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LOCAL STOCKS OF AUTUMN CHUM SALMON IN THE AMUR BASIN

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The degree to which salmon return to their native streams within the extensive Amur river System is a matter that has not as yet been fully clarified. It is essential that we have knowledge of this, especially now that construction of new fish hatcheries is planned, and also to assist with the further development of salmon fisheries in general. In the Amur, greatest interest attaches to the autumn chum salmon [or keta salmon], whose spawning grounds include a very large portion of the watershed. In just the lower part of the Amur, from the estuary to Khabarovsk, autumn chums enter about 40 rivers for spawning, and among these are such large streams as the Amgun and the Ussuri with their numerous tributaries.

It is necessary that we discover whether the Amur stock of autumn keta is the sum total of a number of smaller stocks, each belonging to a single river or group of rivers within the Amur system. Without marking young fish, a procedure that is not everywhere possible and does not always give completely reliable and verifiable results, a good deal of clarification of the question can be obtained by comparing biological and morphological characteristics of autumn keta in different spawning rivers, as has already been done for sockeye (O. nerka Walb.) and chinook salmon (O. tshawytscha W.) by a number of American investigators (Shmidt, 1947).

In 4 rivers of the Amur basin--the Amgun, Khor, Kur and Bira--suitable materials have been available for several years now. If we have in mind to study the phenomenon of the geographical variation of individual characters, the spatial position of these rivers within the Amur system could not be better for our purpose.

The Amgun River has its origin on the eastern slope of the Burein range and enters the Amur on the left bank, approximately 160 km from the estuary. Its length is 856 km. It is one of the largest rivers of the Far East. The Khor River is a right-bank tributary of the Ussuri, 500 km long. The Ussuri itself enters the Amur on its right bank about 1000 km from the estuary, but its source and that of its right-bank tributaries lies in the eastern division of the Sikhote-Alin mountain range adjacent to the sea of Japan. The Kur River is a left-bank tributary of the Tunguska River, which enters the Amur from the left side, 18-20 km below Khabarovsk. Finally, the Bira River has its source in the northeastern foothills of the Little Khingan range and enters the Amur about 1200 km from the sea. Its length is 250 km.

The principal spawning region of autumn keta in the Bira River basin has always been, apparently, Lake Teploe near its head waters. As is well known, since 1928 [page 159] there has been a fish hatchery there. No spawning fish are allowed into the lake for natural reproduction. The other spawning grounds along the Bira River are almost empty too, according to available data. Therefore we must suppose that at the present time the main mass of keta entering the Bira are produced by artificial means.

The Amgun and Ussuri Rivers and the others are very different in respect to climate and hydrological regimes. Varying quantities of silt enter these basins, there are different amounts of snow and ice cover, and so on (Suslov, 1947); Shostakovich, 1924; and others). We must also observe that in the recent geological past--in Quaternary times--the Amgun River was not a part of the Amur system but was separate from it and had an independent outlet to the sea (Melioransky, 1936).

Table 1. [page 159] Size of autumn keta of the runs of 1949 in the Amgun and Khor Rivers.

River and date	Fork length of body (AC, in cm)		$m_{dif.}$	Number of speci- mens	No. of males (in %)
	Range	$M \pm m$			
Amgun					
30.viii-19.ix	49-82	63.3 ± 0.11	18.7	2000	48.5
Khor					
3.x-25.x	48-84	68.9 ± 0.28	-	369	44.0

We will begin our characterization of the autumn keta which enter these rivers with the morphological characters. First however notice that the quantity of data from the different rivers is in general not the same, but in every case they represent the composition of the stock from the beginning to the end of the run.

First of all we must observe that in respect to average length the autumn keta of one river are rather easily distinguished from those of other rivers, even though length varies within certain limits from year to year. In other words, the size composition of the autumn keta is rather characteristic for each particular river. For example, rather small fish enter the Amgun River for spawning and ascend it almost to the headwaters; while spawners of larger sizes, on the whole, enter the Khor River (and no doubt all other tributaries of the Ussuri) (Tables 1 and 2). It should be observed that the size of the Khor keta is in all probability somewhat understated, since the measurements were taken on the lower spawning grounds, where comparatively small individuals are found (Navozov-Lavrov, 1927).

The autumn keta of the Kur River are of a particularly large size. According to the data of the Amurribvod, the keta

which enter this river are mainly from the schools which return from the sea first, and which are well known to contain the largest fish¹.

We might have expected that in the Bira River, which enters the Amur considerably farther upstream than the Ussuri and Tunguska, we would find even larger fish. In actuality, at the Teploe Fish Hatchery the chum salmon [page 160] are as a rule smaller in average size than those in the Kur and Khor Rivers, and in some years are no different in size from the Amgun chums. It is true that this circumstance might possibly be explained as an unfavourable effect of certain aspects of the fish-cultural process, for example that up to 1950 the young chums were released from the hatchery without any feeding, many of them with the yolk sac still incompletely absorbed. But the fact is important regardless of this.

