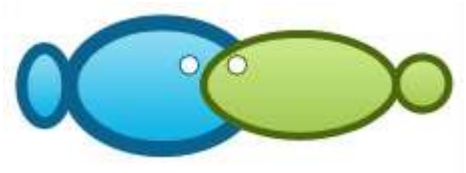

State overview of the Siberian sturgeon (*Acipenser baerii*) population in the Irtysh basin

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Abstract. The article presents a retrospective analysis and the current state of the Siberian sturgeon stocks in the Irtysh basin. For the analysis, published articles on monitoring the state of the sturgeon in the basin reservoirs were used. In total, 39 sources were used, and information on poaching catches and material obtained during operational raids of environmental structures were taken into account. The reasons for the decline in its numbers are shown, including the influence of hydraulic construction and intensive poaching. The biological indicators of the sturgeon population of the Irtysh River for the lastyears are presented, which indicate the undoubted degradation of its stocks. The causes of the depressed state of sturgeon stocks are considered and it is noted that the measures for their protection and the current level of measures for their artificial reproduction are insufficient. The inclusion of individual sturgeon populations in the Red Books of various levels turned out to be an insufficient measure to restore their stocks. Solving the problem of conservation of the nominative subspecies of the West Siberian sturgeon in the Irtysh basin involves the development of a comprehensive program of measures that would include not only the formation of broodstock, artificial reproduction, but also the reacclimatization of the species into the native area, in compliance with the genetic status of individuals released into the basin rivers. The resoration efforts should be backed by maesures taken to curb poaching, and to protect and restore the wintering pits and spawning grounds. The conservation of sturgeon lies in the rational management of their stocks, and this, in turn, consists not only in limiting their fishing but also in artificial reproduction, in order to maintain a stable state of natural populations in nature, together with their protection by preventing illegal fishing. The purpose of this work is to assess the current state of the Siberian sturgeon population in the Irtysh basin and to assess the possibilities of preserving and restoring its population. To ensure success in the restoration of the sturgeon population, measures are proposed to enrich the food base by the preliminary introduction of suitable food organisms, and selection of food objects specific to the invaders. The current sturgeon population is depleted. Despite the measures taken for its protection and artificial reproduction, in the coming years a significant increase in the number is not expected, since the measures to restore the population are irregular and they are not sufficient. The implementation of the project of species acclimatization will allow preserving and restoring the species of depleted biotic communities, by qualitatively improving the composition of the ichthyofauna of water bodies and by preserving the genetic potential of natural populations, and implicitely increasing the biodiversity of the ecosystem by sustainably increasing its natural productivity.

Key Words: abundance, restoration, reintroduction, biodiversity, recommendations.

Introduction. The Irtysh water basin is one of the largest fishery basins in the Republic of Kazakhstan, stretching from northwest to southeast for more than 1,500 km. In modern conditions, this is a rather complex macrosystem in morphological terms, including Lake Zaisan, Bukhtarma, Shulbinsk, Ust-Kamenogorsk reservoirs, as well as the Black Irtysh and Irtysh rivers with their subordinate system. The ichthyofauna of the water bodies of the basin currently includes 36 species of fish, among which there are economically valuable or rare fish (Kirichenko 2012). Inventory and planned studies of rare and endangered species are a priority, their results allow us to judge not only the state of populations of valuable and small species but also to develop measures for the protection and conservation of their populations. The priority of conservation of genetic resources for sustainable development is enshrined in the Convention on Biological

Diversity. In the Irtysh basin, there is a real need to preserve the gene pool of rare valuable species, due to the risk of extinction, including the Siberian sturgeon listed in the Red Book of the Republic of Kazakhstan (Assylbekova & Kulikov 2016).

The Siberian sturgeon (*Acipenser baerii*) is an iconic species of freshwater fish renowned for its role in the caviar industry and its ecological significance within aquatic ecosystems. This prehistoric-looking creature, with its armored exterior and distinctive elongated body, has captured the fascination of both scientists and seafood enthusiasts alike. As the largest freshwater fish in Eurasia, the Siberian sturgeon occupies a unique position in the world of aquatic biodiversity. *A. baerii*, recognized for its high-quality roe, has faced immense pressure due to overfishing and habitat destruction (Ruban G 1997).

