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Experience of forming repair and brood stocks of sturgeon fish: Studies on the example of Siberian sturgeon and sterlet

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ABSTRACT

The conservation and restoration of valuable, rare, and endemic fish species in Kazakhstan, such as the Irtysh sterlet and Nelma, are critical priorities under national and international biodiversity frameworks. Increasing anthropogenic pressures, including poaching and habitat alteration, threaten these species, necessitating artificial reproduction and broodstock development to support their populations. This study evaluates the domestication and rearing of wild sterlet, *Acipenser ruthenus* and Siberian sturgeon, *Acipenser baerii* in recirculating aquaculture systems (RAS) in Kazakhstan. Morphometric, physiological, and hydrochemical parameters were analyzed to assess broodstock viability, growth performance, and adaptation to captive conditions. Results indicate successful domestication of wild sterlet, with optimal hydrochemical conditions (temperature: 14.3–22.3°C, dissolved oxygen: 7.0–9.9 m L^{-1}, pH: 7.0–7.5) supporting sturgeon rearing. Fulton's condition factor increased with age, suggesting effective feeding regimes. Challenges remain in early sex determination, gonad maturation, and feed adaptation, particularly for wild-caught females. The study demonstrates the feasibility of forming sturgeon broodstocks in Kazakhstan's aquaculture systems, providing a foundation for conservation and commercial production while highlighting the need for further research on reproductive biotechnology and stress mitigation in domesticated stocks.

Keywords: Sturgeon conservation, Broodstock development, Artificial reproduction, Recirculating aquaculture systems (RAS).
Article type: Research Article.

INTRODUCTION

Conservation and restoration of the number of valuable, rare, endemic fish species of Kazakhstan (sterlet of the Irtysh population and Nelma) is one of the priorities of the Republic of Kazakhstan and one of the main principles of environmental protection (Behrstock, 1999). One of the important tasks of our time in the field of biodiversity conservation is the preservation of the gene pools of rare fish species. These provisions are clearly spelled out in the International Convention on Biological Diversity, which was ratified by the Republic of Kazakhstan. Environmental studies in the last few decades have shown that approximately 15-20% of freshwater fish species are included in the lists of endangered or disappearing (Kirichenko & Kulikov 2011; Amirbekova *et al.* 2022; Kirichenko *et al.* 2023). If endangered fish species can be artificially reproduced, then lost species cannot be returned, since their unique gene pool has been lost. The economy of Kazakhstan is on the path of rapid development, which increases the anthropogenic load on natural resources and, if adequate measures are not taken

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to reduce it, this will lead to a reduction in the biodiversity of the animal world, and first of all this will affect valuable fish species (Kirichenko *et al.* 2023). Previously, there was no need to form replacement broodstocks of the Irtysh population of sterlet or Siberian sturgeon, and the preservation of natural populations was supported by environmental measures (Kirichenko *et al.* 2023). However, the anthropogenic impact on the populations has reached such proportions (in the form of poaching and the consequences of channel regulation) that their numbers can be maintained, as well as saved from complete destruction, only through targeted work to support natural reproduction with artificial reproduction (Behrstock 1999; Kirichenko & Kulikov 2011; Kirichenko *et al.* 2023). The formation of broodstock of sturgeon fish of the Siberian rivers, carried out in Russia, showed the fundamental possibility of growing these promising aquaculture objects in industrial conditions using artificial feed and forming broodstocks of these species. However, this technology is not applicable to the conditions of Kazakhstan, and it is necessary to conduct our own research and develop technologies adapted for fish farms in the Republic of Kazakhstan. Rare and endangered species of aquatic organisms are a very fragile, but very important part of the biodiversity of our water bodies, which requires priority protection (Amirbekova *et al.* 2022). The priorities for the protection of such species are defined by the Convention on Biological Diversity and Kazakhstan's environmental legislation, primarily the Law of the Republic of Kazakhstan "On the Protection, Reproduction and Use of Wildlife" dated July 9, 2004. However, the measures taken to preserve rare and endangered species have so far been passive. But all the prerequisites have already been created for a practical solution to the problem of preserving the animal world and its biological diversity, by removing the minimum necessary number of young and producers of rare species from their natural habitat, with subsequent artificial reproduction.

MATERIALS AND METHODS

Sterlet was caught using drift nets with a mesh size of 30-36 mm. The caught fish were placed in a cage installed on the reservoir, then transported by road in a polyethylene tank with a volume of 1 ton (Eurocube), with aeration during the entire transportation time. The delivery time from the natural habitat to the site did not exceed 7-8 hours. In addition, morphological data were collected from individuals included in the sterlet broodstock to compile a morphological characteristic of the Broodstock. Individual measurements of fish were taken using a measuring meter and scales. The following morphological characteristics were recorded (Table 1; Pravdin 1966; Bogeruk 2008).

Table 1. Morphological characteristics taken from individuals included in the Broodstock of sterlet.

Indicator	Decoding the indicator	Units of measurement
Q	General weight bodies	g
L	General length	cm
l	Length of fish to the end of the scutes	cm
C	Length heads	cm
R	Length snouts	cm
HC	The greatest height heads	cm
BC	The greatest width heads	cm
SO	Width mouth	cm
H	The greatest height bodies	cm
h	The smallest height bodies	cm
pl	Length tail stem	cm
CC	The largest girth bodies	cm
Sd	Number dorsal bug	pcs
Sl	Number lateral bug	pcs
Sv	Number abdominal bug	pcs
L/H	Index running speeds	ed
O/L	Index girth bodies	ed
KF	Coefficient plumpness by Fulton	ed
sex	Female / Male	♀ \ ♂

Morphometric studies and analysis of the obtained data were carried out in accordance with the guidelines for studying fish (Pravdin 1966; Lakin 1990; Bogeruk 2008). Measurements were carried out according to the scheme below (Fig. 1).

