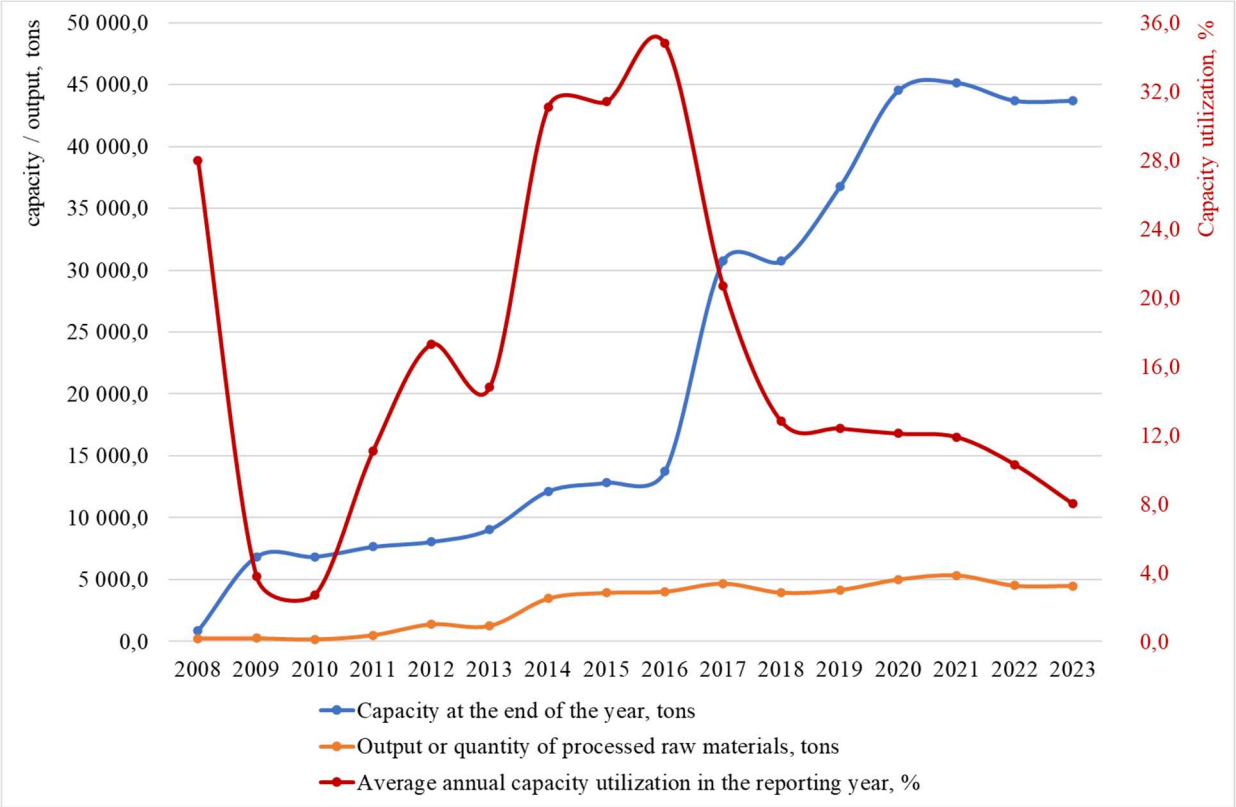

Figure 2 – Dynamics of fish processing capacity formation in the Kyzylorda region

