

COMPARATIVE ANALYSIS OF BIOLOGICAL INDICATORS AND SPECIES COMPOSITION OF ICHTHYOFAUNA OF THE NORTHERN PART OF THE AGRAKHAN BAY

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ABSTRACT

The northern part of the Agrakhan Bay plays a major role in restoration of commercial fish stocks in the Tersko-Caspian region of the Republic of Dagestan. Here the natural bioresources of anadromous, semi-anadromous, non-migratory and lake-river fish species are being reproduced, and up to 600 million young fish species are being replenished annually. The article presents comparative data on the current state of natural reproduction of the main fish species, qualitative and quantitative changes in the structure of ichthyofauna that have occurred in this bay. As a result of this study, it has been determined that commercial species such as Caspian kutum, wels catfish, asp and vimba vimba have practically disappeared in the northern part of the bay, while the age and size-weight parameters of other fish species have increased. The reason for this situation is primarily the unfavourable hydrological regime during the spring-summer floods, which does not meet the necessary requirements for fish reproduction.

Keywords: *Northern part of the Agrakhan Bay, ichthyofauna, reproduction, semi-anadromous, non-migratory and lake-river fish.*

INTRODUCTION

The Tersko-Caspian fishery basin is of great importance for the development of Dagestan's fishery industry, as the main natural stocks of commercial fish species are being reproduced and formed here. The northern part of the Agrakhan Bay plays a leading role in the conservation and restoration of natural biological resources. The peculiarity of the northern part of the Agrakhan Bay is the fact that fresh and saline waters mix in this water body, creating favourable conditions for the spawning of anadromous and semi-anadromous fish species. Necessary conditions have been created here by nature itself for spawning migration of spawners, breeding and fattening of offspring to a viable state [5]. Another important factor is that juveniles of anadromous

and semi-anadromous fish are well adapted from an early age to the marine environment where they enter, grow and mature [12]. I.F. Pravdin, famous Russian ichthyologist, noted that the northern part of the Agrakhan reservoir is the best fish nursery in Dagestan, even in comparison with fish farms [15]. The fact that up to 600 million juveniles of semi-anadromous and lake-river fish reproduce in this bay every year confirms his opinion. Due to the high reproductive rate, the ichthyofauna of this water body is dominated by semi-anadromous fish species, such as common carp, common bream, Caspian roach, zander, and among lake-river fish - carassius, common rudd, Northern pike, European perch, and blicca bjoerkna. In recent years, however, some changes in the structure of the ichthyofauna have been observed in the northern part of the Agrakhan Bay,

with a decrease in the proportion of valuable semi-anadromous fish species and an increase in the number of low-value ones. Such changes are caused by a decrease in the efficiency of reproduction during the spawning period of semi-anadromous fish spawners. It is known that the effectiveness of fish stock formation is significantly affected by the hydrological regime during the spawning period, which is determined by the amount of water discharged in the tailrace of the Terek River. Hydrochemical indicators of water, such as oxygen content, pH, nitrogen content, etc., are also important. These indicators directly depend on the condition of hydraulic structures and water supply canals. Nevertheless, the main role in the efficiency of natural reproduction of fish is played by the hydrological regime, which determines the activity of migration of spawners to spawning grounds and the results of spawning. Thus, a favourable hydrological regime increases the migration activity of spawners, improves spawning conditions and extends the fattening period of juvenile anadromous and semi-anadromous fish. Deterioration of the hydrological regime leads to a decrease in the number of juveniles of valuable fish species and an increase in the proportion of low-value freshwater species. In this connection, the hydrological regime during the spawning period, which determines the efficiency of natural fish reproduction, is of great importance for the formation of fish resources in the Tersko-Caspian basin. Therefore, a study of the state of natural reproduction makes it possible to estimate the commercial stocks of anadromous, semi-anadromous, non-migratory, and lake-river fish in the northern part of the Agrakhan Bay [6].

The aim of the research is to analyse the state of natural reproduction and changes in the qualitative structure of the ichthyofauna of commercial fish species that have occurred in the northern part of the Agrakhan Bay.