If we consider that the mouths of the Amgun and Bira Rivers are separated by a distance of 1000 km, it is completely obvious that the length of the journey made by autumn keta up the Amur in no way governs the size of these fish. And the fact that the fish from the Kur and the Khor Rivers exceed those entering the Amgun and Bira to a different degree, indicates that each of these rivers produces its own local stock of autumn keta. The data on fecundity in these rivers also supports this (Table 3).

As we might have expected, the Amgun females on the average are less fecund than the Khor females. But among the Bira females, even in years when they are not any larger than the Amgun females, contrary to all expectation the average fecundity is considerably higher: it is the same as among fish of the Khor River.

It appears that the keta in these rivers also differ from each other in number of eggs per unit of body length. In the Bira River this number is considerably higher than in the Khor, and the latter in turn is higher than in the Amgun². Evidently

¹On the Amur 3 successive runs [podkhody] of autumn keta are distinguished. In the Kur River only the first two are well represented; the last run, in which the smallest individuals occur, is for some reason very weak [there].

²We cannot compare the number of eggs per unit weight of females, that is, the relative fecundity, because the fish in question are already considerably reduced in weight as a result of their long spawning fast and the demands for energy during their ascent to the places of spawning. For the same reason nothing can be said about weight of the fish in these various rivers.

Table 2. [page 160] Average fork length (AC in cm) of autumn keta in the estuary and in various tributaries of the Amur, in 1948-1953.

Year	Amur estuary (Ozerpakh)		Amgun (village of Sergia- Mikhaïlovskoe)		Khor (Georgiev and Amban spring creeks)		Kur		Bira (Lake Teploe)	
	Mean length	No.	Mean length	No.	Mean length	No.	Mean length	No.	Mean length	No.
1948	67.4	3622	65.9	540	67.1	387	74.0	?	66.3	127
1949	66.1	2424	63.3	2000	68.9	369	78.0	435	63.7	1752
1950	66.2	5150	65.1	1416	69.1	108	72.3	300	63.4	800
1951	66.2	2475	63.3	403	71.4	415	72.7	350	65.8	989
1952	69.1	1827	65.4	412	70.6	345	75.0	?	67.5	1000
1953	66.9	1770	63.3	551	67.9	100	70.4	101	64.8	1008
Σ	67.0	17268	64.4	5322	69.1	1724	73.7	-	65.3	5676

this means that at any given length the females from the Bira and Khor Rivers contain smaller eggs than females from the Amgun. Also, Bira keta have eggs of especially small diameter, which apparently permits these fish, in spite of their small size, to maintain their fecundity at the level that is necessary for adequate survival of their progeny.

Table 3. [page 161] Fork length of females (AC in cm) and fecundity of autumn keta in various Amur tributaries¹.

Year	Amgun		Khor		Kur		Bira	
	Length in cm	No. of eggs	Length in cm	No. of eggs	Length in cm	No. of eggs	Length in cm	No. of eggs
1946	-	-	64	2946	-	-	65	3657
1947	-	-	70	3900	-	-	65	3589
1948	-	-	67	3800	-	-	65.2	3726
1949	62.8	3166	69.4	3734	-	-	63.3	3755
1950	63.4	3295	69.1	?	70.2	4293	63.9	3540
1951	62.1	3120	70.7	3870	-	-	65.5	3832
1952	64.7	3450	70.7	3701	-	-	66.7	3815
1953	62.1	3325	66.9	3781	-	-	63.5	3428
Average	63.0	3258	68.5	3676	-	-	64.8	3668
No. of eggs per cm of length	-	51.7	-	53.7	-	61.1	-	56.5

¹Materials used are as follows: for the Amgun River--our own; for the Khor up to 1949--data from the local Amurribvod Station, and after 1949, from the same station and from V. Ya. Levanidov; for the Kur River--the Amurribvod Station; for the Bira River--partly our own data (1947, 1949), partly from the Teplov Hatchery (1946, 1948), and since 1950 from V. Ya. Levanidov. Since 1949 fecundity has been determined for 858 fish on the Amgun, 325 on the Khor, and 381 on the Bira.

[page 161] It is evident also that the size and fecundity of the autumn keta in each river varies independently from year to year. In the Amgun these variations have a clear pattern: in even-numbered years the length and fecundity of the fish rises, and in odd-numbered years it falls.

More careful inspection shows that in actuality the increase and decrease of the qualitative characteristics of the Amgun autumn keta have a four-year cycle, and this corresponds to the customary maturation of the main mass of the keta in each generation in their fourth year of life. Inasmuch as nothing similar is observed in the Amur estuary and in other rivers in these years, and inasmuch as it is known that the variations in length and fecundity of keta from year to year are to a considerable degree caused by non-uniform strengths of its year-classes, we may conclude that in the Khor and Bira Rivers the dynamics of reproduction of autumn keta is not the same as in the Amgun.

The age composition of autumn keta in these rivers is apparently more or less uniform. In any case a situation where a larger quantity of young individuals entered some tributaries of the Amur, and a larger number of old individuals entered others, has apparently never been observed. For example, in the Amgun the percentage of the different age groups of keta is almost the same as in the Khivanda River, which enters the Amur 300 km farther upstream and on the opposite shore. And in both rivers it is little different from the percentages which we observed in the Amur estuary. At all 3 points the fourth-year group predominates to almost the same extent (Table 4), but the size of the autumn keta in the Amgun and Khivanda Rivers is different (Table 5).

