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by V.K. Klokov

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Variability in measurement and weight indices of chum salmon of the northern coast of the Sea of Okhotsk.

By V.K. Klokov.

The problem of the rational utilization of the stocks of commercial fish includes a detailed study of the intra-specific structure of commercial items. The need to solve this problem is dictated not only by the purely practical requirements of clarifying the individual local fish groupings but it is also of great importance in the study of the adaptation mechanism of species to different habitats. 81*

In the present work the intraspecies structure of chum salmon of the continental coast of the Sea of Okhotsk, where it is one of the most important species of the industry, is examined on the basis of an analysis of measurement and weight features.

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

The existence of local populations of chum salmon has been established in different regions of the Far East, by a number of authors, in the Amur basin (Birman, 1956; Levanidov, 1954; Lovetskaya, 1948), in Sakhalin (Dvinin, 1952; Volovik and Landyshevskaya, 1968), in Kamchatka (Semko, 1954). Data was obtained which confirm the isolation of the Anadyr population from other groups of chum salmon (Volobuev and Nikulin, 1970; Ostroumov, 1967). V.I. Ivankov (1970), by a correlation of the main biological indices of the chum salmon of the Asian and American stocks - the absolute fertility and the body measurements - distinguishes within them five types of local groupings. The works of V.L. Kostarev (1964, 1967, 1970) are devoted to the questions of the biology of chum salmon of the north-western 81
coast of the Sea of Okhotsk.

Systematic works on the study of the populations of chum salmon in the northern part of the Sea of Okhotsk started in 1960 after the organization in 1959 of the Magadan branch of TINRO. The analysis of the bio-statistical data confirmed the presence of differences in the Okhotsk and northern salmon, but also indicated the existence in some indices of a similarity which manifested itself quite clearly in individual years.

Research of the Okhotsk laboratory and the salmon laboratory of the Magadan branch of TINRO, which are based on

the analysis of different qualitative indices of salmon (measurement and weight characteristics, age and sex composition and the dynamics of abundance of spawning stocks as well), originated from the position that there are two populations of salmon - the Okhotsk, whose spawning geographic range is spread along the 81
rivers of the north-western coast of the Sea of Okhotsk from Inna to Aldoma and the salmon population of the Northern coast, whose spawning grounds are located in the rivers of Taui, Yama and Gizhiga Bays and possibly in the rivers of Penzhina Bay (the rivers Paren' and Penzhina), and further on, closely connecting with the basins, come the rivers of the Kamchatka coast of Shelikhov Bay where the western Kamchatka salmon spawn. Such a subdivision into popula-
tions of the salmon of the continental coast of the Sea of 82
Okhotsk has existed from those times when the coastal industry was carried on and was most probably a consequence of territorial demarcations of spheres of activity of different fish catching enterprises, in particular in recent years, the Okhotsk and Magadan Fish Combines, rather than the result of generalizing scientific research.

At the present time the volume of accumulated data enables us to conduct a comparative analysis of qualitative indices of individual populations of salmon on the continental coast of the Sea of Okhotsk, which, in turn, may provide an answer to the question of whether two salmon populations really exist.

When analysing the data the discrete spread of the chum salmon population on the continental coast of the Sea of Okhotsk is taken as an initial premise. Such a view of the territorial distribution of the salmon in the region under investigation is based first of all on the theory of "natal" rivers, according to which individual representatives of Far Eastern salmon - sockeye, autumn chum - are very clearly attached to their birth- 82
places, up to the individual section of the "natal" river; the other species, for example pink salmon, when returning to spawn may enter neighbouring rivers (Levanidov, 1969). Probably the summer form of chum salmon is quite closely attached, if not to the river itself which is its birthplace, at least to the region of this river. On the continental coast of the Sea of Okhotsk it is possible to distinguish geographically several groups of large salmon rivers, more or less isolated from each other by vast areas with a number of small rivers. First of all there is the group of Okhotsk rivers - the Inya, Ul'ya Urak, Ul'teya, Kukhtui and Okhota, northerly located rivers of Taui Bay - the Taui, Yana, Arman', Ola, in Yama Bay practically one large river - the Yama and, finally, in the northern part of Shelikhov Bay are the rivers of Gizhiga

Bay - the Nayakhan, Garmanda, Gizhiga and Avekova. The importance of these groups of rivers in the total balance of spawning areas of salmon can be evaluated by data of aerovisual calculation of the brood stock which enters them to spawn, taking only 1967 as an example (according to the data of A.V. Evzerov). In this year in the rivers of the continental coast of the Sea of Okhotsk around 5 million adult chum salmon spawned. Of this number 42.5 percent of the brood stock entered the Okhotsk rivers, around 6 percent entered the rivers of Taui Bay, 17.5 percent entered Yama Bay and about 34 percent of the total number of adult fish spawned in the rivers of Gizhiga Bay. 82

We must assume that only in a large river with a large stock of spawning areas, or in a group of sufficiently closely located rivers with similar hydrological and hydro-chemical parameters, can a more or less clearly localized salmon population with its inherent genotype, which is preserved during a definite period, emerge. In our case the description of the populations, whose spawning areas are considered to be the above-mentioned group of rivers, is given from samples from the individual and largest rivers. The share of these rivers according to the number of spawners in the spawning grounds in 1967-1968 comprised the following amounts: among the Okhotsk rivers, the Kukhtui River - from 8 to 17 percent, in Taui Bay the river Taui - from 44 to 65 percent; from 50 to 80 percent of the total number of spawners in the rivers of Yama Bay entered the Yama River, and from 33 to 53 percent of the total number of fish in this region spawned in the Gizhiga River, the largest river of Gizhiga Bay.

It should be emphasized that the premise about the dis- 82
creteness of the spread of the chum salmon on the continental coast of the Sea of Okhotsk is accepted for the population level but not for the species as a whole, whose representatives are found in practically all the rivers of the coast.

In the end it is considered fundamental that the continental 83
coast of the Sea of Okhotsk is an area of continuous occurrence of chum salmon (the irregular state of the geographic range results only from the irregular state of the river distribution), which in a number of places, especially where there is a group of rivers or just one river but with a considerable spawning stock, forms local populations more or less isolated from each other territorially by areas with a weakly developed river network. Based on this, four regions are distinguished where the presence of individual populations of chum salmon is assumed. The existence of chum salmon as populations which are confined to individual rivers is recorded for the Amur, western Kamchatka and Sakhalin chum

salmon. For the Sakhalin chum salmon which enters the rivers located in distant regions, significant differences in the heaviness of the run, the dates of the run, the size, the weight, fertility, growth rate and other indices are noted. The indicated differences which are expressed to a lesser degree are also traced when comparing fish from neighbouring rivers of the same coast (Volovik and Landyshevskaya, 1968). It is possible therefore at this state of research that it is more correct to speak about populations* of the Kukhtui River, Taui River, etc.

In the present work with the study of the measurement and weight indices of chum salmon the aim is to determine the similarity and difference in the variations in these characteristics in different populations of chum salmon of the coast of

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* By "population" we understand the definition given by G.V. Nikol'skii (1961) and N.V. Lebedev (1967) for stock as a biological self-reproducing intraspecies grouping of fish, smaller than a race and differing from other groupings by biological features, often confined to definite regions constantly, or in certain periods of the yearly life cycle, that consists of all age groups, that is, represented by all generations. Applying directly to the studied groups of fish, a particular case of such a definition is the first type of spawning population, which is a population consisting only of fish spawning for the first time (Monastyrskii, 1953). A more general concept is the designation of a population as a group of individuals inside of which panmixia takes place and which for the lifetime of more than one generation is genetically isolated from other similar groups (Shmal'gauzen, 1968, Yablokov, 1966). In this definition two essential sides of the real objectivity of a population are underlined - isolation from other similar groups and the presence of panmixia inside this group.

the Sea of Okhotsk. That is, to use the indicated bio-statistical indices and their dynamics as a criterion for the demarcation of individual populations. 83

The term "stock", which is used in the work, is used to designate a spawning grouping of salmon which is confined to a definite region of reproduction. For the convenience of the presentation, we will for the present call the stocks of chum salmon of individual rivers populations.

