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RESEARCH ARTICLE

Actual status of fishing reserves of the Yesil River

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ABSTRACT. In this article, the study and prediction of the state of fish resources in the Yesil River was carried out to determine the boundary reference points of the reserve and management decisions in case they are exceeded, to ensure sustainable fisheries and preserve biological diversity. Ichthyological studies, retrospective analyses and rankings of the effects of the water supply of the Yesil River on fish stocks have been carried out, critical values of the biomass of fishing reserves have been determined, as criteria for biologically safe fishing values and targets for management of fish stocks at reaching the boundary values of 24.03 tonnes have been established. According to the results of studies of basic biological indicators, it was determined that roach, bream, pike and perch populations each had an LC50 above LM50, which indicates their low utilization in the fishery industry. A strategy for management of fish stocks, recommendations for the conservation of fishery resources and their rational use has been developed as a result of these findings. The list and status of the monitored indicators for the careful management of fish stocks, as well as a list and indicators of the boundary indicators for the state of fish stocks, was established. These parameters included the fish size of 50% of the sampled fish and 50% of maturity achieved, where the LC50 was observed in the fish in question from 19 to 45.4 cm and LM50 from 12.3 to 41 cm, respectively. The minimum and maximum river levels that ranged from 111 up to 159 cm, as well as the critical value of the commercial reserve, corresponded to the boundary value of 24.03 tonnes. The results of this work will serve as the basis for making future managerial decisions, necessary for sustainable fisheries and conservation of the biological diversity of the Yesil River.

KEY WORDS. Biomass of fishing reserve, catch, fish productivity, ichthyological studies.

INTRODUCTION

The Yesil River is an important fishery reservoir in Northern Kazakhstan, not only socially, but also for preserving the biological diversity of the region. It is necessary to evaluate fish productivity and possible catches of fish in the different scenarios of water availability of the main fishing reservoirs of the country. For each of these scenarios, the boundary reference points of the fishery and the list of managerial decisions for its optimization should be defined.

For the Yesil River, boundary reserve guidelines have been defined to develop a strategy for cautious inventory management and sustainable fisheries, in accordance with the principles of responsible fishery management as outlined by the FAO. This will result in compliance with international norms and the conservation of fish stocks as the critical limits are approached (Koutsikos et al. 2012).

The stated research relates to ecological and fishery spheres and fully complies with the priority tasks of the "Concept on the Transition of the Republic of Kazakhstan to the Green Economy" (approved by the Decree of the President of the Republic of Kazakhstan of 30 May 2013 #577).

For the Yesil River, strategies (known as management decision schemes) have been developed for each of the possible scenarios of the state of the reserves. It should be remembered that, while recommending a particular catch factor for each fish species and setting limits on its catch, we do not take into account non-commercial catch. As a result, even if the recommended withdrawal rates are met, valuable fish species may be overfished. Therefore, a precautionary approach is necessary.

Fishes are the important indicator of an aquatic ecosystem and occupy a remarkable position from a socioeconomic point of view (Bera 2014). Due to their content of proteins, fats, vitamins, phosphorous and other compounds, the elements present in ichthyofauna have been used as a diet for humans since time immemorial. They also contribute to the economies in society (Ashok 2014).

In accordance with the chosen research direction, the following tasks were set: 1) Ichthyological studies, retrospective analyses and ranking of the impact of the water supply of the Yesil River on fish stocks; 2) Determination of critical values of the biomass of the commercial reserve, as criteria for biologically safe fishing values and targets for management of fish stocks when boundary values have been reached; 3) Development of strategies for management of fish stocks, recommendations for the conservation of fishery resources and their rational use; 4) Setting up lists and status of monitored indicators for careful management of fish stocks and 5) Setting lists and indicators of boundary guidelines for the state of fish stocks.

MATERIAL AND METHODS

The material was collected as a result of field trips in the period from 2016 to 2017. The volume of the collected material is given in Table 1.

Table 1. Volume of the collected material.