Table 4. [page 162] Age composition of autumn keta of the 1948 runs (in %).

Place of capture	Age groups				Number of fish
	2+	3+	4+	5+	
Amur estuary	5.8	70.4	23.8	-	650
Amgun River	1.8	76.3	21.5	0.4	224
Khivanda River	4.0	72.0	24.0	-	100

[page 162] I do not have any data on the age of the Khor and Bira keta¹, but the fact that they are larger than the Amgun keta does not in any way indicate that they are older

¹The trouble is that the chums arrive in these rivers in a very late stage of nuptial development characterized by deep imbedding of the scales in the body, and as a result it is not possible to take samples for age determination.

Table 5. [page 162] Size of autumn keta of the 1948 runs.

Place of capture	Fork length (AC, in cm)			Number of fish	Number of males in %
	Range	M+m	m dif.		
Amgun River	57-81	65.9±0.17	9.3	540	38.0
Khivanda River	54-81	68.6±0.23		367	28.0

also. In support of this there is the following fact. In 1951 when the superiority in size of the Khor over the Amgun autumn keta was especially marked in the spawning stocks, the following relative numbers of the age-groups were observed among autumn keta taken from the Amur estuary: 3rd-year fish (2+)--0.3%, 4th-year (3+)--98%, and 5th-year (4+)--1.7% (1050 scale samples were examined, collected throughout the whole run). Thus the autumn keta of the 1951 runs were almost all the same age. Obviously there can be no question that the 3rd-year or 5th-year fish might predominate in some particular spawning river, or even be represented by a moderately large number of individuals. It is evident that in all three of the Amgun, Khor and Bira Rivers there must have been a predominance of individuals of the same age category--4th-year fish. Hence their lack of uniformity in length must be a result of differences in rate of growth. Thus it is certain that in this respect the Amgun autumn keta are considerably inferior to those of the more southern tributaries of the Amur, even so close a one as the Khivanda River¹.

[page 163] So the rate of maturation of the autumn keta in all the rivers under study is undoubtedly the same. Therefore we may now list the following morphological characters which may be used to decide on the presence of local stocks of autumn keta and distinguish them one from the other:

- 1) rate of growth and size of the fish.

¹From the mouth of the Amur to the Khivanda is about 450 km, while to the Amgun River it is no more than 160 km. However the Khivanda is a river only 60 km long, while the main mass of autumn keta swim up the Amgun for a distance 8-9 times greater. This once again indicates that the occurrence of the smaller keta in the Amgun is in no way to be explained by any inability of the small fish to ascend higher up the Amur, whether to the Khivanda or to more distant rivers. It is simply that the Amgun has associated with it this stock of comparatively small slow-growing autumn chum salmon.

- 2) fecundity and number of eggs per unit length of the females.
- 3) size of the eggs in fish of a given length (hypothetical).
- 4) the nature of the variation in length and in fecundity from year to year.

In addition to these, certain purely morphological features characterize each stock. This is indicated by numerous measurements of autumn keta which I made along the lower reaches of the Amgun and Ussuri Rivers and at the Teplov fish hatchery during the autumn of 1953. Of course I had to work with fish which had already developed rather pronounced nuptial dress. This made it necessary for me to restrict the measurements to females only, in which the form of the body scarcely changes even when breeding dress is well developed. In the Ussuri and at the Teplov hatchery the fish were coloured somewhat more brightly than in the Amgun, since they had made a longer journey through fresh water.

Table 6. [page 163] Average length (in cm) and age composition (in percentage) of the fish measured.

Place of capture	Length of the trunk (<u>cm</u>)	Age groups (in %)			Number of fish
		2+	3+	4+	
Amgun River	48.3	-	86.7	13.3	30
Ussuri River	47.2	8.3	91.7	-	24
Bira River (L. Teploe)	47.9	?	?	?	30

The condition of the gonads was also studied. In the Amgun females the eggs were mainly in the III-IV stage of maturity, a few in stage III; the Ussuri fish were in stage IV, and the Lake Teploe fish were running. As we shall see below, such differences in the biological condition of the fish not only do not prevent a comparison, on the contrary they are even very opportune.

Inasmuch as during the breeding period the skeleton of the head undergoes some change even among females, in addition to the fork length of the fish it was necessary to measure the length of the trunk and use it as the basic index of size of the fish. Of course it was also necessary to avoid the various

measurements of the head itself, except for its depth through the occiput, and in general to shorten the schedule of measurements considerably.

I attempted to study fish of approximately uniform size and age composition from three rivers, and to a considerable degree I was successful, since both in the Amgun and in the Ussuri 4th-year fish predominated (Table 6).

As is evident from Tables 7, 8 and 9 the autumn keta from the Ussuri and Bira Rivers were markedly different from the Amgun fish in a number of characters. Above all, in the Ussuri and Bira keta, in spite of their more advanced nuptial dress and more mature sexual products, the body and the head were considerably more slender than in keta from the Amgun.

