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by L.A. Kuderskiy

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On Fish Resources of the Volga-Kama Cascade Reservoirs

By L. A. Kuderskiy

(State Scientific Research Institute of Lake and River Fish Culture)

As a result of hydroelectric power construction work 92*
in the Volga basin, ten large and medium-sized reservoirs have been created, not to mention the series of lesser ones situated on the small tributaries of the Kama, Oka and Volga and on the upper reaches of the latter. Moreover, in the near future the Cheboksarskoe and Nizhne-Kamskoe reservoirs will come into existence. After their creation the Volga, from Volgograd to its upper reaches, and the Kama, from its mouth to its confluence with the Vishera River, will almost entirely lose their fluvial characteristics and be transformed into cascade-connected reservoirs with a relatively slow flow. Eventually, in conjunction with the plan to transfer part of the flow of the Pechora into the Caspian basin, the

* Numbers in the right-hand margin indicate the corresponding pages in the original.

upper reaches of the Kama River will be regulated as well.

The emergence of reservoirs in the Volga basin with their specific conditions has entailed substantial changes in the composition of fauna and in the processes of production of biological resources in the former river segments. In summation, all of this has had a direct effect on the state of the fishing industry and has given it a number of distinctive features which were absent during the fluvial period.

The Volga-Kama reservoirs constitute a significantly large water resource for the fishing industry. Their total area is equal to 2.3 million hectares (Table 1). With the creation of the Cheboksarskii and the Nizhne-Kamskii hydroelectric power systems it will increase to 3.0 million hectares. In the future, after the construction of the Pechoro-Kamskiĭ hydroengineering complex, the water area of the reservoirs will increase even more.

The Volga-Kama reservoirs are of the shallow (the average depth at normal backwater level (NBL) does not exceed 13.3 m), easily heated type. In most reservoirs sizable areas are occupied by shoals* which constitute the main areas for the reproduction of phytophilous fish, as well as zones for the production of detritus which serves as food for aquatic forage invertebrates. Shoals constitute from

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*In this article shoals has the usual meaning of areas of the reservoirs with depths up to 2 m as measured by НПУ - normal water level. The term "shoal zone" is in need of clarification.

14 to 48% of the water area of the Volga-Kama reservoirs.

The series of major reservoirs of the Volga-Kama basin is located in highly developed agricultural land, which results in biogenous elements entering the reservoirs from the spillways at an increased rate.

Таблица 1

1. Основные параметры волжско-камских водохранилищ 2.(по Антиповой, 1961, и Бахтиарову, 1969)

3 Водохранилище	4 Год начала наполнения	5 Площадь при НПУ, км²	6 Площадь мелководий		9 Средняя глубина при НПУ, м	10 Проектная глубина сработки		13 Среднемноголетний водообмен
			7 км²	8 в % к площади зеркала		11 м	12 в % максимального напора	
14 Иваньковское	1937	327	156	48	3,7	4,5	29	8,6
15 Угличское	1940	249	89	36	4,8	5,5	38	8,9
16 Череповецкое	1963	1670*	171**	45**	3,3**	1,2	9	—
17 Рыбинское	1941	4550	950	21	5,6	4,0	20	1,2
18 Горьковское	1955	1591	396	25	7,0	2,0	11	6
19 Куйбышевское	1955	6448	1035	16	8,9	7,5	26	4,4
20 Саратовское	1967	1830	386	21	6,9	0,0	0,0	17,9
21 Волгоградское	1958	3309	565	17	10,1	3,0	11	7,3
22 Камское	1954	1915	400	21	6,2	7,5	36	4,6
23 Воткинское	1961	1120	159	14	13,3	4,0	17	6

Key to Table 1: 1. Basic parameters of the Volga-Kama reservoirs 2. (according to the Antipova, 1961, and Bakhtiarov, 1969) 3. Reservoir 4. Year in which filling began 5. Area at N B L, km^2 6. Area of shoals 7. km^2 8. in % of surface area 9. average depth at N B L, m m 10. Planned depth of drawdown. 11. m 12. in % of the maximum head 13. Average long-term water exchange 14. Ivan'kovskoe+ 15. Uglich 16. Cherepovets 17. Rybinsk 18. Gor'kovskoe 19. Kuĭbyshev 20. Saratov 21. Volgograd 22. Kama 23. Votkinsk

* Including Lake Beloe

** Excluding Lake Beloe

+Translator's note : Names of reservoirs in this article are Russian adjectival forms derived from the names of towns or cities located near the reservoirs. Wherever possible the name of the city or town has been given in the translation. However, in some cases the adjectival form has been retained due to difficulty in verifying the town name.

