Vernal and Hiemal Races among Anadromous Fishes

BY L. S. BERG
(Translated by W. E. Ricker)

TRANSLATOR'S PREFACE

The paper to follow is one of the most interesting of the numerous scientific contributions of the late geographer and ichthyologist L. S. Berg, a member of the Academy of Sciences of the USSR. It marks the first attempt to bring together scattered information concerning intra-specific seasonal groups among anadromous fishes: that is, groups differentiated in respect to the time of their approach to fresh water and the time of their spawning. These seasonal races, as Berg calls them, occur in quite a variety of fishes, including a number of the important commercial fishes of Canada. A recognition of their existence is of profound importance both for fish-cultural procedures and for management policies. On the other hand, these seasonal races (often called runs in America) are not necessarily the smallest recognizable unit within a species: each seasonal group can, in a large river, be made up of a number of individual stocks associated with specific tributaries.

Many additional examples of seasonal runs have been described since 1934, in the old world and in the new. In fact it now appears that Berg's treatment must be broadened, because more than two seasonal runs have been recognized among anadromous fish in certain rivers. In the Sacramento, for example, three rather distinct groups of stocks of *Oncorhynchus tshawytscha* are recognized — the spring chinooks, fall chinooks and winter chinooks. Similarly Driagin (in *Doklady Akademii Nauk SSSR*, 71: 785–788, 1950), basing his distinctions partly on the fish's reaction to injections of pituitary extract, has recognized no less than four "races" of *Acipenser gilaezus* in the Kura River—named early vernal, late vernal, summer-arriving hiemal and autumn-arriving hiemal; the first two spawn during the year of arrival, the last two winter over and spawn the following spring.

Such examples suggest that although Berg's analogy with the cereal grains is interesting, no attempt should be made to force all known stocks of anadromous fishes into one or other of the two categories vernal and hiemal. The various examples quoted by Berg, taken with those described since 1934, exhibit almost every conceivable combination of season of arrival, season of spawning, and length of stay in fresh water before spawning.

Professor Berg's introduction to the subject of seasonal races is of such wide interest that it is profitable to make an English translation available, even 25 years after its original publication. A few footnotes have been added to clarify the English text; these and other interpolations are put in square brackets.


2Fisheries Research Board of Canada, Translation Series, No. 206.

3[The words here translated as "vernal" and "hiemal" are *yarovoi* and *ozimyi*, respectively, words which are primarily used with reference to agricultural crops. The adjectives *vesennii* and *zimnii* are translated as "spring" and "winter", respectively. The distinction is necessary in order to avoid confusion of the various kinds of races described, particularly as some of Berg's "hiemal" races enter the river as early as the late spring or summer previous to the year of spawning, while others do not arrive until early spring of the year of spawning; and the "vernal" races variously enter in late spring, summer, or even in autumn. This distinction is maintained in the translation even throughout the comparison with cereal grains in the Discussion, where the usual English equivalents of *yarovoi* and *ozimyi* would be "spring" and "winter" (wheat, etc.).

The Russian word *rasa* is translated as "race", but the text makes it clear that there are not necessarily any systematic, taxonomic or genetic implications attached to this term as Berg uses it.]

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J. FISH. RES. BD. CANADA, 16(4), 1959.
Printed in Canada.
DIADROMOUS FISHES are defined as those which, for reproduction, leave the environment to which they are accustomed and migrate from salt water to fresh water or, conversely, from fresh water to salt. The eel, *Anguilla anguilla* (L.), belongs to the latter category; for reproduction it goes out of the rivers and down to the depths of the ocean. All other diadromous fishes leave salt water and go into fresh water for spawning; to this group belong many representatives of the lamprey, sturgeon, herring, salmon and carp families.\(^4\)

It is noteworthy that anadromous fishes are peculiar to the temperate and to some extent the polar latitudes of both hemispheres; the tropics lack them.

One of the most puzzling phenomena of fish biology is the occurrence among many anadromous fishes of two forms or races, which are distinguished from one another by their times of entry into the river from the sea for spawning or, more exactly, by the time when these fish (while in the sea) receive the impulse to enter the river for spawning. Such races can be called *seasonal* races.

Seasonal races also exist among non-anadromous fishes; they are especially clearly developed among, for example, the sea herring, *Clupea harengus*. But in the present article we will discuss seasonal races of anadromous fishes only.

**SALMON FAMILY**

The best studied seasonal races are found among fishes of the salmon family. They are especially clearly and simply developed in one of the Pacific salmon, *Oncorhynchus keta* [the chum or keta salmon], with which species we will begin our exposition.

On the Amur River the chum salmon are divided into *summer* keta and *autumn* keta. The migration of the summer keta from the sea into the Amur begins in the first days of July and usually ends at the time the autumn run begins—about the middle of August. In consequence the summer keta arrive on the spawning grounds a month earlier than the autumn; their spawning takes place about the middle of August, while that of the autumn keta begins in the middle of September. The summer keta does not ascend the river as far as does the autumn keta: it reaches the confluence of the Ussuri River and enters that river in small numbers, whereas the autumn keta goes much farther upstream, as far as Zabaikalia [the region near Lake Baikal]. Now let us observe an extremely important fact, noted by V. K. Soldatov (1912, p. 137): *the autumn keta arrives from the sea with its sexual products in a much less advanced state of development than what is observed among the late individuals of the summer keta that are migrating at the same time*. For example, among 20 late-arriving summer keta caught in the Amur estuary from August 24 to September 1, 1907, the weight of the eggs averaged 13.7% of the total body weight, while among 63 autumn keta taken at the same time it averaged 5.6%.

\(^4\)[Fishes of this latter sort are usually called *anadromous* in English. This more familiar word will be used from here on to translate "prokhodnyi", and was also used in the title.]

\(^5\)[There are, of course, none in the near-polar latitudes of the southern hemisphere.]
Morphologically, the summer and autumn keta differ, as far as known, only in their size; the summer form is considerably smaller. According to V. K. Soldatov's (1912) data, the mean length of the male summer keta from the lower Amur is 61 cm, while male autumn keta average 65 cm (these data refer to 1907 and 1908). The number of eggs in summer keta is correspondingly smaller: 2500, as compared with 3900 among autumn keta.

Similarly, there are no morphological differences between vernal grains and hiemal grains; but hiemal grains are more hardy and have more productive growth.

The differences which distinguish autumn keta from summer keta can be summarized as follows:

1. they enter the river later than the summer keta
2. at time of entering they have less developed sexual products
3. they spawn later
4. they migrate farther upriver
5. they are larger and heavier than the summer keta
6. they are more fecund.

In abundance, autumn keta in the Amur now considerably exceed the summer keta; but before the war [World War I] it was otherwise: the summer keta exceeded the autumn.

The opinion has been expressed that the summer keta are nothing more than autumn keta younger in age. But this is not true: the summer keta in the Amur are of the same age, 3–6 years, as the autumn keta, and they also return from the sea at an [average] age of almost 4 years as a rule. Hence there is no basis for regarding them as a different age-group from the autumn keta.

The question now arises, could not a summer keta under existing natural conditions transform itself into autumn keta, or vice versa? Here we must answer no—this is impossible; for every keta, whether of the summer or the autumn run, dies immediately after spawning. In general, all Pacific salmon of the genus *Oncorhynchus* lay eggs only once in their life and perish after spawning.