MATERIAL AND PROCEDURE

In this work the variations are examined in the measurement and weight indices of fish, which comprise the spawning stocks, the connection of the variability of these features with the activities of various environmental factors, and the degree of gradation in such indices among the salmon populations studied. With this aim data were used of biological analyses of spawning stocks of chum salmon from the rivers Taui, Yama and Ginzhiga, collected in 1960-1968 by the personnel of the laboratory for the study of salmon of the Magadan Branch of TINRO. Data on chum salmon from the Yama River for 1964-1968 were collected by workers of the Okhotsk fisheries. Altogether were examined: 5,088 specimens from the Taui River, 2,965 from the Yama River and 3,361 from the Gizhiga River.

The biological analyses were conducted by the generally accepted method (Pravdin, 1966) and from them two indices were 84
used for this work - body length AC and the weight of ungutted fish. In addition, the age of all the fish studied was determined by scale specimens.

Similar data of V.L. Kostarev on the Okhotsk chum salmon, collected in the Kukhtüi River in 1960-1968 in the quantity of 5,600 specimens, were used for comparison.

The statistical processing of the obtained data was conducted according to the method presented in the handbooks P.F. Rokitskii (1961) and V.Yu. Urbakh (1963). When interpreting the results of the mathematical analyses to explain the biological connections, the directions of V.S. Smirnov (1968) regarding the disparity of the actual natural samples with the purely mathematical models were used.

A comparison of size and weight indices of chum salmon in different rivers was conducted both for each year of research and for all the studied period, differentiating in both cases by two main age groups - fourth-year and fifth-year. The study of the variability of the size and weight indices was carried out by an analysis of the root mean square deviation (σ) of these features and the variation coefficient (C) as well. In all cases when comparing the

different features of chum salmon of individual rivers, the weighted mean indices according to the number of fish in the 84
tests were used.

RESULTS AND DISCUSSION

The size and weight indices of chum salmon of different populations for the 1960-1968 period are presented in Table 1 [p. 37]. The averaged data to a considerable extent clouds the influence of different factors (the variability of these indices in individual years, the relative quantity of males and females), but nevertheless they give a general idea of each of the populations as a whole and can serve as a starting point for a further analysis of the bio-statistical indices, reflecting the tendency in their spatial changes.

As follows from the data of the table, the averaged data already indicate the existence of a definite order in the variations in the size and weight indices of chum salmon within the limits of the region studied on the continental coast of the Sea of Okhotsk. These variations are traced both through each of the populations as a whole and through the individual main age groups. First of all, the most similar indices are found in fish which are in the outer points of the geographical range studied - from the rivers Kukhtui and Gizhiga. The chum salmon of these rivers is relatively small in size and accordingly

weighs less. The Taui chum salmon is larger, but the largest chum salmon are of the Yama population. Thus an increase 85
occurs in the average sizes of the chum salmon from the Okhotsk rivers up to the Yama, and when moving further northwards up to Gizhiga Bay, the size and weight indices decrease again. In particular, very small sizes of chum salmon were noted in the Paren' River in 1969 - on the average, around 60 cm, weight 2.8 - 2.9 kg. A similar conformity is also traced in the two main age groups - the fourth-year and the fifth-year (Table 1) [p. 37].

There is information that in previous years a decrease was observed in the size of chum salmon from the Yama River northwards along the Okhotsk coast. According to data of V.K. Arsen'ev (1925), in 1922 the average weight of chum salmon in pounds was as follows: in the Yama River - 8 - 8.5; in the Tumany - 7. - 7.25, in the Gizhiga - 6.5 - 6.75; in the Penzhina - 5.75 - 6.0.

What is the cause of such variations in the features of the chum salmon of different regions? Most likely, the variations in the sizes of the fish are due to habitat conditions and, possibly, our example is an illustration of the Bergman rule (Shmal'gauzen, 1968, page 108), according to which the northern forms (mammals and birds) differ by larger sizes from the southern representatives of the same group. The regular

variations in the features of a number of fish from the south to the north 85
was noted by L.S. Berg (1922); for related species, the increase in the number of vertebrae in the northern forms as compared to the southern was traced (Iordan, 1891, 1893; Rass, 1941). Schmidt I. (1930) discovered that within the very same species in the northern and oceanic populations there is usually a larger number of vertebrae than in the southern and coastal populations.

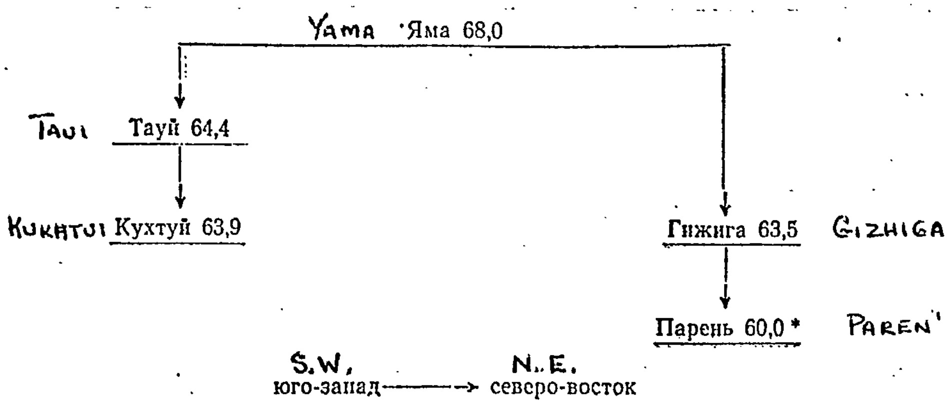
Similar regularities are recorded in other orders of animals as well (Arnol'di, 1939). There are data relating to fish (Garside, 1966) that with an increase in salinity and a decrease in the water temperature (that is, with an increase of density and viscosity) in the process of embryogenesis in a number of species - salmon, herring, eelpont and others - the number of vertebrae, scales in the lateral line and rays in the dorsal and anal fins is increased. Similar variations in the morphological features in fish under the influence of the thermal conditions of development were noted by K.I. Tatarko (1968) as well. M.I. Men'shikov (1951), establishing in a number of fish an increased number of elements in meristic features according to a south to north direction, also considers the temperature to be a determining factor of this phenomenon. Gray I. (1928) also showed the inverse relation of the body sizes of the embryos to the temperature of the environment, having found that trout embryos, incubated at various temperatures, reached at the moment of hatching the largest weight at the lowest temperatures. G.V. Nikol'skii (1969) considers that these variations are an adaptive reaction which changes the hydrodynamics of the body in relative conformity to the variations in the properties of the water in which the fish moves. 85

Hence, one can assume that the large Yama chum salmon is attached to colder places of habitation as compared with other regions. Actually, in the region of the Yama Islands in June-August, the lowest temperatures on the surface of the sea and the highest salinity of the upper layer of the water were noted (Moroshkin, 1966). So, in June the water temperature in the region of the mouth of the Yama River fluctuated from 1 to 2°, at the Gizhiga - from 2 to 5° at the Taui - from 6 to 8° and on the Okhotsk coast - from 1 to 7°; in August along most of the coast the temperature of the surface layer of the water fluctuated from 8 to 10°, whereas in the region of Yama Bay water temperatures of up to 2° were observed. The salinity of the water in Yama Bay varied from June to August from 33 to 32.5 percent, in other parts of the coast - from 33 to 27 percent.

If we assume that the formation of a phenotype occurs 86
not only in the period of embryogenesis but in the subsequent stages of development as well, then there is no doubt that

the above changes of environment in the coastal parts of the sea exert a certain influence on the change in the size and weight indices of the chum salmon. The qualitative difference of the juveniles which arose in the early stages of development is possibly consolidated in the subsequent conditions of the feeding migration in the sea. According to the data of I.A. Piskunov (1959), fry of the western Kamchatka chum salmon, having migrated from the rivers to the sea, stay until late autumn close to the mouths of the "natal" rivers, appearing again in these regions after wintering in the south as a second-year fish. The accumulations of the immature second-year chum salmon at the shores of the southern part of western Sakhalin were also noted by 86
P.A. Dvinin (1949). Therefore we can assume that the effect of the differences in the conditions of the early stage of the feeding migration of juvenile chum salmon continues for a sufficiently long time in order to have an effect on the finally formed phenotype of fish from individual regions of reproduction. On the other hand, the nature of the change in the fish features does not fit into a simple "environment-organism" scheme and being clearly outlined at extreme values, it does not reveal regular relationships with other indices which are inside these values. Therefore for the present, leaving the question open about the causes of the observed nature of the

change in the size and weight indices of the chum salmon, we can present the following scheme of the spatial change in the sizes of the salmon (the length AC is given in cm): 86



The fluctuation limits in the size of the chum salmon of the Okhotsk coast for different populations have divergences in their extreme values. The length of the Okhotsk chum salmon in the period from 1960 through 1968 fluctuated between 49 and 79 cm; in other populations the size of the chum salmon varied within the following limits: the Taui chum salmon - from 47 to 82 cm, and the Yama - from 53 to 84 cm; the largest range of fluctuations in the body size - from 49 to 86 cm - was observed in the Gizhiga chum salmon. Thus, the shortest length of the chum salmon of the studied region was 47 cm, and the largest sizes of chum salmon reached 86 cm. The average length of chum salmon of different populations during the studied period varied within the following limits: the Okhotsk chum salmon - from 61.3 to 67.0 cm, the Taui - from 62.7 to

69.9 cm, the Yama - from 66.7 to 70.1 cm, the Gizhiga - from 61.1 to 69.7 cm (table 2).

