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BERING-ALEUTIAN SALMON INTERNATIONAL SURVEY (BASIS): POPULATION-BIOLOGICAL RESEARCHES IN THE WESTERN PART OF BERING SEA (RUSSIAN ECONOMIC ZONE). PART 2 - SOCKEYE SALMON *ONCORHYNCHUS NERKA*

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ABSTRACT

This work has represented results of identification of regional complexes of local stocks of immature sockeye salmon on the data of trawl surveys of the R/V «TINRO» in the Bering–Aleutian Salmon International Surveys (BASIS) in the Western Bering Sea in summer-fall periods in 2002-2004. The system of districts of the Bering Sea part of the EEZ of RF, accepted in TINRO-Center for making biocenological researches, was used in this work. Scale structure was used as a criterion for differentiation. In the whole the ages of fishes in mixed marine samples were estimated for the total sample size of 3691 sockeye salmon individuals, including 2678 fishes which ages were identified in particular. In the analysis there were used four age groups - 1.1, 1.2, 2.1 and 2.2, taking in the total more than 90% of immature sockeye salmon in the trawl catches. The basis scale line consisted of 8577 sockeye salmon individuals from the age groups 1.2 + 1.3 and 2.2 + 2.3.

The results of the identification were as next: in 2002 the part of North American sockeye salmon stocks in the districts 5-8 was 41.1% and in the district 12 – 23.1%. The part of sockeye salmon stocks of West Kamchatka in the districts 5-8 was 18.0% and in the district 12 – 24.7%. The occurrence of the stocks of East Kamchatka + Chukotka in the catches was 40.9 % in the districts 5-8 and 52.2% in the district 12. In 2003 during the summer survey the part of the stocks of Alaska in the districts 3-8 was in average 43.0% and in the districts 9-12 – 34.8%. In the fall this part was respectively 39.4% and 15.1%. As for the Asian stocks, the most interesting was the mass occurrence of the stocks of West Kamchatka in this region, among these stocks the Ozernaya River sockeye salmon stock dominated in the abundance. The occurrence of the stocks of West Kamchatka in 2003 was as next: summer – 20.7% in the districts 2-8 and 29.6% in the districts 9-12; fall – 20.1% in the districts 5-8 and 52.4% in the districts 9-12. The complex of sockeye salmon stocks of East and North-East Kamchatka and of Chukotka is indigenous to the Western Bering Sea. Therefore the occurrence of sockeye salmon spawning in these regions was stably high there: summer – 36.3% in the districts 2-8 and 35.6% in the districts 9-12; fall – 40.5% in the districts 5-8 and 32.5% in the districts 9-12. In the fall of 2004 the occurrence of North American sockeye salmon stocks was 23.0% in the districts 3-8 and 16.1% in the district 12. The occurrence of sockeye salmon of West Kamchatka was the most evident (23.9%) in the district 12. To the North, in the districts 3-8 the part of these fishes was visibly reduced, up to 5.4%. The stocks of East Kamchatka and Chukotka predominated in the catches, their occurrence in the districts 3-8 was 71.6% and in the district 12- 60.0%.

INTRODUCTION

The results discussing here are a generalization made over the population-biological researches on the identification of the origin of the complexes of local stocks of foraging sockeye salmon in the Western Bering Sea. These researches are a part of the Bering-Aleutian Salmon International Survey (BASIS) designed for the whole area of the Bering Sea but the part is carried only in the Economic Zone of RF. We already demonstrated preliminary data on the identification of immature sockeye salmon stocks from trawl catches obtained by RV TINRO in 2002-2004 in the Western Bering Sea from scale criteria before (Bugaev 2004, 2005, 2006).

In this presentation we demonstrate clarified data, taking into account the age ratio in mixed and baseline samples. This clarification was required to provide minimization of the deviations which can appear due to the interannual difference in the growth rate during freshwater or the first oceanic year periods of life of sockeye salmon. The difference has taken into account through using the baselines which age composition is in average one year older comparing to that in the mixes samples. The principle age of immature sockeye salmon examined is .1 and .2 (the average approximated oceanic age is 1.5) and of adult fishes - .2 and .3 (the average approximated oceanic age is 2.5). Thus there was provided the maximal bringing together the years of spawn for sockeye salmon from the mixed samples and from the baselines. That allowed us to get more accurate results of local stock identification of immature sockeye salmon in the Western Bering Sea. Indeed, making such clarifications requires spending more time to get final results, therefore the preliminary results practice is often necessary as providing quick decisions on different population-biological issues concerning sockeye salmon and the other Pacific Salmon species.

The purpose of this work was to make identification and assessment of potential abundance of regional complexes of sockeye salmon local stocks on the data from the trawl catches by RV TINRO in the Western Bering Sea in summer-fall seasons in 2002-2004.

MATERIALS AND METHODS

Sockeye salmon scale samples and biological characteristics collected by scientists of TINRO-Center in the trawl catches RV TINRO in the Western Bering Sea in summer-fall seasons 2002-2004 were the material to be analyzed. Collection of the material was accomplished according the standard scheme accepted in biocenological researches in the Russian zone of fishing in the Far East (Shuntov 1986; Volvenko 2003). The total size of the mixed marine materials used is: 3691 aged individuals and 2678 individuals identified (Table 1). All assessments of the abundance/biomass of Pacific salmon in the Western Bering Sea and adjacent waters of the northwest part of the Pacific Ocean were provided by the scientists of TINRO-Center and submitted in NPAFC (NPAFC 2003, 2004, 2005).

The baseline samples were collected by scientists of KamchatNIRO, ChukotNIRO, Sevvostrybvod and Department of Fish and Game (Anchorage, Alaska, US) in 2003-2005. The baselines included the scales from 8577 sockeye salmon individuals from the watersheds of Kamchatka, Chukotka and Alaska. The total pool included 36 local stocks engaged (Table 2, Fig. 1).