The aim of the current work was to assess the current state of the population of *A. baerii* in the Irtysh basin, to assess the possibilities of conservation and restoration of the sturgeon population of the Irtysh basin, to develop recommendations for the conservation, reproduction, and sustainable use of the gene pool of valuable fish species of the Upper Irtysh basin, and to assess the success of natural and artificial reproduction of Siberian sturgeon.

Material and Method

This review is based on published articles on monitoring the state of sturgeon in water bodies of the Irtysh basin. A total of 39 sources were analyzed, 9 of them in English. The study used a number of publications based on the results of the author's field studies as part of complex fishery expeditions to the reservoirs of the Zaisan-Irtysh basin in 2001-2015, related to the history and current state of the West Siberian sturgeon population. The catch of the Siberian sturgeon in the Irtysh basin is prohibited, therefore, the study of the sturgeon population in the river was carried out in the course of the research fishing of sterlet to assess the state of its stocks. Monitoring of the state of populations of valuable rare fish species, including sturgeon (Siberian sturgeon) was carried out in recent years within the framework of various projects, during 2001-2015, but also starting from 2021 within the framework of the project "Development of scientifically based recommendations on increasing the fish productivity of fishery reservoirs through the introduction and reintroduction of fish and hydrobionts - components of the food base of fish", (grant No. BR10264205). In addition, information on poaching catches was taken into account, as well as the material obtained during the operational raids of environmental structures. When catching valuable small or rare and endangered fish species, the method of intravital selection was applied. After measuring and weighing, the sturgeon was released into the water alive. Determination of the age of the sturgeon was carried out according to literary sources and stock materials based on the analysis of size and weight indicators. Populations of valuable rare fish species were assessed according to IUCN criteria. Fishing was carried out with a set of standard fishing gear, which made it possible to obtain information on the species, sex, age composition of fish populations, their relative abundance, etc. A rafting net was used with the following parameters: a length of 50 m; a height of 1.5 m; a mesh of 35-40 mm; a row of 200 mm. At each site under study, networks with a mesh of 20, 30, 40, 50, 60, 70, 80, 90 mm were set up. The height of the nets is 3 m, the length is 25 m each. Net installations are carried out in the dark for 12 hours, the operation of the rafting net is carried out both in the daytime and at night. Catch processing includes the following procedures: species identification; calculation of the total number and weight of each species in the catch; the entire catch was subjected to mass measurements (measurement of the body length of fish without a tail fin). The biological analysis includes determining the total body weight; the full length of the fish; the length of the fish from the top of the snout to the end of the scale cover.

Results and Discussion

For water bodies of the Irtysh basin, the West Siberian sturgeon of the nominative subspecies *Acipenser baerii baerii* (Brandt 1869) is endemic (Berg 1948). The resident

form, which previously lived in the Bukhtarma reservoir and ascended along the Black Irtysh to China (Berg 1948), practically disappeared in the 1980s (Yevseyeva et al 2019). The migratory form of *A. baerii* was distributed throughout the Irtysh River, but currently only found below Semey (Prokopov & Tagayev 2017; Kirichenko 2012). The conditions and characteristics of the habitat of the West Siberian sturgeon in the waters of the Irtysh basin have not been studied enough, while the subspecies is on the verge of extinction, being listed in the Red Book of the Republic of Kazakhstan in category II, as "Endangered", due to a decrease in its population, as it faces a high risk of extinction in the wild (Kirichenko 2010; Kirichenko & Kulikov 2011). The status of this species in the IUCN Red List is persistently "endangered species" (IUCN Red List of Threatened Species 2019). *A. baerii* in the Upper Irtysh was a widespread species almost until the middle of the last century. Along the river, it was found everywhere up to the state border (Kirichenko & Isbekov 2016). In the Tobol River sturgeon comes from the Irtysh to feed (Karasev 2003).