The body weight of the chum salmon underwent rather significant fluctuations, and, besides this, differences in the extreme values in fish of different populations were also traced here. The weight of the Okhotsk chum salmon varied from 1.5 to 7.2 kg, Taui - from 1.1 to 6.9 kg, Yama - from 1.7 to 8.1 kg, Gizhiga - from 1.5 to 7.5 kg. Thus, the 87
extreme values of the body weight of chum salmon of the continental coast of the Sea of Okhotsk are from 1.1 to 8.1 kg.

The average body weight of the chum salmon of different regions fluctuated by years within the following limits: the Okhotsk chum salmon - from 3.02 to 4.01 kg, Taui - from 3.22 to 4.40 kg, Yama - from 3.72 to 4.48 kg and Gizhiga - from 3.11 to 4.23 kg (table 2).

The variations in the size and weight indices in the main age groups of chum salmon - the fourth-year and fifth-year - show up more clearly (table 2). [page 38]. So, the average sizes of the fourth-year Okhotsk chum salmon varied from 59.3 to 63.3 cm (without data for 1968), close to them are the fluctuation limits of the sizes of the Gizhiga chum salmon - from 59.7 to 67.4 cm (maximum average size was in 1968).

The largest sizes were noted in fourth-year chum salmon of the Yama River - 65.6 to 69.2 cm. Chum salmon of the Taui River has an intermediate position between the Yama and two other populations: its average sizes fluctuated within the limits of from 62.0 to 69.7 cm. The same sequence of the distribution of the populations according to the fluctuations in their average sizes is traced in the fifth-year fish also: close to one another are the indices of the Kukhtui and Gizhiga populations - 61.9-66.5 cm and 66.5 to 70.3 cm respectively; the Yama population - 66.3 to 72.6 cm - is distinguished by its large sizes, the Taui population has an intermediate position - 64.1-71.4 cm.

If we look at the data which defines the variations in the body weight of chum salmon at the age of four and five years, then we can also find here the above established regularity.

Thus, when examining the intervals of the values of the size and weight indices also among the different age groups, the existence of divergences in the fish of four populations by these indices is confirmed.

In order to establish the degree of divergence of the populations by the size and weight composition of fish it is necessary to investigate the variations in these characteristics for each year. In order to allow for the influence of the variation in the age composition on the size and weight structure of the spawning stock, preference is given to the analysis of individual groups - fourth-year and fifth-year fish. Other groups - third-year and sixth-year - are represented in the catches by a small number of specimens and therefore are not examined. Since the two main age groups comprise more than 90 percent of the fish in the samples, there are grounds for transferring to the whole population the data obtained from analysing them.

As is widely accepted in research connected with the analysis of bio-statistical material, the authenticity of the differences between the compared features was determined using the values of the standard deviation (t) according to the formula

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_d},$$

(Рокицкий, 1961). (Rokitskii, 1961)

where

$$S_d = \sqrt{S^2\bar{x}_1 + S^2\bar{x}_2}$$

When using the criterion of the standard deviation (t) for the comparison of the size and weight indices

of salmon of four populations, the results obtained are pre-
sented in figs. 1-2 [pp39-40].In them on the ordinate axis the
values of t from 0 to 9 are plotted; the large values
are not presented since also when t = 3 the reliability of the
divergence of the features is sufficiently high (Urbakh,
1963; Rokitskii, 1961; Pravdin, 1966). When comparing the
size and weight features of the four populations, using
the standard deviation, rather wide amplitudes of fluctuation
in its values - from 0 to 31 - were noted which compels us 90
to take into account not the absolute values of this criterion
but rather the tendency of its variation. The differentiation
of the studied populations into age groups, examined during
each year, allows us to trace the dynamics of the differences
of the populations for the studied period.

When analysing fig. 1 [p. 39]. attention is drawn first of all
to the large divergences in the size feature which
are observed in all of the four populations, at least during
one year. At the same time a definite connection between some
populations (Kukhtui, Gizhiga) and the difference of the 91
Yama population from all the others, were noted. These differences in the
closeness of relation of the feature being studied are quantitatively
expressed as follows: in the period from 1962 through 1968 reliable diver-
gences in the size composition of the fish, when comparing

fourth-year and fifth-year, were observed between the Taui and Yama populations in five out of six cases (there are no data for the Yama chum salmon in 1964), between the Yama and Gizhiga populations, in six cases, and the Yama and Kukhtui, in five cases.

Reliable differences between the Kukhtui and Gizhiga 91
populations were found in fourth-year fish only in 1967,
and in fifth-year in 1964 and 1967. Divergences between 92
the Taui and Gizhiga populations in each age group were not found in two out of seven cases and between Taui and Kukhtui - in three cases out of the six which were examined.

Comparison of the weight composition of fish of the different populations shows that the nature of the connections, which was established from the size indices (fig. 2). [p. 40].is preserved here also. We can note a decrease in the divergences of the weight indices by the absolute value of the t criterion, and also an increase in the number of cases when reliable differences between the compared populations were not observed (in 31 cases against 21 cases by size indices). In particular, there were few divergences between the four populations according to the average weight of the fish in 1963.

The coefficient of the variation of the sizes of fish of the different populations varied from 5.3 to 5.9, the variability in the weight - from 18.0 percent to 19.3 percent. The figures in the individual age groups - fourth-year and fifth-year - were of the same order.

Hence, when analysing the differences and similarities among the populations in our case, it is probably necessary to consider the size characteristics as the main criterion. When analysing the response reactions of the populations to the influence of the external factors, the variations of the body weight are apparently more significant. This example can be considered a special case of the general situation: features with a wider amplitude of variability reflect more precisely the morphological variability of specimens in the complex inter-relations of the "environment - population" system (Yablokov, 1966). 92

A further stage in the study of size and weight characteristics of chum salmon of different regions of the continental coast of the Sea of Okhotsk is the comparison of the variability of these features, expressed by the standard deviations (sigmas). In connection with this, we will indicate the definite distribution sequence of the populations by the mean values of the sigmas of the size indices of the fish. The ascending series of the

weighted mean values of the sigmas indicates the following population distribution: Kukhtui - 3.39, Gizhiga - 3.50, Taui - 3.76, Yama - 4.0 (table 1). Similarly distributed are the sigmas of the individual age groups as well. We can state that, with the population distribution by the sigmas of length, we have the same sequence as in the analysis of the size characteristics. The fluctuation amplitude of the root mean square deviations of the length of the fish for 93
1960-1968 is shown in table 3 [p. 41].

Judging by table 3, an increase is observed in the mean sigmas' values or an increase in the variability of the size characteristic of chum salmon with an increase in the absolute value of its indicator: the largest root mean square deviation is in the body sizes of the large Yama chum salmon population; the smallest is in the small size Gizhiga form. Further, a tendency to an increase in the fluctuation range of the root mean square deviation appears when moving from south-west to north-east. This tendency is observed not only in the spawning stocks as a whole, but also in individual age groups (some divergences are found only in fourth-year). Finally, an increase in the range of variability is observed in an older age group - fifth-year - as compared with fourth-year (the Okhotsk chum salmon is the exception).