Hydrological regime (samples)	Biological analysis of fish (pic.)	Mass measures (pic.)	Network (pic.)	Fishing reserve (tons)
40	1076	2380	38	60

The observation stations were located along the entire length of the Yesil River. Sampling sites were chosen in order to conduct ichthyological research and determine commercial fish stock. The sites were found using echo-sounders and recorded using navigators. According to the Fig. 1, sampling was carried out in summer and autumn periods. Sampling in the summer period was carried out mainly from the riverbed of Esil River in the Akmola region. The major criterion for the determination of sample sites is, first of all, the fact that the water in these areas warms up evenly and creates favorable conditions for the rapid growth and development of zooplankton and benthic groups of organisms (the main food of ichthyofauna) and also creates favorable conditions for the growth and development of juvenile fish.

In autumn, determination of sampling sites was based on the fact that, in the North Region, rivers have wider channels, deeper sections and greater concentration of wintering pits and the bulk of the fish in the pre-winter period is concentrated in these pits in the riverbed. Hydrochemical properties are most favorable in these areas.

For the sampling, echo-sounders were used to determine the “dumps” – transitions from shallow to deep waters. Fish are mainly concentrated in these areas, which are favorable for feeding. These places were recorded by navigators. Subsequently, sampling was conducted at these sites. For the research, five areas were selected on the summer expedition and five areas on the autumn expedition (Fig. 1).

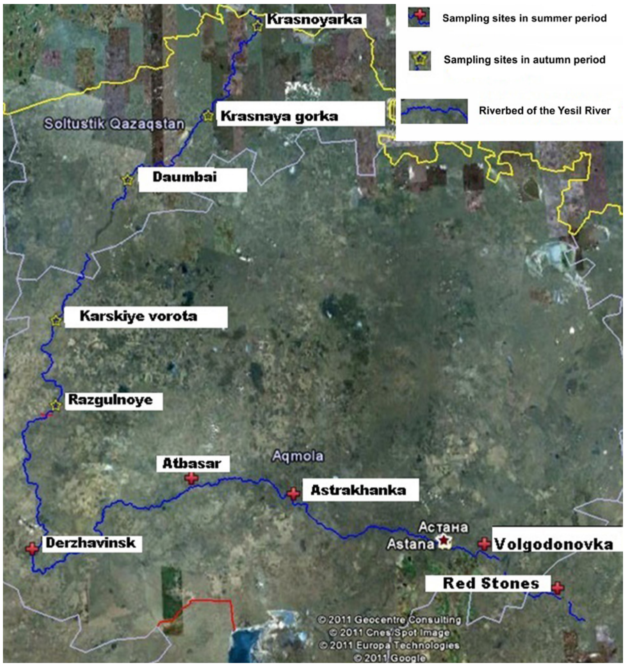

Figure 1. Yesil River with indicated sampling sites on the territory of the Republic of Kazakhstan.

Ichthyological analysis included the determination of linear dimensions, weight, sex and maturity stages of fish, according to standard methods (Pravdin 1966). Fish age was determined by the generally accepted method which is as follows: when scales were examined under magnification, concentric formations located around the centre in circles were observed. The number of such circles formed within one year is an annual ring. The number of annual rings corresponds to the age of the fish. Age determination could also be carried out by looking at the gill cover, ear bones (otoliths) and vertebrae. On the gill, the annual rings of the otoliths, after appropriate treatment (drying, degreasing, lightening and even boiling), are clearly visible.

The calculation of the number and industrial volume of fish catches was carried out according to the standard method of networking (Kushnarenko and Lugarev 1983, Sechin 1986), since the use of alloy networks, due to high weed density and a lack of necessary depths, was not possible. The basis was the formula: $N = (Q \times S)/k$, where: Q is the number of fish in catches in pcs., S is the registration area of the reservoir in hectares, k is the correction factor obtained by multiplying the three main coefficients for each size group (network): $K_i = P \times K \times C$, where: P is the coefficient of probability of meeting fish with fishing gear, K is the network catchability factor and C is the catch area. These coefficients are calculated on the basis of experimental data (Kushnarenko and Lugarev 1983, Sechin 1986).

The coefficient P is calculated on the basis of the formula, proposed by Sechin (1986). The coefficient of network efficiency is assumed equal to 0.5.

The catch area was calculated using the formula: $C = V \times t \times g \times (2 \times b + 3.14 \times Vt)$, where: V is the radial yaw rate (m/min.), t is the network setup time in minutes, g is the number of fixed networks and, b is the network length in meters.