A sharp decrease in the population of sturgeon in the Irtysh River occurred after the construction of three hydroelectric power plant (HPP) dams: Ust-Kamenogorsk (1959), Bukhtarma (1953-1966) and Shulbinsk (1976-1989), when the conditions for the reproduction of sturgeon fish were sharply violated. There was shallowing of the river and destruction of natural spawning grounds and wintering pits due to dredging, excavation of soil in the channel and sand intake (Yereshchenko 1970; Yereshchenko 1986; Galushchak & Kulikov 2003; Kirichenko 2003; Kirichenko 2012). The regulation of the Irtysh River below the constructed HPP caused sturgeon spawning grounds located in the upper reaches of the river to become silted up and unusable; spillway dams made it impossible for individuals seeking to spawn to penetrate upstream.

Sturgeons are very demanding in terms of spawning conditions: sometimes the violation of even one environmental factor leads to negative consequences. The anadromous sturgeon, like the sterlet, turned out to be isolated from almost all of its spawning grounds, except for the section of the river from the city of Semipalatinsk to the dam of the Shulbinsk HPP (Figure 1).

Note: - the range of the Siberian sturgeon

Figure 1. The Irtysh River area populated by *Acipenser baerii*.

However, the hydrological conditions here have changed dramatically: the natural flood has been replaced by an artificial one and water is released through the dam of the Shulbinsk HPP. Normal conditions for the reproduction of sturgeon and starlet are missing (Kirichenko & Isbekov 2016). HPP dams have created an insurmountable barrier to the exchange of individuals (genotypes) between populations (subpopulations) of fish from

different parts of the basin, negatively impacting the habitat and the reproduction. The sharp decrease in stocks and catches of sturgeon is associated with an increase in poaching catch (Popkova 2014).

Wintering of the semi-anadromous sturgeon occurs together with the nonmigratory, often together with the sterlet. The presence of a large amount of oxygen dissolved in water is a prerequisite for wintering sturgeon. Wintering pits within the Kazakhstani part of the Irtysh are practically not studied. Popov (2007) stated that in the Irtysh, the main part of the wintering pits is located in the lower reaches of the river. Kassal (2012) highlighted that the spawning grounds of the West Siberian sturgeon in semi-anadromous and aquatic forms are located not only in the southern part of the territory of the Omsk region, but also on the territory of the Republic of Kazakhstan. The Irtysh River in the middle reaches (in the southern part of the Omsk region and in northern Kazakhstan) is the only natural breeding site for the endemic subspecies of the West Siberian sturgeon (Kassal 2012; Zaitsev et al 2013).

According to the results of research in 2010-2015, about 4 wintering pits were noted in the border area of the Kazakhstani part of the Irtysh River (Kirichenko & Isbekov 2016). An inventory of sturgeon spawning grounds in the late 1990s downstream of the Shulbinsk HPP dam revealed only 3-4 dozen small areas potentially suitable (Galushchak & Kirichenko & Kulikov 2003). Thus, due to the regulation of the flow of the Irtysh River the spawning migration routes of the sturgeon were disturbed, and its spawning grounds above the Shulbinsk HPP dam disappeared. In addition, the state of sturgeon stocks is extremely negatively affected by poaching of juvenile and adult fish, which, unfortunately, did not stop even after the sturgeon was listed in the Red Book (Kirichenko 2012; Chemagin 2020). The Irtysh River within the Pavlodar region is important as a place of wintering and feeding for fish species. According to our data, the most intensive reproduction of sturgeon is currently observed in the Doloni region and below, although spawners still migrate up the river to the Shulbinsk HPP dam. Sturgeon, which are attached to the spawning substrate as one of the necessary conditions for spawning, are attracted by the gravel and gravel-sand deposits located above the Semey city. In the downstream, the are less sediments, and the content of gravel is reduced from 70% to 1-5% below the Krivinka village (Mitrofanov & Dukravets 1986).