The scheme of the scale criteria used for identification of regional complexes of sockeye salmon local stocks is demonstrated in Fig.2. The scale criteria were analyzed and processed mathematically according the international standards accepted in NPAFC. We have provided the description of the methodical aspects in the details in Part 1 of the work "Bering-Aleutian salmon international survey (BASIS): population-biological researches in the western part of Bering Sea (Russian Economic Zone)" and many publications (Bugaev 2003a, 2004, 2005, 2006).

RESULTS AND DISCUSSION

Characterization of trawl samples

Distribution and abundance

In this work we were rather interested in getting the assessments of the abundance of foraging sockeye salmon instead in characterization of the distribution of the catches, therefore we discuss the trends of the spatial and quantitative distribution of sockeye salmon in general. More in details biological characterization of sockeye salmon on the results of the Bering-Aleutian Salmon International Survey (BASIS) in the Western Bering Sea and adjacent water of the northwest part of the Pacific Ocean is demonstrated in the work by I.I. Glebov (2007).

Mature and immature (young) individuals and postcatadromous fishes were identified on the size-weight characteristics and condition of gonads. The immature sockeye salmon individuals dominated absolutely among the fishes in the trawl catches, therefore the group was analyzed especially.

As follows from the schemes of the distribution of the immature sockeye salmon catches in the Western Bering Sea presented on the data from the trawl catches RV TINRO in the summer0fall seasons 2002-2004, the frequency of the immature individuals in the epipelagial in the districts 8 and 12 was very high almost everywhere (Fig. 3-5). The catches in average were of 100-500 fishes/km^2 approximately. In 2002 and 2003 the catches of sockeye salmon in some sites reached 1000 and more fishes/km^2. Quite clear trends of distribution hardly can be figured out. The stock of sockeye salmon in the district 8 can be distributed throughout the whole area (falls in 2002-2003) or concentrated in the northern part of the district (summer 2003 and fall 2004). The maximal catches in the district 12 were recorded westward from 167-168^0 E. The catches at the edge of the Economic Zone within this district were visibly lower.

The assessments of the abundance and the biomass of immature sockeye salmon were made for every statistical district (Table 3, Fig. 6) on the base of the data on the distribution of the catches. The maximum high abundance /biomass of sockeye salmon was recorded in fall 2002: 77.18 million fishes/92.36 thousand t in the districts 5-8 and 75.30 million fishes/86.06 thousand t in the district 12. In 2003 and 2004 the level of the assessments of the abundance/biomass of immature sockeye salmon was in general similar. On the data of summer survey in 2003 the assessment in the districts 2-8 was 70.68 million fishes/53.07 thousand t, and in the districts 9-12 it was 41.04 million fishes/30.78 thousand t. Fall survey demonstrated decreased abundance/biomass in the districts 5-8 to 32.82 million fishes/28.72 thousand t and increased abundance/biomass in the districts 9-12 up to 68.46 million fishes/61.90 thousand t. The effect of the possible migration of a part of immature sockeye salmons from the North to the South cannot be excluded. In fall 2004 the abundance/biomass of immature sockeye salmon in the districts 3-8 was strongly higher – 73.80 million fishes/64.60 thousand t. In the districts 9-12 the assessment was same as in 2003 – 48.15 million fishes/44.30 thousand t.

In the whole in 2002-2004 the abundance of immature sockeye salmon assessed was high. This fact has strong explanation as Pacific Salmon abundance increased for the boundary period XX-XXI what was evidenced by stably high catches of sockeye salmon in Asia and North America. However, it should be taken into account that such high abundance of foraging sockeye salmons recorded in the Bering Sea part of Russian Economic Zone is almost equal to the world stock abundance of this species. By no means should it be taken into account that the method of the square assessments unfortunately provides unavoidable bearing off.

When we analyze modern view of the distribution of the river and near shore catches of sockeye salmon in Asia and North America we can note visible dominance of Alaskan stocks in the commercial removal (Fig. 7). The high abundance of foraging sockeye salmon in the Western Bering Sea probably can be due to the additional (higher the average for many years) inflow of fishes originated from Alaska to this area. The suggestion made can serve as a confirmation of favorable ecological conditions revealed at the current period of studying for Pacific Salmon foraging in the Western Bering Sea (Shuntov and Sviridov 2005).

Moreover, the maximally high catches (~ 15-18 thousand t) have been observed since 2002 on the west coast of Kamchatka (the Ozernaya River). Such high catches are the historical maximum recorded for the last one hundred years (Bugaev and Bugaev 2003). That cannot bring no effects to building the abundance of sockeye salmon in the Economic Zone of Russia. We would underline additionally that for today an increase in the abundance of Northeast Kamchatka sockeye salmon has been observed, although official statistics of the catches and covering spawning grounds in this area is far from its' real state. The principle factor causing this situation is a large scale poaching. In recent years the problem has been sensible in the Kamchatka River also. The basin of the river is the area where a number of settlements is situated what inevitably brings effects into the abundance of sockeye salmon in the river.

In general the abundance of immature sockeye salmon on the data of the trawl surveys by RV TINRO is rather high and exciding the world level of the annual runs (the catch + the escapement) of sockeye salmon to the coasts of Asia and North America (~ 40-50 million fishes) as 2-3 times as much. In principle that should indicate of a high level of mortality of foraging sockeye salmon for the period in the ocean, especially in connection to the fact that the research covered just a part of the area inhabited by this species. Such high mortality can be probably due to the increased abundance of predators. The indication of that are also the data about the high level of oceanic traumatism among Pacific Salmon caused by predators (Sviridov et al. 2004; Bugaev and Shevlyakov 2007).

The ration between mature and immature fish

All individuals (100%) in the samples of sockeye salmon from the trawl catches by RV TINRO in the Western Bering Sea in June-August and September-October 2002-2004 were immature. Single mature sockeye salmon individual was revealed in the sample from the summer survey 2003. Such low percent of mature sockeye salmon individuals in the catches can be indeed as the prespawning migrations of the East Kamchatkan sockeye salmon stocks, making the basis of the anadromous aggregations in the Bering Sea part of the EZ of Russia, have been finishing in the second part of July (Bugaev 2003 a, b).