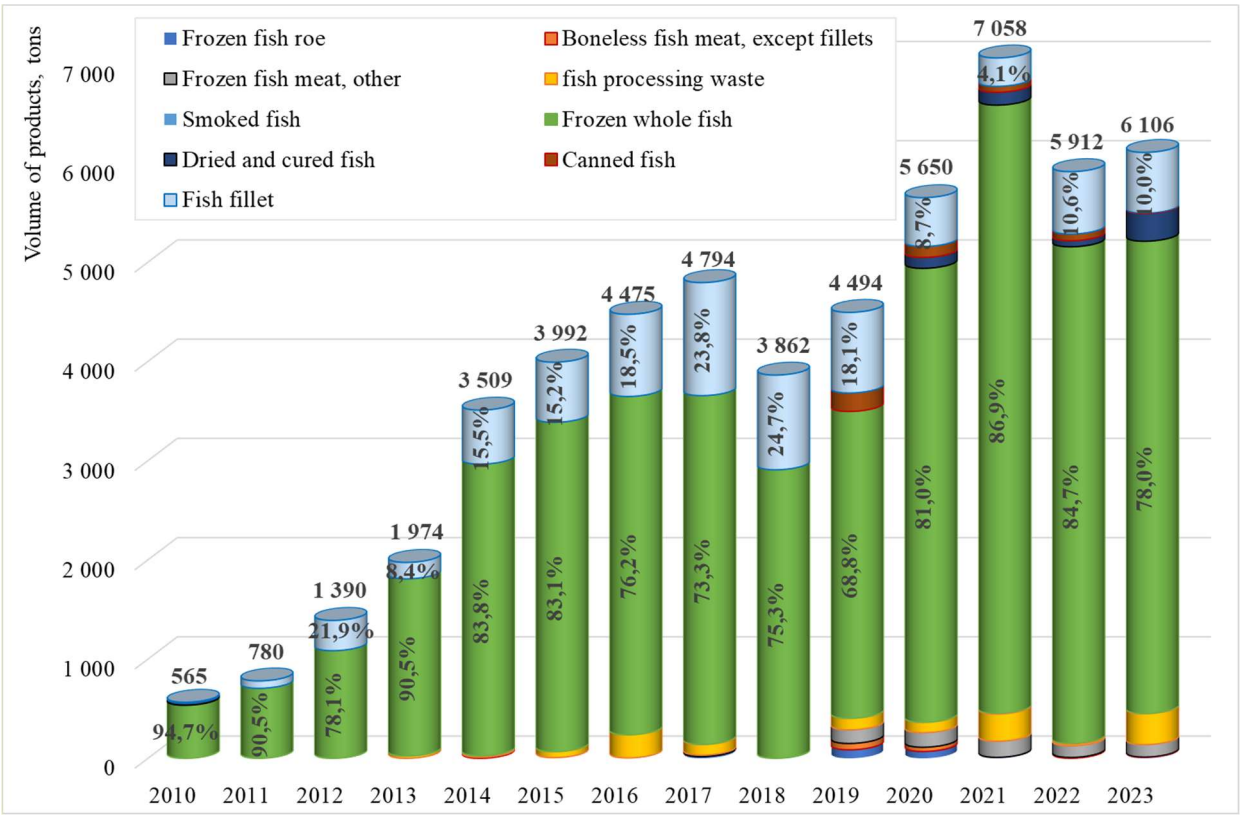

Figure 3 – Range of fish processing products at enterprises in the Kyzylorda region, tons