Under the current conditions, it becomes very important to obtain up-to-date data on the state of *A. baerii* population, a particularly valuable species, which will contribute to solving the problem of conservation and restoration of the population of this species, especially under conditions of the increasing anthropogenic impact. It is rather difficult to assess the current state of the stocks of the Irtysh population of the West Siberian sturgeon in the conditions of a year-round ban on its fishing and in the absence of monitoring studies of the species over the past many years, when there is no complete data on the biological indicators of individuals, on the migration of spawners to breeding sites and spawning conditions. Fragmentary information on sturgeon can only be obtained from the by-catch of this species, mainly its juveniles. Studies conducted since the early 2000s have shown that the most productive catches of Siberian sturgeon were obtained in the border area of the Irtysh River within the Pavlodar region. Studies carried out on 3 different sections of the river showed different population densities of sturgeon. Thus, in the section of the river below the Pavlodar city, sturgeon was absent in the catch. Monitoring of the results of previous years shows that sturgeons live in this area, while up to 5-10% of the catch can be immature sturgeon, weighing up to 1 kg. Larger sturgeon in this area are quite rare (Kirichenko 2008,2012,2016).

According to the results of fishing with rafting nets, the lower border section of the Irtysh River should be recognized as the most productive. As a result of 2 raftings, two dozen sterlet, 23-35 cm in size, and 2 immature sturgeon with a body length of 34 and 38 cm and a weight of 285 g and 390 g, respectively, were caught. In the spring period (May), larger sturgeon, weighing up to 10-15 and even 30 kg, are also found in catches with a rafting net. But such specimens make up no more than 1-2% of the total number of sturgeons found in this area (Kirichenko 2016).

An echo sounding survey carried out on the border section of the Irtysh River, below the village of Bashmachnoye, in the area of the sturgeon pit located here, showed

at a depth of 7.5 m a concentration of sturgeon fish of about 50 specimens; some individuals reached a weight of 22 kg, 35 kg and 70 kg. It was noted that at the end of summer sturgeons concentrate on wintering pits. Only those sturgeons that came out of the pit onto the channel and became available for fishing with a standard rafting net were caught in the rafting net, but these were not large individuals, weighing up to 2 kg. In the catches of 2004-2005, sturgeon juveniles were represented mainly by individuals with a body length of up to 48 cm and a weight of up to 900 g, aged from 1+ to 4 years (Table 1). In recent years, the presence of sturgeon in the border area of the Irtysh River has increased, and the size and age category of individuals has also expanded. Until 2011, the bulk of the studied sturgeon specimens were included in the category of juveniles, since more than 85% of the sample were fish with a body length of up to 50 cm and a weight of up to 1,055 g, aged 1-4 years, and older sturgeons were present in the catches of subsequent years (8 years), which accounted for more than 6% of the catch (Kirichenko 2008). All studied fish were immature. In the course of research in the border area of the Irtysh, it was noted that large specimens of sturgeon are brown in color, which correlates with the color of the Irtysh water and allows us to attribute these individuals to the aquatic form. Sturgeon fry, with a length of no more than 40-50 cm, has a gray, smoky color and refers to the semi-anadromous form of the sturgeon. The same color differences were noted for various forms of the Irtysh sterlet (Berg 1948; Ruban & Akimova 1991; Ruban 1989; Ruban 1999; Kirichenko 2013; Popkova 2014). The habitat of the residential populations, permanently living in the Irtysh, is completely colonized by the migratory, semi-anadromous populations, but specimens of the West Siberian sturgeon differ from semi-anadromous ones and not only in the body color (Georgii & Ruban 1997; Gerbilsky et al 1970; Ruban 1997; Kassal 2018).

Table 1

Biological parameters of juvenile *Acipenser baerii*

Year	*Parameters*	*Age groups, years*							*M*
		1	*2*	*3*	*4*	*5*	*7*	*8*	
2004	Length, cm*	24.3	34.3	40.0	46.8	-	-	-	36.3
	Weight, g	125	298	501	776	-	-	-	425
	%	18	35	29	18	-	-	-	100
2011	Length, cm*	19.2	29.7	43.5	51	-	67	-	35.0
	Weight, g	57.5	167.5	718.3	1.055	-	2.815	-	499
	%	13	53	20	7	-	7	-	100
2012	Length, cm*	25.5	29.5	32	35.5	-	64	70	35
	Weight, g	135	194	180	253	-	1.665	3.195	476
	%	12.5	50	6.2	18.7	-	6.2	6.2	100
2015	Length, cm*	19	36.8	-	54	59	-	-	41.1
	Weight, g	130	351	-	1.255	1.760	-	-	684
	%	11.1	55.6	-	22.2	11.1	-	-	100
2021**	Length, cm*							78	78
	Weight, g							4.000	4000
	%							100	100

*body length to the base of the middle rays of the caudal fin; **material obtained during the operational raids of environmental structures.

