

БИОЛОГИЯ ҒЫЛЫМДАР - БИОЛОГИЧЕСКИЕ НАУКИ - BIOLOGICAL SCIENCES**UDC 639.3.05****Bazhenova Diana**

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GROWTH DYNAMICS OF STERLET (*Acipenser ruthenus* L.) REARED IN A RECIRCULATING AQUACULTURE SYSTEM

Abstract: The study evaluated the growth dynamics of sterlet (*Acipenser ruthenus* L.) reared in a recirculating aquaculture system (RAS) at the “Aqua Ferma PV” fish farm, Kazakhstan. The production cycle was followed from egg incubation to the fingerling stage, with particular attention to body weight, growth rate and survival. During the 188-day fingerling rearing period, mean body weight increased from 15.1 to 347.5 g. Total weight gain was 332.4 g, average daily gain was 1.77 g/day, and specific growth rate was 1.67%/day. Survival during this period reached 96.7%. Water quality parameters remained relatively stable during the monitored period. The obtained results demonstrate stable growth and high survival of sterlet under the applied RAS production conditions and are generally comparable with published data for juvenile sterlet reared under controlled conditions.

Keywords: recirculating aquaculture systems, sterlet, fish growth, growth dynamics;

Introduction. Aquaculture has become an increasingly important part of the fisheries sector in Kazakhstan. Growing demand for fish products, together with the need to reduce pressure on natural fish stocks, has encouraged the development of commercial fish farming and the introduction of more intensive production technologies. This trend has been particularly noticeable in recent years. Along with conventional pond and lake-based farms, Kazakhstan is developing cage and tank culture as well as recirculating aquaculture systems (RAS). According to official data, the volume of farmed fish production in the country increased from 6.8 thousand tons in 2020 to 17.1 thousand tons in 2023; RAS and tank-based farms are also represented within the structure of the country’s aquaculture enterprises [1].

Recirculating systems are of particular interest for intensive fish production because most of the water is treated and reused within the facility. Mechanical and biological filtration, aeration or oxygenation, and temperature control make it possible to maintain relatively stable water quality throughout the production cycle. Such systems are widely used in intensive sturgeon culture because they allow closer control of temperature, oxygen regime and nitrogen compounds while reducing water exchange requirements [2,7,8]. This is especially relevant for Kazakhstan, where a sharply continental climate and large seasonal temperature fluctuations can limit the duration of outdoor fish farming.

Recent studies in Kazakhstan and elsewhere show that sturgeons can be successfully reared in recirculating systems, although production results remain strongly dependent on culture conditions. Akhmetova et al., studying Siberian sturgeon (*Acipenser baerii* L.) in a recirculating system, showed that a controlled environment can support fish production

throughout the year and considered RAS-produced juveniles suitable for subsequent transfer to tanks, ponds and cages [2]. Aidos et al. [4] demonstrated that stocking density affected growth and muscle development in early-stage Siberian sturgeon larvae, while Mocanu et al. [6] showed that dietary probiotic supplementation influenced growth performance and physiological indices of Siberian sturgeon. These findings illustrate that RAS provides a controlled production environment, but the biological response of sturgeons is determined by the management of key technological factors.

Sturgeons are valuable aquaculture species due to their biological characteristics and the high commercial value of their products [5,8]. Under intensive culture, however, their performance depends on more than the type of production system itself. Water temperature and dissolved oxygen, stocking density, feeding practices, the quality of the initial stock, incubation conditions, and the transition from endogenous to exogenous feeding may all affect survival and subsequent growth [4-6,8].

Sterlet (*Acipenser ruthenus* L.) is one of the sturgeon species of interest for intensive culture. In Kazakhstan, Aitkaliyeva et al. [3] studied juvenile sterlet and Siberian sturgeon originating from the Irtysh River under recirculating conditions, with particular attention to water quality, morphological and production characteristics, stocking density, survival and growth. Nicula et al. [7] evaluated the growth performance of juvenile sterlet reared in RAS, whereas Ginayatov et al. [9] investigated the effects of oxygen concentration and stocking density on sterlet growth and development. Other studies have focused on more specific production factors: Thomas et al. [10] examined sterlet development and behaviour under enrichment and polyculture conditions, while Bavi et al. [11] assessed the effects of dietary taurine on growth, feed utilization and physiological responses of juvenile sterlet. Thus, previous research has addressed a wide range of individual factors affecting sterlet performance under controlled rearing conditions.