In this case, the key figure is V. It was borrowed from the directory (Radakov and Protasov 1964). Yaw rate for perch and pike is 0.04; for bream and roach it is 0.05.

The industrial reserve was calculated according to the following formula: $M = N \times m$, where M is the ichthyomass of age/population, N is the age/population number, defined by the formula (1) and, m is the average weight of individuals at the age/population.

The LC50 and LM50 indices were determined in accordance with the recommendations of the FAO (Mees 2006). In connection with the lack of fishing on the Yesil River, a simulation of the fishery was carried out, i.e. for analysis, a separate order of networks with characteristics as close as possible to commercial networks was used. Of course, it is impossible to predict what networks the future nature user will use. In this regard, the order of 40 mm was used, which provides some underestimation of the LC50. This can also be attributed to our precautionary approaches.

All calculations were carried out on a PC using the MS Excel software (Zhivotovsky 1991, Korosov and Gorbach 2007, Buyul and Ceofel 2005).

RESULTS

The estimation of boundary reference points by biological indicators was done for the main commercial species. Pike-perch, tench and burbot were not evaluated due to the low populations of these species.

Roach is an aboriginal species in the Ob-Yertish basin, to which the Yesil River belongs. In the riverbed, the roach is one of the most numerous species distributed throughout the water area and occupies various biotopes. As such, it is one of the main fish species targeted in amateur fishing (Averintsev 1929, Alyoshina 2009). The biological parameters of the roach are not high, which is explained by the low fodder of the Yesil River (Table 2)

The catch is dominated by individuals aged 2+ to 4+ years. Beginning in 2010, seven-year-olds appeared in the catches and, since 2011, eight-year-old individuals of roach have been be found. This allows researchers to draw conclusions about the positive dynamics of roach age composition. The age range is limited to the eighth year. The maximum age of males is 7+ years. The well-being of the species in the Yesil River further confirms this thesis.

The average size of a roach relates to individuals which have already spawned more than once. The LC50 is significantly higher than the LM50. Moreover, the difference in these indicators clearly indicates an extremely low use of roaches in the fishery.

Bream is an acclimatizer and was not observed in the Yesil River until 1970 (Berg 1948, 1949a). The appearance of this species in the ichthyofauna of the river is associated with acclimatization work at the Sergeevsky and Vyacheslavsky reservoirs. At present, this species has spread widely throughout the entire river and has become a common species in the Yesil River system. Bream, possessing unpretentiousness in breeding conditions and eating a wide range of food, is common in almost all biotopes of the river (Berg 1949b, Borisov and Ovsyannikov 1954). The biological characteristics of the bream are not high, which is explained by the low fodder of the Yesil River (Table 2).

Table 2. Basic biological parameters of fish. $L_{average\ –\ average\ length\ of\ fish}$ (cm); $M_{average\ –}$ average mass of fish (g); L_{C50} – the length at which 50 percent of the fish is selected in the fishery (cm); L_{M50} – the length at which 50 percent of the fish reach puberty (g).

	Year	$L_{average}$	$M_{average}$	L_{C50}	L_{M50}
Roach	2016	14.6 ± 0.03	74.7 ± 0.03	20 ± 0.01	12 ± 0.05
	2017	14.5 ± 0.04	73.4 ± 0.01	20.1 ± 0.03	12.3 ± 0.02
Bream	2016	18.3 ± 0.02	164.6 ± 0.03	21 ± 0.01	13 ± 0.04
	2017	18.9 ± 0.03	152.3 ± 0.04	20.4 ± 0.03	12.8 ± 0.03
Pike	2016	40.3 ± 0.04	702.7 ± 0.04	47 ± 0.06	41 ± 0.05
	2017	38.7 ± 0.06	563.4 ± 0.03	45.4 ± 0.04	41.2 ± 0.05
Perch	2016	16.0 ± 0.02	88.5 ± 0.02	19 ± 0.03	13 ± 0.04
	2017	15.9 ± 0.03	88.4 ± 0.02	19.2 ± 0.01	12.4 ± 0.02

The catch is dominated by individuals aged 4+ and 5+ years. In the catches from 2006 to 2008, there were no older age groups; starting in 2010, eight-year-old bream species appeared and beginning in 2014, nine and ten-year-olds were caught in the catches, facts which allow one to conclude that the age composition is positive. The age range is limited to the tenth year. The maximum age of males is 7+ years (Veselov 1977). This also confirms the thesis about the well-being of the species in the Yesil River.