The occurrence of the postcatadromous juvenile individuals was visibly higher comparing to that of mature individuals, but only the immature part of stocks was examined in this research. It is connected to the problem of sampling the scales from juveniles, when the scales can be lost in the course of trawling and the scales get sampled from different parts of fish bodies, which cannot be used for the adequate differentiation from the scale criteria.

The age structure

The age structure of immature sockeye salmon in the Western Bering Sea is quite typical for this period of life in the ocean. For 2002-2004 the fishes from four age groups dominated including 1.1, 1.2, 2.1 and 2.2 (Table 4). The groups answer to the principle age groups of mature sockeye salmon in Asia and North America, including 1.2, 1.3, 2.2 and 2.3. The summary pool of all age groups listed takes about 90% of all adult fish of this species in North Pacific (Burgner 1991; Bugaev 1995), this is why the individuals from these age groups make up the composition of the baselines. Therefore in the mixed marine samples only the individuals from the available age groups (AAG) which summary pool determines the information level of the results obtained can be identified.

In our observation the pool of the available age groups (AAG – 1.1, 1.2, 2.1 and 2.2) varied from 84.85 to 94.58%. The level like this to cover the mixed sample is enough for making the identification from the scale criteria. Over that for the period of the observation in the whole the fishes from the age groups 1.1 and 2.1 dominated in the catches, the summary pool of these fishes varied in the range 50-80%. The fishes from the groups 1.1 and 2.2 contributed 20-40% approximately. The contribution of the other age groups usually was less than 10%.

The baselines

The cluster and discriminate analyses

As a result of the cluster and discriminate analyses carried out there were the joint-trees and the schemes of the distribution of the scale baselines on the baseline data for 2003-2005 (Fig. 8-13). The complex approach was applied initially, in the other words the baselines from particular rivers were grouped on their regional membership. It was determined by the requirement to make the methodical approach standard, as the principle North American baseline from the Bristol Bay (Port Moller) is a group of stocks of this region, but not a separate stock. This fact is not principle for the identification of mature sockeye salmon, because the anadromous aggregations of sockeye salmon in the Bering Sea waters adjacent Kamchatka and contiguous waters of Pacific Ocean are represented by Asian stocks only (Bugaev 2003a). However, in the case of immature sockeye salmon this circumstance immediately gets principle, as the feeding voyages of this species can be too distant from the places of spawning (Konovalov 1971; French et al. 1976; Forrester 1987), hence we also made united all the other local stocks into the groups on the regional membership.

The baselines formed allow quite clear figuring out three principle complexes of stocks, including West Kamchatkan, East Kamchatkan (+ Chukotka) and Alaskan. More in details differentiation can be made sometimes, but not always, due to the none identical composition of the baselines by years, therefore we use the standard form for presentation of the results. In principle such information level is quite satisfactory for the current research and allows to make the unavoidable error level.

It should be noted in general that the Ozernaya River stock, which is the main stock in Asia, can be differentiated most successfully on the results of the cluster and discriminate analysis. The stocks of East Kamchatka (the Kamchatka River and the group of minor stocks of North East Kamchatka) often are quite similar in scale structure to sockeye salmon from Alaska. That mostly concerns the group of Bristol Bay stocks. In our earlier works we already mentioned this trend as recognized at a macrolevel. Nevertheless, the similarity does not provide evidences of identity of the scales, but says about the maximal analogy in the baseline system used. In the cases when the scale structure similarity was observed for the West and East Kamchatkan sockeye salmon stocks the membership was given the more abundant the stock, the more preferably.

Pair bi-selective t-test for the average meanings

The level of the difference of the marked out components of the baseline models was assessed by the method of paired bi-selective t-test for the average meanings (Table 5). The results of testing have indicated that in the scale baselines of sockeye salmon the most reliably can be differentiated the complexes of stocks in the age group 2.2 + 2.3 – 87-93%. Over that all the components of the models work efficiently as for Asian, as for American stocks. It is very important, because the fishes from these age groups make up the basis in the age composition of the principle Asian stocks of sockeye salmon in the lakes Kurilskoye (the Ozernaya River) and Azabachye (the Kamchatka River).

The baselines on the age group 1.2 + 1.3 work less effective. The level of the authentic difference for them varies in the range 53-79%. The likely error exactly for these age groups can be the highest. Among the facts known it stays the problem of scale criteria similarity between sockeye salmon stocks of East, North-East Kamchatka and Alaska. Over that the difference between these complexes and West Kamchatkan group of the minor stocks are also none authentic in some cases. In this case it can be none grounded interception of the part of mixed samples of immature individuals from the age groups 1.1 and 1.2 in favor of one of the stock complexes. The main cause of that can be the wide diversity of phenotypes of the scales of minor sockeye salmon stocks of West and East Kamchatka, where the age of the spawners is 1, resulting in the similarity of the scale criteria at different levels. It is clear, that we don’t mean the total similarity. In the essence the similarity is observed at the edge of the interannual differences in particular stocks. The scale criteria similarity can vary in different stocks with time. These variations can be explained by the variations in the conditions of foraging ecology in the freshwater and first marine year of life. Nevertheless, taking into account the fact that the trend is observed in all baselines on the age group 1.2 + 1.3, the error can be reckoned as standard for the whole period of observations.

The simulation

The mean accuracy of the baselines obtained was estimated by the method of the dependent simulation (Tables 6-11). The average among the sum of the assessments obtained for each of stock complexes is the resolution ability of the simulation. The finally results are transformed into the percents. In the whole the resolution ability of the simulations was rather high and varied in the range 84.52-91.24%. These expected percents have indicated the possible error of the identification about 10-15%. In principle this level is not critical despite the problems revealed in the reliability of the difference between some components of the baseline simulations of sockeye salmon from the age group 1.2+1.3.