This promotes an increase in the overall productivity of the reservoirs. When the reservoirs were being filled, sizable areas were inundated, including productive regions containing large areas of floodplain and tracts of cultivated land; this had a positive effect on the quantitative development of fauna during the early stages of its development.

An increase in the content of ~~biogenous~~ chemical or physical elements in the water of the reservoirs, in comparison with the former fluvial conditions is evident from the data in Table 2.

Таблица 2

1. Изменение содержания биогенных элементов в волжских водохранилищах по сравнению с исходными речными условиями 2 (Денисов и Мейснер, 1951; Зенин, 1965)

3 Водохранилище	4 Сумма минерального азота, мг N/л		7 Фосфор, мг P/л	
	5 река	6 водохранилище	8 река	9 водохранилище
10 Иваньковское . . .	0,07—0,34	0,63—2,27	—	—
11 Горьковское	0,16—0,52	0,06—2,36	0,002—0,005	0,002—0,074
12 Куйбышевское . . .	0,02—0,44	0,04—0,95	0,003—0,018	0,002—0,079
13 Волгоградское . . .	0,02—0,38	0,06—1,29	0,002—0,034	0,001—0,078

Key to Table 2 : 1. Changes in the content of biogenous elements in the Volga reservoirs in comparison with the former fluvial conditions 2. (Denisov and Meisner, 1961; Zenin, 1965) 3. Reservoir 4. Amount of mineral nitrogen mg N/l 5. river 6. reservoir 7. Phosphorus, mg P/l 8. river 9. reservoir 10. Ivan'kovskoe 11. Gor'kovskoe 12. Kuibyshev 13. Volgograd

An abundance of shoals, satisfactory (on the average) temperature conditions, a flow of ~~biogenes~~ biogenic elements from the spillways, a slow water exchange and a number of other positive factors have created favourable conditions for an increase in the biological productivity of the reservoirs compared to the former river segments. The residual biomass of zooplankton and benthos

in the reservoirs exceeds the fluvial indices by a considerable amount (Table 3). Due to this, the forage reserve for food fish has increased substantially. Stocks of forage organisms have increased, not only in calculation per unit of bottom area and volume of water, but also in overall calculation, since the total area of the reservoirs and the volume of their water mass are several times greater than the comparable figures for the river. 94

Таблица 3

1. Остаточная биомасса зоопланктона и бентоса в водохранилищах и исходных речных участках*

2. Водохранилище	3 Биомасса зоопланктона, г/м³		6 Общая биомасса бентоса, г/м²		9 Биомасса бентоса без моллюсков, г/м²	
	4 река	5 водохранилище	7 река	8 водохранилище	10 река	11 водохранилище
12 Горьковское . . .	0,22—0,38	1,0—2,3	—	—	0,92—1,62	1,4—6,4
13 Куйбышевское . .	—	2,3—4,4	4,5—28,5	15,4—144,0	—	4,3—6,3
14 Волгоградское . .	0,98	0,7—3,6	2,91	38,37	0,49	2,61

Key to Table 3: 1. Residual biomass of zooplankton and benthos in the reservoirs and in the former river segments* 2. Reservoir 3. Biomass of zooplankton, g/m^3 4. river 5. reservoir 6. Total biomass of benthos, g/m^2 7. river 8. reservoir 9. Biomass of benthos excluding molluscs, g/m^2 10. river 11. reservoir 12. Gorkovskoe 13. Kuibyshev 14. Volgograd.

* This table has been compiled from the data of the following authors: Aristovskaya, 1970; Belyavskaya, 1965; Mirgorodchenko, 1970; Strugach, 1965; Ustelentseva, 1964; Chernysheva, 1970.

In view of this, the total yield of the reservoirs is, as a rule, several times greater than the yield of the corresponding river segments (Table 4). At the same time, fish production in the waters has increased.