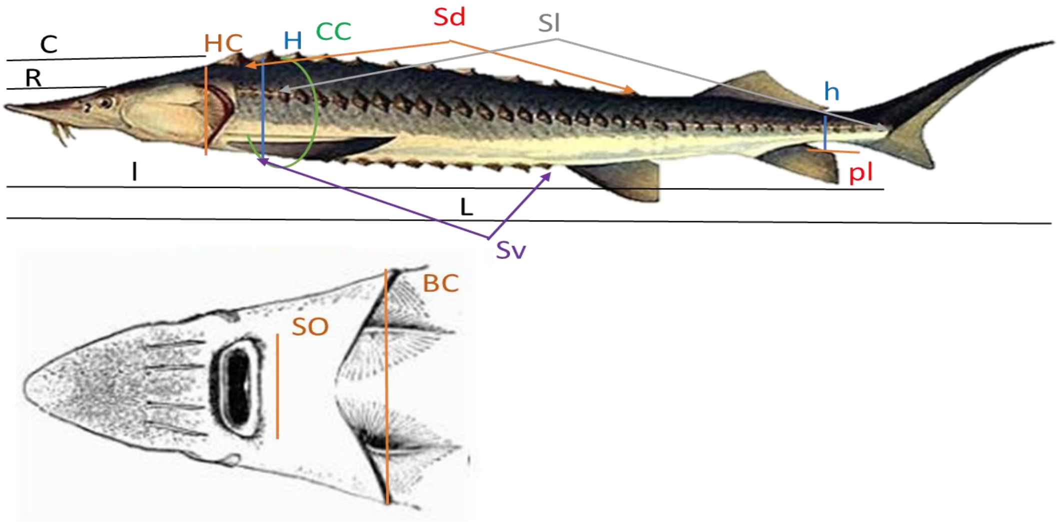

Fig. 1. Scheme for taking measurements of sturgeons.

Statistical processing of the values of absolute indices of plastic and meristic traits was performed using the Microsoft program Office Excel. We used formulas and built-in algorithms for calculating such indicators as the coefficient of variation (Cv), standard deviation (σ), median (Me), mode (Mo), excess (Ex), etc.

RESULTS AND DISCUSSION

Analysis of the conditions of keeping Siberian sturgeon in the RAS of LLC «Caspian Royal Fish». Data on the conditions of keeping Siberian sturgeon in RAS were collected and processed (Fig. 2).

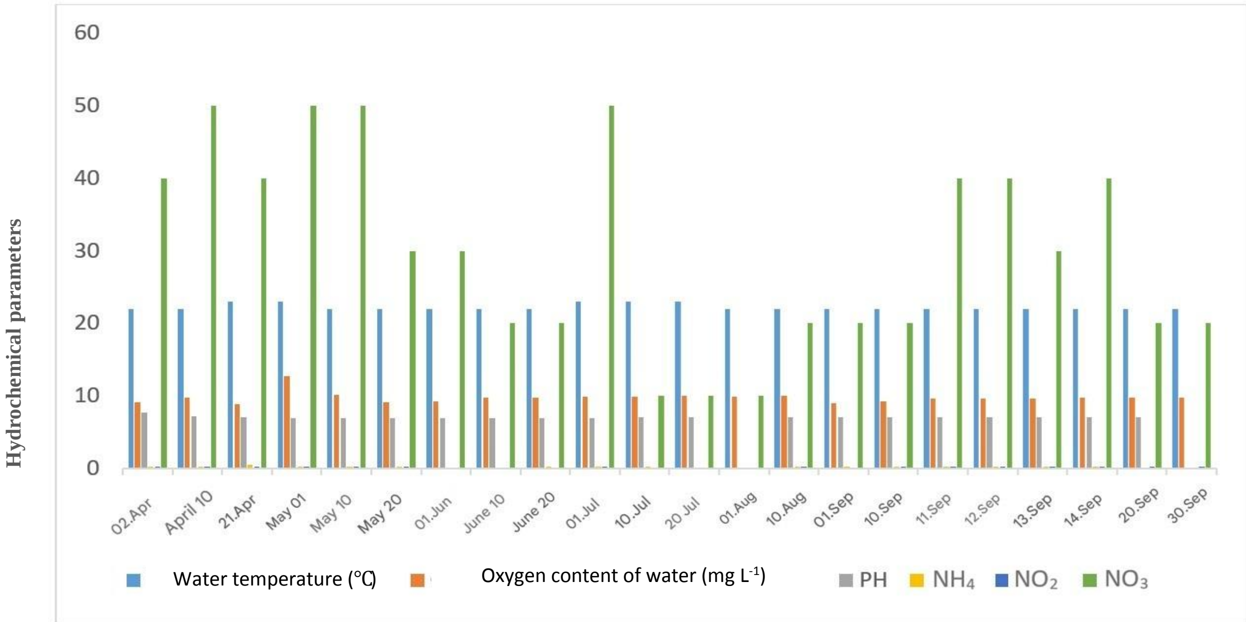

Fig. 2. Main hydrochemical parameters of the RAS of LLC «Caspian Royal Fish» where is the Siberian sturgeon Broodstock kept.