The identification of the regional complexes of local stocks

Distribution of the stock complexes

The results of the identification of sockeye salmon local stocks are demonstrated in Table 12 and Fig. 14-16. The data improved can reflect the preliminary results obtained earlier on the distribution of the regional complexes of stocks in 2002-2004 quite accurate. Nevertheless, in some cases the differences occur. For example, in 2002 the part of American stocks in the catches has visibly increased. Their part improved in the districts 5-8 was 41.1% and in the district 12 – 23.1%. In the first case the increase was approximately of 10%, whereas in the other case – of 20%. Nevertheless, taking into account the high abundance of spawning sockeye salmon in 2002, comparing to that in 2003 and 2004, that can be quite real. Over that the part of West Kamhatkan stocks has decreased to 18.0% in the districts 5-8 and to 24.7% in the district 12. The part of East Kamchatkan and Chukotkan stocks almost has not changed and took 40.9% in the districts 5-8 and 52.2% in the district 12.

In 2003 there were mostly improved the results of the identification for the summer period. The part of American stocks has strongly decreased in the districts 9-12 to 34.8%, what differs from the preliminary result in 25.9%. In our case this improvement also can be reckoned as logical, because such high percent of Alaskan sockeye salmon obtained from the preliminary results is strongly discussing. It probably the interannual variations in formation of scale elements could play the role in raising the error.

In the districts 2-8 during the summer survey in 2003 the part of American stocks in average was rather close to the preliminary assessment of 43.9%. The assessments obtained by fall also have not improved substantially the mode of the distribution of Alaskan sockeye salmon in the districts 5-8 and 9-12. In the first case the part was 39.4 and in the second case – 15.1%.
Both data pools – of preliminary data and improved data, indicate of significant inflow of American sockeye salmon stocks for feeding into the Western Bering Sea as in 2002, as in 2003. The process can be a consequence of the ecosystem level macrotransformations observed in the early 2000th (Shuntov and Sviridov 2005).

The most interesting stock occurring in this region among the Asian stocks is the stocks of West Kamchatka, where the Ozernaya River sockeye salmon stock is dominating in the abundance. The parts of West Kamchatkan stocks in 2003 were: 20.1% in the districts 2-8 and 29.6% in the districts 9-12 in summer and 20.1% in the districts 5-8 and 52.4% in the districts 9-12 by fall. Such high occurrence level of this group of stocks in the Western Bering Sea can be strongly determined by stably high abundance of sockeye salmon of West Kamchatka and by its' intention to spawn in the more appropriate ecological conditions. The complex of sockeye salmon stocks of East and North-East Kamchatka and Chukotka is indigenous for the Western Bering Sea. Therefore the occurrence of sockeye salmon spawning in these regions is stably high: 36.3% in the districts 2-8 and 35.6% in the districts 9-12 in summer and 40.5% in the districts 5-8 and 32.5% in the districts 9-12 by fall.

By fall 2004 the assessments obtained were rather similar to the preliminary assessments. The differences occurring vary in the range 10% and can answer the error of the method. The occurrence of American sockeye salmon stocks was 23.0% in the districts 3-8 and 16.1% in the district 12. The occurrence of West Kamchatkan sockeye salmon was maximal 23.9% in the district 12. To the North, in the districts 3-8 the part has been visibly reduced to 5.4%. The stocks of East Kamchatka and Chukotka dominated in the catches - 71.6% in the districts 3-8 and 60.0% in the district 12.

In the whole the modes of the distribution of the stock complexes revealed answer the logic of the insight to the migrations of Asian and American stocks of spawning sockeye salmon in North Pacific (French et al. 1976). The dominance role of Asian stocks in the Western Bering Sea can be quite grounded. Over that the part of American sockeye salmon in the "northern" part of the Bering Sea Economic Zone of Russia (the districts 1-8) was visibly higher than in the "southern" part (in the districts 9-12) (Fig. 17). This fact also answers to the known trends of the distribution of sockeye salmon in both continents, especially taking into account the maximal geographical closeness of this Russian part of the Bering Sea area to Alaska.

Several moments should be underlined in conclusion, as they appear in the analysis of the results of the immature sockeye salmon regional stock complexes identification in the Western Bering Sea. The data obtained have demonstrated that the region is the area of the active mixing of Asian and North American stocks. This phenomenon was known long ago in principle, but recent researches have been indicative for the scale of the mixing. The assessment of the abundance and the ratio between the local stocks have revealed significant increase of foraging sockeye salmon "visitors" from Alaska or West Kamchatka. Most likely it is the complex effects brought by density and ecosystem factors, although the span of the observation is not enough to reveal whatever correlations allowing to provide the forecast in the fisheries practice.

Nevertheless, the assessments of the abundance obtained for the complexes of local stocks can serve indicators providing the competence of making decision for a long period of the exploitation of sockeye salmon stock and the resource of the other species of Pacific Salmon. Making the recommendations should be built on the results provided by different methods of the identification able when using to complete each other. Using that would provide improving the system of communication on the assessment of the potential abundance of salmons in all regions in the Far East. The trawl researches would benefit especially as the researches are carrying out for practical purposes of the forecast of the runs of the mass species. The percent of the potential errors of the forecast could be strongly reduced.

The estimates of the abundance and biomass of the stock complexes

The assessments of the abundance and biomass of identified Asian and American immature sockeye salmon from the data of the trawl surveys by RV TINRO are shown in Table 13. Let's underline once more that sockeye salmon abundance/biomass assessed was high. In fall 2002-2004 in the "southern" part of the Bering Sea part of the Economic Zone of RF (the districts 9-12) the assessments for Russian stocks ranged from 26.76 million fishes/20.07 thousand t to 58.12 million fishes/ 52.55 thousand t. The assessments for American stocks in this district ranged from 7.75 million fishes/ 7.13 thousand t to 17.39 million fishes/19.88 thousand t. In the "northern" part (the districts 2-8) the abundance/biomass of Russian stocks ranged from 19.89 million fishes/17.40 thousand t to 56.83 million fishes/49.74 thousand t. The assessments for American stocks ranged from 12.93 million fishes/11.32 thousand t to 31.72 million fishes/37.96 thousand t.