Finally, is it possible that under natural conditions we could obtain autumn keta from eggs laid by summer keta, and vice versa? Although no experiments have been conducted with keta, yet on the basis of what we know about another species of *Oncorhynchus*, the chinook salmon (*O. tshawytscha*), we must suppose that under natural conditions the eggs of summer keta must develop into summer keta, and autumn keta must produce autumn keta.

I will say a few words about the remarkable observations made by the American ichthyologists Rich and Holmes on chinook salmon migrating into the Columbia River. The native chinooks there are divided into two races—the summer chinooks, which enter the river from July to September and which correspond to the summer keta, and the spring chinooks which correspond to the autumn...
keta. The authors mentioned, by wholesale marking of fingerlings, showed that from fingerlings of spring races of chinooks spring spawners were obtained, and from the fingerlings of summer races they obtained summer spawners. They performed their experiments like this: eggs were taken from the Willamette River, a tributary of the Columbia where only spring chinooks spawn, and placed them in the tributaries of the Columbia where nothing but summer chinooks spawn; they hatched the eggs there and liberated them. Nevertheless, when adult, they returned from the sea as spring fish. Experiments were also made with summer chinooks: their eggs were reared under the conditions of spring fish, but nevertheless they produced summer chinooks.

In a word, it was not possible either to change the summer form to the spring, or the spring form to the summer (at least under the conditions of these experiments).

Taking all the above into consideration, I have separated the autumn keta as a special race, the infraspecies biennis Berg (1932, p. 115) (the summer keta being the typical form). We must bear in mind that the summer and autumn keta lay their eggs in different places and at different times, and therefore the chance of forming hybrids between them is not great.

In addition to keta and chinooks, seasonal races are known for a third Pacific salmon, the sockeye (see Berg, 1932, p. 126). It is possible that they exist among other species of Oncorhynchus also.

Such is the situation among Pacific salmon of the genus Oncorhynchus. The general picture of the existence of two races appears here to be quite simple and completely definite, although the actual condition under which these races arise is not clear to us as yet.

Analogous races exist in the so-called Atlantic salmon (genus Salmo), but here the picture is much more complex and confused. [page 714] The picture is comparatively simple for the salmon [losos] of our northern rivers, or semga (Salmo salar, and in the White Sea Salmo salar breviceps). Among the semga two forms are distinguishable, a summer and an autumn form.

1. the summer form enters the rivers in summer with well-developed sexual products and lays its eggs the same autumn, without migrating very far upstream; its size is usually not very large;

2. the autumn form (infraspecies biennis Berg, 1912, p. 137) enters the rivers in autumn with weakly developed sexual products, usually migrates far upriver and lays its eggs in the autumn of the following year, after having spent a whole year in the river (without feeding all the while); its size is large, as a rule.

6[This identification of the spring chinooks with the autumn keta seems rather remarkable, but it is not discussed further. Actually, what Berg calls summer chinook (letniaia chavycha) are commonly called fall chinook on the Columbia; the usual division between the spring and fall runs is made at August 1, and the fall fish continue to run into October.]

7See Ryby presnykh vod SSSR, 3rd Ed., Vol. I, 1932, page 15, for what constitutes an "infraspecies".

8To call these salmon Atlantic is not wholly correct, since representatives of the genus Salmo also occur in the Pacific Ocean.

9[Apparently semga is a name applied to S. salar in north Russia, being more specific than losos, which latter can refer to salmon in general as well as to salar specifically. I have translated losos as "salmon", but retain semga wherever it occurs.]
The analogy with the summer and autumn keta is remarkable. But there are also very important differences. Although the autumn keta lays its eggs later than the summer keta, it does lay them in the same year. However the autumn semga delays its spawning until a year after the summer semga; in every case it winters over in the rivers, without spawning, and lays its eggs the following autumn. Hence the autumn race of semga can with complete accuracy be called, as I have done, a *hiemal* race (*biennis*), in contrast to the summer semga which matures in the same year and is a *vernal* race.

The question arises, does an autumn semga never change into a summer semga under natural conditions? V.R. Aleev (1928) thought that he had succeeded in demonstrating the transformation of a White Sea summer semga into an autumn one. Here is how the experiment was arranged. In the first half of the summer of 1924, on the Zimniaia Zolotsa River which flows into the White Sea north of Arkhangelsk, semga-"zakroika" were put into a rearing enclosure. Eggs were obtained from one semga 59 cm long and 1.48 kg in weight, and then she was marked and released. A year later, on October 11, this fish was again taken in the same river; she had only just come from the sea, and had all the external features of an autumn semga, "was clean, fat and silvery"; at a length of 67 cm she weighed 3.15 kg. So Aleev concludes that the "spring" semga of 1924 had changed into the "autumn" semga of 1925.

However, this experiment is not pertinent, for a *zakroika* is itself an autumn semga—one which has spent the winter just off the mouth of a river or just in the mouth, and in the spring (at the beginning of summer) has ascended the river. The *grilse* of the English, or *tinda* of our northern fishermen, are salmon which have spent one winter in the sea and have ascended the river—usually in July—for spawning. Thus the tinda is a vernal form. Calderwood, an excellent observer of the biology of Scottish salmon, categorically denies any possibility of a grilse transforming itself into what I call a hiemal race and what in Britain is called a *spring salmon*—vesennii losos (1930, p. 40): "spring salmon" also have a stage analogous to grilse, but it is spent in the sea; in Scottish rivers in autumn it is possible [page 715] to observe both occasional specimens of grilse (that is, grilse of the hiemal race) and a few "spring salmon" which are their equals in age but are of even smaller size than grilse. Consequently it cannot be considered that in nature [ordinary summer] grilse develop later into hiemal semga. "Spring fish cannot be bred from grilse", says Calderwood (p. 43).

Thus we have as yet no basis for believing that, under natural conditions, salmon which first lay their eggs as summer fish can next time enter the river as autumn fish.

The reverse also has never been demonstrated: that autumn salmon can make their second entry into a river as spring salmon.

On the other hand, we have no basis for insisting on a hereditary basis for the summer and autumn races in salmon. The constancy of these races might be

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10This has also been observed in our country, on the Kola peninsula. For example, in the Ponce River in the fall, along with the comparatively large autumn (hiemal) semga there can also be found autumn semga less than 40 cm long.
explained merely by the fact that they always lay their eggs in different places in the river, and so do not produce hybrids between the two. But it is only that this has not yet been demonstrated; it is unlikely that hybridization is impossible.

Even if the summer and autumn forms of salmon do not change from one to the other in the adult condition, that does not exclude the possibility that, from a single batch of fertilized eggs, we might get both the slow-growing grilse, and the faster-growing autumn salmon. For an analogy we might look to the very interesting data obtained by P. V. Tiurin (1933) concerning perch (Perca fluviatilis) of Lake Chana in western Siberia. In this lake there are two forms of perch:

1. morpha phragmiteti Berg 1933, small, slow-growing and early-maturing, lives in the emergent vegetation shoreward and belongs to the so-called “peaceful” [non-piscivorous] fishes; and

2. large, fast-growing, maturing a year later; it lives in the open part of the lake and feeds on fishes (I consider this perch to be of the typical form).

At early ages both forms live together. According to Tiurin's observations, the large perch are for the most part (83%) females. He explains this on the basis that the large perch arise from the small ones by a transformation of the part of the latter which have a carnivorous manner of life.

In a similar manner, in salmon too the fast-growing individuals might become the autumn salmon, and the slow-growing ones the summer salmon.