Таблица 4

1. Годовые уловы в речной период и в водохранилищах (тыс. ц)

2 Водохранилище	3 Улов в речной период	4 Автор данных	5 Наибольший улов в водохранилище
6 Иваньковское	0,3	13 Денисов, Мейснер, 1961	8,5
7 Рыбинское	1,0	14 Антипова, 1961	43,0
8 Горьковское	2—3	15 Кожевников, 1965	8,6
9 Куйбышевское	13—19	16 Лукин, 1961	52,7
10 Волгоградское	14—22	17 Яковлева, 1960	29,2
11 Камское	1,0	18 Букирев, Козьмин, Соловьева, 1969	7,0
12 Воткинское	0,5	19 Соловьева, Зиновьев, 1968	3.5

Key to Table 4: 1. Annual yields during the fluvial period and of the reservoirs (thousand centners) 2. Reservoir 3. Yield during the fluvial period 4. Author of data 5. Maximum yield from the reservoir 6. Ivan'kovskoe 7. Rybinsk 8. Gor'kovskoe 9. Kuibyshev 10. Volgograd 11. Kama 12. Votkinsk 13. Denisov, Meisner, 1969 14. Antipova, 1961 15. Kozhevnikov, 1965 16. Lukin, 1961 17. Yakovleva, 1960 18. Bukirev, Koz'min, Solov'eva, 1969 19. Solov'eva, Zinov'ev, 1968.

The phenomenon figuratively described by P. L. Pirozhnikov (1969) as the "bioproductive effect of the headwater" manifests itself in the changes in the content of biogenous elements in the water, and in the levels of biological and fish production of the reservoirs, in comparison with the former river.

In addition to the positive aspects mentioned above, there are a number of features peculiar to the Volga-Kama reservoirs which impede the development of the fishing industry, thereby reducing the effectiveness of the work of this branch. In individual reservoirs there are significant drawdowns of the water level. In the Kuibyshev and Kama reservoirs, in particular, the yearly amplitude of fluctuation of water-level reaches 7.5 m, which constitutes 26 -36% of the maximum head. Water-level conditions unfavourable for the fishing industry often

occur during the spring-summer period which will be discussed in greater detail below. In view of the drawdown of the water level during the latter period, winter killing occurs repeatedly, and which was not the case in the river. High inflow is characteristic of some reservoirs. In the Rybinsk reservoir, designed for flow regulation on a long-term basis, the water exchange equals only 1.2, while in the Ivan'kovskoe, Uglich and Volgograd it amounts to 7.3 - 8.9, and in the Saratov it reaches 17.9. Serious damage is being done to the fishing industry by inadequate coordination of the work of various branches which are 95 exploiting the reservoirs, and, above all, by lack of concern for the interests of the fishing industry on the part of hydroelectric power authority.*

Up to now, the reservoirs created along the Volga and the Kama have acquired considerable significance for the fishing industry. Total yields from them have exceeded by several times the volume of yield from the rivers in the pre-reservoir period. In the years 1961 - 1970, the yield of fish from the Ivan'kovskoe to the Volgograd reservoirs inclusive reached, in individual years, almost 145 thousand centners, averaging 123 thousand centners per year (Table 5).

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*Examining the various factors which determine the effectiveness of the work of the fishing industry, we take as a point of departure a proposal which excludes completely the influence of industrial and domestic sewage on the reservoirs.

Таблица 5

1 Уловы в водохранилищах волжско-камского бассейна (тыс. ц)

2 Водохранилище	1961 г.	1962 г.	1963 г.	1964 г.	1965 г.	1966 г.	1967 г.	1968 г.	1969 г.	1970 г.
3 Иваньковское	4 Нет св.	3,80	3,68	3,75	3,89	3,76	4,00	3,60	2,63	3,10
5 Угличское	" "	1,59	1,69	1,85	1,58	2,33	2,80	2,40	2,50	2,00
6 Череповецкое	—	—	—	0,04	0,38	0,86	1,32	1,07	1,05	1,09
7 Рыбинское	29,75	33,16	38,44	43,85	39,63	33,93	26,60	28,40	25,50	24,93
8 Горьковское	7,58	7,51	8,60	8,15	7,98	4,50	4,90	4,60	4,99	5,60
9 Куйбышевское	39,88	40,72	46,48	52,78	48,34	48,91	46,10	39,50	36,12	40,80
10 Саратовское	—	—	—	—	—	—	—	0,50	0,85	1,78
11 Волгоградское	15,58	20,10	29,24	26,44	21,56	27,06	24,60	27,70	25,02	25,30
12 Камское	5,87	5,35	5,67	6,46	7,02	5,01	5,50	4,50	4,36	3,60
13 Воткинское	—	—	0,50	1,40	2,80	3,30	3,30	3,50	3,29	3,17
14 Всего	—	112,23	134,50	144,72	133,18	129,66	119,12	115,77	106,31	111,37