In summer of 2003 in the "southern" part of the Bering Sea part of the Economic Zone of RF the abundance/biomass of Russian immature sockeye salmon was 26.76 million fishes/ 20.07 thousand t, and the abundance/biomass of American immature sockeye salmon – 14.28 million fishes/ 10.71 thousand t. In the "northern" part the assessments were 40.29 million fishes/ 30.25 thousand t for Russian stocks and 30.39 million fishes/22.82 thousand t for American stocks.
The total abundance/biomass as a rule was higher in the districts of the "northern" part. Only 2003 was exceptional, when in fall in the districts 9-12 the abundance of sockeye salmon was higher than in the districts 5-8. The higher abundance of immature sockeye salmon in the districts of the "northern" part perhaps is connected to the presence of sockeye salmon originated in Alaska. In principle it can be noted, that the strategy of sockeye salmon feeding migrations like this is stable for summer-fall period in the west part of the Bering Sea. The dynamics of the process against a background of the ecosystem transformations since XXI century is required to be clarified in the further researches.

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Appendix figures and Tables

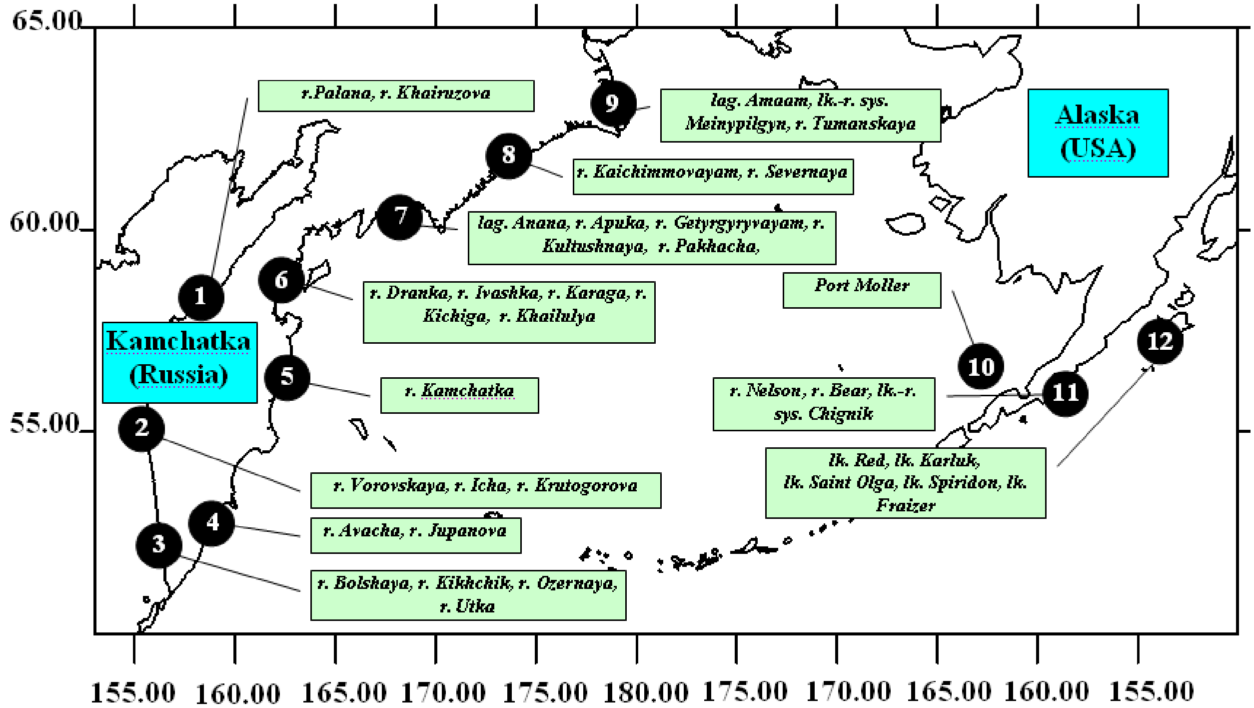


Fig. 1. The scheme of the districts of sockeye salmon scale samples used for the forming the basis scale lines 2003-2005

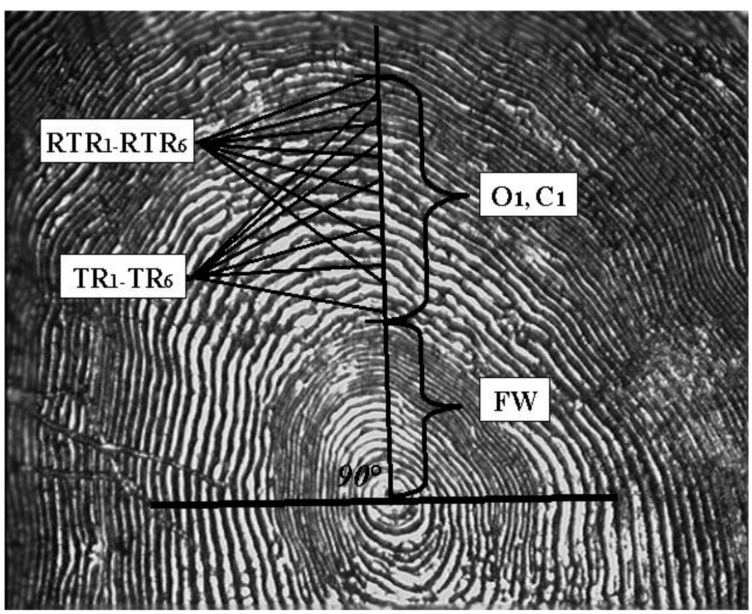


Fig. 2. Scheme of scale image used for identification local stocks of sockeye salmon: FW – the total radius of freshwater zone; O_1 – total distance in the first annual ocean growth zone; C1 – number sclerites in the first annual ocean growth zone; TR_1-TR_6 – triplets circulus distance from first circuli in the first annual ocean growth zone (sixth triplets); RTR_1-RTR_6 – reverse-triplets circulus distance from last circuli in the first annual ocean growth zone (sixth reverse-triplet)