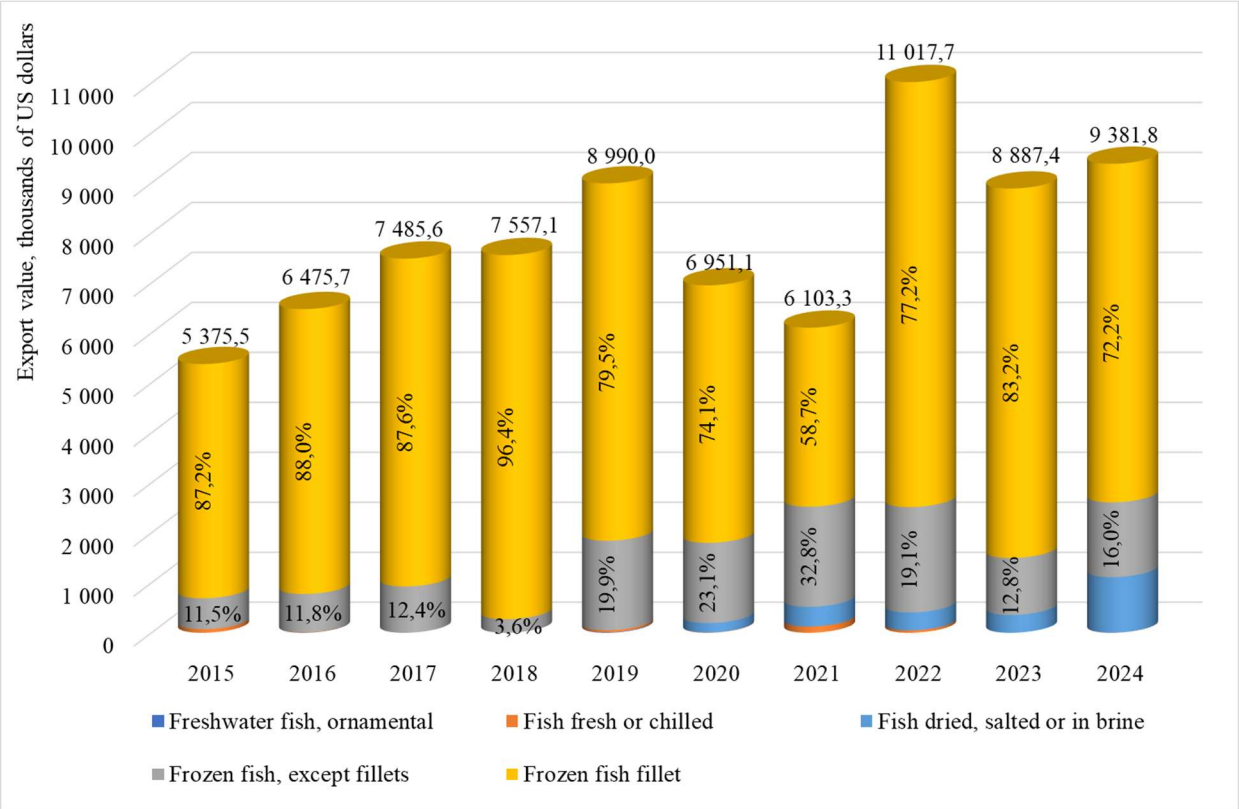

Figure 4 – Value of fish exports from the Kyzylorda region, thousands of US dollars

Lake farms are the technology with the lowest degree of intensification of biotechnical processes. In lake farms, fish use natural food sources and natural hydrophysical and hydrochemical regimes. Intensification measures include the formation of the desired fish fauna by removing the native fish fauna and replacing it with commercially valuable fish species through annual stocking. In more developed lake farms, pond fertilization, fish feeding, and the use of cages may be applied. The area of reservoirs in the region designated for lake farms purposes is 13,943.5 hectares. Ultimately, the productivity of lake farms depends not only on the productivity indicators of the natural food base, but also on how effectively technological methods are applied. Most lake farms operate on an extensive basis, i.e., they use only the natural food base and stock the reservoir with young fish of valuable species without radically transforming the ichthyofauna, which is why the productivity of most lake farms does not exceed 50 kg/ha on average. There are no technological fish farming standards for lake farms in Kazakhstan, which does not encourage natural resource users to increase the efficiency of fish farming. There are no incentive standards in the current nature use agreements either. The only document that specifies the volume of possible production is the fish farming and biological justification, which does not always indicate modern technologies that increase the productivity of fish farming. The literature provides several options for the productivity of reservoirs in fish farming areas close to the Kyzylorda region (Zone V of pond fish farming [10]). For one of the reservoirs in the Almaty region, the fish productivity of the lake farms is calculated at 2,634.72 kg/ha [11]. This is most likely a calculation error, as the fish productivity estimates for other reservoirs are significantly lower. For reservoirs in the Kyzylorda region, the average fish productivity is given as 110 kg/ha [12], which, in our opinion, is an underestimate, since as early as the 1980s, the first lake farms opened in the Kyzylorda region achieved an average fish productivity of 400 kg/ha. Such fish productivity can be achieved in reservoirs where semi-intensive farming is practiced with fish feeding and the use of cage- ing technology [13]. For lake farms, it is recommended to use small reservoirs with an area of no more than 1,000 ha [14], optimally with an area of 100–300 ha [13, 14]. Thus, based on the area of

reservoirs allocated to natural resource users for lake farms and the final productivity of 400 kg/ha with technologically competent use of lake farms, the production of such farms in the region as a whole may amount to 5,577.40 tons/year.

The development of cage aquaculture in the Kyzylorda region is hampered by the sharply continental climate, which is characterized by significant seasonal fluctuations in water temperature. Under such conditions, the optimal species for cultivation are native fish species, i.e., carp and sturgeon. Currently, Kazakhstan has not officially adopted fish farming standards for commercial fish farming using cage technology or standards for the maximum area of water bodies permitted for cage farms. However, existing experience in fish farming under similar conditions in neighboring countries allows us to calculate the potential production of cage farms. The final stocking density for sturgeon in cage farming is 20 kg/m² [15]. The stocking density for carp can be significantly higher. Currently, the stocking density of carp in the cage farm of Protect Wildlife LLC on the Tuyabuguz Reservoir (Tashkent Region, Uzbekistan) is 40 kg/m³. In the future, it is planned to increase the carp yield to 100 kg/m³ [16].