The average size of the bream of individuals that have already spawned more than once rises slightly. The LC50 is significantly higher than the LM50. Moreover, the difference in these indicators clearly indicates an extremely low use of bream in the fishery.

In the Yesil River, the pike is represented by unproductive populations. In the commercial shoals, younger age groups dominate. In experimental catches, it is represented by single specimens. Despite this, it is one of the most common species in the river system of Yesil, being found throughout the river (Vyshegorodtsev 2002, Zinoviev and Mandritsa 2003). Biological indicators of pike are not high (Table 2).

For the entire period of work (from 2005 to 2008 and from 2010 to 2016), the age limit of the pike caught in the river was 6+ years. In the population of the pike from the Yesil River in 2016, the age group dominates: 1+. Since 2010, 6+ years of age have been recorded in scientific catches, but the absence of older age groups prevents any discussion on the positive dynamics of the age composition. In addition, the dominance of individuals of younger age groups indicates a high pressure on the pike population in the Yesil River. The maximum age of males is 5+ years. This also confirms the thesis about the high pressure on the pike population in the Yesil River. The average size of the pike relates to individuals who have already spawned more than once. LC50 is higher than LM50.

Perch is an aboriginal species in the Yesil basin (Il'mast 2005, Kafanova 1984). Along with the roach, this species is the most abundant in the ichthyofauna of the river system of Yesil. This species is distributed throughout the water area and occupies various biotopes; it is one of the main objects of amateur fishing. The biological parameters of the perch are not high (Table 2).

The catch is dominated by individuals aged 3+ years. In the catches from 2006, 2008 and 2010, there were no older age groups. Starting in 2011, seven-year-olds appeared and since 2012, eight and nine-year-old perch species appeared as well, suggesting a positive dynamics in age composition. The age range is limited to the ninth year. The maximum age of males is 7+ years. This further confirms the thesis about the well-being of the species in the Yesil River.

The average size of perch falls on individuals who have already spawned more than once. The LC50 is significantly higher than the LM50. Moreover, the difference in these indicators clearly indicates the extremely low use of perch in the fishery.

In the Yesil River, a special ichthyocenosis was formed that is sufficiently well adapted to existing habitat conditions. There are a number of species that form the backbone of the community and fishery: roach, perch, bream and pike (Lebedev 1967, Lebedev et al. 1969, Lyagina 1984). In some areas, they are joined by tench and pike perch, which are not resistant and often exhibit unprecedented fluctuations in numbers. These species are of secondary importance, both in the cenotic and in the utilization plan.

In the Yesil River, the maturation of 50% of the roach population occurs when the length reaches 12–12.3 cm. Therefore, the indicator of the stability of the state of the population is the seizure of individuals exceeding the length of 12.3 cm. While the basis of catches in the simulation of commercial fishing was the specimen of 20–20.1 cm, this means a boundary reference point will not be reached soon. LC50 > LM50. The results of our studies indicate that a higher seizure factor of the commercial population than 0.311 (Malkin and Borisov 2000) may be applied.

Maturation of 50% of the bream population occurs when the length reaches 12.8–13 cm (Nikolsky 1971, 1974). Proceeding from this, the indicator of the stability of the state of the population is the seizure of individuals exceeding the length of 13 cm. While the basis of catches in the simulation of commercial fishing was individuals of 20.4–21 cm, this means the boundary landmark will not be soon reached. LC50> LM50. A higher capture factor of the commercial population than 0.311 (Malkin and Borisov 2000) may be applied.

For the pike population, maturation of 50% of individuals is typical when the length reaches 41–41.2 cm (Nikolsky 1980). Proceeding from this, the indicator of the stability of the state of the population is the seizures of individuals exceeding the length of 41.2 cm. While the baseline of catches in the simulation of commercial fishing was 45.4–47 cm, this means a boundary reference point will soon be reached. LC50 = LM50. When predicting the volume of seizures, the coefficient of seizure of the fishing population should be 0.266 (Malkin and Borisov 2000).