[page 165] I had already called attention in 1946 to the slimness of the Bira keta, but did not attach enough importance to it. If we compare them with autumn keta captured in the Amur estuary in respect to greatest depth of the body, we discover that among fish that go upriver as far as the Teplov hatchery a completely transformed "humped" male with big teeth has a body which is no deeper than males which have only just arrived in fresh water and have not yet lost their streamlined marine body form and silver colour. Among females from the Bira River which were ready for spawning, the body was more slender than in silvery females from the Amur estuary having immature sex products of only half the weight (Table 10).

Very recently, on the basis of measurements made in the Amur estuary L. D. Grigo (1953) discovered a number of morphological characters which distinguish the autumn keta as a whole from Amur summer keta. Among other things, in the autumn keta the body is relatively more slender than in the summer keta.

[page 166] However this peculiarity does not characterize all autumn keta, but apparently only the main mass of them which, as is well known, ascend the Amur considerably farther upstream than the Amgun River. In the Amgun, autumn keta cannot be distinguished from summer keta by the depth of the body (Table 11).

It is possible that in the Amur basin there are two varieties [raznosti] of autumn keta--a deep-bodied type characteristic of the Amgun, and a slender-bodied, elongate type whose region of reproduction comprises the rivers that enter the Amur farther south including the Ussuri and its tributaries, and the Bira. But this is only a provisional hypothesis. Clarification of this question will require supplementary data concerning other rivers, those which enter the Amur between the Amgun and the Ussuri.

Local stocks possessing the distinguishing feature of a given variety, and which are one of its components, can

Table 7. [page 164] Comparison of the relative size of certain morphometric characters of autumn keta of the rivers Amgun, Ussuri and Bira (Lake Teploe).

Characters	Range			Averages ($\bar{M} \pm m$)			^a m dif		
	Amgun	Ussuri	Bira	Amgun	Ussuri	Bira	Amgun- Ussuri	Amgun- Bira	Ussuri- Bira
As % of length of trunk									
Depth of head through occiput	20.4-25.7	19.2-22.8	18.6-22.8	22.6 $\pm$ 0.20	20.7 $\pm$ 0.20	20.7 $\pm$ 0.20	6.8	6.8	0
Greatest depth of body	30.7-36.8	27.9-33.9	27.1-33.8	33.7 $\pm$ 0.27	30.2 $\pm$ 0.33	30.2 $\pm$ 0.32	8.4	8.5	0
Least depth of body	8.8-10.5	8.5-10.3	8.1-10.5	9.7 $\pm$ 0.09	9.3 $\pm$ 0.09	9.2 $\pm$ 0.11	3.1	3.6	0.7
Length of caudal peduncle	20.2-23.5	19.8-23.5	21.0-25.7	21.5 $\pm$ 0.15	21.8 $\pm$ 0.19	22.6 $\pm$ 0.18	1.2	4.8	3.4
Length of dorsal region of caudal peduncle	14.2-18.3	14.7-17.8	14.7-19.1	16.4 $\pm$ 0.14	16.7 $\pm$ 0.19	17.2 $\pm$ 0.19	1.2	3.2	1.8
Length of ventral region of caudal peduncle	14.4-18.5	14.4-19.4	15.8-18.9	16.5 $\pm$ 0.15	16.8 $\pm$ 0.24	17.1 $\pm$ 0.12	1.1	3.2	1.1
Length of base of dorsal fin	12.2-16.9	11.8-15.7	11.0-16.6	14.3 $\pm$ 0.19	13.7 $\pm$ 0.18	12.8 $\pm$ 0.19	2.5	5.7	3.3
Height of dorsal fin	15.4-22.1	15.9-21.5	15.7-20.9	19.0 $\pm$ 0.26	18.2 $\pm$ 0.28	17.5 $\pm$ 0.19	2.1	4.6	2.1
Length of ventral fin	13.2-17.9	13.9-17.3	13.3-16.8	15.7 $\pm$ 0.19	15.2 $\pm$ 0.15	14.6 $\pm$ 0.14	2.1	4.6	3.0
Length of ventral fin, as % of distance from anterior edge of ventral fin to anal fin (VA)	55.2-76.6	55.0-77.4	55.3-67.9	65.7 $\pm$ 0.91	64.1 $\pm$ 0.95	62.5 $\pm$ 0.65	1.2	3.3	1.4
Least depth of body, as % of length of ventral portion of caudal peduncle	48.8-67.1	46.4-65.3	45.9-63.9	58.2 $\pm$ 0.89	55.4 $\pm$ 0.87	53.5 $\pm$ 0.80	2.2	3.9	1.6

^a [Difference divided by standard error of difference]

Table 8. [page 165] Greatest depth of the body as a percentage of the length of the trunk, in autumn keta of age 3+ in the Amgun and Ussuri Rivers.

Place of capture	Range	M±m	m ² dif.	Number of fish
Amgun River	30.7-36.8	33.6±0.27	-	26
Ussuri River	27.9-33.9	30.0±0.31	8.6	22

Table 9. [page 165] Relative height of the body of autumn keta of the same size in the Amgun, Ussuri and Bira Rivers.