Despite the available studies, most published work focuses on individual technological or nutritional factors and relatively short experimental periods. Production-scale data that follow the same sterlet batch through successive rearing stages are less frequently reported. For commercial RAS, such information is important because changes in relative and absolute growth during the production cycle influence feeding, grading, stocking and biomass management. Following one production batch from incubation through the fingerling stage therefore provides a practical view of how growth and survival develop under routine farm conditions.

Therefore, the aim of the present study was to assess the growth dynamics of sterlet (*Acipenser ruthenus* L.) at different stages of rearing in a RAS, from egg incubation to the fingerling stage, and to compare the obtained growth performance with published data for sterlet reared under controlled conditions.

Materials and Methods.

RAS production system at “Aqua Ferma PV”.

The study was carried out at the “Aqua Ferma PV” fish farm on a production batch of sterlet (*Acipenser ruthenus* L.) reared in a recirculating aquaculture system (RAS). The system included mechanical and biological filtration, UV treatment and oxygenation. Separate facilities were used for egg incubation, larval rearing and further rearing of sterlet fingerlings. The fingerling unit consisted of six circular tanks, each 3.5 m in diameter and 1.2 m in height, with a working volume of 6.5 m³. During the fingerling rearing period, water temperature was maintained at approximately 19°C. Water quality was controlled as part of routine RAS

management: pH, nitrite and nitrate were generally measured once every three days using commercial drop test kits, while dissolved oxygen was measured daily using a Merke oximeter. The monitored parameters were compared with recommended ranges for sturgeon culture in RAS [7,8].

Main production processes of sterlet rearing.

The studied batch originated from fertilized eggs delivered to the farm in December 2025. The production cycle was followed from egg incubation to the fingerling stage, until August 2026. Farm production records were used to obtain data on egg incubation and hatching, larval survival and mortality, feeding, grading and transfer of fish, as well as control weighings performed during the rearing period.

Fertilized sterlet eggs were obtained from the “Karaganda Osetr” fish farm. The eggs were collected on 30 November 2025 and delivered to “Aqua Ferma PV” on 2 December 2025. The batch consisted of 1.5 kg of eggs, corresponding to about 100,000 eggs.

Incubation started on 2 December 2025. Four Weiss jars were used, with approximately 350 g of eggs placed in each jar. According to technology water temperature was maintained at 14°C during incubation. Methylene blue was used as a preventive treatment against fungal infection.

Egg development was monitored during the incubation period, and non-developing eggs were removed. Hatching started five days after the beginning of incubation and continued for approximately two days. After hatching, the larvae were transferred to the larval rearing unit.

Sterlet larvae were kept in separate larval rearing troughs. During the first days after hatching, the larvae remained on endogenous nutrition. Active feeding started on days 7-8 after hatching.

At the beginning of exogenous feeding, newly hatched *Artemia* nauplii and a commercial starter feed (Aller Aqua Silver, 0.2 mm) were used. During the first three days of active feeding, the larvae were fed up to 12 times per day. *Artemia* nauplii were supplied according to feed consumption. Live feed was used together with the starter diet during the initial feeding period, followed by gradual transition to the commercial diet.

The condition of the larvae, feed consumption and mortality were monitored throughout this period. The first grading was performed on 10 January 2026. Larval rearing continued until approximately 60 days of age, when the fish were transferred to the fingerling rearing unit.

At 60 days of age, sterlet fingerlings were transferred to the circular tanks of the RAS fingerling unit. The initial stocking rate was 2,000 fish per tank.

Fish growth was monitored by regular control weightings. The interval between successive weightings ranged mainly from 10 to 20 days according to the farm production schedule. Body weight recorded at each control point was used to follow the growth of the studied batch throughout the fingerling rearing period.

Commercial feeds were used during this stage, with pellet size adjusted as the fish increased in size. The pellet size increased to 2 mm in March 2026 and to 3 mm in June 2026. Grading and redistribution of fish between tanks were carried out when required during the production cycle.

Control observations continued until August 2026. Successive body weight measurements were subsequently used to assess the growth dynamics of the studied sterlet batch. The main production stages and rearing conditions of the studied sterlet batch are summarized in Table 1.

Table 1 - Main production stages and rearing conditions of sterlet at the “Aqua Ferma PV” fish farm.

Production stage	Period	Rearing facility	Feeding	Monitoring
Egg incubation	Dec 2025	4 Weiss jars; ~350 g eggs/jar	-	Egg development, hatching
Larval rearing	Dec 2025-Feb 2026	Larval rearing troughs	<i>Artemia</i> nauplii + Aller Aqua Silver, 0.2 mm	Survival, feeding, grading, body weight
Fingerling rearing	Feb-Aug 2026	6 circular tanks, 6.5 m ³ each	Commercial formulated diets; pellet size adjusted to fish size	Control weighing, growth

Monitoring of fish-biological indicators.