Maturation of 50% of the perch population occurs when the length reaches 12.4–13 cm (Silivrov 2008). Proceeding from this, the indicator of the stability of the state of the population is the seizure of individuals exceeding the length of 13 cm. While the basis of catches in the simulation of commercial fishing was made up of individuals 19–19.2 cm, this means the boundary landmark will not soon be reached. LC50> LM50. Thus, the results of the studies indicate that a higher seizure factor of the commercial population than 0.311 (Malkin and Borisov 2000) may be applied.

The water regime of the river is characterized by the high spring water (85–96% of the annual runoff) and a long low-water period. The spring rise of the level usually begins in mid-April, reaching a maximum in late April, early May. The duration of high water in the upper part of the river is 1.0–1.5 months and increases downstream to 2–3 months. The annual volume of runoff in the high water period may exceed the runoff of the shallow years by a hundredfold (Chugunova 1959).

Figure 2 shows the dynamics of the average annual water level in the river (Turgenevka and Volgodonovka) and the commercial fish stock for 2008–2017.

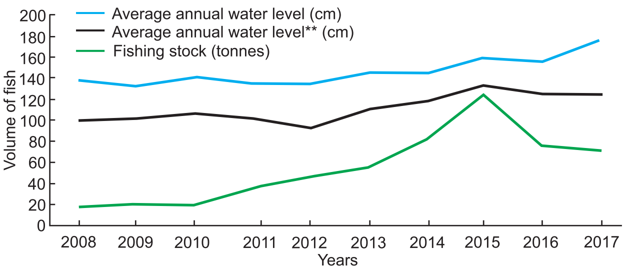

Figure 2. Dynamics of hydrological indices and industrial volume of fish in the Yesil River for the years 2008–2017.

Analysis of the available data shows the dependence of the commercial fish stock in the Yesil River on the average annual water level. Data on the average annual water level in the river for 2017 covers only an eight-month period.

Based on the available data from 2008 to 2017 (Table 3), a high correlation existed between the average annual water level in the river and the commercial fish stock. Thus, the relationship between the average annual water level in the river and the indicators for the commercial productivity of populations is present and its reliability is high.

Table 3. Correlation (R) of average annual water level and biomass of commercial fish stocks in the Yesil River.

Index	Water level										
	Law water					Medium water		Law water			
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	R
Annual average level* (cm)	137	133	140	135	135	144	144	159	157	174	0.694
Annual average level** (cm)	99	101	106	100	93	111	118	131	125	125	0.851
Industrial stock, t.	19.3	19.4	19.3	35.1	45.5	56.6	81.1	123.5	75.0	71.3	–

*Turgenevka vil., **Volgodonovka vil., 2017: data on the water level for eight months.

In the period from 2008 to 2010, the biomass of commercial fish stocks was in a stable state and was at a low level during this period. From 2011 to 2015, there was an increase in the commercial fish stock in the river, which lasted until 2015. In 2016 and 2017, there was a decrease in total biomass, probably in connection with the spring overspills of the Yesil River, as a result of which a significant part of the commercial shoals of fish remained in floodplain reservoirs.

To determine the effect of water availability on the number of commercial stocks and determine the critical values of the water regime for the state of fish stocks, the average annual water level in the Yesil River was chosen.

In the range of investigated years, the water content of the Yesil River was generally low (low water period) and only the last five years can it be characterized as medium and high water. The critical value of the average annual level is 144 cm in the area of Turgenevka village and 111 cm in the area of Volgodonovka village. In addition, it should be noted that the critical water content for the Yesil River is also an increase in the water level of more than 159 cm in the area of the village of Turgenevka and 131 cm in the area of the village of Volgodonovka.

However, in view of the absence of fishing gear and the prospects for its development on the river, it is hardly possible to propose any specific management measures. The only thing that can be offered is the optimization of water consumption, including the use of alternative sources of water supply and the strengthening of work to save the young from reservoirs separated from the river. To implement this, local executive bodies should plan financing for said management.