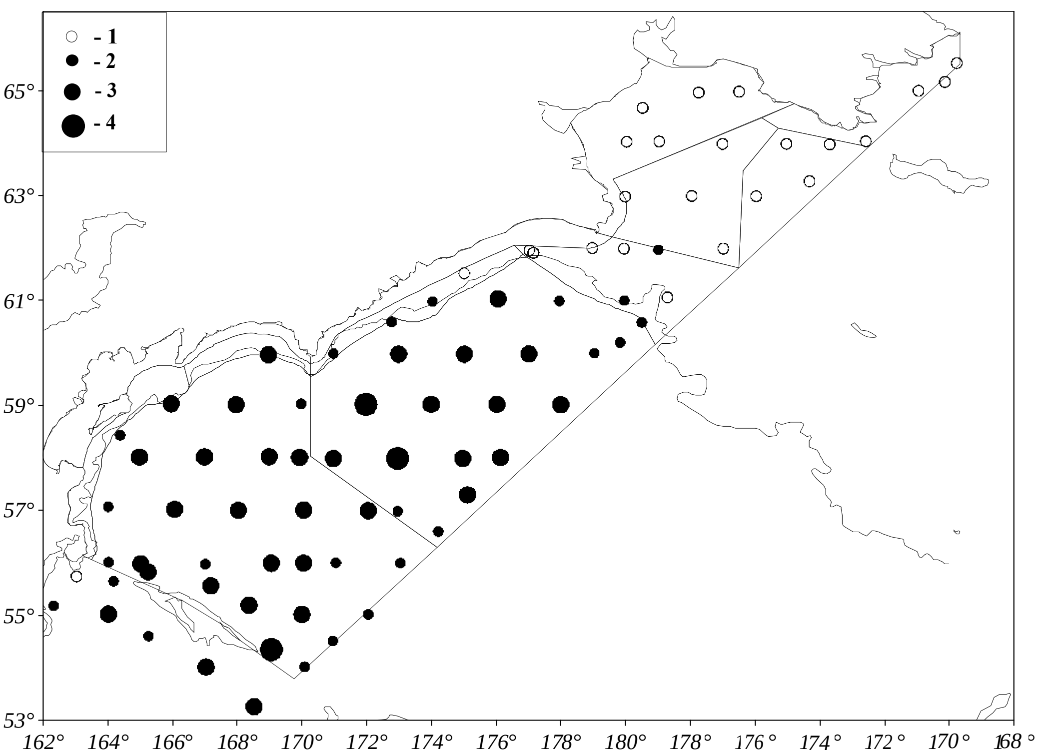


Fig. 3. The spatial distribution of sockeye salmon relative abundance (ind./km^2) in the Western Bering Sea in September-October of 2002. The designations: 1 – no catches; 2 – 1-10; 3 – 11-100; 4 - 101-1000