Place of capture	Length of trunk		Depth of head through occiput	Greatest depth of body	Number of fish
	Range	Mean	As % of the length of the trunk		
Amgun R.	47.5-48.4	48.0	22.7	34.1	7
Ussuri R.	47.5-48.3	47.9	20.7	30.2	7
Bira R.	47.4-48.4	47.9	20.5	29.4	10

Table 10. [page 165] Depth of the body of autumn keta of the 46 runs in the Amur estuary and in the Bira River.

Place of capture	Sex	Weight of gonads (g)	Length of trunk (cm)	Greatest depth		Number of fish
				Mean (cm)	As % of length of trunk	
Estuary (Ozerpakh)	Males	-	47.8	16.0	33.5	1071
	Females	251	47.1	14.9	31.5	1038
Bira River (L. Teploe)	Males	-	47.9	15.9	33.2	123
	Females	525	47.9	14.1	29.4	177

Table 11. [page 166] Relative depth of the body of summer and autumn chum salmon.

Place of capture	Greatest depth of body (as % of length of trunk)		Number of fish
	Range	$M \pm m$	
Autumn keta:			
Bira River	27.1-33.8	30.2 ± 0.32	30
Ussuri River	27.9-33.9	30.2 ± 0.33	24
Amgun River	30.7-36.8	33.7 ± 0.27	30
Amur estuary	27.2-34.3	31.6 ± 0.19	60
Summer keta:			
Amur estuary	31.1-37.0	33.7 ± 0.21	60

nevertheless also exhibit various other morphological peculiarities that will distinguish one stock from another. The Ussuri keta are distinguished morphologically from the Amgun keta only by the lesser depth of the body and head, but the Bira keta are distinguished, in addition, by the smaller size of their dorsal and ventral fins and the greater length of the caudal peduncle; this last character twiflxchange in magnitude; the more anterior is the position of the anal fin. In such features as the length of the caudal peduncle along the lateral line, the length of the pelvic fins and the length of the base of the dorsal fin, the Bira autumn keta also differ from the Ussuri keta--but not as much, to be sure, as from the Amgun keta.

There are also characters by which the Bira keta differ equally from the Amgun and Ussuri keta. It is true that the differences in these cases are weak-- m_{dif} is less than 3, but nevertheless they exist. For example, as a percentage of the length of its base (which latter is identical in keta of all three rivers¹) the average height of the anal fin is 82.8 ± 1.27 , 82.9 ± 1.1 and 80.2 ± 1.05 among the Amgun, Ussuri and Bira keta respectively; the least depth of the body, also expressed as a percentage of the length of the anal fin base, averages 62.3 ± 0.69 for the Amgun, 62.4 ± 1.24 for the Ussuri, and 59.8 ± 0.8 for the Bira.

Judging by the size of the errors, the number of fish I measured was clearly insufficient to demonstrate conclusively the existence of differences in these two characters.

¹In the Amgun it averages $15.4\% \pm 0.15$ of the length of the trunk, in the Ussuri 15.0 ± 0.23 , and in the Bira 15.4 ± 0.17 .

But this has no real importance for our conclusions. [page 167] I have made no attempt, and indeed it is impossible, to explain in detail how autumn keta of the various Amur tributaries differ from each other morphologically. This objective could be achieved only if the opportunity arose to take measurements of keta of all the various local stocks in the sea or in the Amur estuary, that is, before they transform to the breeding condition. Then, presumably, it would also be possible to clarify the nature of certain other local morphological peculiarities of this salmon.

For the present, the only thing that I have had in mind is to show:

1) that between the autumn keta of different rivers of the Amur system there can be, and there actually are, very considerable morphobiological differences;

2) that such differences exist even between local stocks of autumn keta that are close neighbours;

3) that not only in respect to morphobiological characters, but also in a number of morphological features, the Amgun autumn keta differ from those of the Ussuri and Bira Rivers more importantly than the stocks of the latter two rivers differ from each other.

The facts presented above seem to demonstrate this clearly.

It is no less clear that all these differences are to be explained primarily by differences in the physiographic conditions existing in the spawning areas occupied by autumn keta. However, much remains to be learned before we can answer the question of what exactly is the cause of a particular morphological feature of the autumn keta of a particular local stock.

It is permissible, I think, to hypothesize that depth of body in autumn keta is associated with the length of river migration which they perform. But to prove this we should first have to examine the situation for autumn keta of other rivers, those entering the Amur below the Amgun, between the Amgun and the Ussuri, and above the Bira. In respect to such characters as the greater or lesser length of the caudal peduncle and of the dorsal and anal fins, the length of the ventral fins, etc., it can scarcely be doubted that here specific hydrological conditions of the spawning rivers are involved (gradient of the channel, depth and speed of the current on the spawning grounds, etc.). It is possible that the depth of the body, too, is related to these conditions. However we must discover the concrete causal connections. All this is a matter for future investigations.

As for the difference in size between autumn keta of the

Amgun and of the more southern Amur tributaries, it seems to me that we cannot understand the cause of this until we have settled the question of genetic relationship of the Amur chum salmon to the chums of neighbouring regions of the Far East. In fact, this question is the subject of some observations in the following section of the present article.