In general, the following indicators of sustainable development were adopted for the Yesil River: the equality of replenishment and seizures for pike; and for bream, roach and perch, an excess of seizure over replenishment (Table 4).

Table 4. Status of indicators of sustainable development. TAC: total allowable catch, MAC: maximum allowable catch.

Types of fish	Target TAC (MAC)
Roach	Replenishment < fishing
Bream	Replenishment < fishing
Pike	Replenishment = fishing
Perch	Replenishment < fishing

In the Yesil River, in the age structure of the roach population, a gradual expansion of the age range has been observed beginning in 2010 and, in the last year, a noticeable increase in the number of juveniles occurred. The catch is dominated by individuals aged 2+ to 4+ years, accounting for a total of 65%. The most productive part of the shoal has been in a stable state for several years. In such circumstances, a target in evaluating the potential for roach extraction should be a small excess of the fishing over the replenishment process.

In the Yesil River, in the age structure of the bream population, from the year 2010, eight-year-old individuals appeared and, beginning in 2014, nine and ten-year-old individuals were noted in the catches, which led to positive dynamics within the age composition. The catch is dominated by individuals aged 3+ to 5+ years, accounting for a total of more than 59%. The most productive part of the shoal has been in a stable state for several years. In such circumstances, a target in evaluating the potential for bream production should be a small excess of the fishing over the replenishment process.

The state of commercial pike stocks in the Yesil River can be estimated as satisfactory. In the age structure of the population, individuals today are from 1+ to 3+ years old, accounting for more than 65%. The most productive part of the shoal has been in a stable state for several years. In addition, the dominance of individuals of younger age groups indicates a high pressure on the pike population in the Yesil River. In this situation, the target for the assessment of the possibilities of extraction should be an equality between fishing and replenishment processes.

Seven-year-old individuals appeared in the Yesil River in the age structure of the perch population, starting in 2011 and, starting in 2012, eight and nine-year-old individuals were caught in the catches, which led to positive dynamics within the age composition of the species. The catch is dominated by individuals aged 3+ to 4+ years, totalling more than 52%. The most productive part of the shoal has been in a stable state for several years. In such circumstances, a target in evaluating the possibilities for perch production should be a small excess of the fishing over the replenishment process.

Other secondary fishery objects do not play a significant role here and the pressure on them is quite sparing, bordering on insignificant.

The critical values of the biomass of the commercial stock of the population (or the entire commercial shoal) of fish in the Yesil River were determined on the basis of analysis of the long-term dynamics of the fish population in the reservoir and are equal to the biomass of the year preceding the achievement of the minimum values of fish biomass or the next lowest biomass value (Table 5).

Table 5. Total biomass of commercial fish stocks by years in tonnes.

Years	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Roach	5.58	5.55	5.60	6.33	10.46	8.56	12.95	18.49	11.96	13.39
Bream	4.06	4.03	4.20	7.30	10.88	13.83	15.71	21.04	17.61	13.56
Tench	–	–	–	–	0.88	1.70	3.36	2.31	1.95	2.52
Perch	4.32	4.30	4.40	6.71	11.96	14.60	21.60	29.86	25.93	24.27
Zander	–	–	–	–	–	1.99	3.37	3.03	1.57	3.33
Pike	5.35	5.47	5.10	14.71	11.33	15.87	24.13	48.74	14.66	14.22
Burbot	–	–	–	–	–	–	–	–	1.28	–
Total	19.31	19.35	19.30	35.05	45.51	56.55	81.12	123.47	74.96	71.29

In the period from 2008 to 2010, the biomass of commercial fish stocks was in a stable state and was at a low level during this period. Since 2011, there has been an increase in the commercial fish stock in the river, which lasted until 2015. In 2016 and 2017, there was a decrease in total biomass, probably in connection with the spring overspills of the Yesil River, as a result of which a significant part of the commercial shoal of fish remained in floodplain reservoirs.

Figure 3 shows the fluctuations in the biomass of commercial fish during the period under study and, in particular, a significant increase in 2015 and then a sharp decline in the biomass of the commercial pike shoal. The remaining species of studied fish did not undergo a significant change in the studied parameters.