Main daily hydrochemical parameters of the RAS of LLC «Caspian Royal Fish», where the Broodstock of Siberian sturgeon is contained are presented in Table 2. During the study period, the temperature was maintained within the optimal range for growth, on average 22.3 °C, fluctuations in the content of dissolved oxygen in water averaged 9.9 mg L^{-1}, which corresponds to the optimal standards for the content of broodstock of sturgeon fish. The pH of the environment was neutral and equal to 7.0 (Bogeruk 2008; Maratkyzy Maratova 2023). Biogen content, on average, in the RAS system also did not exceed the standard values (NH_4: 0.2 mg L^{-1}, NO_2: 0.2 mg L^{-1}, NO_3: 36.7 mg L^{-1}) and was stable, which indicates good operation of the biological water purification and a properly selected feeding ration. LLC «Caspian Royal Fish» comply with the standards for RAS (Bogeruk 2008; Vasilyeva *et al.* 2010).

Table 2. Fluctuations in the main hydrochemical parameters of the RAS of LLC «Caspian Royal Fish», where the Siberian sturgeon broodstock is kept.

Indicator	Temperature water (℃)	Oxygen content of water (mg L^{-1})	pH (units)	Biogen		
				NH_4 (mg L^{-1})	NO_2 (mg L^{-1})	NO_3 (mg L^{-1})
Average meaning	22.3	9.9	7.0	0.2	0.2	36.7
Minimum meaning	21	8.84	6.8	0,1	0,1	10
Maximum meaning	23	13.6	7.7	0.6	0.3	60

Broodstock assessment of Siberian sturgeon (*Acipenser baerii*) LLC «Caspian Royal Fish» by fish-breeding, biological and morphometric indicators.

Siberian sturgeon, *A. baerii* is a fish of the sturgeon family, forming semi-anadromous and freshwater forms. The maximum body length in nature is 200 cm, and the weight is up to 210 kg. The body is spindle-shaped with several longitudinal rows of scutes. The snout is short, and triangular. In front of the mouth on the lower surface of the head there are 4 rounded barbels without fringe. In the dorsal row there are 12-19 scutes, in the lateral rows on each side 37-56, and in two abdominal rows 9-15. The formation of the broodstock was started in 2014. Siberian sturgeon producers (Lena population) in the amount of 20 heads were purchased from Karmanovsky Rybkhoz LLC (Russia, Bashkortostan). Of these, over the following years, the reproduction of Siberian sturgeon was carried out annually, the formation of replacement stock using the “from eggs” method, the obtained data on the quantitative and age structure for 2022 are presented in Table 3.

Table 3. Quantitative composition and age structure of the Siberian sturgeon Broodstock for 2022.

Age	Quantity (pieces)	Average weight (kg)	Biomass (kg)
0+	20,000	0.25	5,000
1+	6,000	1,2	7 200
2+	5,000	2.5	12,500
3+	1870	3.0	5 610
4+	1100	3.8	4 180
5+	1080	4.5	4 860
6+	1050	5.2	5 460
7+	1000	6.0	6,000

The Siberian sturgeon were fed with Aller feed, Aqua Bronze, 3, 4.5, 8 mm. During the current period, the feed coefficient for older age groups was 1.22 units. Feeding was carried out manually, the ration was calculated based on the feeding standards proposed by the manufacturer. For more efficient use of feed, the daily ration was adjusted every 10 days. The size of the daily rations and the feeding regime also need to be adjusted when the abiotic conditions in the fish-breeding tanks change, especially when the temperature rises beyond the optimal values. Feed was given 2-3 times during daylight hours when the oxygen content in the water was at least 6 mg L^{-1}. Fish-breeding and biological parameters of different age groups of Siberian sturgeon broodstock are presented in Table 4.

Table 4. Fish-breeding and biological growth indicators of individuals of the Siberian sturgeon Broodstock LLC «Caspian Royal Fish».

Indicators	Fish age				
	7+	5+	4+	3+	1+
Average daily increase (g)	7.05	4.1	2.5	2.4	1.02
Absolute increase (g)	1220	709.3	432.5	415.2	177.3
Survival rate (%)	100	100	98	98	84

The absolute weight gain of the breeding stock over 173 days averaged 1220 g, with the average daily weight gain being 7.05 g. The growth graph is shown in Fig. 3.

Morphometric characteristics of the Broodstock of the Siberian sturgeon, *Acipenser baerii*

In 2022, morphometric and exterior data were collected from Siberian sturgeon individuals included in the broodstock. The morphometric characteristics of Siberian sturgeon individuals were assessed based on morphological data taken from each age group included in the broodstock. Below are the results of the analysis of morphometric parameters of Siberian sturgeon individuals aged 7+, 5+, 3+ and 1+. Data on body weight (Q), total body length, body length to the end of the middle rays of the caudal fin, and Fulton fatness of broodstock Siberian sturgeon individuals are presented in Tables 4-9.