Thus, according to the results of studies at all stations of the Irtysh River, a clear pattern can be traced: the number of sturgeon species of fish increases in the direction to the lower reaches of the river, reaching a maximum in the border areas. Currently, the restoration of sturgeon stocks is topical. In the water bodies of Kazakhstan, Siberia, as well as throughout the world, the stocks of sturgeon tend to diminish (Ruban 1999; Friedrich 2019; Chemagin 2020; Chemagin 2021; Kirichenko 2022). The extinction of the Siberian sturgeon, which largely lost the possibility of natural reproduction, made it necessary to artificially breed it (Korentovich & Litvinenko 2018).

To preserve the population of the Siberian sturgeon, it is necessary to make an inventory and effectively protect the possible wintering and spawning areas of the species in the corresponding periods of the year. To preserve the species, it is necessary to stop the flourishing poaching and compensate for the damage caused by it, annually supplementing natural reproduction with a release in the Irtysh River artificially bred juveniles (Hochleithner & Gessner 1999; Kassal 2019; Kirichenko & Assylbekova 2022). Administrative fines, according to the data of the fish inspection department for the Pavlodar region of the RGA "Zaisan-Yertis Interregional Basin Fisheries Inspectorate of the Fisheries Committee of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan", show that, only in 2018-2019, 12 cases of poaching were recorded, with a seizure of Siberian sturgeon of a total weight of 122.945 kg. Such effectiveness of poaching may indicate not only the presence and productivity of the sturgeon population in this section of the Irtysh River, but also the need to strengthen conservation measures. In 2012, as part of the implementation of the republican budget program 038, 130,000 specimens of Siberian sturgeon underyearlings weighing from 12 to 30 g were released into the Black Irtysh River. In 2015, they measured a length of 59 cm and a weight of 860 g (Kirichenko et al 2019; Kirichenko & Assylbekova 2022). This indicates the possibility of restoring the sturgeon population in the conditions of the reservoir and the need to continue the work of reintroduction (Chemagin 2019; Friedrich 2019). In 2020 and 2021 a private fish-breeding enterprise (the village of Saratovka, East Kazakhstan region) released 4 thousand sturgeon, weighing 2-2.5 kg. However, it should be noted that such fish breeding activities are not of a systemic nature, and given the small volumes of release, one should not expect a quick effect of reacclimatization measures (Cooke et al 2021). Despite the measures taken for protection and artificial reproduction, sturgeon stocks in the Irtysh River continue to be at an extremely low level. Currently, it is allowed to catch sturgeon only for the purpose of artificial reproduction. Therefore, to study the state of the population of this species, due to its special conservation status, is currently associated with certain difficulties. Thus, the analysis of the condition of the sturgeon in the reservoirs of the Upper Irtysh allows us to state that at present its number is at a low level and, despite the measures taken for its protection and artificial reproduction, in the coming years, a significant increase in the number is not expected, since measures for the restoration of populations are not regular in nature and they are not sufficient. With such insignificant volumes of artificial reproduction of sturgeon and the existing poaching catch, its numbers will be at an extremely low level.

Conclusions. The analysis of the current state of *A. baerii* in the Irtysh basin shows that its number, in conditions of increased anthropogenic impact, continues to remain at a low level, and the measures taken to preserve the population demonstrate poor effectiveness. In order to achieve more successful and tangible results of the restoration of the population, it is recommended to continue the work on the reintroduction of *A. baerii* by more massive and regular stocking over a number of years, using genetically tested fish planting material. The implementation of the sturgeon reintroduction project will restore the population, preserving its genetic potential.

Conflict of interest. The authors declare no conflicts of interest.

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