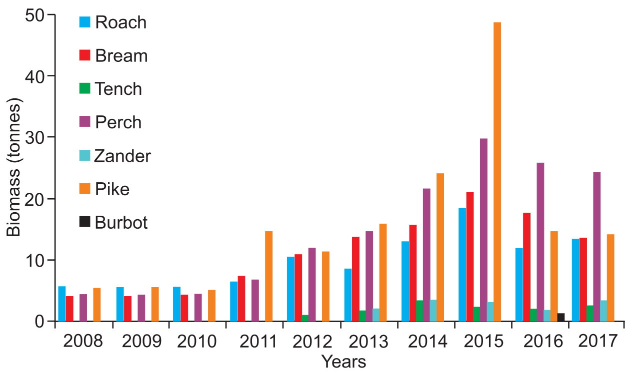

Figure 3. Total biomass of commercial fish stocks in tonnes.

It should be noted that populations of commercial fish stocks increase their biomass quite rapidly (Fediy 1964, Fulton 1906). In some cases, the biomass of the commercial part of the population may increase more than two times in just one year (Schultz 2003).

Table 6 shows the fishing stock for the last two years and the critical values of the fishing stock.

Table 6. The commercial reserve of the Yesil River over the last two years and the critical biomass of the commercial reserve.

Types of fish	Maximum fishing stock (ton)	Minimum fishing stock (ton)	Fishing stock in 2016 (ton)	Fishing reserve in 2017 (ton)	Critical biomass values of the commercial reserve (ton)
Roach	18.49	5.55	11.96	13.39	5.58
Bream	21.04	4.03	17.61	13.56	4.06
Tench	3.36	0.88	1.95	2.52	1.70
Perch	29.86	4.30	25.93	24.27	4.32
Zander	3.37	1.57	1.57	3.33	1.99
Pike	48.74	5.10	14.66	14.22	5.10
Burbot	1.28	1.28	1.28	–	1.28
Total	126.14	22.71	74.96	71.29	24.03

According to population-fishing indicators, the ichthyocenosis of the Yesil River is stable in its main fish species (roach, bream, perch and pike). The indicator of Lin's fishing stock in 2016 approached a critical value, even higher than the last year. The commercial pike perch in the current year was above the critical value; however, this species is recommended to be used only for reproductive purposes.

In accordance with the conducted studies and also taking into account the absence of commercial fishing on the Yesil River, we consider establishing the following list of boundary landmarks: a) $L_{C50} = L_{M50}$; b) critical water content; c) critical biomass values of the fishing stock.

Table 7 shows the list and status of the monitored indicators of the boundary indicators of the state of the fish stocks of the Yesil River.

Table 7. List and status of monitored indicators of the boundary reference points of the state of fish stocks in the reservoir of the Yesil River.

Indicators	Indicator value		
	Type of fish	L_{C50}	L_{M50}
Indicators L_{C50} and L_{M50}	Roach	20.00	12.3
	Bream	20.40	12.8
	Pike	45.40	41.0
	Perch	19.00	12.4
Critical water content	Minimum level (v.Turgenevka)	144.00	
	Maximum level (v.Turgenevka)	159.00	
	Minimum level (v.Volgodonovka)	111.00	
	Maximum level (v.Volgodonovka)	131.00	
Critical biomass values of the fishing stock	Roach	5.58	
	Bream	4.06	
	Tench	1.70	
	Perch	4.32	
	Zander	1.99	
	Pike	5.10	
	Burbot	1.28	
	Total	24.03	

DISCUSSION

For the purpose of assessing the state of fish stocks, developing their approaches to rational management and sustainability of use, research was carried out for the first time in this direction on the Yesil River, which attained the status of a water basin of international significance for the first time in 2016 and 2017.

Studies were carried out at eight stations, the ranking of water content was undertaken, the effect of the hydrological regime on fishery indicators was assessed, boundary reference points were drawn and critical biomass values of the commercial reserve for the population of the main fish species were determined.

Research conducted by scientists of the Kazakh Scientific Research Institute of Fisheries LLP has revealed that 13 species of fish from four families – carp, pike, perch and burbot, live in the Yesil River. Ichthyophagous are represented by the following species: xhtiophags – common pike and common pike-perch; ichthyobenthophagous: common perch, common ruff and burbot; euryphagous – Siberian roach, ide and tench; benthophagous – common minnow and bream. Ordinary stakes, Siberian and silver dace are, respectively, planktophag, planktobentophagous and phyto-benthophagous.