Changes in mean body weight were used as the main indicator of growth. For each available control weighing, the date, fish age, number of individuals and mean body weight were recorded. These measurements were used to construct the growth curve from the early stages of development to the juvenile stage. During grading, the minimum and maximum body weights were recorded for each size group. For further analysis, mean body weight was calculated as the arithmetic mean of the minimum and maximum recorded values.

Based on these data, growth performance was assessed using absolute weight gain (WG), average daily gain (ADG), and specific growth rate (SGR), following approaches commonly applied in studies of sturgeon growth [4-6].

Absolute weight gain (WG) was used to determine the increase in mean body weight over a given rearing period and was calculated as:

$$WG = W_2 - W_1 \quad (1),$$

where W_1 - body weight at the beginning of the period (g), and W_2 - body weight at the end of the period (g).

Average daily gain (ADG) was calculated to estimate the average increase in body weight per day during each interval between control weightings:

$$ADG = \frac{(W_2 - W_1)}{t} \quad (2),$$

where W_1 - body weight at the beginning of the period (g), and W_2 - body weight at the end of the period (g); t - the period between measurements (days). ADG was expressed in g day⁻¹.

Specific growth rate (SGR) was used to characterize growth relative to the body weight of the fish. SGR was calculated as:

$$SGR = \frac{\ln W_2 - \ln W_1}{t} \times 100 \quad (3),$$

where W_1 - body weight at the beginning of the period (g), and W_2 - body weight at the end of the period (g); t - the period between measurements (days); $\ln$ - the natural logarithm. SGR was expressed as % day⁻¹.

Survival rate (SR) was determined separately for the main production stages as:

$$SR = \frac{N_2}{N_1} \times 100 \quad (4),$$

where N_1 - the number of fish at the beginning of the period; N_2 - the number remaining at the end of the period. Survival was expressed as a percentage (%).

Calculated growth parameters were compared with published data for sterlet and other sturgeon species reared in RAS.

Results. During the incubation period, the first sterlet larvae appeared five days after the beginning of incubation, while hatching continued for approximately two days. According to the production records, about 20,000 larvae were recorded at the swarming stage. During the transition to exogenous feeding and adaptation to the commercial diet, larval mortality was approximately 10-15%. At the first grading, performed on 10 January 2026, the mean body weight of sterlet was 0.5 g.

Further rearing was characterized by a continuous increase in body weight. At the beginning of the fingerling rearing period, approximately 12,000 fish were distributed among six rearing tanks. At the first control weighing on 10 February, body weight ranged from 14.7 to 15.5 g, with a calculated mean value of 15.1 g. By 22 March, mean body weight increased to 61.0 g, and on 20 April it reached 87.0 g. A further increase was recorded in May and June, reaching 122.5 g on 26 May and 167.5 g on 15 June.

The highest increase in body weight was observed during the summer period. Mean weight increased from 167.5 g on 15 June to 232.5 g on 8 July and reached 285.0 g by 27 July. At the last control weighing, performed on 17 August 2026, body weight ranged from 340 to 355 g, with a calculated mean value of 347.5 g (Figure 1). Thus, during the 188-day fingerling rearing period, mean body weight increased from 15.1 to 347.5 g.

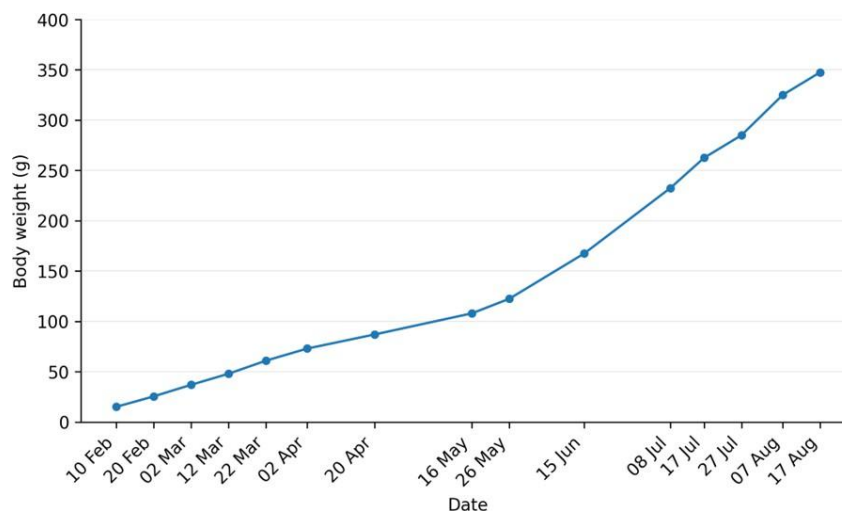


Figure 1 - Dynamics of mean body weight of sterlet (*Acipenser ruthenus* L.) during the fingerling rearing period.