RESEARCH MATERIALS AND METHODS

The study examined the biological characteristics of the fish population structure, in particular the species composition, age, and size-weight parameters of commercial fish. When catching fish to form ichthyological material for research purposes, we used fixed nets with meshes of 30 to 90 mm, fyke nets (32-36 mm) and small trawls (6 and 10 meters long, 6 mm mesh) [14]. To characterize the biological performance of the fish studied, an average sample consisting of different lengths, weights, and species of hydrobionts was formed. The length of species was measured from snout to scale covering, weight and fatness coefficient of fish was determined on scales BM-20M and PH-50M [3, 10]. The age of commercial fish was determined by scales, according to traditional methodological guidelines [15, 17]. The species composition of fish was studied using identifiers, atlases and annotated catalogues of invertebrates and fishes [1, 2, 7, 9, 11, 13, 17].

RESEARCH RESULTS

The results of hydrological-hydrochemical surveys carried out by season during 2017-2020 indicate that the northern part of the Agrakhan Bay is in a critical condition, there is a sharp drop in water levels due to a decrease in the runoff of the Terek River. As a result, the area of the northern part of the Agrakhan Bay has decreased by almost 1,500 ha in 2020 compared to 2018, and the spawning area has decreased by almost 500 ha. In addition, the efficiency of natural reproduction of fish was reduced due to the fact that there were differences in air and water temperatures during the day and night, which reached 5-80 C, resulting in delayed spawning of some species and increased escape of larvae in the early stages of development [5], especially of anadromous and semi-anadromous fish species, which ultimately affected the biological indicators and species composition of fish fauna in the northern part of the Agrakhan Bay.

In general, the hydrological regime and meteorological conditions during these years were not favourable for the reproduction of some fish species. However, hydrochemical parameters in the Bay are rather good, with water transparency ranging from 0.25 to 0.29 m, oxygen content from 6.4-6.7 mg/l, ammonia nitrogen from 0.03 to 0.07 mg/l, total water salinity is 462-550 mg/l [6].

Higher aquatic vegetation plays a special role in fish reproduction processes as habitat, substrate for spawning, refuge and fattening area for juvenile fish as well as serves as food for phytophilous fish species. However, overdevelopment of aquatic vegetation reduces the fish productivity of a reservoir. It should be noted that whereas in 1964 only 13% of the bay surface was covered by reeds, the current coverage is 60%. The implementation of measures aimed at aquatic vegetation control is extremely important, as they contribute to improving the condition of the ichthyofauna as a whole. For this purpose, in recent years a biological method of vegetation control has been carried out by introducing herbivorous fish, in particular grass carp, into the pond. Its presence helps to create favourable abiotic conditions for fish, significantly improves the food base and, in general, increases the fish productivity of the reservoir.

The hydrobiological study revealed that zooplankton organisms consisted of freshwater forms capable of tolerating significant salinity fluctuations and were represented by 21 species: 7 rotifers, 9 cladocera species, 5 copepods and also euryhaline species were found in the shallow water part of the Caspian Sea. Another important factor is that zooplankton concentrations were seasonal, with the highest biomass occurring during the spawning period and decreasing towards the autumn. The zooplankton community is formed in typical brackish-water conditions typical of the western areas of the Middle Caspian Sea. The favourable development of the foraging zooplankton community for larvae that have switched to active feeding contributes to improved survival and growth rates of the offspring. In 2019, the number of migrating spawners of commercial fish species during the spawning season in the northern part

of the Agrakhan Bay was 767,000, which is 11% less than in 2018. This may be explained by the fact that the mentioned year was marked by offshore winds, which contributed to a decrease in water levels on the spawning grounds. Most of the spawners migrating to spawning grounds were species of vimba vimba, common bream, Caspian roach and crucian carassius. In 2019, as in the previous year 2018, 14 species of juvenile anadromous, semi-anadromous and lake-river fish were registered on the spawning grounds, but the total number of commercial fish species was the lowest in all years of observations at 303 million species, almost a third less than in 2016 [6]. Zander, tench, European perch, blicca bjoerkna and carassius had the highest numbers of

juveniles this year, showing a significant upward trend over the last 2 years. In general, it should be noted that the biological condition of commercial fish species is good, and they retain the necessary potential to reproduce [6].

In 2019, the highest number of juveniles (over 40 million fish) of the studied fish species was recorded for common bream, carassius and common carp, the lowest number (less than 10 million fish) was recorded for blicca bjoerkna and asp, also small number of juveniles (slightly more than 10 million fish) was recorded for Caspian kutum, common rudd and Caspian roach (Table 1).