When analysing the root mean square deviations in the body weight of chum salmon of different populations, it is clear 93 that an increase in the mean sigma values takes place with an increase in the mean weight values here also (table 1) [p. 37]. As far as the amplitude of the variability of this feature is concerned, it is wider in the Yama population and is the smallest in the Gizhiga, that is, the patterns in the fluctuation of the amplitude of variability that have been derived for size characteristics, are not indicated by these data. Taking into account those conclusions which were arrived at earlier about the utilization of size and weight indices as criteria for substantiating different aspects of the effect of environmental factors on the populations, we may give the following explanation of the connections between the categories "variability of feature", understanding by this concept the root mean square deviation, and "amplitude of variability", as well as differences in the nature of the variability of the size and weight indices.

On the continental coast of the Sea of Okhotsk there are differences in the local (ecological) conditions. Differences in the indices of the temperature and salinity of the coastal waters in individual seasons were indicated above, and, in addition, according to the data of the agro-climatic handbook (Magadan, 1966), each region differs from the others in individual climatic indices. 93

So, for example, the sum of the positive temeratures higher than 10° for Yamsk is 768°, for the coast of Gizhiga Bay - 666°, for the coast of Taui Bay - 739°. A.S. Kuznetsov and V.A. Mefodiev (1967) noted a decrease in the snow accumulations from north-east (northern part of Gizhiga Bay to the south-west (basins of the rivers Okhota, Ul'bei, and Inn) in the winters of 1962/1963 and 1963/1964. Differences in the habitat conditions (more precisely applicable to salmon in reproduction conditions) lead to the heterogenity of the species, which at the level of populations acquires the form of more or less clearly expressed genetic polymorphism which, in particular, is revealed in the differences in the average size and weight indices of chum salmon, and is included in the composition of the individual populations. One can consider (Nikol'skii, 1955, 1958, 1969) that the features studied by us are of an adaptive character and along with other features determine the "norm" of each population, which corresponds to the habitats in the highest degree.

In exactly the same way, the inherent variability of one

feature on another, which determines the degree of adapt-
ation to all the ecological niches in specific conditions 93
of the aggregate of the heterogeneous organisms which make
up the population, is the norm of each population.

In this sense the "norm" (by which is understood
the reaction of the total of the specimens which actually
survive in specifically different habitats and which leave
progeny behind) is only an arbitrary average norm (Shmal'gauzen,
1968, p. 109). Obviously, therefore, we should speak not
about a fixed norm, expressed by the average indices,
but about its range, that is, the amplitude of the varia-
bility of the features should be included in this concept.

Thus if the increase or decrease in the absolute values
of the root mean square deviation, going along with the
increase or decrease in the average indices of the features,
indicates the existence of genetic differences between the
populations (including also the average indices of varia-
bility apparently hereditarily fixed for each population),
then the range of fluctuation of the features and the indices 94
of variability can indicate the degree of variability of
the environmental conditions. As G.V. Nikol'skii (1962)
noted, an increase in the amplitude of variability of
features usually occurs towards the periphery of the

geographic range, and our data agree with this when they recorded an increase in the fluctuation range of the 94
size feature in the more northerly regions where, besides a decrease in the total size of the spawning stock, the abundance of chum salmon is subjected to more significant fluctuations (in 1960-1968 in the rivers of Taui and Yama Bays the abundance of individual generations of chum salmon fluctuated fifty times and in the rivers of Gizhiga Bay - 120 times.

In this case, we will arbitrarily call the most northerly of all the regions studied by us the periphery of the geographic range. It is not excluded that a study of the salmon of the Penzhina Bay and, farther on, north-west Kamchatka will give a more accurate picture of the population variability of the chum salmon of the northern part of the Sea of Okhotsk.

Examining the comparative variability in the size and weight features, we should note that the variations in the body size of fish have only one vector, whereas its weight during their lifetime fluctuates considerably, acquiring in individual periods (for example, when they cease feeding) a reverse vector (Polyakov, 1960). Earlier it was noted that the body sizes of fish are more stable features as compared to its weight. This situation can be caused by a greater multiplicity of factors of the hereditary base of the size features as compared to the weight, that is a closer correlation of the size features with other features of the organism (Kurshakova, 1967). Hence, one can assume that organisms in most cases do not have time and are unable to respond to short-term changes in environmental factors by corresponding changes in the vector of size features. At the same time the reversible physiological regulation of the organism to the random and short-term influence of the environment when manifested with sufficient intensity can be reflected in such an unstable feature as body weight. Of course, the body weight of fish has its growth regularities and is closely connected with the increase in the body sizes - the correlation coefficient between the body weight of the Okhotsk chum salmon and its sizes, according to the data of V.L. Kostarev (1969), equals 0.99. On the other hand, the body weight, since it is a more unstable feature, has a wide amplitude of variability. One can assume that, on the strength of this, the amplitude of variability of the weight of fish can indicate the character of the comparatively recent influence of environmental

factors on a population. In particular, in the Gizhiga population of chum salmon, the smallest value of the 94
amplitude of weight variability which was noted earlier, can be the result of the comparatively homogenous habitat conditions during the feeding migration which precedes spawning.

The nature of the influence of unstable environmental factors is illustrated, for example, by data on the size and weight characteristics of chum salmon in 1963. This year the body sizes of the fish of individual populations differed reliably, while the chum salmon of individual regions in most cases did not differ by body weight.

According to data of the Kolyma hydro-meteorological service of the winter of 1962-1963 was abnormally warm - the maximum ice cover of the Sea of Okhotsk was only 63 percent, while the maximum ice cover in the cold season of 1966-1967 was 97 percent. The abnormality of the 1962-1963 season, on the basis of hydrological and hydrobiological material, was also shown by A.D. Kovalev, V.M. Glagol'ev (1965) and L.A. Kotlyar (1965).

Earlier it was shown (Klokov and Frolenko, 1970) that the abnormality of the 1962-1963 conditions had an

effect on the elementary chemical structure of the scales of pink salmon, which was reflected first of all in the 95
similarity of the content of individual elements in different pink salmon populations of the coast of the Sea of Okhotsk. The advection of warm waters from the Pacific Ocean, as a result of which large areas of the Sea of Okhotsk had comparatively homogenous physical and biotic conditions (the thermal) regime, the salt composition of the water, the spectrum of the food items) was pointed out as one of the possible causes of this phenomenon.

From table 2, [p. 38], where the yearly data by body weight of chum salmon of individual populations are presented, it can be seen that in 1963 the average weight of chum salmon from different regions was practically the same. Fig. 2 [p. 40] illustrates this situation for individual age groups - fourth-year and fifth-year. It can be seen from fig. 1 [p. 39] that significant differences in fish body sizes were observed in most cases among the populations.

In concluding this section we will quote data which characterize the degree of similarity and difference among the four studied populations according to the variability of body sizes. K.V. Arnol'di (1939) and A.V. Yablokov (1966) showed that the study of variability by an examination

of the distribution of the values of the root mean square deviation allows us to obtain data which indirectly determine the degree 95
of similarity among the populations. In particular, these authors applied the method of comparing not the absolute, but the relative values of the root mean square deviations, which were also used by S.R. Tsarapkin. Modification of this method allows us to compare different chum salmon populations by the chronological variability of the studied feature.

The variations in the absolute values of the root mean square deviations of the body size of chum salmon at the age of 3+ in different populations are shown in fig.3. [p. 42]. presented graphs, it is difficult to arrive at any conclusion about the degree of similarity in the four populations. One can only note that the value of the sigmas in the Yama population by its absolute value exceeds the sigmas of the other populations and that the value of the sigmas in the Kukhtui population are the smallest. But these conclusions were arrived at on the basis of data on the mean long-term values of sigmas (table 1) [p. 37]. Significant yearly fluctuations of the sigma values are also obvious. In future we will use the method of biometric profiles suggested by K.V. Arnol'di (1939). This method consists of comparing the relative values of the root mean square deviations. As a base we can take any popula- 96
tion; in this case the Kukhtui is taken, so that:

$$\frac{\sigma \text{ Tawi}}{\sigma \text{ Kukhtui}} \qquad \frac{\sigma \text{ Yama}}{\sigma \text{ Kukhtui}} \qquad \frac{\sigma \text{ Gizhiga}}{\sigma \text{ Kukhtui}}$$ 96

and these relative values are calculated for each year. The distribution of the obtained data is shown in fig. 4. Here one can already note the community of the tendencies of the changes in the relative values in the three populations of the northern coast of the Sea of Okhotsk and, in addition, the well-defined differences among all the four populations in 1965-1967 and the similarity in 1961-1963.