The research conducted in the Yesil River indicates that, throughout the area of the study, the reservoir is a typical perch and roach watercourse, since these species predominate in the ichthyofauna.

The data of our studies indicates that in the riverbed, the roach is one of the most numerous species distributed throughout the water area and occupies various biotopes, serving as one of the main objects of amateur fishing. Bream is an introduced species. The biological characteristics of the bream are not high, which is explained by the low fodder of the Yesil River. Pike is represented by low-productive populations. In the commercial shoals, younger age groups dominate. Perch represents aboriginal populations. Along with the roach, it is the most abundant in the ichthyofauna of the river system of Yesil. Distributed throughout the water area, perch occupy various biotopes and are also one of the main objects of sports and amateur fishing.

The results of our studies indicate that, after comparing pike, zander and bream populations to those of roach and perch, a higher seizure factor of the commercial population may now be applied.

The critical values of the biomass of the commercial stock of the population (or the entire commercial shoal) of fish in the Yesil River vary considerably. Especially large fluctuations in the fishing stock are observed in the pike population. The data indicates a significant decrease in the productive shoal of fish (pike) with significant mass and size classes. Overfishing can undermine the qualitative-quantitative state of the natural, healthy population of these species of fish.

The research data shows dominance amongst peaceful fish, like the roach and amongst predators, such as the perch.

We established, in the course of research, that the water level of the Yesil River was mostly low; in other words, low-water periods were observed. However, over the past four years, the water level of the Yesil River has increased significantly and is now considered as medium- and high-water, which significantly improves the habitat of the ichthyofauna. The reason for the improvement in the state of the environment is the fact that, in Akmola and Derzhavinka Regions in recent years, annual precipitation has increased from 230 to 320 mm, respectively and in winter, the snow cover increases, which favorably affects the flow of the riverbed in the spring. At the same time, we noted that, in 2017, biomass of ichthyofauna decreased due to increasing water level. The bulk of small fish were distributed over estuaries. This is also an indirect cause of the redistribution of ichthyofauna. In the summer, in the coastal areas, there is a large concentration of the food supply for many fish species, in particular roach, perch and, to some extent, bream. Predatory fish approach the coastal zone in the same way, following the fry and other aquatic organisms.

FINAL REMARKS

The analysis of the obtained data showed the dependence of the commercial fish stock in the Yesil River on the average annual water level. For the period from 2008 to 2017, there is a high degree of correlation here and a high level of reliability of the data.

In the range of years investigated, the water content of the Yesil River was generally low (with low-water periods) and only the last four years can it be characterized as medium and high-waters. We consider the level of 144 cm in the area of Turgenevka village and 111 cm in the area of Volgodonovka village to be critical values for the average annual levels. In addition, it should be noted that the critical water content for the Yesil River is also an increase in the water level of more than 159 cm in the vicinity of Turgenevka village and 131 cm in the vicinity of Volgodonovka village.

Critical values of the biomass of commercial fishing stock for the species studied were calculated. Several approaches were used to determine this indicator. Their choice was determined by methodological logic. As a result of this analysis, it was revealed that the situation with commercial reserves in the Yesil River is rare with few exceptions.

It should be noted that the definition of critical biomass of commercial fishing stock was carried out on the basis of available data for 2008–2017. This time interval is clearly insufficient to produce rigid conclusions on quantitative indicators. It is necessary to return annually to their revision for at least the next three years.

The materials obtained can form the basis for the concept of sustainable management of the river's fishery resources.

However, in view of the absence of fishing gear and the prospects for its development on the river, it is hardly possible to propose any specific management measures. The only thing that can be offered is the optimization of water consumption, including the use of alternative sources of water supply and the strengthening of work to save the young from reservoirs separated from the river. To implement the latter, local executive bodies should plan financing.

Recommendations on the strategy of fisheries management include: a) optimization of water consumption (regulation of the water level in the river Yesil); b) strengthening the work to save young fish from reservoirs separated from the river (especially in the years of high water); c) strengthening of control over sport (amateur) fishing.

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