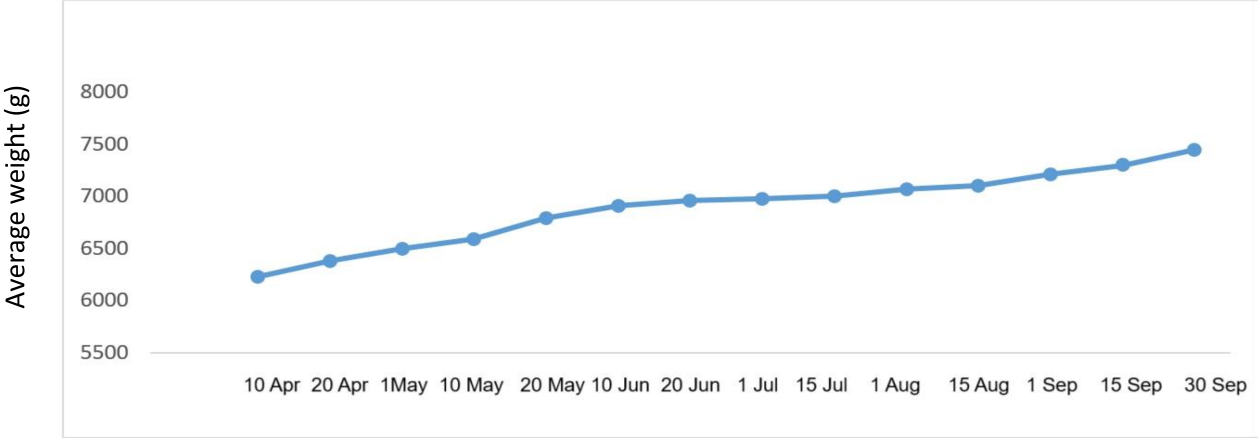

Fig. 3. Growth chart of Siberian sturgeon aged 7+.

Table 5. Statistical parameters of the body mass index (Q) of different age groups (7+, 5+, 3+, 1+) of Siberian sturgeon LLC «Caspian Royal Fish».

Indicators	7+	5+	3+	1+
Average value of the feature (X ± m; g)	6020.0 ± 713.8	4760.0 ± 889	2860.0 ± 102	620.0 ± 50.99
Median (*Me*; g)	5850	5200	1750	600,0
Fashion (*Mo*; g)	6500	3860	2900	600
Excess (*Ex*)	-0.99	-2.83	-0.18	-0.18

Weight in the 7+ age group is characterized by slight variation and is characterized by a smooth distribution and an even distribution of individuals, both large and small (50:50). Body weight in the 5+ age group is characterized by average variation, with a predominance of individuals with values above average (60%). The body weight indicator for three-year-olds is characterized by a uniform distribution, as is the same indicator for yearlings.

Table 6. Statistical parameters of the body length indicator (L) of different age groups (7+, 5+, 3+, 1+) of Siberian sturgeon LLC «Caspian Royal Fish».

Indicators	7+	5+	3+	1+
Average value of the feature (X ± m; cm)	109.2 ± 5.05	99.6 ± 5.1	89.2 ± 1.7	65.2±3.54
Median (*Me*; cm)	108.5	100	89.0	64.0
Fashion (*Mo*; cm)	111.3	96	85.3	
Excess (*Ex*)	-0.58	-1.64	-0.02	3.50

Body length is characterized by small variation in all age groups. The share of small individuals in the age group 7+ according to the commercial body length indicator is 36.55%, medium: 51.2%, and large: 12.25%. In the age group 5+, the commercial length indicator is characterized by the predominance of medium-sized individuals. The share of small individuals in the age group 3+ is 56.6%, medium: 30.2% and large: 13.3%. The excess indicator in yearlings is characterized by a relatively peaked distribution. In other age groups this indicator has a negative value and characterizes a relatively smoothed distribution. It should also be noted that yearlings and earlier juveniles are characterized by a small ratio of normotypic fish and fish with anomalies (Assylbekova *et al.* 2022).

Table 7. Statistical parameters of the body length indicator to the end of the middle rays of the caudal fin (l) of different age groups (7+, 5+, 3+, 1+) of Siberian sturgeon.

Indicators	7+	5+	3+	1+
Average value of the feature (X ± m; cm)	91.9±4.87	83.2±4.45	75.2±0.75	53.0±2.68
Median (*Me*; cm)	90.0	84.0	75.0	52.0
Fashion (*Mo*; cm)	90.0	81.5	76	52
Excess (*Ex*)	0.17	0.01	0.75	2.93

Table 8. Statistical parameters of the fatness index according to Fulton (*Up F.)* of different age groups (7+, 5+, 3+, 1+) of Siberian sturgeon.

Indicators	7+	5+	3+	1+
Average value of the feature (X ± m; cm)	0.46 ± 0.05	0.48 ± 0.03	0.40 ± 0.02	0.22 ± 0.02
Median (*Me*; cm)	0.5	0.5	0.4	0.15
Fashion (*Mo*; cm)	0.1	0.55	0.35	0.2
Excess (*Ex*)	2.20	-1.39	-0.79	4.16

Fulton fatness of seven- and five-year-olds is characterized by an average variation, by predominance of individuals with values below average. By age group, the most well-fed individuals are in the 5+ age group, the lowest indicator was obtained in the 1+ age group. All obtained indicators of fatness varied within the limits of standard values. The average values of exterior indicators of Siberian sturgeon individuals making up the broodstock are shown in Table 8.

Table 9. Average values of exterior indicators of different age groups (7+, 5+, 3+, 1+) of Siberian sturgeon

Indicators	7+			5+			3+			1+		
	KF	L\H	O/L	KF	L\H	O/L	KF	L\H	O/L	KF	L\H	O/L
Wed	0.46	7.46	36.72	0.48	7.51	36.40	0.40	8.11	35.20	0.22	9.31	26.89
min	0.40	3.96	33.65	0.44	7.13	34.95	0.37	7.91	33.71	0.19	9.00	25,00
Max	0.58	8.37	43.50	0.52	8.00	37.89	0.44	8.38	35.87	0.24	9.60	27.69

The elongation index (L \ H) decreases as the fish grow, the body girth index (O/ L) has the opposite tendency, increasing as the fish grow. Morphometric indices of broodstock of Siberian sturgeon are presented in Table 10.