The further path of formalizing the obtained data, leading to a more accurate comparison, goes through a digression from the chronological sequence of the distribution of the relative values of the sigmas. The data are distributed in decreasing order, forming a descending curve on the graph. Exactly the same curves are plotted for the other populations as well and then the height of location of these curves is compared. Here the order of sequence of the individual values of the sigmas is determined only by their relative magnitude and, naturally, the order can be different in two compared flows. Thus, in this case the sum of the values of the feature, obtained in the period of research, is compared.

The position that random values with different math- 97
ematical expectations can be summed up (Smirnov, 1968) is

the basis of the quoted plottings. In this case we calculate the sigma ratios which are independent random values and, 97
accordingly, the result is an independent random value as well. As is known (Aksyutkina, 1968), the mathematical expectation of the sum of two random values equals the sum of their mathematical expectations, which in turn allows us to digress from the order of the sequence of random values.

The results are presented in fig. 5. [p. 44]. Here can be seen very well the degree of connection of the individual populations among themselves in relation to the base population (Kukhtui). Closest of all to the Kukhtui population is the Gizhiga and the largest differences are observed between the Kukhtui and Yama chum salmon; the Taui population occupies an intermediate position.

CONCLUSION

The analysis of the size and weight indices of chum salmon in 1960-1968 allow us to distinguish on the continental coast of the Sea of Okhotsk at least four populations - Kukhtui (Okhotsk), Taui, Yama and Gizhiga, which differ clearly enough among themselves in their average body sizes and weights.

The study of the variability of the body sizes 98
of chum salmon of the different populations confirms

the existence of divergences among them in this indicator: for each population its own average value of variability is 98 characteristic, and is determined by the root mean square deviation of the body size of the fish. Since in the studied populations the larger sigma corresponds to the greater arithmetical mean of the feature, we can assume that these populations differ genetically among themselves (Kurshakova, 1967). The regular decrease in the size and weight indices of chum salmon to the south-west and north-east of Yama Bay . is of interest. It is possible that, besides the mentioned dependence of such changes on the conditions in the period of embryogenesis and the feeding migration in the coastal regions, this phenomenon is connected with the presence of the centre of the geographic range where the largest specimens dwell. Understanding by the concept of the centre of the geographic range the"biological centre" (Naumov, Nikol'skii, 1962), we must consider it to be the region of the Okhotsk rivers where the most numerous chum salmon population dwells. The presence of the smallest variability in features in the Okhotsk salmon also corresponds to this position and is one of the criteria in determining the biological centre of the geographic range (Nikol'skii and Pikuleva, 1958; Naumov and Nikol'skii, 1962). Such a conclusion will be correct at the same time only on

condition that we deal with inter-connected populations, united at least by a partial exchange of the genofund.* 98
Otherwise with the complete localization of the population we will deal only with independent fluctuations of the variability of the features whose average values are characteristic of each region. In either case we can assume the existence of adaptive reactions which are connected with the geography of distribution of the species in the studied region. It is important that the variability of the features, or more precisely the amplitude of variability, increases in those populations (for example, in the Gizhiga) which are more remote from the so-called "biological centre of the geographic range", which, in this case, we can for our purposes accept as the region of the habitat of the Okhotsk chum salmon population. This confirms the point of view of G.V. Nikol'skii (Naumov, Nikol'skii, 1962) on the variability of the features as an indicator of intensity in the "organism - environment" system; in particular, he considers that the amplitude of the variability of the features increases with the deterioration of the habitat conditions, which is characteristic of organisms which live on the periphery of the geographic range.

*Revisor's note. "Genofund" has been taken directly from the original Russian genofond, for which no other suitable equivalent is available.

Thus we can assume that the chum salmon populations examined by us are different ecotypes, or populations, 98
selected and created by the factors of the habitat and adapted to it.

The generalization of the material quoted in this work shows that when analysing inter-population relations from such variable features as weight and size characteristics, in order to obtain reliable conclusions it is necessary to study these features not as cronologically fixed, but in the process of their variability during a number of years. Obviously, this requirement is well-founded for the investigations of those levels of population gradations with which we are dealing at the present time. The study of population features during one year only can lead to erroneous conclusions (for example, in 1963 there was the greatest similarity in the size and weight characteristics of chum salmon in all the four populations, by contrast with 1965 when a divergence in all the populations in these indices was observed). Analyses, one only done each year, can lead to contrary conclusions. Thus, it is necessary first of all to study, along with the spatial differentiation of the features, their dynamics in time also. S.P. Volovik (1968) and also S.P.
Volovik and A.E. Landyshevskaya (1968), on the basis of a 99

study of the complex of biological indices (time of the spawning run, size weight, fertility, growth rate, 99
plastic and meristic features and scale structure) of the Sakhalin salmon - chum salmon and pink salmon - came to the conclusion that owing to the variability of these features, conclusions about local salmon populations can be made based only on mass long-term material.

Thus, in spite of the fact that only two features which characterize the phenotype of chum salmon of different regions of the northern part of the coast of the Sea of Okhotsk were analysed, nevertheless the use of long-term representative material allows us to assume with enough certainty the presence of the indicated populations in the studied region. From here the necessity arises to study the peculiarities of the biology of the chum salmon of each of these populations, their dynamics of abundance, and also the explanation of the paths of the microevolution of chum salmon of the northern coast of the Sea of Okhotsk at the population level.

Table 1.

The weighted mean indices of the size and weight features of chum salmon in 1960-1968.

Таблица 1

Средневзвешенные показатели размерно-весовых признаков кеты в 1960—1968 гг.

1 Исследуемые признаки	2 Возрастные группы											
	3 Все возрастные группы				3+				4+			
	4 Кухтуй	5 Тауй	6 Яма	7 Гижига	4 Кухтуй	5 Тауй	6 Яма	7 Гижига	4 Кухтуй	5 Тауй	6 Яма	7 Гижига
8 Длина AC, *см*	63,9	64,4	68,0	63,5	61,4	64,3	67,7	62,2	63,8	65,6	69,3	66,0
9 Вес Q, *кг*	3,63	3,68	3,96	3,50	3,43	3,69	3,87	3,38	—	3,86	4,23	3,82
10 σ длины	3,39	3,76	4,00	3,50	3,10	3,58	3,89	3,26	3,22	3,54	3,79	3,26
11 σ веса	0,70	0,71	0,72	0,64	0,68	0,74	0,68	0,61	—	0,68	0,67	0,69
12 C длины	5,3	5,8	5,9	5,6	5,0	5,6	5,7	5,3	5,0	5,5	5,5	4,9
13 C веса	19,3	19,3	18,0	18,4	19,8	19,9	17,5	17,9	—	17,6	15,8	17,8

1. Studied features. 2. Age groups. 3. All age groups.
4. Kukhtui. 5. Taui. 6. Yama. 7. Gizhiga.
8. Length AC, cm 9. Weight Q, kg 10. σ of length.
11. σ of weight. 12. C of length. 13. C of weight.

Table 2. 88 and 89

The size and weight indices of chum salmon of the continental coast of the Sea of Okhotsk.