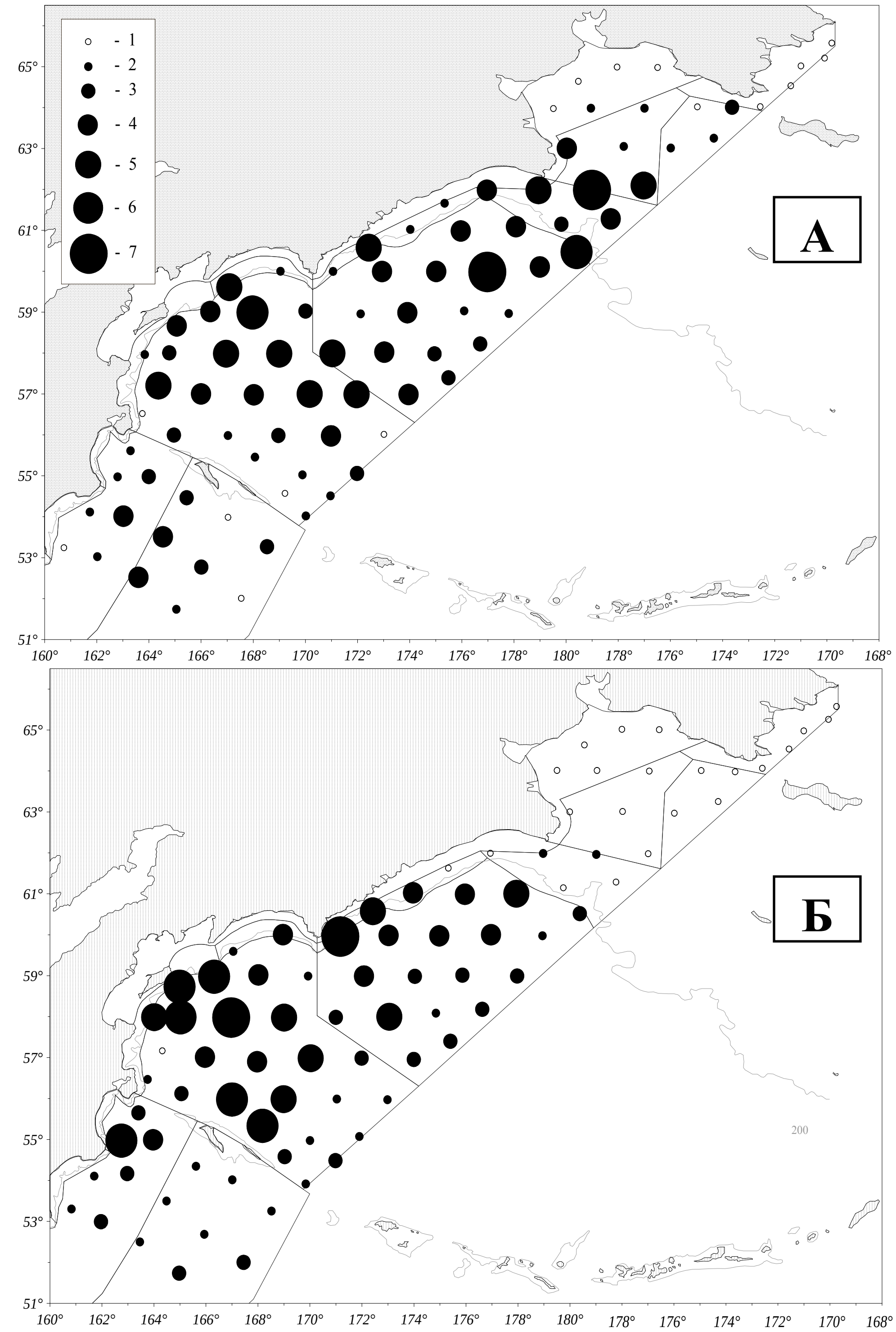


Fig. 4. The spatial distribution of the relative abundance of sockeye salmon (ind./km^2) in the Western Bering Sea in July–August (A) and in September–October (B) of 2003. The designations: 1 – no catches; 2 - < 50; 3 – 51-100; 4 – 101-250; 5 – 251-500; 6 – 501-1000; 7 - > 1001

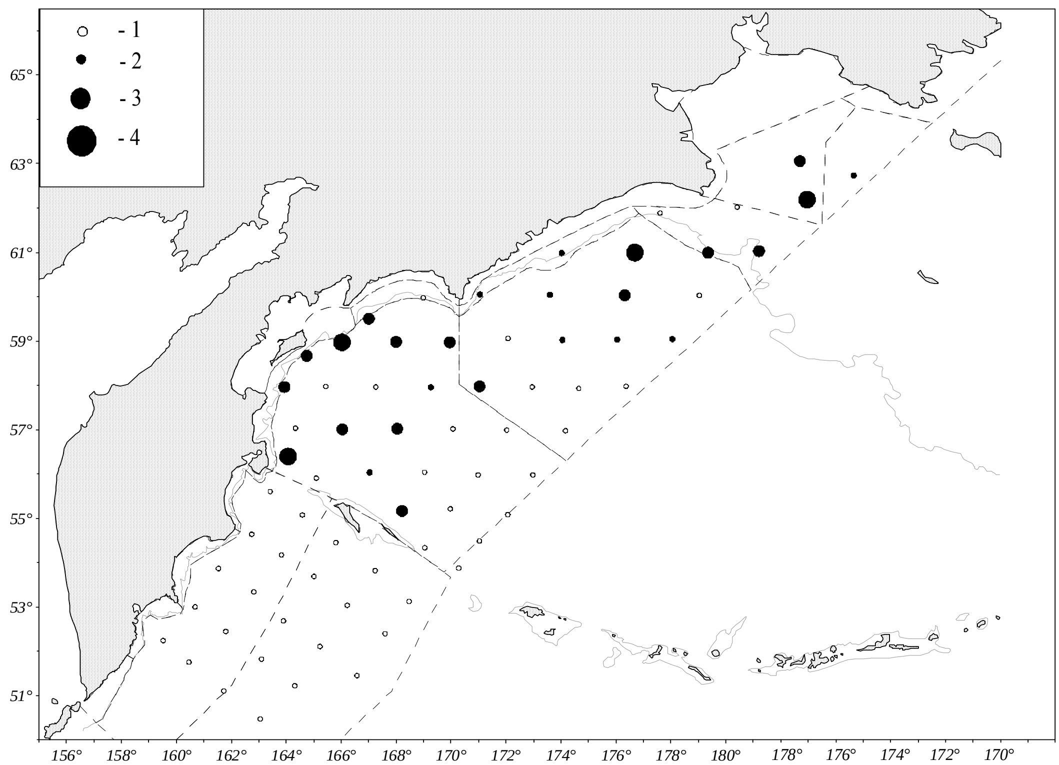


Fig. 5. The spatial distributions of the relative abundance of sockeye salmon (ind./km^2) in the Western Bering Sea in September-October of 2004. The designations: 1 – no catches; 2 – 1-10; 3 – 11-100; 4 - 101-500