Analysis of the conditions of keeping the sterlet broodstock in the conditions of the fish farm of LLC "OST Fish».

The basic fish farm for the formation of the sterlet broodstock is LLC "OST Fish». The main activity is artificial breeding of sturgeon species in a closed water supply system (RAS), as well as the production of food black caviar. It was put into operation in 2016. The design production capacity of the enterprise is 4 tons black food caviar and 45 tons commercial sturgeon per year. The production capacity of the farm is represented by three independent, separate fish-breeding workshops. The area of each workshop is 1400 m ^{2}. Each workshop is made according to one single type. Each fish-breeding workshop of the RAS has its own individual distinctive zone. This is a caviar production complex with an area of 160 m^2 in the first workshop, a fry zone of 160 m^2 in the second workshop, quarantine zone of 160 m^2 in the third workshop. Quarantine areas are allocated for keeping caught sterlet specimens (to avoid various parasites and infections getting into the system). Water samples for hydrochemical analysis were collected in the M11 and B10 RAS pools, where the objects of study will be kept, in May 2024. The samples were analyzed to determine the physicochemical properties, gas regime, ionic and biogenic composition. The water temperature in the M11 pool was 14.3 °C. The dissolved oxygen content in the pool was 7.0 mg dm^{-3}, the saturation percentage was 68.4%, which is considered quite favorable for the life of fish. According to the pH value, the environment in the pool is slightly alkaline (Table 11). The organic matter content (according to permanganate oxidizability) was low; the waters in the pool are characterized by very low oxidizability. According to the mineralization value, the studied water samples are classified as fresh. The hardness value, caused mainly by calcium and magnesium salts, in the pool was 27 mg- eq dm^{-3}, which corresponds to the water group "very hard". The concentration of hydrocarbonates was 250.1 mg dm^{-3}, the content of sulfates was 138 mg dm^{-3}, and chlorides – 128.7 mg dm^{-3}. The content of calcium ions was 150 mg dm^{-3}, magnesium – 72 mg dm^{-3}, and sodium – 0.27 mg dm^{-3}. Thus, hydrocarbonates were the predominant anions, and calcium ions dominated among the cations. According to the classification of O.A. Alekin, the water in the pool belongs to the chloride class, calcium group, first type, which is consistent with the mineralization values (Alekin 1959; Semenov 1977). Of the biogenic compounds, water samples were analyzed for the content of ammonium nitrogen, nitrite, nitrate, and phosphate ions (Table 7). The content of biogenic substances was within the established values for waters of quality class 2, which allows us to conclude that there is sufficient water exchange in the basin, which does not allow biogenic substances to accumulate. The water temperature in pool B10 was 16.7 °C. The dissolved oxygen content in the pool was 7.18 mg dm^{-3}, and the saturation percentage was 73.7%, which is considered to be quite favorable for fish life. The pH environment in the pool is slightly alkaline. The hydrocarbonate content was 91.5 mg dm^{-3}, the sulfate concentration was 297.0 mg dm^{-3}, and the chloride content was 128.7.0 mg dm^{-3}.

Table 10. Morphometric indices of Broodstock of Siberian sturgeon.

Indicators	**Age of fish**							
	7+		**5+**		**3+**		**1+**	
	$\bar{X} \pm m_{\bar{x}}$ σ	**Cv (%)**	**$\bar{X} \pm m_{\bar{x}}$ σ**	**Cv , %**	**$\bar{X} \pm m_{\bar{x}}$ σ**	**Cv (%)**	**$\bar{X} \pm m_{\bar{x}}$ σ**	**Cv (%)**
Mass (g)	4900.0 ± 7200.0	11.8	3600.0 ± 5800.0	18.6	2700.0 ± 3000.0	3.57	550.0 ± 700.0	8.22
General length (cm)	100.0 ± 117.0	4.6	93.0 ± 107.0	5.1	87.0 ± 92.0	1.93	62.0 ± 72.0	5.44
Length of fish to the end of the scutes (cm)	85.0± 102.0	5.2	76.0 ± 89.0	5.3	74.0 ± 76.0	1.00	50, 0 ± 58.0	5.06
Length heads (cm)	7.0 ± 24.0	26.0	18.0 ± 22.0	7.4	17.0 ± 18.0	2.13	13.0 ± 15.0	5.46
Length snouts (cm)	5.5 ± 9.5	16.8	8.0 ± 10.0	7.8	8.0 ± 8.0	0	5.5 ± 6.5	6.13
The greatest height heads (cm)	9.0 ± 12.0	8.5	7.5 ± 13.5	20.1	7. 0 ± 8.0	5.06	4.0 ± 5.5	12.68
The greatest width heads (cm)	9.5 ± 13.0	8.6	8, 0 ± 11.0	11.3	7.5 ± 8.0	3.14	5.0 ± 6.0	5.75
Width mouth (cm)	5.3 ± 7.0	8.9	5, 5 ± 5.5	0	5.5 ± 5.5	0	3.5 ± 3.5	0
The greatest height body (cm)	12, 8 ± 28.0	28.4	12.0 ± 15.0	8.0	10.5 ± 11.5	2.87	6.5 ± 7.5	4.52
The smallest height body (cm)	3, 5 ± 8.0	29.0	3.0 ± 4.5	16.1	2, 5 ± 3.0	6.90	1.5 ± 2.0	13.61
The largest girth body (cm)	35.0 ± 43.5	5.5	35.0 ± 38.0	2.7	30.0 ± 33.0	3.25	17.0 ± 18.0	2.56
Coefficient plumpness	0.46		0.48		0.40		0.22	

Table 11. Values of the main hydrochemical parameters of the waters of the RAS basin.