Таблица 2

Размерно-весовые показатели кеты материкового побережья Охотского моря

1 Годы	2 р. Кухтуй M±m	σ	c	n	3 р. Тауй M±m	σ	c	n	4 р. Яма M±m	σ	c	n	5 р. Гижига M±m	σ	c	n
								6 ДЛИНА КЕТЫ АС, см								
1960	62,4±0,07	3,56		2 366	62,7±0,13	3,48	5,5	700					61,5±0,32	4,58	7,4	206
1961	62,3±0,07	3,53		2 283	65,1±0,16	3,64	5,6	491	66,7±0,15	3,03	4,5	391	61,7±0,12	3,05	4,9	600
1962	64,7±0,05	3,33		3 998	67,4±0,17	3,84	5,7	490	69,3±0,16	3,48	5,0	491	64,0±0,20	3,40	5,3	290
1963	61,7±0,07	3,37		2 211	64,6±0,18	3,60	5,6	396	68,3±0,20	3,90	5,7	389	65,2±0,22	4,31	6,7	397
1964	63,2±0,16	3,64		537	62,9±0,18	3,94	6,2	496	—	—	—	—	63,0±0,20	3,94	6,3	400
1965	61,3±0,14	3,56		695	63,2±0,14	3,55	5,6	636	66,8±0,22	4,69	7,0	449	61,1±0,17	2,90	4,8	300
1966	63,8±0,05	3,17		3 317	62,8±0,13	3,65	5,8	818	67,3±0,27	4,62	6,9	300	63,0±0,16	3,05	4,8	388
1967	65,0±0,07	3,42		2 458	63,9±0,20	4,34	6,8	488	67,3±0,18	3,94	5,9	495	61,6±0,15	3,00	4,9	380
1968	67,0±0,16	3,66		499	69,9±0,18	4,06	5,8	495	70,1±0,20	4,18	6,0	450	69,7±0,21	4,12	5,9	400
								7 ВЕС КЕТЫ, кг								
1960	3,02±0,02	0,56		699	3,22±0,02	0,57	17,7	700					3,11±0,05	0,74	23,8	203
1961	3,47±0,03	0,67		600	3,58±0,03	0,70	19,5	491	3,72±0,04	0,71	19,1	393	3,17±0,02	0,54	17,0	600
1962	3,87±0,02	0,65		698	3,81±0,03	0,68	17,8	490	4,06±0,02	0,52	12,8	491	3,48±0,03	0,57	16,4	290
1963	3,82±0,03	0,71		600	3,86±0,03	0,71	18,4	396	3,77±0,04	0,70	18,5	393	3,86±0,03	0,67	17,3	396
1964	3,75±0,03	0,75		537	3,68±0,04	0,81	22,8	496	—	—	—	—	3,51±0,04	0,75	21,4	400
1965	3,41±0,03	0,79		696	3,55±0,03	0,76	20,8	686	3,80±0,03	0,68	17,9	448	3,21±0,03	0,58	18,1	300
1966	3,53±0,02	0,61		684	3,54±0,02	0,62	17,5	814	3,97±0,04	0,78	19,7	298	3,40±0,03	0,59	17,4	390
1967	3,92±0,03	0,73		700	3,83±0,04	0,79	20,6	488	3,87±0,05	0,72	17,8	497	3,40±0,03	0,64	18,8	381
1968	4,01±0,04	0,87		499	4,40±0,04	0,88	20,0	495	4,48±0,04	0,96	21,4	450	4,23±0,04	0,77	18,3	400
								8 ДЛИНА ЧЕТЫРЕХЛЕТОК КЕТЫ АС, см								
1960	59,5±0,15	2,65	4,4	294									60,4±0,33	3,94	6,5	144
1961	60,5±0,25	2,78	4,6	126	64,1±0,25	3,46	5,4	198	—	—	—	—	—	—	—	—
1962	64,0±0,43	3,56	5,6	70	66,5±0,22	3,36	5,1	229	68,2±0,22	3,58	5,2	260	63,7±0,26	3,50	5,5	186
1963	63,0±0,15	3,17	5,0	462	63,8±0,25	3,34	5,2	181	68,4±0,20	3,58	5,2	308	63,4±0,22	3,20	5,0	206
1964	62,2±0,17	2,59	4,2	235	62,7±0,20	3,84	6,1	360	—	—	—	—	62,2±0,20	3,60	5,8	311
1965	60,6±0,13	3,40	5,6	653	62,0±0,17	3,46	5,6	392	65,6±0,25	4,06	6,2	251	60,9±0,18	2,90	4,8	270
1966	59,3±0,29	3,02	5,1	109	62,2±0,15	3,19	5,1	448	68,1±0,36	5,00	7,3	190	59,7±0,54	2,87	4,8	28
1967	63,3±0,33	3,49	5,5	113	63,3±0,23	4,04	6,4	300	66,6±0,22	3,78	5,7	298	61,4±0,15	2,80	4,6	332
1968					69,7±0,19	3,84	5,5	417	69,2±0,21	3,75	5,4	316	67,4±0,41	3,64	5,5	80
								9 ДЛИНА ПЯТИЛЕТОК КЕТЫ АС, см								
1960	61,9±0,15	3,05	4,9	403									64,1±0,61	4,65	7,2	59
1961	62,9±0,16	3,23	5,1	432	65,8±0,21	3,54	5,4	285	—	—	—	—	—	—	—	—
1962	64,9±0,12	3,29	5,1	696	67,8±0,22	2,83	4,3	166	70,2±0,20	2,80	4,0	198	64,3±0,29	2,94	4,6	84
1963	66,5±0,35	3,09	4,6	73	65,1±0,25	3,56	5,5	208	69,0±0,50	4,12	6,0	68	66,8±0,32	4,24	6,24	175
1964	63,9±0,21	3,24	5,1	241	64,3±0,32	3,44	5,4	115	—	—	—	—	65,5±0,44	4,02	6,14	82
1965	64,0±0,71	3,81	6,0	29	64,9±0,28	4,05	6,2	286	68,4±0,34	4,71	6,9	188	62,5±0,52	2,70	4,3	27
1966	63,1±0,13	3,12	4,9	564	64,1±0,17	3,32	5,2	377	66,3±0,41	3,82	5,8	85	63,2±0,15	2,78	4,4	356
1967	65,0±0,16	3,36	5,2	463	65,5±0,30	3,80	5,8	165	68,5±0,28	3,79	5,5	185	63,0±0,43	2,68	4,3	39
1968					71,4±0,50	4,24	5,9	75	72,6±0,33	3,78	5,2	122	70,3±0,17	3,00	4,26	314
								10 ВЕС ЧЕТЫРЕХЛЕТОК КЕТЫ, кг								
1960	2,84±0,03	0,51	18,6	294									2,93±0,05	0,61	20,5	144
1961	3,17±0,05	0,58	18,3	116	3,41±0,05	0,65	19,1	198	—	—	—	—				
1962	3,62±0,15	0,90	23,9	38	3,80±0,01	0,67	17,6	229	3,90±0,04	0,57	14,6	260	3,47±0,04	0,56	16,2	186
1963	3,72±0,03	0,72	19,4	465	3,74±0,05	0,72	19,2	191	3,75±0,04	0,66	17,6	313	3,71±0,04	0,61	16,2	205
1964	3,68±0,04	0,63	17,1	264	3,63±0,04	0,77	21,2	360	—	—	—	—	3,38±0,04	0,68	20,1	311
1965	3,38±0,03	0,76	22,5	656	3,36±0,03	0,68	20,2	392	3,62±0,03	0,50	13,8	249	3,19±0,03	0,56	17,5	270
1966	3,27±0,05	0,55	16,8	109	3,50±0,03	0,62	17,7	447	3,91±0,06	0,81	20,7	188	3,03±0,09	0,46	15,2	28
1967	3,82±0,07	0,76	19,9	113	3,67±0,05	0,85	23,2	300	3,74±0,04	0,67	17,9	299	3,38±0,03	0,62	18,4	333
1968					4,30±0,04	0,88	20,3	417	4,28±0,05	0,86	20,0	316	3,92±0,08	0,67	13,4	80
								11 ВЕС ПЯТИЛЕТОК КЕТЫ, кг								
1960													3,55±0,11	0,85	20,5	59
1961					3,64±0,04	0,69	19,0	285	—	—	—	—	—	—	—	—
1962					3,90±0,04	0,54	13,9	166	4,22±0,03	0,41	9,7	198	3,48±0,06	0,56	16,1	84
1963					3,96±0,05	0,73	18,5	208	4,08±0,08	0,64	15,7	67	4,00±0,05	0,67	16,8	175
1964					3,97±0,07	0,71	17,9	115	—	—	—	—	3,96±0,09	0,81	20,5	82
1965					3,81±0,04	0,67	17,6	286	4,02±0,05	0,71	17,4	187	3,42±0,10	0,55	16,1	27
1966					3,62±0,03	0,60	16,6	376	4,16±0,07	0,68	16,3	85	3,43±0,03	0,38	16,9	357
1967					4,23±0,06	0,81	19,1	165	4,05±0,05	0,72	17,8	185	3,57±0,12	0,75	21,0	39
1968					4,70±0,10	0,88	18,9	75	4,96±0,09	0,99	20,0	121	4,32±0,04	0,80	18,5	314

1. Years. 2. Kukhtui River. 3. Taui River. 4. Yama River. 5. Gizhiga River. 6. Length of chum salmon AC, cm. 7. Weight of chum salmon, kg. 8. Length of fourth-year chum salmon AC, cm. 9. Length of fifth-year chum salmon AC, cm. 10. Weight of fourth-year chum salmon, kg. 11. Weight of fifth-year chum salmon, kg.