Key to Table 5: 1. Yield of the reservoirs of the Volga-Kama basin (thousand centners) 2. Reservoir 3. Ivan'kovskoe 4. No information 5. Uglich 6. Cherepovets 7. Rybinsk 8. Gor'kovskoe 9. Kuibyshev 10. Saratov 11. Volgograd 12. Kama 13. Votkinsk 14. Total.

The bulk of the yield of the majority of reservoirs (excluding the Votkinsk, Ivan'kovskoe and Uglich) is made up of valuable fish such as bream, perch and pike. They are proportionately numerous in the Rybinsk, Volgograd and Kama reservoirs. In the years 1969 - 1970 the three species mentioned here, together with catfish and burbot constituted from 61.9 to 82.1% of the total yield (Table 6).

Таблица 6

1 Уловы крупного частика, сома и налима в волжско-камских водохранилищах (в % от общей добычи рыбы)

2 Водохранилище	1969 г.	1970 г.	3 Водохранилище	1969 г.	1970 г.
4 Иваньковское	28,5	19,4	10 Саратовское	33,8	57,8
5 Угличское	6,4	10,0	11 Волгоградское	63,2	62,3
6 Рыбинское	61,9	64,1	12 Камское	82,1	71,9
7 Горьковское	49,1	39,3	13 Воткинское	13,1	12,1
8 Куйбышевское	57,1	51,7			

Key to Table 6: 1. Yield of major small fish, catfish and burbot from the Volga-Kama reservoirs (in % of the total yield. 2. Reservoir

Key to Table 6 (cont...)
3. Reservoir 4. Ivan'kovskoe 5. Uglich 6. Rybinsk 7. Gor'kovskoe 8. Kuibyshev 9. Saratov 10. Volgograd 11. Kama 12. Votkinsk.

The differences in the yield of valuable fish are caused by the typological peculiarities of individual reservoirs as well as by the manner in which the fishing industry is conducted, and by the special nature of its interrelations, in each individual case, with other departments exploiting these reservoirs.

Despite the substantial increase in the yield of the reservoirs compared to the former river segments, the volume of yield attained falls short of the potential fish productivity of these reservoirs and is far from the figures determined by 96
the forecasts (Table 7). The latter depends on a number of causes, both objective and subjective. Of these the following should be regarded as the leading ones:

1) exaggerated predictions of possible fish productivity laid down in the plans;

2) failure to carry out the piscicultural and acclimatization work stipulated in the plans, or the execution of part of it with a considerable delay;

3) water-level conditions in the spring period which do not favour the natural reproduction of stocks of fish;

4) failure to observe the seasonal schedule of water-levels (summer drawdown; winter conditions, excluding the development of destructive phenomena, etc.)

5) insufficient utilization of the stocks of small fish and poor development of the active yield in the open areas of the reservoirs;

6) widespread fish poaching;

7) anthropogenic influences.

Таблица 7

1 Прогнозируемая и фактическая рыбопродукция волжско-камских водохранилищ

2 Водохранилище	3 Улов по проекту		6 Фактический улов, кг/га	
	4 тыс. ц	5 кг/га	7 максимальный	8 в 1970 г.
9 Иваньковское	15	45	26	9,5
10 Рыбинское	70	16	9,6	5,5
11 Горьковское	56	35	5,4	3,5
12 Куйбышевское	240	40	8,2	6,3
13 Волгоградское	175	50	8,8	7,6
14 Камское	25	14,5	3,7	1,9
15 Воткинское	28	25	3,1	2,8

Key to Table 7: 1. Projected and actual fish production of the Volga-Kama reservoirs 2. Reservoir 3. Projected yield 4. thousand centners 5. kg/hectare 6. Actual yield, kg/hectare 7. maximum 8. in the year 1970 9. Ivan'kovskoe 10. Rybinsk 11. Gor'kovskoe 12. Kuibyshev 13. Volgograd 14. Kama 15. Votkinsk