Autumn chum salmon and the former
geography of the Amur system

Outside the limits of the Amur River system autumn keta are distributed, as is well known, in rivers of the Maritime Province south to the Korean border, in the rivers of Sakhalin, and on the Island of Hokkaido. Apparently only autumn chum salmon occur on the Japan Sea coast of south Sakhalin and in Aniva Bay, in the southern rivers of the Maritime Province region, in the Tumen-Ula River and on Hokkaido (Berg, 1948; Dvinin, 1952). It is interesting that in the Amur basin the greater part of the autumn keta enter the more southern rivers, that is, the Khor, Bikin, Iman, Ulakhe and Daubikhe Rivers which are tributaries of the Ussuri; also the Khungari, Anfuï and Tunguska Rivers, the Bira, the Bidzhan, and others.

[page 168] It is true that there are also autumn-spawning chum salmon in the northwestern rivers of the Okhotsk Sea and in other northern regions of the Far East, for example the Manok on Kamchatka (Abramov, 1948), but these fish are scarce, and it is in no way appropriate to give them the name autumn keta. The principal form of keta there is the summer keta, as L. S. Berg has shown.

The autumn keta of the Amur, Maritime Province and Sakhalin are considerably larger chums than those of the remaining regions of the Far East. Following I. I. Kuznetsov (1937), it is appropriate also to consider that the Amur autumn keta exceed the autumn keta of the rivers of the Maritime Province and Sakhalin in size. Actually, according to Kuznetsov the Amur fish reach an average length of 73.7 cm, the Maritime Province fish 70.1 cm, and the Sakhalin fish 65.1 cm. However it is necessary to correct a vexatious error.

As Kuznetsov (1928) himself shows, he obtained an average length for Amur autumn keta from 2564 specimens taken not in the Amur estuary, but mainly in the following spawning rivers: Anfuï [or Onfuï] and Khungari, Tunguska, Bira, Bidzhan, Khor and Iman. These are those southern tributaries of the Amur to which the largest autumn keta go. It follows that Kuznetsov exaggerated the length of the Amur autumn keta.

In addition, in his 1937 work Kuznetsov compares the

average weight of the Amur and Tumnin autumn keta. The former appeared to be heavier than the latter by only 100 g, which is understandable if you consider that in the one case he was handling chums which had only just entered the Data Bay from the sea, and in the other it was fish already much exhausted by their ascent up the Amur.

In addition, Kuznetsov used materials collected in different years for the comparison--1930 for the Tumnin River, and 1925-26 for the Amur. However, there are later data by E. A. Lovetskaiā taken in the year 1929 for the Amur estuary (Puir), from which it appears that at that time the average length of the Amur autumn keta did not exceed 68.7 cm--they were smaller than the Tumnin keta (Lovetskaiā, 1948).

Unfortunately collections of biological materials from anadromous salmons of the Maritime Province rivers have as yet been made only sporadically. At the present time we have data on the size of Tumnin autumn keta only for 1948 and 1949 (materials collected by A. F. Pushkareva). In the runs [podkhody] of both years the average length of the fish was exactly the same, and was almost the same as in 1930--69.7 cm. In the same two years the average length of the south Sakhalin autumn keta was 67.1 cm (Dvinin, 1952), while the Amur keta measured 66.8 cm, according to observations in the Amur estuary.

We can, however, compare the autumn keta of the Amur and the Sakhalin rivers over a longer period of time. In 1946-1949 their average length on Sakhalin varied from year to year within the range 64 to 69.6 cm, and in the Amur estuary it varied from 65 to 66.1 cm (Birman, 1951). The average sizes for the whole period were 66.1 and 65.7 cm, respectively.

From these various figures we can only conclude that in all three regions the size of the autumn keta is very similar. Apparently this indicates that the autumn keta of the Amur, the Maritime Province and Sakhalin have a uniform congenital capacity for growth, and that foraging conditions permit the realization of this capacity. The feeding grounds of the Amur, Sakhalin and Maritime Province autumn keta, in all probability are in the same region.

For this there are very important historical reasons. G. U. Lindberg (1953) believes that during the phase of antepenultimate regression of the sea, which apparently preceded the onset of the Quaternary period, during^{the} antepenultimate transgression which followed it and which marked the beginning of Quaternary time, and during the subsequent penultimate regression phase the Amur [page 169] still flowed into the region of the present Strait of Tartary [by the channels] to-day occupied by Lakes Kadi and Kizi; and during this regression phase it [the Amur] continued far south into the Sea of Japan, including in its system all the rivers of the Maritime Province, western Sakhalin and Western Hokkaido.

That the Amur formerly actually did flow into the Strait of Tartary by way of the valleys and basins of the present-day Lakes Kadi and Kizi has been shown beyond question by V. A. Melioransky (1936) on the basis of certain orographic and hydrographic characteristics of the surrounding region. The submerged valley of the Paleoamur can be followed rather easily along the bottom of the Strait of Tartary (Lindberg, 1946).

Thus in the not distant past the Amur, Sakhalin and Maritime Province varieties of autumn keta were not isolated from each other, but their entire spawning region lay within the confines of the single Paleoamur River system, and naturally they had common feeding grounds. This identity of feeding grounds was preserved, apparently, even after the Amur became a river of the Okhotsk Sea.