But among salmon the matter is very complex. Here it is impossible to make any general rule that autumn salmon are always larger than summer salmon. For example, among the salmon of the Soiana River (a tributary of the Kuloe flowing into the Gulf of Mezensk), [page 716] according to E. S. Kuchino's studies we do not find any difference in rate of growth between the summer and the autumn form:

<table>
<thead>
<tr>
<th>Number of complete years</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>River period</th>
<th>Sea period</th>
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<tbody>
<tr>
<td>Summer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6 (237 pieces)</td>
<td>39</td>
<td>89</td>
<td>131</td>
<td>162</td>
<td>380 682 mm</td>
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<tr>
<td>8 (140 &quot; )</td>
<td>42</td>
<td>95</td>
<td>135</td>
<td>162</td>
<td>360 618 &quot;</td>
<td></td>
</tr>
<tr>
<td>Autumn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 (105 &quot; )</td>
<td>39</td>
<td>87</td>
<td>129</td>
<td>160</td>
<td>375 622 &quot;</td>
<td></td>
</tr>
<tr>
<td>8 (351 &quot; )</td>
<td>42</td>
<td>92</td>
<td>134</td>
<td>160</td>
<td>377 603 &quot;</td>
<td></td>
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</tbody>
</table>

Against the possibility of any transformation of the summer semga into autumn semga we can also cite the analogy of the races of chinook salmon (Oncorhynchus tschawytscha) mentioned above (p. 518).

On the other hand, in our northern rivers the grilse are almost exclusively males. For example, the Niva River flowing into the White Sea near Kandalaksha, and the Teriberka, produce only male grilse; on the Soiana in 1932 there were only 9 females among 153 grilse; in collections made from the Voronia River (Murman) in 1933 there were 312 male grilse and only 9 females. In France also, grilse are observed to be almost wholly males. In Norway there are 19% females
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among grilse, in the Rhine 17% and in Scotland about 50%. Among summer salmon, in general, males predominate. Among autumn salmon, by contrast, females predominate. Thus in the Niva or Voronia male grilse must as a rule spawn with female summer salmon. But it may perhaps be that they also fertilize the eggs of the autumn salmon?

Special experiments are needed to decide these questions.

Such are the semga of the Murman, the White Sea and the Pechora.

But in the Atlantic Ocean the state of affairs seems more complex. In the Rhine, along the coasts of France, in England and in Scotland the summer (vernal) salmon behave much the same as in our north, but the hiemal salmon are for the most part not autumn fish but winter fish: their principal migration takes place from December or January and continues into March (although the run begins in the autumn). In a word, in the warm climate of the Atlantic littoral we observe an analogy with the hiemal cereal grains of our southern regions—the pre-Caucasus and Turkestan, where these grains are sometimes sown in January.

Let us consider in more detail the biology of the Scottish salmon. Small autumn salmon with poorly developed sexual products (called spring salmon in English) begin to enter Scottish rivers from the ocean as early as the second half of September. These salmon will lay their eggs the following year in October or November. But the main run of this race, which reaches a size of 15 kg, belongs to February, March and the beginning of April. Toward the end of May the “spring salmon” usually cease to be caught at the mouths of the Scottish rivers. But here is what is remarkable. In April and May, along with the “spring” salmon, summer salmon begin to appear [page 717] in the river. In size, form, colour, and condition of the eggs and milt they cannot be distinguished from the spring salmon, and the fishermen do not distinguish them. They can be distinguished only by the scales, on which are imprinted the history of their feeding conditions: the summer salmon have fed immediately before entering the river, while the spring salmon had ceased to feed some considerable time previously, during the cold part of the year, and during the following months exhibit little growth (Menzies, 1931, pp. 109–110).

Thus, although in principle the difference between the hiemal and the vernal race is preserved, in details the situation seems much more complicated than among the salmon of our northern rivers.

Both with us and in Scotland, among both the autumn and summer salmon running into the river from the sea, there are individuals which have spent one winter in the sea, two winters, three winters and occasionally even more. Why does one salmon come into a river to spawn after spending only one winter in the sea, when for another a similar instinct brings it back after two years, and a third, after three? Some suggest that even these kinds of salmon represent separate forms or races, each of which is distinguished by its own special length of sojourn in the sea before first spawning. But, as Menzies says (p. 198), is it really possible that these “races” do not mingle on the spawning grounds, where the eggs of a

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11 In Scotland examples are known, rare to be sure, of salmon that have spent 5 successive years in the sea (Menzies, p. 97).
salmon of one group may be fertilized by the milt of a salmon of another group, a year or two older or younger? Specially designed experiments are required to decide this question.

In general, there is still much that is puzzling in the biology of salmon, even though much work has already been done on these fish, both here and abroad.

This same existence of two races is observed in another fish related to the salmon, the kumzha12 (Salmo trutta), although here the phenomenon seems more complex for the kumzha has the habit of entering rivers on non-spawning [as well as spawning] migrations; such kumzha, having spent some time in the river, return again to the sea. In Scotland a large part of the kumzha lay their eggs in the same year as they enter the river (Nall, 1930, p. 253); but in the River Tweed, for example, part of those entering in early winter lay their eggs during that season, but a larger part will not spawn until the following winter (Nall, pp. 173, 255). Fish which enter during spring and summer lay their eggs the same year. Thus here too a vernal and a hiemal race occur. The existence of these two races is indicated also for the kumzha of the Rhein. The same has been shown for the kumzha of the Ponoe River (Kola Peninsula) from the observations of the Institute for Lake and River Fisheries in 1932 (A. G. Smirnov).

Vernal and hiemal races are especially clearly developed in the Caspian salmon [losos] Salmo trutta caspius. This salmon is close to the kumzha (S. trutta) in number of scales, but in number of gill rakers it approaches the northern salmon (S. salar). I assign it to S. trutta on the basis of the fact that in rivers of the Caspian basin [page 718] it develops a freshwater form that never migrates to sea—the trout [forel] S. trutta caspius morpha fario. And a capacity to develop trout forms is one of the characteristic features of the kumzha. However, the possibility is not excluded that the Caspian salmon is an offshoot of the northern salmon, Salmo salar, which in the Caspian has changed some of its features in the direction of the kumzha.

However that may be, among the Caspian salmon there are two races.

1. Vernal. This race enters the Kura River in October with almost ripe sexual products; its weight is comparatively small—not over 12 kg; and it does not go very far upriver—not over 600–700 km from the mouth (i.e., no higher than the middle reaches of the Kura) and spawns the same year. The numbers of the vernal salmon or lokh, as they are called on the Kura, are insignificant in comparison with the hiemal race: in the autumn of 1915 in the lower course of the Kura at the Bankov fishery 49 female and 13 male “lokh” were taken, while more than 20,000 of the hiemal race were taken.

2. Hiemal. This race begins to enter the Kura in October, but the main run arrives in November and December. The hiemal race, having poorly-developed sexual products, goes very far up the Kura—above Tiflis to Akhaltsikhe and the confluence of the Aragva, and spawns in the uppermost parts of the rivers in October–November, about 9–11 months after entering the Kura from the sea.

12[Here again I will use the Russian word in the English text to avoid possible confusion. The nearest English equivalent of kumzha is "sea trout" but, in America at least, this term usually refers to a general rather than a specific category of salmonids.]
This race is much larger than the summer race, reaching 51 kg (so large an Atlantic salmon has never been reported, but that doesn't mean that these fish necessarily are kumzha on that account)\textsuperscript{13}.