It is necessary to note that recently miscalculations in the prediction of possible yields from the Volga-Kama reservoirs are often exaggerated and cited as the sole reason for the discrepancy between projected and actual fish production. Thus, voluntarily or involuntarily, shortcomings in the exploitation of the reservoirs as bodies of water of complex purpose are underestimated. It seems to us that despite the definite exaggeration of the productivity of the Volga-Kama reservoirs made in the plans, it would be incorrect to explain the generally poor yields by this factor alone. Comparison with several large lakes commensurable with the reservoirs shows that the fish productivity of the reservoirs under

consideration should be much higher than that attained.

In Table 8, data pertaining to the yields of several large lakes in the North-West of the European part of the USSR are provided. By comparing the data of Tables 7 and 8 it becomes evident that fish production in the Volga-Kama reservoirs situated below Rybinsk is considerably inferior to analogical figures for Seliger, Il'men and Pskovsko-Chudskoe lakes and approaches the quantities characteristic of northern lakes such as Beloe, Vodlozero and Syamozero. Such a state of affairs cannot be considered normal. It is indicative of the presence, in the reservoirs, of certain significant deviations in that part of the biological processes which leads to the final link - fish production. Just what these peculiarities are is clearly shown by comparing the yields from the lakes and the reservoirs of biological fish groups such as planktophages, benthophages and predators*. 97

Таблица 8

1 Уловы в больших озерах Северо-Запада *

2 Озеро	3 Площадь, км²	4 Средняя глубина, м	5 Уловы, кг/га
6 Сямозеро	266	6,7	3,5—5,6
7 Водлозеро	334	3,1	6,9—14,8
8 Белое	1125	3,0	4,1—13,0
9 Селигер	222	5,8	14,0—27,5
10 Ильмень	1124	2,6	12,1—32,1
11 Псковско-Чудское	3566	6,9	17,4—34,0

Key to Table 8: 1.Yield from the large lakes of the North-West 2. Lake 3. Area, km² 4. Average depth, m 5. Yield, kg/hectare 6. Syamozero 7. Vodlozero 8. Beloe 9. Seliger 10. Il'men 11. Pskovsko-Chudskoe.

*(footnote for text;footnote to Table 8 on the following page) In addition to the groups of fish listed in the data presented (Table 9), small fish of group III are set apart since it does not seem possible to group them according to species.

*(footnote to Table 8)
Catches taken: from Lake Beloe - from 1939 - 1954; Vodlozero - 1934 - 1957; Syamozero - from 1950 - 1957; from the remaining lakes - 1950 - 1966. In this table data are cited from the following works: Kuderskii, 1969a; Morozova, 1955; Mosevich, 1955; Nikanorov, Nikanorova, 1963; Lakes of Karelia, 1959; Fish Resources of the Leningrad District. 1941; Shirkova, Pikhu. 1966.

Таблица 9

1 Уловы (%) различных групп рыб в больших озерах Северо-Запада и волжско-камских водохранилищах*

2 Водоем	3 Планктофаги	4 Бентофаги	5 Хищники	6 Мелочь III группы
7 Озера				
8 Белое (1939—1954)	43,3	22,6	28,4	5,7
9 Селигер (1951—1962)	30,4	28,5	8,3	32,8
10 Ильмень (1961—1970)	40,3	17,9	24,4	17,3
11 Псковско-Чудское (1950—1959)	38,7	17,1	14,0	30,2
12 Водохранилища				
13 Иваньковское (1962—1970)	—	51,5	4,5	44,0
14 Рыбинское (1961—1970)	12,5	51,3	32,4	3,8
15 Горьковское (1961—1970)	1,5	64,3	29,3	4,9
16 Куйбышевское (1961—1970)	—	37,1	20,6	42,3
17 Волгоградское (1961—1970)	—	48,8	24,2	27,0
18 Камское (1961—1970)	—	66,6	23,2	10,2

Key to Table 9:1. Yield(%) of various groups of fish from the large lakes of the North-West and the Volga-Kama reservoirs 2. Body of water 3. Planktophages 4. Benthophages 5. Predators 6. Small fish of group III 7. Lakes 8. Beloe 9. Seliger 10. Il'men 11. Pskovsko-Chudskoe 12. Reservoirs 13. Ivan'kovskoe 14. Rybinsk 15. Gor'kovskoe 16. Kuĭbyshev 17. Volgograd 18. Kama

*This table is compiled from the laboratory materials of the raw material source of the State Scientific Research Institute of Lake and River Fish Culture and data from the following works: Morozova, 1955; Nikanorov, Nikanorova, 1963; Shirkova, Pikhu, 1966.