Pool No.	**pH**	**Dissolved gases**			**Biogenic compounds (mg dm^{-3})**				**Org. substance (mgO dm^{-3})**	**Minerals (mg dm^{-3})**
		CO_2 (mg dm^{-3})	**dissolved oxygen**		**NH_4**	**NO_2**	**NO_3**	**PO_4**		
			mg dm^{-3}	**% sat.**						
Pool M11	8.86	0.1	7.00	68.4	0.24	0,009	0.12	0.103	4.1	535
Pool B10	7.98	0.1	7.18	73.7	0.62	0.068	0.14	0.110	4.3	614

The calcium cation concentration was 150 mg dm^{-3}, the magnesium content was 66 mg dm^{-3}, and the sodium content was 0.27 mg dm^{-3}. According to the classification of O.A. Alekin, the water at the well outlet belongs to the sulfate class, calcium group, second type. A fairly high content of calcium and magnesium ions causes water hardness. The hardness value was 26 mg-eq dm^{-3}, which allowed the water to be classified as “very hard”. In accordance with the mineralization value, the water is characterized as fresh (Alekin 1959). The organic matter content was low and corresponded to the very low oxidation of waters. The concentration of biogenic compounds in the water of the B10 basin was within the limits of fishery standards. In general, according to the analysis results, the water in the M11 and B10 RAS basins is characterized by a favorable oxygen regime, slightly alkaline pH, very low oxidation, and fresh water mineralization. The content of biogenic compounds did not exceed the established fishery standards and corresponded to waters of quality class 2. It can be concluded that water exchange in the RAS basins allows for the timely removal of fish waste products and the water quality meets the standards for sturgeon farming (Vasilyeva *et al.* 2010). During the maintenance of wild sterlet in the pools of the RAS of LLC "OST Fish» water temperature and oxygen content are measured daily. Results speakers oxygen-temperature regime presented on in the Fig 4.

Based on the results of the conducted research and monitoring of temperature and oxygen conditions, it was established that the conditions for keeping Irtysh sterlet in RAS are optimal.

Assessment of fish-breeding and biological indicators of broodstock of sterlet kept in the conditions of sturgeon fish farm of LLC "OST Fish».

At the moment, one method is used to form the broodstock of sterlet: domestication of wild individuals. Considering that LLC "OST Fish» was created on the basis of high-intensity technologies and equipped with all modern equipment, modern methods of working with wild sterlet individuals were tested and introduced into production practice, such as electronic marking of individuals, diagnostics of gonad maturity and early diagnostics of sex by ultrasound device. Based on the results of the work carried out, the sex composition of the senior repair formed by the broodstock of the Irtysh sterlet was established, individual marking with PIT tags was carried out.

Description of the formed sterlet Broodstock. The formation of the broodstock began earlier in 2016, from natural populations. At the moment, the following remain:

Females – 6 pieces (average weight: 6.1 kg);

Males – 1 piece (weight: 5.2 kg).

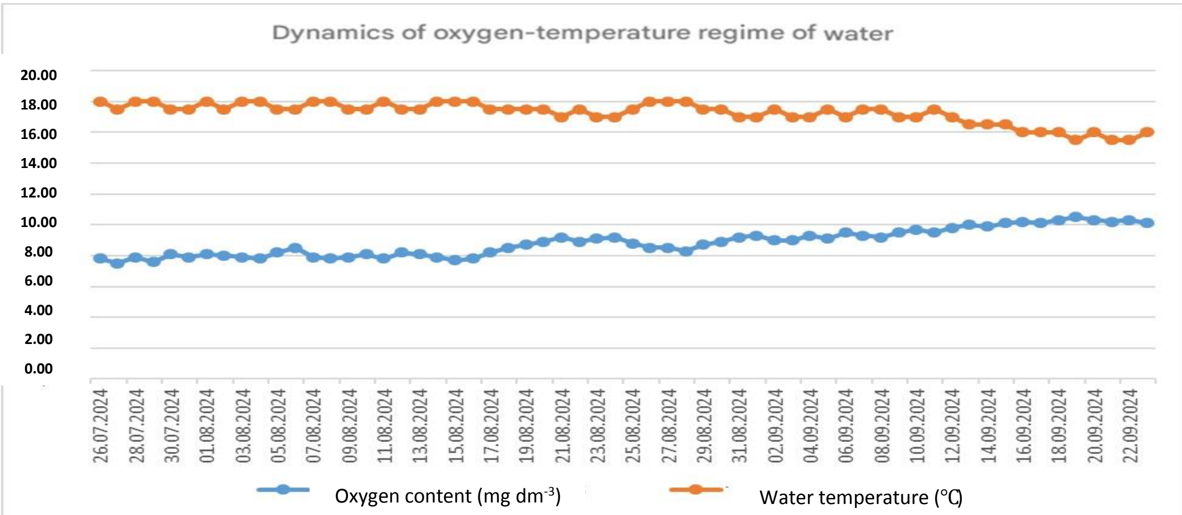

Fig. 4. Dynamics of oxygen and temperature regimes RAS pool with wild sterlet.

There was no reproduction of these individuals. This year, 22 individuals were also harvested from natural populations. Data on the quantitative composition and sex structure for 2024 are given in Table 12. Juvenile individuals predominate in the quantitative composition of the Broodstock sterlet, there are 7 females of different ages and 3 males.

Table 12. Quantitative composition and age structure for 2024.