Since both races enter the Kura almost concurrently and since the vernal Caspian salmon are caught only by tens, whereas hiemal ones are caught by thousands, here the hypothesis that vernal Caspian salmon in nature transform into hiemal ones is impossible.

In the rivers of the south Caspian there are also two races, but in detail they exhibit many peculiarities; in general they are very poorly known. In the rivers of the Kubin coast of the Caspian there are apparently only small, vernal salmon ("lokh") of 2–3 kg weight.

In the rivers of Samur (Dagestan) and in the Terek both races occur. At the present time salmon enter the Volga only in small numbers, but in the 17th Century, according to A. N. Derzhavin's (1934) information, many were caught in the Volga up as far as Kazan (and apparently even farther), in the Oka, and in the Kama. From a study of 500 specimens of salmon from the Volga delta Derzhavin showed that its run lasted from August (5.8\%) to December (0.2\%), the peak of the run being in October when 56.5\% of the total were caught, in September 17.2\%, and in November 20.2\%. The mean weight of this salmon is 8.7 kg (maximum 22 kg); it is a hiemal salmon. Vernal [page 719] salmon are scarcely to be found in the Volga, although the possibility that a few individuals enter is not excluded.

Among other salmonids, we observe the presence of two races in the Arctic char \textit{Salvelinus alpinus}\textsuperscript{14}; they may possibly occur among the Arctic omul \textit{(Coregonus autumnalis)}.

**STURGEON FAMILY**

Vernal and hiemal races are developed extremely clearly in acipenserids, although up to now this phenomenon has not been recognized as parallel to what has been observed among salmonids. We will present briefly the facts pertaining to this question, dwelling, because of limitations of space, mainly on the acipenserids of the Caspian Sea.

**SEVRUGA**

The sevriuga or stellate sturgeon \textit{(Acipenser stellatus)} begins to enter the Ural River from the Caspian Sea at the middle of April; the run continues through May. The spawning of this sevriuga—we must call it a vernal race—takes place in

\textsuperscript{13}I will quote from the data of V. N. Beliaev (1932) the monthly average catches of salmon, in thousands of individuals, taken in the lower Kura during the years 1922/23 to 1927/28:

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<tr>
<td>X</td>
<td>XI</td>
<td>XII</td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
<td>Year</td>
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<tr>
<td>0.8</td>
<td>6.8</td>
<td>9.5</td>
<td>3.1</td>
<td>1.6</td>
<td>0.4</td>
<td>0.1</td>
<td>0.02</td>
<td>22.3</td>
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</table>

\textsuperscript{14}Observations of A. N. Probatov in the Kara River flowing into the Gulf of Kara (see Berg, 1933, p. 842).
May and June. The main period of fishing for these fish occurs in the Ural during the months mentioned.

But from the middle of August sevriuga again begin to enter the Ural and continue to do so up to the middle of October; this sevriuga lies over winter in the river in deep holes ("yatovis") and in spring it ascends and lays its eggs in May. These evidently are *hiemal* sevriuga; they are considerably smaller than the vernal ones.

In his remarkable writings concerning the life of the sturgeons of the Ural River, N. Severtsov (1863) has pictured the life of the sevriuga in that river in the following manner; in spring it enters from the sea into the lower reaches of the Ural and lays its eggs, then it returns downstream to the sea; at the beginning of autumn it again enters the Ural, and winters there in the yatovi; in spring it goes farther upstream, lays its eggs, and again returns to the sea. Thus on this basis there is only one race of sevriuga, which lays its eggs every year, spending the winter alternately in the river and in the sea. But in my opinion this picture is wrong: we have two races of sevriuga, one the vernal race, the other *hiemal*. It is difficult to imagine that a sevriuga which has laid its eggs in May or June could succeed in returning to the sea, mend itself there and build up enough food reserve to be in condition to go upriver again at the middle of August. (In the river the sevriuga apparently feeds very little; see Derzhavin, 1922, p. 87.) For the Don sevriuga, which in its general mode of life is similar to the Ural, this is impossible—simply because of the times involved: it spawns from the second half of May to the end of June, and the summer–fall run begins there as early as June.

In the Volga the sevriuga behaves similarly to what we know for the Ural. I will cite the very valuable data concerning the catches of sevriuga in the north Caspian, reported by Grimm (1893). They pertain mainly to the region off the mouths of the Volga and to the delta of this river and they represent the landings of one important fishery in the Volga delta. The figures are the mean monthly catches in number of fish for the years 1879–1892 old style:

<table>
<thead>
<tr>
<th></th>
<th>Pieces</th>
<th>%</th>
<th></th>
<th>Pieces</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>3</td>
<td>0.01</td>
<td>July</td>
<td>356</td>
<td>1.8</td>
</tr>
<tr>
<td>Feb</td>
<td>–</td>
<td>–</td>
<td>Aug</td>
<td>602</td>
<td>3.1</td>
</tr>
<tr>
<td>Mar</td>
<td>272</td>
<td>1.4</td>
<td>Sept</td>
<td>442</td>
<td>2.3</td>
</tr>
<tr>
<td>Apr</td>
<td>6457</td>
<td>32.9</td>
<td>Oct</td>
<td>236</td>
<td>1.2</td>
</tr>
<tr>
<td>May</td>
<td>6908</td>
<td>35.2</td>
<td>Nov</td>
<td>23</td>
<td>0.1</td>
</tr>
<tr>
<td>June</td>
<td>4308</td>
<td>22.0</td>
<td>Dec</td>
<td>6</td>
<td>0.03</td>
</tr>
</tbody>
</table>

15 Yamy (singular, *yama*), literally pits; here, depressions in the bed of the river, for which the best colloquial English is "hole" or "deep hole"—as in "the old swimming hole".
16 The word yatov comes from the Turkish root yata—to lie. Literally translated, a yatov is a zalezhka or lezhbishche.
17 This refers to the Julian calendar, which was used in Russia up to 1918. At that time it was 13 days behind the Gregorian calendar ("new style"); that is, January 1 old style = January 14 new style.
As we see, the principal run of sevriuga from the Caspian into the Volga occurs in spring; the sevriuga begin to ascend the river with the disappearance of the ice, and large numbers are observed from the middle of April to the end of May. This—vernal—sevriuga for the most part lays its eggs the same season, in May, June and partly in July in the lower and middle Volga, from Akhtuba to Tetiush (Berg, 1911, p. 302). However, as early as June sevriuga begin to be encountered, in the lower Volga, which have poorly developed eggs and sperm—apparently individuals of the hiemal race. Hiemal sevriuga continue to occur up to November, but their run is very light compared to the vernal run, as the above tabulation shows. Occasional individuals lie in the lower reaches of the Volga over winter, in the deep holes or "yatovi". In spring and at the beginning of summer of the following year the hiemal sevriuga, which have wintered over in the river, will lay their eggs. According to the observation of A. V. Podlesny (1930), in the lower Volga between Vladimirovskaiia and Dubovkaia these sevriuga spawn in two groups:

1. in flood channels [v poloiakh], from the end of May to July at a depth of 1¥1/2 to 2 m;
2. in the main Volga, in mid-channel, from the middle of June to August, at depths of 9 to 13 m.