As is evident from the data of Table 9, the bulk of the yield from the large lakes is made up of planktophages(smelt, whitefish, zope, etc.) which constitute from 30.4% to 43.3% of the total yield of the body of water. Unlike in the lakes, when there is a commensurable volume of small fish of group III caught in the reservoirs, including a certain quantity of

fish which feed on plankton, the bulk of the catch is made up of benthophages(bream, large white bream, roach, ide etc.). In the reservoirs the specific gravity of these fish in the catch reaches 48.8 - 66.6%. It is lower only in the Kuibyshev reservoir (37.1%) and, even so, considerably exceeds analogical figures for the large lakes. At the same time, in the majority 98
of reservoirs planktophages (zope, smelt, etc.)* are of no importance to the fishing industry. Only in the Rybinsk reservoir do zope and smelt together constitute 12.5% of the total yield, which is considerably less than the specific gravity of planktophages in catches from the large lakes.

It is true that small planktophages(the fry of roach and perch, bleak, the fry of other fish) make up part of the so-called small fish of group III. However, when taking this factor into account, the yield (in %) of planktophages from the reservoirs is considerably lower than that from the large large lakes.

Taking into consideration the correlations between groups of fish differing in their manner of feeding, one can conclude that in the conditions of the Volga-Kama reservoirs, zooplankton is used for the reproduction of fish, mainly through the fry of commercial , small fish of little value and the predators which feed upon them (perch, pike, catfish, etc.)

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*The group of planktophages partially (50% of the yield) includes sichel which has a mixed manner of feeding (plankton and predation).

The shortage of users of zooplankton is naturally corrected to a certain extent. As is generally known, smelt, whitefish and tyulka have begun to actively settle in the Volga reservoirs (Kuderskii, 1967, 1969b). In addition, benthophages come to feed on plankton from time to time. For example, in the conditions of the Kuibyshev reservoir, zooplankton is one of the basic components of the diet of bream measuring up to 20 cm (seldom up to 30 cm) (Egereva, 1964).

Thus, in the majority of the Volga-Kama reservoirs, given the existing ichthyofauna composition, there is a one-sided utilization of food resources. In them, relatively numerous schools of fish consuming benthos have developed, due to the small number of planktophages. In view of this, the food resources of the ground fauna are used quite intensively by the fish. Moreover, there is an urgent necessity to replenish benthofauna because of the acclimatization of new species of invertebrates now taking place in the Volgograd, Kuibyshev and Gor'kovskoe reservoirs. The acclimatization of fish which are users of zooplankton* should be regarded as one of the practicable ways of increasing the fish productivity of the Volga reservoirs. Similar recommendations have been made repeatedly. Proposals to introduce carp into the Volgograd reservoir were made as early as the period of construction when the

*In this article we will not deal with phytoplankton whose residual biomass in the Volga reservoirs is sufficiently high; a more complete utilization of its resouces would also make additional fish production possible.

forecast for the fishing industry was being prepared (Pirozhnikov, 1954), but have still not been implemented.

From the analysis given of the extent of utilization of food resources in the Volga reservoirs, it appears that, in order to increase the fish productivity it is necessary to:

a) enrich the ground fauna at the expense of new primarily aquatic forage invertebrates;

b) reconstruct the ichthyofauna by means of acclimatization of new food fish that consume plankton.

However, acclimatization measures alone cannot resolve the problem of dramatically increasing the productivity of the reservoirs, since the latter is strictly limited by the activities of various sectors of the national economy. In the presence of this, water-level conditions exert a particularly important influence on the reproduction of fish stocks and hence on the fish productivity of the reservoirs.