Table 1. Numbers of juvenile commercial fish species in the northern part of the Agrakhan Bay in 2016-2019

Years	Number of recorded juveniles, mln.															
	Common bream	Common carp	Caspian kutum	Wels catfish	Vimba vimba	Northern pike	Tench	Carassius	Common rudd	European perch	Caspian roach	Zander	Asp	Blicca bjoerkna	Other*	TOTAL
2016	73.2	68.4	30.3	16.9	35.9	30.4	19.4	43.2	16.8	10.3	25.8	14.7	6.9	3.9	-	401.0
2017	60.7	57.6	21.8	14.1	32.2	39.9	18.2	36.8	13.9	11.8	42.6	15.9	6.1	4.2	-	378.0
2018	68.5	55.3	18.2	15.7	33.5	29.8	15.9	37.9	14.6	11.9	44.7	18.8	7.7	5.8	-	386.3
2019	49.9	45.0	10.1	16.9	13.1	26.2	22.8	48.9	11.9	12.8	10.9	25.2	3.9	5.9	2.9	303.0

* Other: grass carp, hypophthalmichthys, ballerus ballerus

A comparative assessment of changes in the number of juvenile fish in the 4 years under analysis shows that in 2019 the total number of juvenile fish decreased by 25% compared to 2016, it should be noted that the reduction in juvenile fish occurred in almost all fish species except tench, carassius and zander, with the largest decreases occurring in young Caspian kutum by almost 3 times, vimba vimba by 2.7 times and Caspian roach by 2.2 times. It is also noteworthy that in 2019, for the first time, young grass carp, hypophthalmichthys and ballerus ballerus were recorded, with a total of 2.3 million species, which were not recorded in previous years. The conducted studies have established that the natural reproduction of semi-anadromous fish species is currently at a relatively low level, which is caused by deteriorating hydrological and hydrochemical regimes and intensive vegetal invasion of the reservoir in the fish spawning areas.

In order to improve the natural reproduction of commercial fish species in the bay, the necessary measures should be taken to improve the hydrological and hydrochemical and ecological conditions during the spawning season [4].

The ichthyofauna in the areas of the reservoir of the northern part of the Agrakhan Bay during the research period was mainly represented by semi-anadromous and lake-river fish. Very seldom, anadromous fish such as Caspian salmon, Stenodus leucichthys and Caspian kutum were encountered. Of the semi-anadromous fish, it can be noted that Caspian roach, common bream and, to a lesser extent, common carp and zander dominated in this area. Lake-river freshwater fish were represented mainly by predators (European perch, Northern pike, wels catfish, zander), and low-value species: common rudd, carassius, blicca bjoerkna, tench, etc., as shown in Table 2. The total stock of commercial fish species for 2017 was 2,900 tonnes, with common bream, common carp and wels catfish having the largest biomass (500 to 320 tonnes), while European perch, tench, Caspian roach, blicca bjoerkna and plant-eating species: grass carp and hypophthalmichthys had the smallest biomass (under 100 tonnes). Small non-commercial fish species, which have dominated the ichthyofauna of the bay in recent years, are of great biological importance as food for valuable species.

Table 2. Forecast of fishing stocks of the main fish species in the northern part of the Agrakhan Bay for 2017

Fish species	Common bream	Common carp	Caspian kutum	Wels catfish	Vimba vimba	Northern pike	Tench	Carassius	Common rudd	European perch	Caspian roach	Zander	Asp*	Blicca bjoerkna	Grass carp*	Hypophthalmichthys*	TOTAL
Number of fish species, thous.	50 1.2	32 0.1	17 8.3	15 6.9	29 8.4	20 5.7	89. 3	40 9.3	10 3.8	69. 7	18 7.8	18 4.2	64. 6	60. 8	27. 2	42.7	29 00
<i>*Note: The stock is determined by calculation</i>																	

Analysis of the population structure of commercial fish in 2020 (Table 3) shows that the qualitative composition of the ichthyofauna was represented by 9 species, of which such fish as common carp, common bream, blicca bjoerkna, Prussian carp, European perch, and common rudd are in satisfactory condition, characterised by increasing numbers of older age categories and good morphometric indicators, such as length, weight, and fatness. Of particular concern are the populations of valuable fish species, such as zander, Northern pike, and Caspian roach. Their main fish

breeding characteristics tend to decrease. This is confirmed by the fact that when analysing the experimental materials obtained, the predominance of younger age groups, low morphometric indicators, as well as fish breeding: growth rate, fatness and insignificant recruitment of offspring were found. It should be particularly noted that such commercial species as Caspian kutum, wels catfish, asp, and vimba vimba were not caught in the Agrakhan Bay, apparently their populations are in a critical condition.