In all probability the hiemal sevriuga spawn early in the flood channels, and the vernal sevriuga spawn later in the main Volga. We must suppose that the vernal sevriuga spawn in the lower part of the Volga and the hiemal sevriuga farther upstream. All these suppositions require verification, but they are based on information which is true of the Kura sevriuga.

In the Kura the sevriuga also ascend twice—in spring and in autumn. The autumn run, although much less important than the spring run, is nevertheless much better developed than it is on the Volga: in the lower reaches of the Kura at the present time not less than 10% of the yearly landings of sevriuga are taken in October (while 40% are taken in May). In the first half of the 19th century the autumn run of sevriuga in the Kura was even more important than at present (although still considerably less than the spring run) as is apparent from the averages shown below, which are computed from the data of Ber and Danilevsky (1863) extending over 26 years (1829–1845 and 1847–1855), old style, and pertaining to the lower reaches of the Kura (the great Bozhii fishery):

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieces</td>
<td>613</td>
<td>898</td>
<td>26240</td>
<td>52030</td>
<td>18590</td>
<td>5471</td>
</tr>
<tr>
<td>%</td>
<td>0.3</td>
<td>0.2</td>
<td>16.1</td>
<td>31.9</td>
<td>11.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year's total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieces</td>
<td>1288</td>
<td>3644</td>
<td>21613</td>
<td>26468</td>
<td>7551</td>
<td>330</td>
<td>156614</td>
</tr>
<tr>
<td>%</td>
<td>0.5</td>
<td>2.0</td>
<td>13.3</td>
<td>16.3</td>
<td>4.6</td>
<td>0.2</td>
<td>100</td>
</tr>
</tbody>
</table>
Concerning the Kura sevriuga, A. N. Derzhavin (1922, p. 105) writes: “at the time that some autumn females possess developed ovaries and have become ready to lay their eggs during the current spawning season, other individuals have a relatively low index of ripeness; there is no doubt that their small eggs could achieve maturity only in the following season”. At Mingechaur (middle course of the Kura), where the principal spawning grounds of the Kura sevriuga are situated, in August sevriuga can be seen in two stages of maturity: some will lay their eggs within a very short time, others only in the next year; in late autumn at this place the only sevriuga encountered are those which lay their eggs the following spring (Derzhavin, p. 106).

The spawning period of the sevriuga on the Kura extends from the middle of April through the middle of September, and for a few individuals even to the middle of October, new style (Derzhavin, p. 163).

I postulate that the Kura vernal sevriuga spawn in summer, and the hiemal ones in spring. Pertinent to this suggestion are certain observations of A. N. Derzhavin, according to whose data (p. 163) the sevriuga which winter in the Kura spawn in the spring; their spawning does not last very long, up to the middle of May, because, Derzhavin says, an intensive fishery in the lower course of the Kura prevents the arrival of new spawners. But I do not believe the cause lies there; rather it lies in the peculiarities of the biology of the hiemal sevriuga. The vernal sevriuga begin to lay their eggs a month after the hiemal, at the middle of June; at Mingechaur their principal spawning is in July. In a similar manner vernal grains mature later than hiemal ones.

Thus the main part of the sevriuga in the Ural, the Volga and the Kura belong to the vernal race.

ÖSËTR

The biology of the osëtr or Russian sturgeon (Acipenser güldenstädti) is more complex. At first glance it might be assumed that the Volga osëtr has only a single hiemal race. But in fact the spawning of this fish takes place in the middle Volga in May, whereas the run into the Volga delta from the Caspian begins later than the run of sevriuga, at the beginning of June. Thus the osëtr running in May will lay their eggs only in the following year [page 722] after having wintered in the river. This is well known on the middle Volga; there, in the reaches between Kamyshin and Saratov the main run of osëtr is in the first half of the summer, while spawning takes place there beginning in the first days of May; obviously the spawning osëtr are those which arrive there the previous year. Thus in the Volga there are hiemal osëtr, without any doubt.

However, the data collected by A. N. Derzhavin (1913, p. 15) show that the first approach of osëtr to the Volga delta (Olia village) was recorded at the observation point of the Astrakhan Ichthyological Station as early as March 23, new style; since observations were not made during the winter, by analogy with the Kura (for which see below), we can postulate with considerable assurance that the first arrivals show up at the beginning of March.
BERG: VERNAL AND HIEMAL RACES

The above is supported by Grimm’s (1893) data concerning the catches of osëtr in the Volga delta and off its mouths. Mean monthly number of pieces of osëtr for 1879–1892, old style, were as follows:

<table>
<thead>
<tr>
<th>Month</th>
<th>Pieces</th>
<th>%</th>
<th>Month</th>
<th>Pieces</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>13</td>
<td>0.1</td>
<td>July</td>
<td>2136</td>
<td>12.7</td>
</tr>
<tr>
<td>Feb</td>
<td>12</td>
<td>0.1</td>
<td>Aug</td>
<td>1024</td>
<td>6.0</td>
</tr>
<tr>
<td>Mar</td>
<td>324</td>
<td>1.9</td>
<td>Sept</td>
<td>515</td>
<td>3.0</td>
</tr>
<tr>
<td>Apr</td>
<td>4123</td>
<td>24.5</td>
<td>Oct</td>
<td>246</td>
<td>1.5</td>
</tr>
<tr>
<td>May</td>
<td>4829</td>
<td>28.7</td>
<td>Nov</td>
<td>77</td>
<td>0.5</td>
</tr>
<tr>
<td>June</td>
<td>3518</td>
<td>20.9</td>
<td>Dec</td>
<td>19</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Because, according to the observations of A. V. Podlesny (1930), it appears that osëtr lay their eggs in the lower reaches of the Volga beginning at Vladimir-rovka (near Yenotaevsk), evidently the vernal osëtr which enter the Volga in the early spring have sufficient time to proceed to their spawning grounds during the same year.

Grimm (1896, p. 80) has already noticed that in the Volga delta “osëtr of the winter run, up to March, all go [directly] to the spawning grounds, but those of the summer run go farther upstream and spawn in the spring of the following year”. Consequently among the Volga osëtr, as among its sevruga, there are two races—hiemal and vernal; but among the osëtr, in contrast to the sevruga, the hiemal race predominates.

The above is confirmed by the biology of the osëtr on the Ural River. According to the observations of N. Severtsov (1863), osëtr begin to go up the Ural from the Caspian in the middle of April, new style, right after the beluga and sharpnose sturgeon, and almost concurrently with the sevruga or slightly earlier than it. These evidently are vernal osëtr. In the delta of the Ural and Gurev, spawning of osëtr is observed in the middle of May. This, we must suppose, is the spawning of the vernal osëtr. A more intensive run of osëtr in the Ural begins at the end of May; and it continues up to the end of the summer, although tapering off. These, hiemal, osëtr lie throughout the winter in holes in the bed of the Ural River between the village of Kalenovsk (which lies between Gurev and Uralsk) and Uralsk. In spring they go higher and lay [page 723] their eggs in the region of Uralsk at the end of April or beginning of May. Thus the hiemal osëtr go farther upriver and, like the hiemal sevruga, lay their eggs earlier than the vernal race.