The influence of water-level conditions on the fishing 99
industry manifests itself primarily in the following three respects:

a) in the spring period the movement of water-levels determines the effectiveness of fish production;

b) in the summer period water-level conditions affect the formation of the spawning substratum of phytophilous fish and determine the entry into the reservoirs of detritus which serves as the basic food for aquatic invertebrates;

c) the winter drawdown influences the wintering

conditions of food fish and forage fauna in the shoal zone.

The winter drawdown of water levels, brought about first of all with the object of producing additional electrical energy in the winter when the demand for it is particularly high and, secondly, in order to prepare the reservoirs to receive spring floodwaters by dropping the water level below the fixed critical marks, has a negative effect on fish stocks. Drainage of the vast shoal zones results in settling of the ice cover in sizable areas. Therefore, in the Kama reservoir in the winter period, ice which has settled to the bottom occupies two thirds of the total area of the reservoir in its summer boundaries (Pomerantsev, 1961). Large areas drained in the winter become covered with ice in the Kuibyshev, Ivan'kovskoe and other reservoirs. This leads to the mass destruction of young fish of various ages in the frozen reservoirs which remain. Moreover, the winter drawdown of the water level and the subsequent freezing of the shoals reduce the forage reserve of the fish, as a result of the destruction of invertebrates settling in the drained zone. Lowering the water level during the winter period also leads to asphyxiation and to the destruction of fish due to an oxygen deficiency (Ivan'kovskoe, Gor'kovskoe reservoirs and others).

In the summer period there is, as a rule, no substantial lowering of water level in the Volga-Kama reservoirs - a factor which has an unfavourable effect on the state of

fish stocks. First of all, due to the lack of a summer drawdown of the water level in the shoals, meadow vegetation is not replenished, which deprives phytophilous fish of their natural spawning substratum (Tyurin, 1961). Secondly, a direct decrease in the number of forage invertebrates can be noted in this instance, The latter is clearly illustrated by B. M. Sebentsov, E. V. Meisner, P. V. Mikheev (1953), using the example of individual Upper-Volga reservoirs:

	5 Без летования мелководий	6 После летования мелководий
1 Биомасса тендипедид, г/м² . . .	3,1	8,4
2 Численность тендипедид, экз/м² .	472	1520
3 Численность *Copepoda*, экз/л . .	8	159
4 Численность *Cladocera*, экз/л . .	28	348

Key to table: 1. Biomass of tendipedae g/m² 2. Number of tendipedae specimens/m² 3. Number of Copepoda, specimens/l 4. Number of Cladocera, specimens/l 5. Without estivation of shoals 6. After estivation of shoals.

Thirdly, the summer drawdown of water levels has an indirect influence on the forage reserve since meadow vegetation developing during the second half of the summer serves not only as a substratum for the spawning of fish, but also as a source of detritus. The entry of detritus from shoals which have become overgrown during the second half of the summer has an important significance in the balance of organic matter in the reservoirs because, as they "age", the reserves of organic matter which have entered the reservoir with the flooding of dry valleys, fields and other land, diminish rather quickly. In view of this, the forage reserve of aquatic invertebrates is reduced and, consequently their biomass

decreases. This effect manifested itself to the fullest extent in the Rybinsk reservoir where, for a number of years, 100 a reformation of ground fauna as well as a reduction in the indices of its development have been noted (Mordukhai - Boltovski, 1957). this did not play a definitive role in the general reduction of the yield which decreased by 18.92 thousand centners or by 43% from the years 1964 to 1970.

In the spring period water-level conditions have a decisive significance for the formation of stocks of food fish. In years when water-levels are high and stable during spawning, productive generations of phytophilous fish appear in the reservoirs. On the other hand, when bench marks are low and there is a fluctuating water level, spawning proves to be far less effective. For the sake of clarity, using the example of the Kuibyshev reservoir, water levels are given in Table 10 for the month of May which determine the appearance of non-productive (1960) and productive (1963) generations of bream.