Year blanks	Quantity (pcs.)	Average weight (kg)	Floor		
			♀	♂	Juvenile
2016 year	7	6.1	6	1	-
2024 year	22	0.77	1	2	19
TOTAL	29		7	3	19

For all large individuals (over 1 kg), ultrasound diagnostics were performed to determine sex and stage of gonad maturity. Of the females in the replacement stock, 3 are at maturity stage II, while 3 females have gonads at maturity stage IV. On the scanner echogram, the ovary at maturity stage II looks like a granular " cloud-like " structure of mixed echogenicity with uneven edges without membranes visible on the echogram. The fatty part of the gonad in the individual caught in 2024 is insignificant both in longitudinal and transverse scanning and is visualized as darker areas, in contrast to the lighter generative tissue. In individuals caught in 2016, gonads were at the gonad stage II semi-fatty; in a longitudinal section of the ovaries at the second semi-fatty stage, individual egg-bearing plates are visible as zones of increased echogenicity, alternating with hypoechoic fatty zones. In this case, visually the egg-bearing plates "grow" from the lateral to the medial zone of the gonad. In females at the fourth stage of maturity, when examining the gonads, clearly distinguishable large, uniform in size oocytes, close to the definitive sizes, were found. On the echogram, the testicles of the analyzed male sterlet look like a homogeneous fine-grained structure of light gray color with clear hyperechoic boundaries. They have a clear lobular structure with smoothly curving edges (Chebanov *et al.* 2004).

Morphometric characteristics of Broodstock sterlet. To describe the morphometric characteristics of the formed broodstock of the Irtysh sterlet, data were collected according to the specified method. Samples of sterlet specimens harvested in 2016 and the current year were analyzed separately, the results are presented in Tables 13, 14, 15, 16, 17.

Table 13. Morphometric parameters of sterlet specimens harvested in 2016.

Indicators	Values		
	$\bar{X} \pm m_{\bar{x}}$	σ	Cv (%)
Mass (g)	5600 ± 431.1	657.27	11.7
General length (cm)	86 ± 7.3	5.89	6.9
Body length to the end of the middle rays of the caudal fin (cm)	75.14 ± 5.4	6.12	8.1
Length heads (cm)	15.14 ± 1.1	0.4	4.2
Length snouts (cm)	5.29 ± 0.77	1,1	19.3
The greatest height heads (cm)	8.57 ± 1.45	0.2	5.7
The greatest width heads (cm)	11.71 ± 0.88	1,1	8.7
Width mouth (cm)	3.79 ± 0.08	0.3	15.4
The greatest height body (cm)	14.43 ± 1.4	2,2	11.1
The smallest height body (cm)	11.00 ± 0.77	1,1	10.6
Length tail stem (cm)	6.29 ± 0.41	0.5	9.3
Number dorsal bug (pcs)	13.43 ± 2.11	0.5	6.0
Number lateral bug (pcs)	53.71 ± 5.49	14.2	7.1
Number abdominal bug (pcs)	13.00 ± 1.02	0.6	5.8
Coefficient plumpness	0.93		

Given the large difference in size and weight indicators and, accordingly, different ages, there are many differences between the two groups. As can be seen from the data, the fatness coefficient according to Fulton increases as the fish grow. Another significant difference is the presence of a large number of lateral scutes in juveniles.

Table 14. Morphometric parameters of sterlet specimens harvested in 2024.

Indicators	Values		
	$\bar{X} \pm m_{\bar{x}}$	σ	Cv (%)
Mass (g)	280.4 ± 3.33	28.9	11.1
General length (cm)	30.91 ± 1.32	1,12	3.77
Body length to the end of the middle rays of the caudal fin (cm)	26.11 ± 0.33	1.62	4.22
Length heads (cm)	4.22 ± 0.09	0.89	5.08
Length snouts (cm)	2.86 ± 0.1	0.78	10.33
The greatest height heads (cm)	3.41 ± 0.03	0.16	4.70
The greatest width heads (cm)	3.21 ± 0.05	0.52	6.12
Width mouth (cm)	2.17 ± 0.02	0.17	4.94
The greatest height body (cm)	4.74 ± 0.1	0.51	3.78
The smallest height body (cm)	2.11 ± 0.02	0.09	4.43
Length tail stem (cm)	2.77 ± 0.04	0.20	6.21
Number dorsal bug (pcs)	12.01 ± 0.15	0.80	4.82
Number lateral bug (pcs)	15.11 ± 0.33	0.87	4.86
Number abdominal bug (pcs)	67.70 ± 0.27	1.89	4.30
Coefficient plumpness	14.07 ± 0.22	1.45	11.71
Mass (g)	0.58		

Table 15. Statistical parameters of body weight (Q), total body length (L), body length to the end of the middle rays of the caudal fin (l) and fatness according to Fulton (Up $_{F.}$) of sterlet harvested in 2016.

Indicators	Q	L	l	Up $_{F.}$
Average value of the feature (X ±_m; kg)	5600 ± 431.1	86 ± 7.3	75.14 ± 5.4	0.93 ± 0.3
Median (*Me*)	5600	85	75	0.88
Excess (*Ex*)	-1.29	2.05	2.82	0.52

Mass of this group of sterlet is characterized by average variation, with a predominance of individuals with values above the average (69.4%). Negative excess shows a relatively smoothed distribution. Body length is characterized by narrow variation with a slight predominance of small individuals (55.12%), the breadth of variation is ensured by the heterogeneity of individuals. The excess indicator demonstrates a relatively peaked distribution of indicators. Fulton fatness in this group of fish is characterized by small variation, by the prevalence of individuals with values above average, but all the obtained indicators of fatness vary within the limits of standard values. There are three individuals (2 females and 1 male) with a fatness exceeding that of individuals caught in the natural environment (1.02-1.39 units), which is apparently associated with good fattening conditions in the RAS and the provision of high-quality feed.