In the Ural River the hiemal race of osëtr predominates, as it does in the Volga.
The situation is different on the Kura River. According to Ber and Danilevsky's (1863) data the run of osëtr in the lower Kura (the great Bozhii fishery) for 1829–1855 was distributed on the average in the following manner (old style):

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieces</td>
<td>44</td>
<td>302</td>
<td>3864</td>
<td>4536</td>
<td>1290</td>
<td>1101</td>
</tr>
<tr>
<td>%</td>
<td>0.1</td>
<td>1.4</td>
<td>23.2</td>
<td>27.1</td>
<td>7.7</td>
<td>6.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Year's total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieces</td>
<td>694</td>
<td>1366</td>
<td>1733</td>
<td>1801</td>
<td>505</td>
<td>58</td>
<td>16154</td>
</tr>
<tr>
<td>%</td>
<td>2.8</td>
<td>7.2</td>
<td>10.3</td>
<td>10.8</td>
<td>2.9</td>
<td>0.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Here the main run of osëtr takes place in the second half of April, new style, and the main spawning is at the end of July and in August. However, according to V. N. Beliaev's (1933, p. 72) observations, the part of the osëtr which enter the Kura at the end of May and in the summer and autumn months have sexual products in stage III, that is, far from being mature; these osëtr winter over in the Kura and lay their eggs in the following year, and "a spawning, apparently of this group of osëtr, occurs in the second half of April and in May". Thus the Kura hiemal osëtr, just like the Kura hiemal sevriuga and the Ural hiemal osëtr, lay their eggs earlier than the vernal osëtr.

Consequently, comparison of the biology of the Kura and the Volga-Ural osëtr shows us that in the north Caspian hiemal osëtr predominate and in the south Caspian vernal osëtr do. Also, according to V. N. Beliaev's information, the southern osëtr can be separated biometrically into a special form, the subspecies Acipenser güldenstädti persicus Borodin (see Berg, 1933, p. 836).

On the Dnepr River also the vernal osëtr predominate over the hiemal.

**Beluga**

A completely analogous picture is presented by the beluga or great sturgeon (Huso huso). In the Ural River the vernal beluga begins to arrive starting in the middle of March; this beluga lays its eggs in the delta of the Ural at the middle of May. The beluga which enter the Ural toward the end of the spring and early summer, and also in the autumn, belong to the hiemal race; this race lies all winter in the river, in the yatovi, then in spring it goes up the Ural to lay its eggs at the beginning of May. Hiemal beluga predominate, by numbers, in the Volga delta, where the main part of their run is in September to November.

[page 724] In the north Caspian immediately off the mouths of the Volga and in its delta, the mean monthly catches of beluga, averaged over the years 1879–1892, old style, were as follows according to Grimm (1893) (in pieces):

18Sexual products completely ready for fertilization are designated as stage V.
In the Kura, where beluga to-day are caught only occasionally, those most frequently encountered are vernal beluga, according to information of the Azerbaijan Station; however 75–100 years ago the hiemal race predominated, as in the mouths of the Volga. This is indicated by the excellent statistics of the Kura fishery collected at that time by Ber and Danilevsky, which we have already cited. In the lower reaches of the Kura in the great Bozhii fishery, for the years 1829–1845 and 1847–1855, the mean catches of beluga were as follows, old style:

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>Year's total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieces</td>
<td>64</td>
<td>71</td>
<td>129</td>
<td>23</td>
<td>3</td>
<td>0.5</td>
<td>7239</td>
</tr>
<tr>
<td>%</td>
<td>4.7</td>
<td>5.4</td>
<td>12.4</td>
<td>2.2</td>
<td>0.3</td>
<td>0.1</td>
<td>100</td>
</tr>
</tbody>
</table>

**SHARPNOSE STURGEON [SHIP]**

Sharpnose sturgeon (*Acipenser nudiventris*) enter the Kura River twice, in spring and in autumn. The spring run reaches its maximum in March and the autumn run in October to November, new style. From Ber and Danilevsky (1863) we will cite the following data relative to the catches of sharpnose sturgeon in the lower reaches of the Kura (in the great Bozhii fishery) for the years 1841–1855, old style:

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Nov</th>
<th>Dec</th>
<th>Year's total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieces</td>
<td>251</td>
<td>988</td>
<td>3578</td>
<td>847</td>
<td>116</td>
<td>244</td>
<td>10502</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td>2.0</td>
<td>8.1</td>
<td>31.6</td>
<td>7.5</td>
<td>1.0</td>
<td>2.2</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Since the spawning of the sharpnose sturgeon takes place in the Kura at the end of April and in May it is obvious that here too there are two races, as among the other sturgeons. The vernal race of sharpnose sturgeon predominates in the Kura. However, in the basin of the Aral Sea only the hiemal sharpnose is found (Berg, 1911).

Thus in all the anadromous acipenserids we have two well-developed races—vernal and hiemal, of which now one will be the more important, and now the other. Rarely one of the races can be completely lacking, as is true of the Aral sharpnose sturgeon.

Sterlet

The sterlet (*Acipenser ruthenus*) is a freshwater fish which does not go to sea. However, in the region of the Volga just off the mouths (and also in the regions of the deltas of the Don, the Dnepr and other Black Sea rivers) there are semi-anadromous sterlets which enter the Volga delta twice: in spring along with the sevruga and then in autumn. The spring (vernal) sterlet goes higher up the delta for spawning; fish of the autumn (hiemal) race lie in the deep holes during the freeze-up—either immediately off the mouths of the Volga, in the mouths themselves, or in the lower part of the delta (V. E. Yakovlev, 1870; see Berg, 1911, p. 217). Where the hiemal semi-anadromous sterlets spawn is not known (in general, in the Volga, spawning places of the sterlet have not been found any farther downriver than Chërnyi Yar, 400 km from the mouth, but it is possible that they also occur much lower; see Chugunov, 1928, p. 101).

Concerning the freshwater sterlet in the Volga Basin there are no accurate observations regarding the existence of seasonal races, but indirect information suggests that such races may occur. For example, in the River Viatka near Malmyzh, in the spring at the time sterlets are running fishermen distinguish two groups: some begin to run immediately after the break-up of the ice, and stay close to the bank; among these sterlets the sexual products even in the largest ones are far from mature; for example, one sterlet 62 cm long taken June 8, 1929, contained eggs in stage II–III; without question this sterlet would have had to lay its eggs in the following year, 1930. This apparently is a hiemal sterlet. Other sterlets, which migrate in the spring out in mid-channel, have ripe eggs and milt; these evidently are vernal sterlets; their spawning was observed near Malmyzh in the main channel on May 23–28, 1930 (Lukash, 1933, pp. 31–32).

Lamprey Family

In rivers emptying into the Baltic Sea and its gulfs, particularly the Neva, the lamprey (*Lampetra fluviatilis*) has two races—an autumn and a spring one. In autumn in the Neva a mass migration of lampreys is observed entering from the Gulf of Finland; they winter in the river, then lay their eggs in the first half of June (sometimes toward the end of May). The autumn run begins in appreciable numbers in August, the main part of the run is in September, October and November; but a few individuals of the hiemal minoga begin to enter the river as
early as the first 10 days of June (Ivanova-Berg, 1932). In spring lampreys again approach the Neva delta, at which time they already have well developed sexual products; these lay their eggs the same season.

Apparently here too we have a case of two races, hiemal and vernal. It is curious that in the Tiber the lamprey run is very late (similar to the Caspian salmon in the Kura): at the mouth of the river it lasts from December to April.

CARP FAMILY

It is well known that the anadromous cyprinids, for example the vobla, bream and others, approach the Volga and Ural River deltas twice—in spring and in the fall. It is my opinion (though it needs confirmation) that these approaches are associated with the presence of two races—vernal and hiemal. Let us consider the vobla.