One of the important issues is the maximum permissible area of cages on a reservoir. Previously [17, 18], this issue was resolved by introducing a standard of 0.1% of the reservoir's surface area. Currently, the maximum possible area of cages on a water body is determined in the process of assessing the additional biogenic load on the water body caused by cage farming, which will not lead to eutrophication of the water body. Different authors propose different methods for determining the load: based on primary production, algae biomass, oxygen deficiency, indicator species, fish catch, aquatic macrophyte production, nutrient concentration, or a combination of these factors [19, 20] to assess the productivity of water bodies. Models of various productivity assessment indices have been developed. According to Aïzonou et al. [19], the model developed by Dillon and Riegler [21] provides the most accurate predictions for maintaining the physical, chemical, and biological balance of deep and shallow lakes and reservoirs in both temperate and tropical climates. Research or government regulatory agencies can use any of the models to estimate the maximum allowable biogenic load of cage farms on the ecosystem of water bodies. One of the most common estimates is the area of cages, which occupies 0.1 to 1% of the water body's surface area.

Considering that 5,695 hectares of water bodies are allocated for cage farms, the maximum stocking density for sturgeon is 20 kg/m², the maximum stocking density for carp is 40 kg/m², and the maximum permissible area of the water surface on which cages can be placed must not exceed 1% of the total area of the water surface, additional production from cage farms can amount to about 11,390 tons for sturgeon and about 45,560 tons/year for carp.

Thus, with proper control of the biogenic load on the reservoir and the introduction of intensive technologies, aquaculture can produce more than 51,000 tons of fish, including 5,577.40 tons/year from lake farm production and up to 45,560 tons/year from cage farms. Consequently, aquaculture production can fully utilize the region's processing capacity and create new jobs. In addition, with the supply of stable, predictable, and comparable quality products, illegal fish supply channels become unprofitable. However, this effect is only evident with a developed certification and traceability system for the fish production chain, which does not exist in Kazakhstan. The expansion of aquaculture alone does not guarantee a reduction in poaching; trade control measures, protection of spawning grounds, and combating illegal fishing are necessary, otherwise poaching remains a significant factor. Moreover, the growth of aquaculture without effective control can create new flows of illegal raw materials (e.g., substitution of origin, mixing with wild-caught products) if the certification system is weak [22]. In this regard, the role of state and public control over the circulation of products is also increasing.

An even greater increase in fish processing capacity in the region may occur if the owner of the fish farm and the fish processing enterprise are different, unrelated economic entities, in

which case it is quite possible that commercial fish producers will want to process their own products.

In such a situation, state regulation of the industry plays an important role. A mechanism is needed to encourage natural resource users to intensify their lake and pond farms, and processors to open fish farms.

If aquaculture production and imports of raw materials do not fill processing capacities, then, as practice shows [23, 24], excess extraction and fish processing capacities lead to an increase in IUU fishing, i.e., raw materials will be sent for processing, but through illegal channels.

In addition, preliminary results of a sociological survey conducted in the region [25] showed that older generations were more aware of the historical context of the Aral Sea and would like to restore their livelihoods in order to protect the traditions of the Aral Sea. Many people living around the Aral Sea still want economic development based on agriculture, forestry, and fishing. From this, it can be concluded that it is possible that, in the process of generational change and/or the arrival of fishing companies from other regions not associated with the Aral Sea, the amount of IUU fishing will increase. New people who have no emotional connection to the Aral Sea may take tougher decisions on the removal of fish resources, which could lead to an increase in the share of IUU fishing.

Conclusion.

The Kyzylorda region is a major hub for Kazakhstan's fishing industry, thanks to the Small Aral Sea and the Syr Darya delta lakes. This area supplies a significant portion of the nation's total catch, making it vital for food security. The fish population for commercial purposes mainly consists of bream, roach, and pike perch, which together make up around 90% of all catches.

Aquaculture in Kyzylorda only began to develop actively in 2022 but has already seen notable progress, with carp being the primary species cultivated. However, the region's processing facilities are capable of handling up to 45,000 tons of fish annually, while just about 8,000 tons of raw fish are available. This gap encourages efforts to find new sources of fish—through expanded aquaculture, imports, and interregional supply—and also results in increased illegal fishing.

Lake farms and cage aquaculture, when managed properly with intensive technologies, can greatly boost fish production. Lake-based farms have the potential to yield 400 kg per hectare, and cage aquaculture could produce up to 40 kg per cubic meter, enabling the region to generate up to 51,000 tons of fish yearly beyond traditional fishing, fully utilize processing capacity, and raise profitability.

Nevertheless, if state and public organizations do not effectively regulate and monitor aquaculture development, issues such as water eutrophication, more illegal fishing, and reduced industry sustainability may arise. Therefore, certification, product traceability, and anti-poaching measures are needed.

For sustainable growth in the Kyzylorda fishing sector, an integrated strategy is essential—balancing responsible fishing, expanding aquaculture, modernizing processing, and strengthening government oversight. This approach will safeguard and increase local fish stocks and support long-term social and economic progress. These findings can guide government agencies as they shape regional fisheries policies.

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