Fig. 1. 90

A comparison of the differences (t) in the body length of chum salmon of the four populations.

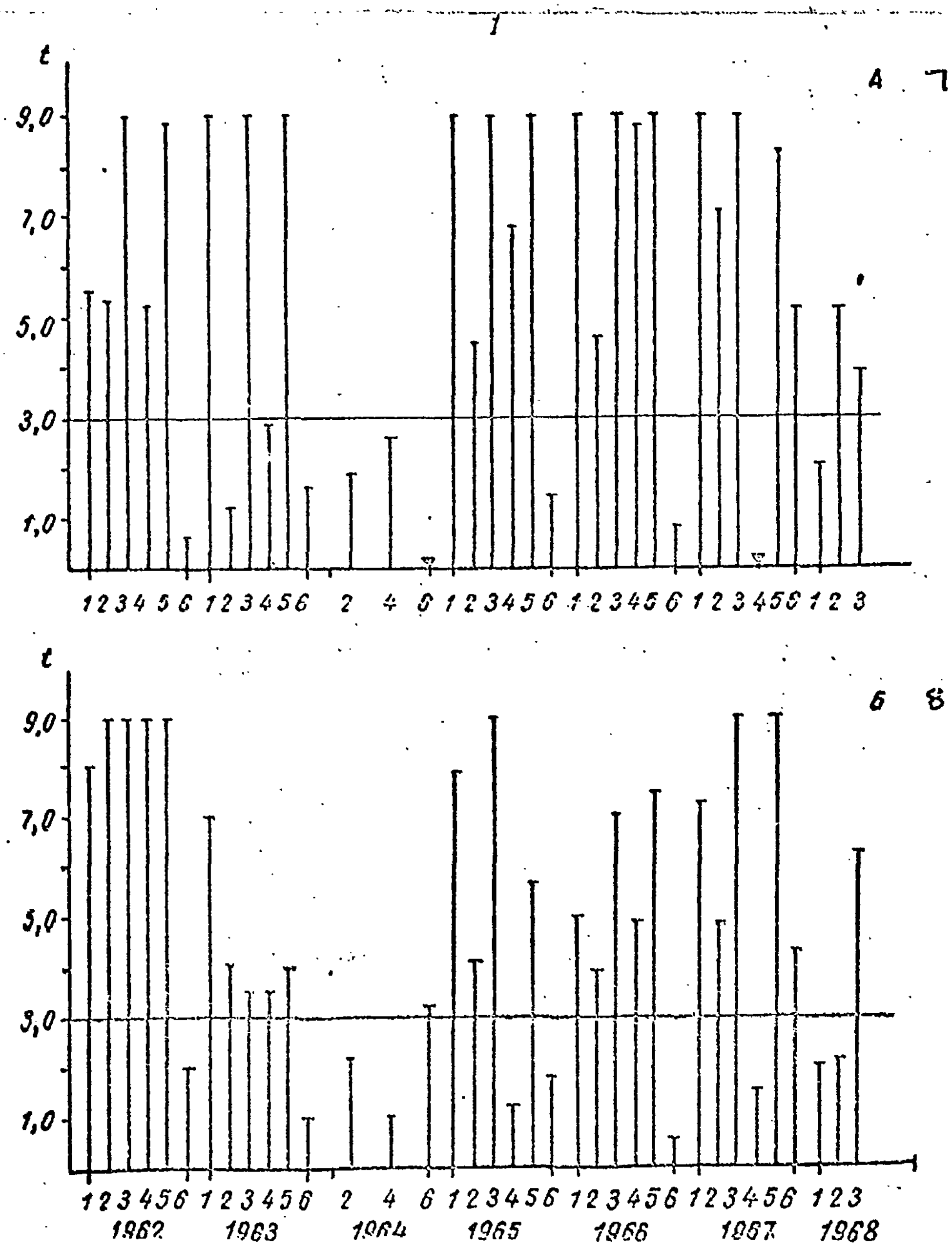


Рис. 1. Сравнение различий (t) длины тела кеты четырех популяций:
1 — тауйская — ямская; 2 — тауйская — гижигинская; 3 — гижигинская — ямская; 4 — кухтуйская — тауйская; 5 — кухтуйская — ямская; 6 — кухтуйская — гижигинская. 7 А — четырехлетки; 8 Б — пятилетки.

1 - Taui - Yama; 2 - Taui - Gizhiga; 3 - Gizhiga - Yama; 4 - Kukhtui - Taui; 5 - Kukhtui - Yama; 6 - Kukhtui - Gizhiga; 7 - Fourth-year; 8 - Fifth-year.

Fig. 2.

Differences (t) in body weight of chum salmon of the four populations (symbols same as in fig. 1)

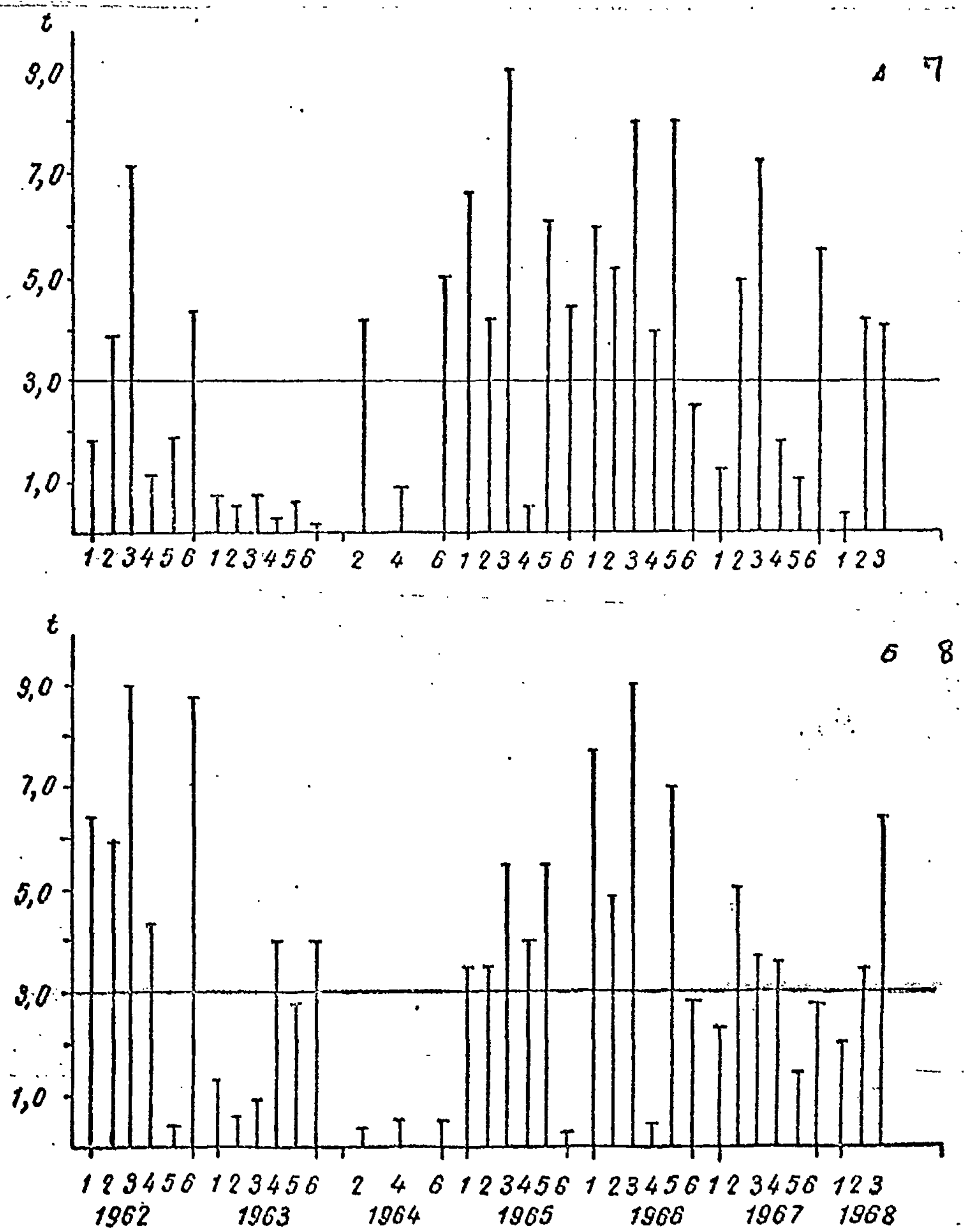


Рис. 2. Различия (t) веса тела кеты четырех популяций (обозначения те же, что и на рис. 1).