Table 16. Statistical parameters of body weight (*Q*), total body length (L), body length to the end of the middle rays of the caudal fin (l) and fatness according to Fulton (Up $_{F.}$) of sterlet harvested in 2024.

Indicators	Q	L	l	Up $_{F.}$
Average value of the feature (X ± m; kg)	280.4 ± 3.33	30.91 ± 1.32	26.11 ± 0.33	0.58 ± 0.05
Median (*Me*)	205	30.5	25.0	0.45
Excess (*Ex*)	6.93	0.76	-1.24	1.77

The weight of sterlets caught in 2024 is characterized by wide variation, with a predominance of individuals with values below average (59.47%). The mass indicator has a smoothed distribution. Body length is characterized by average variation, with a predominance of small individuals (58.1%).

Table 17. Average values of exterior indicators of Irtysh sterlet individuals harvested in 2016.

Indicators	L/H	O/L	KF
Wed	6.11	35.41	0.93
Min	4.71	32,33	0.57
Max	6.9	40.8	1.39

During fish farming activities, visual monitoring of fish behavior is carried out daily, fish are examined to detect diseases, feeding technology is adjusted, hydrochemical parameters (temperature, and oxygen content) are recorded.

Feeding regimen and feeds used in sterlet domestication, assessment of the effectiveness of fish farming activities.

According to literature, the total duration of fish adaptation to artificial conditions varies from one and a half to three months depending on the age of the fish, abiotic and biotic factors, and feeding technology. Transfer to artificial feed is the most difficult period of adaptation for wild individuals and is carried out in stages. Initially, live animal feed (minced fish, and amphipods) was used in the fish diet, with a feeding frequency of 2 times a day. The fish practically did not respond to live feed, but preferred to collect feed components from the walls of the pool. After two weeks, the minced fish was replaced with dry AllerAqua feed with a granule size of 2.5 - 6.0 mm. The ratio of artificial feed to animal feed was 50% to 50%. Given the high selectivity in feeding, the sterlet feed ration did not vary significantly. No noticeable activity in eating feed was noted in the first month of the study. The main fish-breeding and technological characteristics of keeping sterlet in RAS conditions are presented in Table 18. Formation of production stocks of sturgeon fish in artificial conditions is the most urgent problem at present for the purposes of both artificial reproduction and commercial cultivation. This type of activity has been developed on a large scale only in the last 15-20 years and therefore there are many unresolved technological issues (Vasilyeva *et al.* 2010; Assylbekova *et al.* 2020; Maratkyzy Maratova *et al.* 2023). Biotechnologies for the formation of production stocks by the two existing methods have not yet been developed: from caviar to caviar and domestication, including there are no fish farming and biological standards for each type of sturgeon fish. This applies to the method from caviar to caviar to the greatest extent, since all stages of the long-term development of sturgeon producers occur outside the natural habitat, therefore a scientific search for optimal artificial conditions for keeping and feeding fish is necessary (Chebanov *et al.* 2004; Chipinov 2004; Kulikov 2007; Amanov & Evdokimov 2022). Systematic and in-depth biological research is needed to solve the problems of accelerated maturation of fish in schools, early determination of sex and improvement of reproductive performance of females (Kirichenko 2012; Chebanov 2013). In addition, the following issues require in-depth scientific research: effective transfer of wild producers to artificial conditions of maintenance and especially feeding with unusual feeds (Pavel *et al.* 2024; Pěnka *et al.* 2024; Ljubobratović *et al.* 2022). This problem primarily concerns female fish, since they are adapted to artificial conditions after undergoing stress - the operation of obtaining eggs during life.

Table 18. Fish-breeding and technological indicators for transportation, adaptation and maintenance of sterlet in RAS conditions based on LLC «OST Fish».

Indicator	Unit of measurement	Meaning
Initial weight	g	30-1360
Number of individuals kept on the farm	pcs.	22
Parameters pool for contents		
- diameter pool	m	3
- volume	m^3	7
Density landings fish	kg m^{-3}	0.89
Water temperature during maintenance	°C	15.5-18.0
Acceptable temperature	°C	16.0-20.0
Feeding		
- fish ground meat	day	15
- amphipod	day	15
- dry stern	day	45
Multiplicity feeding	once a day	2
Duration of adaptation to artificial feed	day	55+
Survival at transportation	%	95.5
Survival rate of fish during the period of maintenance	%	100

CONCLUSION

The first results of fish-breeding activities have shown the possibility of domestication of different-aged individuals of sterlet on the Ertis River in order to form a replacement stock in industrial conditions. The fundamental possibility of developing standards for procurement, transportation, adaptation and transfer of wild individuals of the Irtysh population of sterlet has also been proven. In the future, repeated processing is planned, taking into account inaccuracies and adjustments to the technology of all activities. The conditions for the formation of the broodstock of the Siberian sturgeon in the conditions of the fish farm correspond to the normative ones. The obtained results of the morphometric studies indicate that there is a tendency for the fatness coefficient to increase as the Siberian sturgeon grows, while the running index (L\H) decreases as the fish grow. In general, the yearlings of the Siberian sturgeon demonstrate uniform development and mass accumulation, which indicates a tendency for their further positive development in the studied RAS for industrial purposes.

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