The Japanese authors Siro Kawakami and Siorai Yokoyama (1932) believe, for example, that keta go to the Amur and to the rivers of the Maritime Province from one and the same region of the sea, namely from the waters of the Pacific Ocean which lave the shores of Hokkaido. The likelihood of this is supported by the following circumstances. When, as a result of a small tectonic upheaval in the region of Lakes Kadi and Kizi, the approach to the Strait of Tartary was closed to the Amur, the whole mass of Amur water was turned to the north and flowed through the channel of the Amgun River into the territory of the Sea of Okhotsk; then, rounding the tip of Sakhalin, it flowed along its eastern coast southward to the ocean, which it reached somewhere near present-day Hokkaido.

This is the way that Lindberg pictures the direction of the Amur at this epoch, on the basis of resemblances in the fauna of typically freshwater fishes of the Amur and of the Sakhalin rivers Tym and the Poronai. In fact, even in our own times the main mass of the Amur water turns in the same direction after going out into the Sea of Okhotsk by way of the Gulf of Sakhalin. According to S. O. Makarov (1894), in waters along the eastern coast of Sakhalin the influence of the Amur is felt down to 25 metres' depth.

We must assume that these mighty streams of Amur water spreading to the southern boundaries of the Sea of Okhotsk, and the track of the underwater valley of the former Paleoamur River, provide some sort of means for orientation, by the use of which the Amur autumn keta find their return route from the ocean to the continental river. It is the same route that they travelled in the past, before the appearance of the Sea of Okhotsk, but then it lay along the now buried portion of the Paleoamur¹.

¹The development of the Sea of Okhotsk considerably shortened the length of the river migration of the Amur keta, and lengthened the sea migration as a result, but their feeding

Finally, V. K. Soldatov (1912) was the first to point out that in the Amur estuary there are occasionally found some specimens of chum salmon with fish hooks of a kind used for catching other fish on [page 170] the eastern coast of Hokkaido. For example, one such specimen of autumn keta was taken in 1951.

In a word, the agreement in size between Amur autumn keta with autumn keta of the rivers of the Maritime Province and Sakhalin is a result, in my opinion, of the fact that these keta were one during the past history of the Paleoamur system of the Japan Sea area, and since the breakup of this river system they have maintained a common feeding ground and consequently uniform conditions for growth.

It is necessary however to take into consideration that among the present rivers of the Amur basin only those which enter the Amur above Lake Kizi belonged to the Paleoamur. At the time of which we speak the Amgun River had its own independent channel through the region which later became covered by the waters of the Sea of Okhotsk (Melioransky, 1936), and it was evidently connected with other northwestern rivers of the same region and in all probability had its own local stock of keta of the Okhotsk variety [raznost].

At the same time, we must bear in mind that the size composition of Amur autumn keta as observed by measuring them during their migration through the Amur estuary is an amalgam of the size compositions of separate local stocks of this salmon belonging to different rivers of the Amur basin.

Turning to Table 12, we see that not all of the Amur autumn keta agree in average size with the autumn keta of the Maritime Province and Sakhalin, but only the main bulk of them, which as stated above go farther up the Amur than the Amgun. And of some considerable part of the Amur keta it can be said that they are larger than the autumn keta of the Maritime Province and Sakhalin rivers.

grounds apparently remained where they used to be, presumably not far from the places where formerly, in one way or another, the Paleoamur system united its waters with the ocean.

The transgression of the sea, generally speaking, established a great gap between the feeding grounds of the salmonids and the rivers where they go for reproduction. However they would scarcely go outside the limits of that region of the sea where they could still detect some kind of link with the native river (possibly something we could not recognize), otherwise it would be impossible to understand their return to the places of their origin. An opinion exists that American salmon do not go far from their native rivers. It may be that our salmon do not go far beyond the places where this ancient river system reached the ocean, which formerly passed through the territories of the Japan, Okhotsk and Bering Seas.

Table 12. [page 170] Size of chum salmon in various rivers of the Far East.

Place of capture	Years	Length of the body (AC, in cm)		Number of fish
		Range	Av.	
South Sakhalin, autumn keta	1948-1949	49 -82	67.1	1108
Maritime Province, Tumnin River, autumn keta	1948-1949	55 -85	69.7	515
Amur basin:				
Amur estuary (autumn keta)	1948-1949	48 -87	66.8	6046
	1952-1953	51.5-90.5	67.0	3597
Khor, Kur and Bira Rivers	1948-1949	45 -89	69.7	more than 3000
	1952-1953	46 -?	69.7	more than 2500
Khivanda River	1949	54 -81	68.6	367
Amgun River	1948-1949	49 -82	64.6	2540
	1952-1953	50 -79	64.3	963
Okhotsk coast:				
Iski River	1953	48 -76	62.2	1002*
Okhota River	1948	46 -78	62.9	? **
Kukhtuĭ River	1952-1953	45 -76	61.9	2351***

*From data of L. D. Vakurova.

**Data of K. N. Palamarchuk.

***Data of V. L. Kostareva.

In the Amgun River the autumn keta are considerably smaller than in the Tumnin and on Sakhalin, and at the same time they differ somewhat in length from the keta of the north-western rivers of the Sea of Okhotsk.