Table 3. 92

Fluctuation range of the root mean square deviation of the body length of chum salmon of the different populations in the 1960-1968 period.

Таблица 3

Пределы колебаний среднего квадратического отклонения длины тела кеты различных популяций за период 1960—1968 гг.

1 Возрастные группы	2 Популяции			
	3 охотская	4 тауйская	5 ямская	6 гижигинская
7 Все возрастные группы	3,17—3,66	3,55—4,34	3,03—4,69	2,90—4,58
3+	2,59—3,56	3,19—4,04	3,58—5,00	2,80—3,94
4+	3,05—3,81	2,88—4,24	2,80—4,71	2,68—4,65

1. Age groups. 2. Populations. 3. Okhotsk. 4. Taui. 5. Yama. 6. Gizhiga. 7. All age groups.

Fig. 3.

Absolute values of the root mean square deviations of the body length of chum salmon at age 3+ years from different rivers.

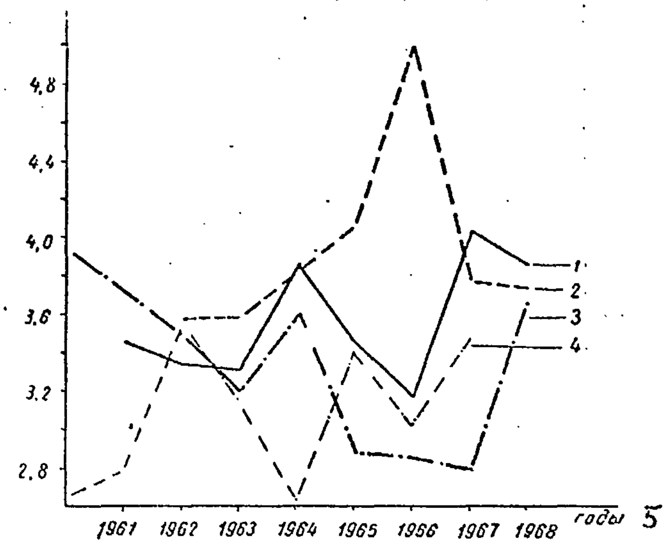


Рис. 3. Абсолютные значения средних квадратических отклонений длины тела кеты в возрасте 3+ лет из различных рек:
1 — Тауй; 2 — Яма; 3 — Гижига; 4 — Кухтуй.

1 - Taui; 2 - Yama; 3 - Gizhiga; 4 - Kukhtui.
5 - years.

Fig. 4. 96

Relative values of the root mean square deviations of the body length of chum salmon. The sigma values of the Kukhtui population are taken as the base.

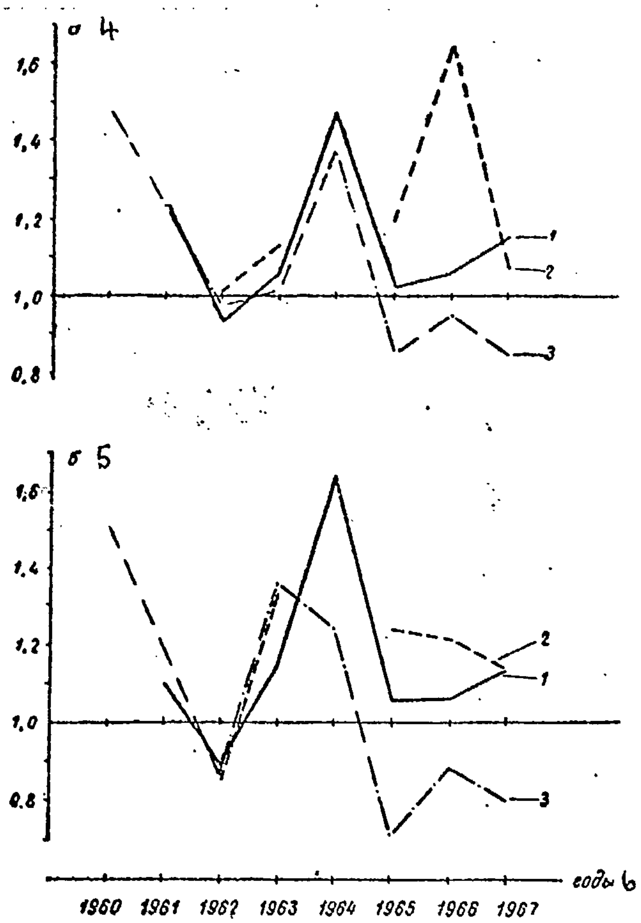


Рис. 4. Относительные значения средних квадратических отклонений длины тела кеты. За основу взяты значения сигм кухтуйской популяции:

1 — тауйская кета; 2 — ямская кета; 3 — гижигинская кета; 4 — четырехлетки; 5 Б — пятилетки.

1 - Taui chum salmon; 2 - Yama chum salmon; 3 - Gizhiga chum salmon; 4 - Fourth-year; 5 - Fifth-year; 6 - years.

Fig. 5. 97

Relative values of the root mean square deviations of the body length of chum salmon of the different populations.

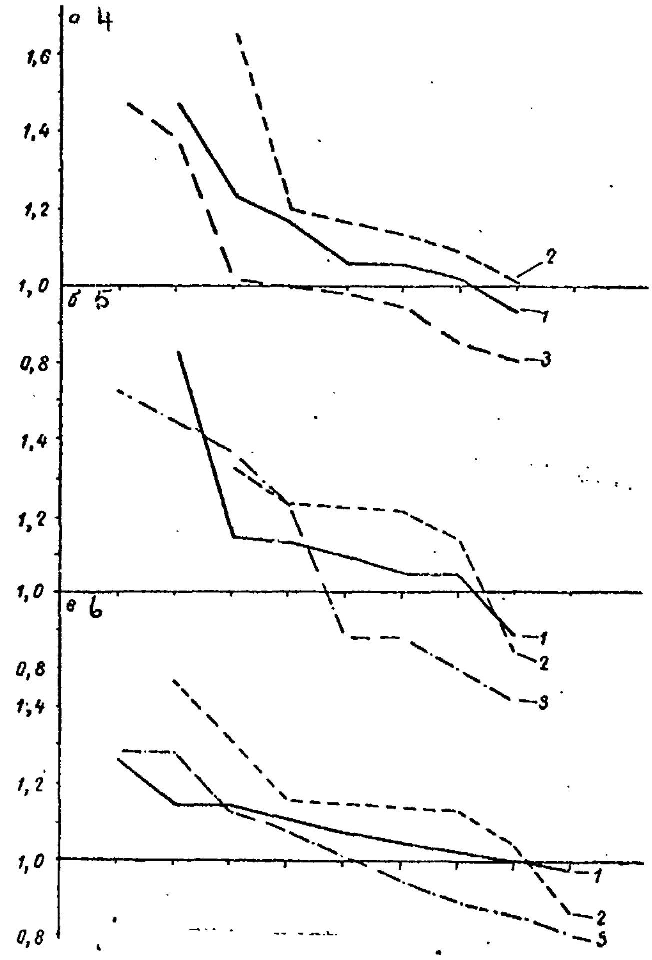


Рис. 5. Относительные значения средних квадратических отклонений длины тела кеты различных популяций:

1 — тауйская кета; 2 — ямская кета; 3 — гижигинская кета. 4А — четырехлетки; 5Б — пятилетки; 6В — все возрастные группы.

1 - Taui chum salmon; 2 - Yama chum salmon; 3 - Gizhiga chum salmon; 4 - Fourth-year; 5 - Fifth-year; 6 - All age groups.

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THE CHANGEABILITY OF MEASUREMENTS AND WEIGHTS INDICES OF THE NORTHERN OKHOTSK COAST CHUM SALMON

V. K. Klokov

Summary

The analysis of measurements and weights indices of chum salmon in the northern Okhotsk coastal part permits to single out four populations: — Kuhtuyskaya (the Okhotsk), Tauyskaya, Jamskaya and Gyzhigynskaya.

More large chum salmon spawns in the rivers of the Jamskaya inlet and the populations distributed further to the south and north have individuals of smaller measurements.

The Changeability of measurements and weights indices within the limits of the investigated area are increasing among the populations distributed further to the north.