Table 3. Status of the population structure of the ichthyofauna in the northern part of the Agrakhan Bay in 2020

Age (%)	Fish species	European perch	Zander	Northern pike	Caspian roach	Common bream	Common carp	Carassius	Common rudd	Blicca bjoerkna
2		-	8.7	11.2	-	-	-	-	4.1	-
3		2.2	29.8	7.4	18.0	6.6	1.4	5.4	10.8	1.2
4		25.5	47.4	39.6	40.1	9.4	3.9	10.8	29.9	15.0
5		15.4	10.1	16.4	24.4	16.1	9.9	13.2	21.6	15.6
6		18.3	3.2	16.4	12.1	25.7	34.0	10.8	12.2	18.8
7		13.5	0.8	8.5	3.8	22.2	30.5	7.6	7.6	20.6
8		14.4	-	1.5	1.6	12.3	9.6	8.2	5.0	15.6
9		5.0	-	-	-	6.2	6.2	7.6	3.7	8.4
10		4.1	-	-	-	1.5	2.9	14.7	2.4	4.8
11		1.6	-	-	-	-	1.1	8.2	1.8	-
12		-	-	-	-	-	0.5	7.6	0.9	-
13		-	-	-	-	-	-	5.9	-	-
Average age (T), years		6.3	4.3	4.1	4.7	6.2	6.9	8.4	5.7	6.0
Average length (L), cm		25.4	41.6	53.9	19.8	31.0	53.3	28.1	23.5	25.3
Average weight (P), g		555	946	1633	201	607	3050	790	396	379
Fatness coefficient, %		3.23	1.29	1.00	2.23	2.04	2.00	3.31	3.13	2.03

In general, the experimental catches in 2020 were dominated by older fish, whose average age was between 6 and 8 years old was represented by six fish species, the proportion being as follows: common carp - 95%; common bream - 84%; blicca bjoerkna- 84%; carassius (silver carp) - 85%; European perch- 72%. Northern pike, zander, Caspian roach and common rudd represented the younger age groups (3-5 years). Analysis of the weights of caught fish shows that the fish were not large, with an average weight of about 1 kg, and larger fish were recorded for zander, Northern pike and common carp at about 0.5 m in length. Smaller species (around and under 0.5kg) were represented by Caspian roach, common rudd, blicca bjoerkna and European perch, with lengths ranging from 20 to 25 cm. However, the coefficient of fatness was quite high in almost all species, from 2 to 3.2%, except for zander and Northern pike - about 1% (Table 4).

The study of the qualitative structure of hydrobionts in the northern part of the Agrakhan Bay shows (Table 4) that 14 commercial fish species were represented in 2013, the basis of the populations were medium age groups (4-5 years), except for common carp, common bream and carassius, the average age of which was slightly more than 6 years.

The values of the fish weights analysed in 2013 indicate that large fish with an average weight of over 1 kg were represented by common carp (3280 kg), wels catfish (2505 kg), Northern pike (2002 kg), and zander (1071 kg); small fish of 100 to 300 g were represented by Caspian roach, common rudd, and vimba vimba. Almost all of the analysed fish had low fatness values, their coefficient was around or slightly above 1%, except for crucian carassius, common rudd, tench, and European perch.

Table 4. State of the population structure of ichthyofauna in the northern part of the Agrakhan Bay in 2013

Fish species Age (%)	C o m m o n c a r p	C o m m o n b r e a m	C a s p i a n r o a c h	Z a n d e r	W e l s c a t f i s h	N o r t h e r m p i k e	C a s p i a n k u t u m	T e n c h	A s p	C a r a s s i u s	C o m m o n r u d d	E u r o p e a n p e r c h	V i m b a v i m b a	B l i c c a b j o e r n k n a
2	-	-	-	6.4	3.3	8.7	3.0	1.6	1.8	1.3	1.6	-	1.3	-
3	0.6	6.3	17.0	20.3	7.8	18.4	32.7	15.4	16.5	6.6	13.6	7.9	8.9	39.3
4	1.7	9.7	40.3	45.8	42.7	34.3	36.3	39.0	24.9	22.4	40.8	41.3	39.6	25.6
5	15.4	16.3	24.2	19.9	23.5	21.2	20.4	26.2	30.6	17.7	23.5	35.7	25.7	10.8
6	45.9	25.8	12.1	4.8	14.1	11.3	6.1	4.5	11.1	12.4	6.0	7.9	15.8	20.4
7	20.0	22.2	4.8	2.0	5.2	4.2	1.5	3.9	9.4	7.1	5.4	3.6	7.4	3.9
8	10.3	12.0	1.6	0.8	1.7	1.5	-	2.5	4.5	10.4	5.4	2.7	1.3	-
9	4.0	6.3	-	-	1.2	0.4	-	2.0	1.2	7.9	2.1	0.9	-	-
10	1.5	1.4	-	-	0.5	-	-	3.3	-	4.3	1.6	-	-	-
11	0.6	-	-	-	-	-	-	1.6	-	5.6	-	-	-	-
12	-	-	-	-	-	-	-	-	-	4.3	-	-	-	-
Average age (T), years	6.4	6.3	4.7	4.8	4.1	4.5	4.7	5.8	4.8	6.7	4.5	4.6	4.7	4.4
Average length (L), cm	54.1	31.2	20.4	43.1	65.3	57.4	43.2	23.3	37.1	26.1	21.9	22.1	20.2	24.1
Average weight (P), g	3280	561	192	1071	2505	2002	1324	396	808	607	303	338	167	273
Fatness coefficient, %	1.89	1.90	2.16	1.37	0.91	1.06	1.61	2.97	1.52	3.11	2.81	2.81	1.91	1.92