Based on the recorded body weight data, weight gain (WG), average daily gain (ADG) and specific growth rate (SGR) were calculated for the fingerling rearing period. The total individual weight gain over the 188-day period was 332.4 g, corresponding to an average daily gain of 1.77 g/day. The overall SGR was 1.67%/day.

The highest SGR was recorded during the initial growth interval, reaching 5.24%/day. As body weight increased, SGR gradually declined, whereas absolute daily weight gain generally increased. The highest ADG was observed between 27 July and 7 August, reaching 3.64 g/day.

At the end of the observation period, 11,600 of the initial 12,000 fingerlings remained in the rearing unit, corresponding to a survival rate of 96.7% (Table 2).

Table 2. Growth performance of sterlet during the fingerling rearing period

Rearing period	Days	WG (g fish ⁻¹)	ADG (g day ⁻¹)	SGR (% day ⁻¹)
10-20 Feb	10	10.4	1.04	5.24

20 Feb-2 Mar	10	11.5	1.15	3.72
2-12 Mar	10	11.0	1.10	2.60
12-22 Mar	10	13.0	1.30	2.40
22 Mar-2 Apr	11	12.0	1.09	1.63
2-20 Apr	18	14.0	0.78	0.97
20 Apr-16 May	26	21.0	0.81	0.83
16-26 May	10	14.5	1.45	1.26
26 May-15 Jun	20	45.0	2.25	1.56
15 Jun-8 Jul	23	65.0	2.83	1.43
8-17 Jul	9	30.0	3.33	1.35
17-27 Jul	10	22.5	2.25	0.82
27 Jul-7 Aug	11	40.0	3.64	1.19
7-17 Aug	10	22.5	2.25	0.67
Overall	188	332.4	1.77	1.67

Water quality parameters remained relatively stable during the monitored period. Dissolved oxygen ranged from 6.5 to 7.0 mg/L, while pH varied between 6.0 and 7.5. Nitrite concentration remained low and ranged from 0 to 0.1 mg/L. Nitrate concentration varied from 5 to 25 mg/L, with a gradual decrease towards the end of the monitored period. Water temperature during the fingerling rearing period was maintained at approximately 19°C.

Discussion. The growth performance obtained in the present study was generally comparable with data reported for sterlet under controlled rearing conditions. Ginayatov et al. [9] reported an SGR of 1.47%/day and an average daily gain of 1.43 g/day in sterlet reared in RAS at a stocking density of 40 kg/m³. In the present study, the corresponding values for the entire fingerling rearing period were 1.67%/day and 1.77 g/day, respectively.

Similar final body weights were reported by Thomas et al. [10] in a 90-day experiment with sterlet. Fish with an initial body weight of 132.6-133.1 g reached 324.7-337.1 g at the end of the experiment, with SGR values ranging from 0.99 to 1.04%/day. In the present study, sterlet reached a mean body weight of 347.5 g by the final control weighing. Although the duration of rearing and initial body weight differed between the studies, the final body weights were similar.

Growth rate varied considerably during the rearing period. The highest SGR in the present study was recorded during the first interval (5.24%/day), followed by a gradual decrease as fish body weight increased. In contrast, absolute daily weight gain was higher during the later stages of rearing, reaching a maximum of 3.64 g/day between 27 July and 7 August. Differences in growth rate during sterlet culture may be related to fish size, duration of the rearing period, feeding conditions and environmental parameters. Bavi et al. [11], for example, reported SGR values of 1.22-1.55%/day in juvenile sterlet with an initial body weight of approximately 14 g during a 70-day feeding trial.

Survival during the fingerling rearing period was 96.7%. This value was also comparable with results reported for juvenile sterlet under controlled conditions. Bavi et al. [11] recorded survival rates ranging from 88.89 to 97.23%, depending on the experimental diet. The high survival recorded in the present study, together with the observed increase in body weight, indicates stable performance of sterlet during the fingerling rearing period.

Conclusion. The study showed that the applied RAS rearing conditions supported stable growth and high survival of sterlet during the fingerling stage. A consistent growth pattern was observed: as body weight increased, relative growth rate declined, whereas absolute daily gain generally increased. The obtained results support the use of RAS for intensive rearing of sterlet

juveniles and provide production-scale information that can be used for feeding, grading and biomass management.

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