Vobla (*Rutilus rutilus caspicus*) migrate to the Volga delta from the northern part of the Caspian Sea at two times of year: in spring, when they spawn, and in fall, when they have in view the spawning of the following year [limeia v vidu nerest v sleduiushchem godu]. Large vobla come in autumn, smaller ones in spring. The autumn run, according to Tereshchenko’s data (1913, p. 7), begins in June and lasts to late autumn, reaching its maximum in October. “Not long after the break-up of the ice on the river large specimens of this fish, which wintered in the river or just off the mouths of the Volga, move out of the depressions in the river bed and proceed upstream.” The main run of vobla begins about 2–3 weeks after opening of the river and lasts from the middle of April through May. The sex composition of the autumn and spring vobla is different: in autumn there are very few males, while in spring they average 47%, or in exceptional instances up to 70% (p. 16). Analogous sex ratios are known also for autumn and summer semga: among the autumn fish males predominate, among summer fish, the females. The size of autumn vobla, as I have said, is large:

<table>
<thead>
<tr>
<th>Year of hatch</th>
<th>Spring 1912</th>
<th>Autumn 1912</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>3-year-olds</td>
<td>1909</td>
<td>131</td>
</tr>
<tr>
<td>3-year-olds</td>
<td>1909</td>
<td>122</td>
</tr>
<tr>
<td>4-year-olds</td>
<td>1908</td>
<td>191</td>
</tr>
<tr>
<td>4-year-olds</td>
<td>1908</td>
<td>160</td>
</tr>
</tbody>
</table>

The condition of the sexual products of autumn vobla is of course much less advanced than in the spring vobla.

How far upriver the spring vobla go, and how far the autumn vobla go, is not known. Apparently the spring migration of autumn vobla begins earlier, and it lays its eggs earlier, than does the spring race.

The Volga–Caspian bream (*Abramis brama*) comes to the Volga delta three times—in spring, summer and autumn. In contrast to the vobla, the greatest run of
bream occurs in autumn—in September, October and November (Tereshchenko, 1917). The biology of the bream has not been studied from the point of view which interests us here, but apparently it too has seasonal races. At least A. N. Derzhavin (1913, p. 33) pictures the run of bream to the Volga delta in 1911 as follows: Right after the under-ice [podlednaia] vobla (that is, the autumn vobla) and the sanders [Lucioperca] there arrive in the outer parts of the delta the deep-hole bream [yamnyi leshch] which ever since autumn have been wintering [page 727] off the mouths of the river and in the deep holes of its lower branches. Then there appear great schools of bream moving in from the sea, that is, bream of the spring race. At the Olia fishery in the Volga delta the main run of the spring bream (which had come from the sea) was on the 22nd and 23rd of April.

In the Kura River bream enter during the winter—from December to February; the peak of the run is in January (Beliaev, 1932).

The carp (Cyprinus carpio) behaves in a similar way in the Volga delta. It arrives at two seasons, spring and autumn. The autumn, or deep-hole carp, resemble the autumn bream, and go upstream in spring earlier than the spring or “sea” carp (Derzhavin). In other rivers also the carp appears twice—in spring and fall.

The cut-tooth [vyrezub], Rutilus frisii (Nordm.), approaches the Dnepr–Bug littoral twice, in spring and autumn. The spring run lasts from March to the end of April; it spawns in the Bug in the region of the rapids from the end of April through the first half of May. The larger, autumn, run begins at the mouth of the Bug in the second half of August (and even earlier), the main part of the run is in August and September; in the mouth of the Dnepr the run begins in October, reaches its maximum in November and lasts in both rivers to the freeze-up (second half of December). The migrating cut-tooth in the Dnepr, both in the spring and in autumn, are far from sexual maturity; both eggs and milt are in Stage II (Syrovatsky, 1929, pp. 151, 153). However in the Bug the autumn cut-tooth are in Stage III, and toward the end in Stage III–IV, while the spring run up to the middle of May are IV and IV–V, and from the middle of May onward cut-tooth are found either in Stage V or in Stage II (Syrovatsky, 1933, p. 43); that is, both vernal and hiemal fish occur at the same time. These latter will remain in the river a whole year.

In the Caspian Sea Rutilus frisii is represented by the sub-species R. frisii kutum (Kam.). In contrast to the cut-tooth, the kutum has its maximum run not in autumn but in spring, though both races occur. Average catches in the Kumbashinka River (southern part of the Caspian, in the Lenkoran region) for the years 1925–1929 were as follows, in thousands of pieces:

<table>
<thead>
<tr>
<th>Year</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
<th>XI</th>
<th>XII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
<td>7.4</td>
<td>113.4</td>
<td>160.0</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>0.9</td>
<td>0.5</td>
<td>283.2</td>
</tr>
</tbody>
</table>

The spawning run reaches its maximum in the second half of March through the middle of April; spawning occurs from the end of March to the end of April.

The third form of R. frisii is the subspecies medlingeri (Heckel), which lives in lakes of the Danube basin (Lakes Traun, Atter, Mond and Chiem) and bears the names Frauenfisch and Perlisch. It never goes to sea, spending its whole life
in the lake; only for spawning does it enter rivers during the first half of May; at other times of year it does not occur in rivers. Seasonal races have apparently not been observed.

The Aral barbel or usach, *Barbus brachycephalus* Kessler, enters the Amu-dar mainly in June-September, with sex organs in Stage II–III of development (M. I. Markun, 1933, pp. 26, 32). This apparently is a hiemal usach, which will spawn in the Amu-dar in spring of the following year. The run of the hiemal race begins as early as May and ends in October–November. But in addition there is a much less numerous spring run; it starts in the middle of March; on May 7, 1930, at Muinak (situated on the sea near the mouth of the Amu-dar) M. I. Markun caught a usach with eggs in not less than Stage IV of maturity (p. 32); this female, which undoubtedly would have spawned the same season, belonged to the vernal race.

Apparently there is a hiemal and a vernal race of the Kura shemaia (*Chalcaburnus chalcoides*). This fish enters the Kura from the Caspian Sea from October to April; the main part of the run is in December and January (Beliaev, 1932). They go upriver very quickly, as far as Aragva, where they are observed near Ananur in April and May (old style). The spawning is in spring, but just where and when is not known for the Kura (in the Tereka it is about the middle of May).

The chekhon (*Pelecus cultratus*) also has seasonal races: in the Don it ascends from the Gulf of Taganrog twice: in spring there is a small run to the spawning grounds (spawning is from the first days of May to the middle of June); the summer-autumn run, a much larger one, begins in July and lasts about to freezeup (V. N. Tikhonov, 1928).

Very remarkable are the races of the Issyk-kul osman, *Diptychus dybowskii*. This fish, one of the carp family native to the waters of central Asia, imitates to an amazing degree the salmonid fishes which are lacking where *D. dybowskii* lives. In the spawning period the dorsal fin of the male osman elongates, somewhat in the manner of the same phenomenon in grayling. Eggs of the osman are large, as in salmonids; they number 5000 to 25,000, and develop slowly. And the way of life of these fish recalls what exists in salmonids. There are two races of osman, a summer and a winter one: the summer osman are smaller, they are caught in summer, they spawn in the second half of June and July, for which event they enter the lower reaches of rivers. The winter osman are larger, they are caught in winter and spring: according to information obtained by our 1930 Expedition (M. I. Fedorova) it spawned in that year in the first half of April; according to the fishermen spawning takes place in the lake itself, alongshore, and begins as early as February.