Таблица 10

1 Уровень воды в Куйбышевском водохранилище у г. Тетюши в период нереста леща (по материалам Татарского отделения ГосНИОРХ)

2 Дата	3 Отметка уровня, м		4 Дата	5 Отметка уровня, м	
	1960 г.	1963 г.		1960 г.	1963 г.
6 11 мая	53,17	53,27	21 мая	52,88	53,87
12 мая	53,18	53,38	22 мая	52,77	53,86
13 мая	53,22	53,49	23 мая	52,71	53,83
14 мая	53,22	53,59	24 мая	52,57	53,76
15 мая	53,33	53,71	25 мая	52,42	53,70
16 мая	53,23	53,80	26 мая	52,25	53,60
17 мая	53,21	53,87	27 мая	52,11	53,52
18 мая	53,17	53,93	28 мая	51,93	53,42
19 мая	53,12	53,87	29 мая	51,82	53,31
20 мая	53,06	53,88	30 мая	51,77	53,27

(Key to Table 10 is on the following page)

Key to Table 10: 1. Water-levels in the Kuibyshev reservoir near the town of Tetyusha during the spawning period for bream(according to the data of the Tatar branch of GosNIORKH*) 2. Date 3. Bench mark , m 4. Date 5. Bench mark, m 6. May 11.

As is evident from the data of Table 10, during the spawning period of bream in the year 1960, between May 11 and 30, the water level fell by 1.4m. However, in the year 1963, water levels were relatively high and stable which resulted in the flooding of large spawning areas and ensured the conservation and the successful development of the fry of bream. As a result, in the year 1960, in an experimental catch of bream using a tuck net for fingerlings, an average of 1.6 were caught in one haul and in the year 1963 - 4.9 or three times as many (Makhotin, 1970).

The example given proves conclusively that the formation of stocks of leading food fish in the Volga-Kama reservoirs is determined first and foremost by the peculiarities of water level (and temperature)conditions in a particular year. The fishing industry is interested in keeping water levels in the reservoirs stable and at high marks during the spring period because sharp fluctuations in water level during the time of reproduction of fish cause drying of the spawning beds. Furthermore, low levels lead to a sharp reduction in spawning grounds which limits the spawning of fish in so far as some of the brood stock are deprived of the opportunity to participate in reproduction.

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* Translator's note:GosNIORKH stands for State Scientific Research Institute of Lake and River Fish Culture.

At present, water level conditions in the reservoirs of the Volga basin still do not ensure the normal, natural reproduction of major food fish. In view of this, it is necessary to plan ways of neutralizing the negative influence of this factor on the formation of stocks of fish. The most radical solution is the optimization of water level conditions for the fishing industry, i.e. the establishment of a schedule of 101 drawdowns of the water level on both a seasonal and daily (in the spring period) basis which would meet the requirements of the fishing industry as stated above. In the conditions of the Volga-Kama basin, observance of the interests of the fishing industry is made considerably easier by the cascade-arrangement of the reservoirs. In order to reduce the damage done by power engineering during such an adjustment of water levels, it is advisable, in the beginning, to fix the optimum levels for the fishing industry in each reservoir two to three times a year, taking into account the water content in each particular year.

Partial compensation for losses due to unfavourable water level conditions can be provided through the effective functioning of spawning and development areas as well as by the utilization of artificial (stationary and floating) spawning beds. In recent years floating artificial spawning beds are being installed in the Gor'kovskoe and Kuibyshev reservoirs in the spring period.

From the brief amount of material presented it appears

that there are ~~preconditions~~ prerequisites for a substantial increase in the fish productivity of the Volga reservoirs. In order to achieve this end it is necessary to undertake a series of measures to improve fish breeding, including the technical improvement of spawning beds, the creation of spawning beds with regulated water levels, as well as artificial spawning beds, the construction of spawning and development areas, and the acclimatization of new species of fish and forage invertebrates. It would be advisable to use the shoal zone for the cultivation of commercial fish and planting material in the separate inlets and drowned estuaries. To ensure the natural reproduction of stocks of valuable fish, it is necessary to implement the optimization of water-levels for the fishing industry, including a summer decrease in water-level. The implementation of a wide array of piscicultural improvement measures together with hydroeconomic and protective measures will help to increase the fish productivity of the Volga reservoirs and the yield from them, bringing these figures closer to the projected ones.

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L. A. Kudersky

ON FISH RESOURCES OF THE VOLGA-KAMA CASCADE RESERVOIRS

SUMMARY

Data are considered on the biological productivity of the Volga-Kama cascade reservoirs, utilization of food supply and catches of commercial fish there in. It is analysed the dependence of the fish production value upon different factors. General suggestions are advanced for increase of fish productivity in the water bodies under consideration.

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