Thus, the performed comparative analysis revealed that quantitative and qualitative changes in the structure of commercial fish populations occurred in the northern part of the Agrakhan Bay in 2020 in comparison to 2013, as

shown by the data presented in Tables 3 and 4. Under current conditions, the number of fish species has decreased, with 9 species recorded in 2020 and 14 in 2013, while the Caspian kutum, wels catfish, asp, and vimba

vimba have virtually disappeared. However, the commercial species of fish caught in 2020 were mostly represented by older groups (6-8 years old), with higher morphometric parameters, with an average weight of 950.8g and a fatness coefficient of 2.3. In the year 2013, the average age of the majority of fish species was lower and was 4-5 years old, weight and size indices were also lower and averaged 813.4 g and the fatness index was lower - 1.9%.

CONCLUSION

The studies carried out have shown that the northern part of the Agrakhan Bay plays an important role in the reproduction of anadromous, semi-anadromous and lake-river fish, which form the basis of stocks of commercial fish species in the Tersko-Caspian Basin of Dagestan. The assessment of natural reproduction efficiency for the four years analysed shows that 2019 was the worst year, as the number of young fish was the lowest in all years of observation at 303 million species. The reason for this was the unfavourable hydrological regime during the spring-summer flood, the water level in the spawning grounds and the duration of standing water level in the spawning grounds which did not meet the necessary requirements for fish reproduction. In addition, the area of aquatic vegetation in the water body under study has increased in recent years, from 13% in 1964 to 64% today. All this contributed to the fact that in 2019, the total number of juvenile fish in 2019 decreased by 25% compared to 2016, the number of juveniles of most fish species decreased, except for tench, carassius and zander; the biggest decreases were in Caspian kutum by almost 3 times, vimba vimba by 2.7 times and Caspian roach by 2.2 times. The stock of commercial fish species estimated for 2017 was 3 thousand tonnes, with common bream, carassius and wels catfish having the largest biomass. European perch, tench, Caspian roach, blicca bjoerkna, herbivorous grass carp, and hypophthalmichthys had the smallest biomass. Lake-river and semi-anadromous fish represented the population structure of the ichthyofauna in the desalinated areas of the bay in 2019. Of the semi-anadromous fish, Caspia roach and common bream dominated in this group, while the share of common carp and zander was insignificant. The lake-river fish can include predators: perch and Northern pike, as well as other less valuable fish species: common rudd, carassius (silver carp), blicca bjoerkna and tench [16]. It was found that the ichthyofauna structure in this bay has changed in recent years, with a reduction in the species composition and the disappearance of commercial species such as Caspian kutum, wels catfish, asp and vimba vimba, but the age composition and size-weight characteristics of other fish has increased. Unfavourable hydrological and hydrometeorological regimes in the spring of 2020 caused by prevailing runoff winds resulted in lower water levels in spawning areas, which negatively affected natural fish reproduction results in the northern part of the Agrakhan Bay.

AUTHORS' CONTRIBUTIONS

The article was written by a team of authors, with all authors contributing equally to the theoretical analysis of the problem and research. Dzhavgarat Ramazanova carried out the experimental research, Ruslan Barkhalov summarized and analysed the results obtained, Natalia Sudakova processed the numerical data of the research results and presented them in tables, Lidiya Vasilyeva wrote and formatted the article in accordance with the requirements.

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