**PERCH FAMILY**

The sander (*Lucioperca lucioperca*) which enter the rivers of the Black, Azov, Caspian and Aral Seas also have two runs—in spring and in autumn, associated apparently with the existence of two races, vernal and hiemal. In the Volga delta the “deep-hole” (i.e., autumn) sanders move upstream in spring earlier than the spring (vernal) sanders, as is true also of the deep-hole vobla, bream and carp.
According to V. V. Petrov's (1934) information, the autumn run of sanders in the Ural River begins at the end of July or beginning of August; its peak is in the second half of October, and by the end of November, with the beginning of the freeze-up, the run stops. The spawning places of the hiemal sanders are far up the river, none below Uralsk. The spring run, much less important, begins right after the opening of the Ural; in 1931 the main spring run in the delta ended about May 1, but odd fish were taken up to the beginning of June; in all likelihood this, vernal, run ascends only to the region of Redut or Yamanka.

CONCLUSIONS

Thus vernal and hiemal races, in the very varied groups of fish which we have reviewed, have a number of common features:

1. The hiemal races spend the coldest time of year either in the river itself or immediately off the mouth of a river, while the vernal races enter the river at higher water temperatures.

2. Throughout the very cold time of year the hiemal races are in a state of vegetative quiet, when they eat little or nothing at all; many lie during the winter in deep holes in the river bed; in vernal races the stage of vegetative quiet, if there is one, is much shorter, and hibernation in depressions does not occur.

3. The vernal races lay their eggs during the same growing season as they approached the river mouth; the hiemal races do it either in the following season or at least after a considerable interval of time.

4. The hiemal races usually spawn earlier than vernal races (that is, they mature, in a given year, earlier than the vernal fish).

5. Hiemal races commonly go farther upriver than vernal.

6. Fish of hiemal races are usually larger than vernal fish.

7. Hiemal races are usually more fecund than vernal.

The analogy with vernal and hiemal races of cereal grains is remarkable. Hiemal grains also must be subjected to cold for a longer period of vegetative quiet than must vernal grains; they mature earlier, produce heavier kernels and have a higher vegetative growth than vernal varieties.

Turning to what might cause the phenomenon of vernal and hiemal races in fishes, I must say that nothing is known on this subject, for the question of the existence of such races, on the scale indicated in this paper, has not been raised heretofore in the literature.

But it is possible to make some suggestions, based on the analogy with vernal and hiemal grains. Hiemal types of grains are those which, when sown in spring, do not form heads during that same growing season. Their sprouting seeds or young plants require the action [page 730] of low temperature on them for a certain length of time; only when they have first been subjected to the influence of cold can they produce heads. By contrast, the vernal grains, when sown in spring, produce heads the same summer.\(^\text{10}\)

\(^{10}\)However, almost all vernal wheats can also be sown in autumn and will then produce heads if they aren't killed by freezing.
In a similar manner the hiemal races of fish also require, for maturing their eggs or milt, a stay in more or less cold river water for several months.

The differences between vernal and hiemal races in fish has great importance for the fishing industry, and especially for fish culture. As an example I will cite our northern salmon, or semga. There, as a rule, the hiemal salmon are generally found to be larger and therefore more valuable than the vernal. But they cannot be caught with mature sexual products in the lower courses of rivers, and therefore it is necessary either to obtain spawners in the upper tributaries, which is very difficult and frequently impossible, or else retain them in holding ponds in the lower part of the river, which is also difficult when it lasts for any long period of time.

Therefore the possibility of changing a hiemal race of fish into a vernal one would have great practical interest. As we have seen, in nature the transformation of one race into the other does not occur; at least no undoubted evidence of such transformation has been produced. But we must suppose that experimentally such a transformation could be successful. The analogy with the vernal and hiemal grains gives this hope. "All the hiemal kinds of grains are not hiemal to the same degree, and the vernal kinds do not all have the same degree of 'vernality'," says Lysenko (1932, p. 10). Some vernal wheats, which when sown in spring produce heads the same summer at Odessa and Kharkov, will not produce heads when sown in the north Caucasus—that is, they behave like hiemal varieties. On the other hand, if we hold sprouted seed of a hiemal wheat in the cold for a while, that wheat behaves like a vernal wheat (Lysenko, 1932). Cases are known where hiemal wheat, on being sown very early in spring, have produced heads the same summer; but they of course are subjected to cold for a considerable time, so that in reality they are still hiemal wheat.

In general it seems unlikely that the differences between vernal and hiemal races of anadromous fishes are anything that would be firmly fixed, judging by general experience. Even the matter of whether a given species or form is migratory or sedentary is a character readily susceptible to change. For example, the carp of the Volga delta is an anadromous or, more accurately, a semi-anadromous fish (it does not as a rule go out into salt water, remaining in the brackish parts off the mouths of the Volga); but above the delta there live non-anadromous carp, which do not take part in the migration to the pro-estuarine area, and which apparently do not have [page 731] seasonal races. *Barbus brachycephalus* in the Aral Sea is a typical anadromous fish, but in the River Chu, which in respect to its fauna belongs to the basin of the Aral Sea but does not now flow as far as the Syr-dar, the local usach has a non-migratory mode of life. The salmon, *Salmo salar* — a typically anadromous fish — develops forms in the lakes of northern Europe (Ladoga, Onega, Vaner, etc.) which never go to sea and which complete their migrations within the confines of the lake system: for spawning these salmon move out of the lake into rivers tributary to it, and then return to the lake. And in southern Norway a dwarf salmon has been described which is able to spawn in the lake itself, without ascending a river. What is more, the salmon, *Salmo salar*, can spawn even in ponds, as has been observed in England and
recently in Denmark, without ever having been in the ocean or even in a large lake. Finally, male salmon (but not females) can become sexually mature before going to sea, and in rivers sexually mature milt-producing males 10–20 cm long are encountered. The anadromous kumzha (Salmo trutta) gives rise in rivers to a non-migratory, purely freshwater form, the trout (Salmo trutta, m. fario). The same is known for some Pacific Ocean fishes, the dolly varden char (Salvelinus malma), the sockeye (Oncorhynchus nerka) and others. The anadromous lamprey, Lampetra fluviatilis, gives rise to the brook lamprey, L. planeri, which never goes to salt water.

In a word, fishes are very plastic in their biological relationships with respect to whether they are anadromous or not. But seasonal races have been differentiated, we must suppose, after the fish became anadromous (this hypothesis requires verification!) and therefore it is a wholly natural assumption that vernal and hiemal races, in fishes as in grain, should not be unchangeable.

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20I called attention to this in “Priroda”, 1933, No. 2, p. 69.

21It is possible that there are seasonal races even among non-anadromous, purely freshwater fishes. At least many river fishes, for example the sterlet and others, go upstream to spawn in spring.

22Concerning the alteration of hiemal rye into vernal rye using uninterrupted 24-hour light during the whole summer, see the remarkable article by Chailakhian (1933): hiemal rye, illuminated 24 hours a day at Leningrad for 64 days from the time of the appearance of its sprouts, produced culms—that is, behaved like vernal rye.

23Russian titles of articles have been translated and are put in square brackets. References are transliterated in the form used by the author.

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*The correct term would be not iarovizatsiia, but estivalizatsiia (Latin aestivalisatio).* L.B.