Chum salmon which agree completely in size with the Okhotsk chums, and which are autumn chums in their time of spawning are encountered in great abundance along the northern borders [page 171] of the Amur estuary, in the Gulf of Schastia and the Iski River which flows into it, that is, in the immediate neighbourhood of Nikolaevsk-on-Amur. Between these Okhotsk keta and the autumn keta of the more southern river systems of the Amur, the Amgun autumn keta occupy a somewhat intermediate position.

Increase in the size of chum salmon southward from the Amgun is not gradual. Three hundred kilometres farther south, in the Khivanda River, we find autumn keta of the same size as on the spawning grounds of the Khor River and the rivers of the Japan Sea basin.

Autumn keta inhabit 14 rivers lying between the Amgun and the Khivanda. Of these, 10 flow into Lakes Kizi and Kadi. The remainder also join the Amur above the Amgun mountain range, which formerly served as an unbroken divide between the Amur and the Amgun. The Khivanda flows into the Amur approximately 100 km above Lake Kizi. It would scarcely be possible in this rather small distance to have a gradual transition from large autumn keta to small ones, the more so as along these 100 km chums enter only two rivers, and those only in small numbers: one of them (the Beshenafia River) enters the Amur 32 km from the Khivanda and the other (the Limuri River) is only 30 km farther downstream and on the opposite bank.

Thus it appears that the Amur autumn keta agree in average size with the Maritime Province and Sakhalin keta, or are heavier than them, only in those rivers which have always been tributaries of the Amur--even during the time when it still flowed through the region of the Japan Sea and included in its system all the rivers that now discharge into the Straits of Tartary.

In the Amgun, however, which is a former river of the Okhotsk Sea basin and only recently has been included in the Amur system, we have apparently a case of mixture of Amur autumn keta and autumn keta of the Okhotsk type. This is the reason that the size of the Amgun fish is less than the autumn keta of the more southern rivers of the Amur basin, and greater than the keta of the northwestern rivers of the Sea of Okhotsk.

Conclusions

Thus the portion of the spawning range of autumn keta within which the fish can be considered as a single biological group is mainly the circle of rivers which now or formerly flowed into the Japan Sea basin. Within this region there are undoubtedly a considerable number of local stocks of autumn keta, morphologically distinct to the degree that is caused by different physiographic conditions in the rivers they inhabit or in different parts of the spawning area [within each river].

All the fairly large tributaries of the Amur, and possibly even the small ones, have their own stocks of autumn keta. In any event this can be regarded as demonstrated for the Ussuri and its tributaries, for the Amgun, the Kur and the Bira. In particular, it is important to observe that the Teplov fish hatchery produces, year after year, an identical and completely distinct stock of autumn keta, which is associated with the Bira River. As we have seen, it is distinguished from other local stocks of autumn keta by certain morphobiological and morphological features.

It has often been stated that autumn keta today do not ascend the Amur River as far as they did formerly when their abundance was considerably greater than at present. If this is really so (we do not have any information concerning how many keta now go above the Bidzhan River and what is the farthest point they reach) this can have happened as a result of a considerable decrease in abundance or complete extermination of some stocks that spawned in tributaries of the middle and upper course of the Amur.

[page 172] Along with all the features by which keta stocks may be distinguished one from another, even stocks of rivers that lie close to one another in some regions, there are also of course features characteristic of all these stocks as a whole, and which are not found in stocks of any other group of rivers. Our objective is to determine what these characters are, in order to separate out from the common mass of keta captured in the Amur estuary groups of stocks from each particular region. This will make it possible to determine, from year to year, a region's contribution to the total mass of keta of a given year-class; that is, to draw conclusions concerning the condition of separate groups within the Amur keta stock from observations on the composition of the whole stock.

All this also applies, of course, to summer keta, among which there are undoubtedly also local stocks. During the last three decades some of them, for example the great stock of the Gorin River, have been almost completely exterminated, and as a result the region where summer keta occur in abundance on the Amur has been considerably contracted.

As for the practical importance of what has been said in the present article, that is quite obvious.

If chum salmon return to spawn into precisely the tributaries of the Amur in which they were hatched from the egg, then improvement measures carried out in a given river can increase the abundance of the local stock only. With improved conditions the general level of its stocks will increase, but this will not affect the abundance of other local stocks of this salmon.

In addition, it is necessary to maintain the region of abundant occurrence of chums in the Amur basin at its widest possible limits, and to try to expand it to its former limits, remembering that the more extensive this region is, and the more rivers are inhabited by large masses of spawners, the more stable will be the production of supplies of chum salmon.

In order to accomplish a general increase in abundance and a relative stabilization of the level of production of autumn keta, it is necessary first of all to restore to their former numbers the stocks of this salmon in the tributaries of the Ussuri (Khor, Bikin, Iman and others), in the Khungari River, in the Aniu and Tunguska Rivers; that is, generally speaking, to restore those stocks whose contribution to the total bulk of Amur autumn keta was always the most considerable.

In these rivers it is necessary to make use of the maximum possible fish cultural and fish protection measures, and this must be linked with a reasonable level of fishing for autumn keta and with strict maintenance of that level within the limits provided by the now existing rules for the fishery.

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