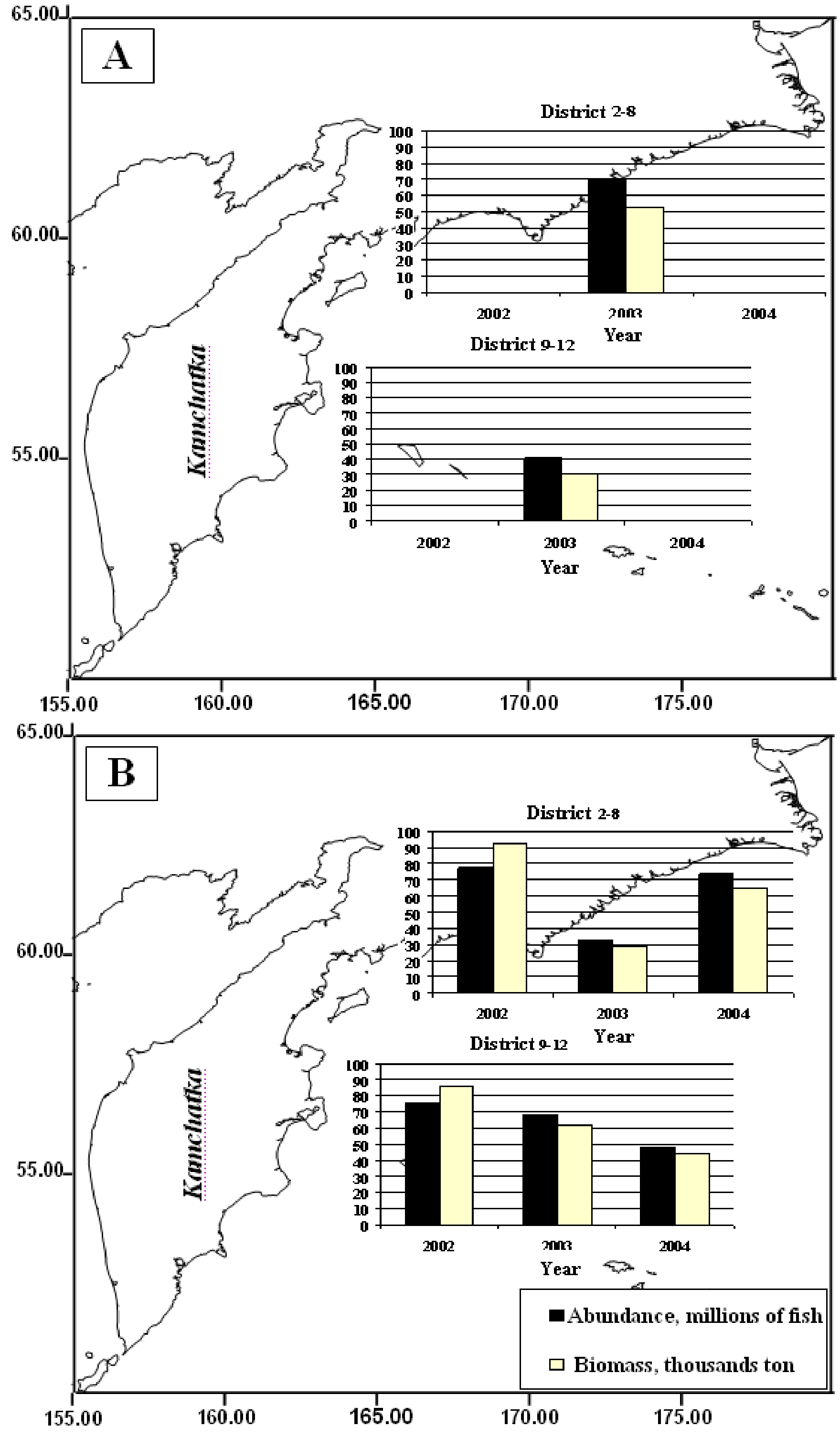


Fig. 6. The distribution of the abundance and the biomass of immature sockeye salmon in the Western Bering Sea in the «northern» (the districts 2-8) and the «southern» (the districts 9-12) groups of the biostatistical districts in July-August (A) and in September-October (B) 2002-2004

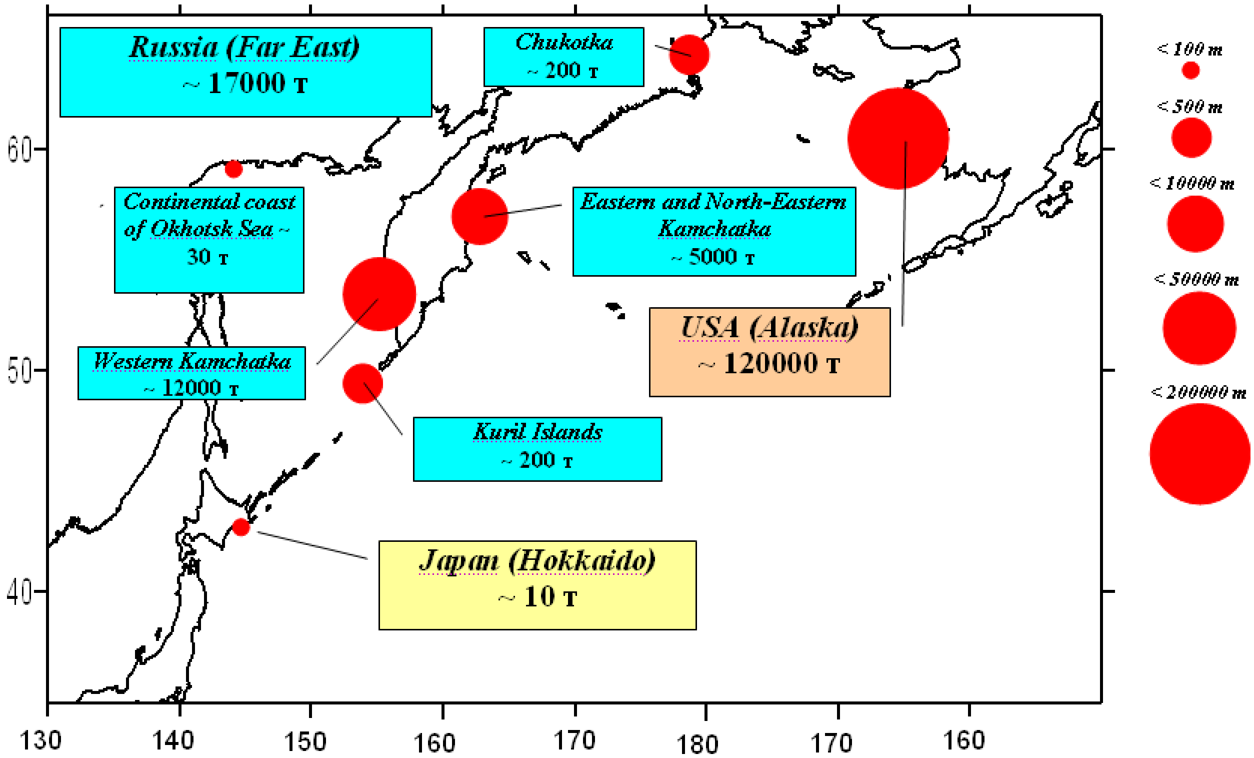


Fig. 7. The distribution of the coastal and river catches of sockeye salmon in Asia and North America on the data for 1996-2005 (from Bugaev and Bugaev 2003 and archival commercial fisheries statistic of KamchatNIRO. Note. Interannual total catches of sockeye salmon from Ozernaya River to attain about 20000 t in 2002-2008)

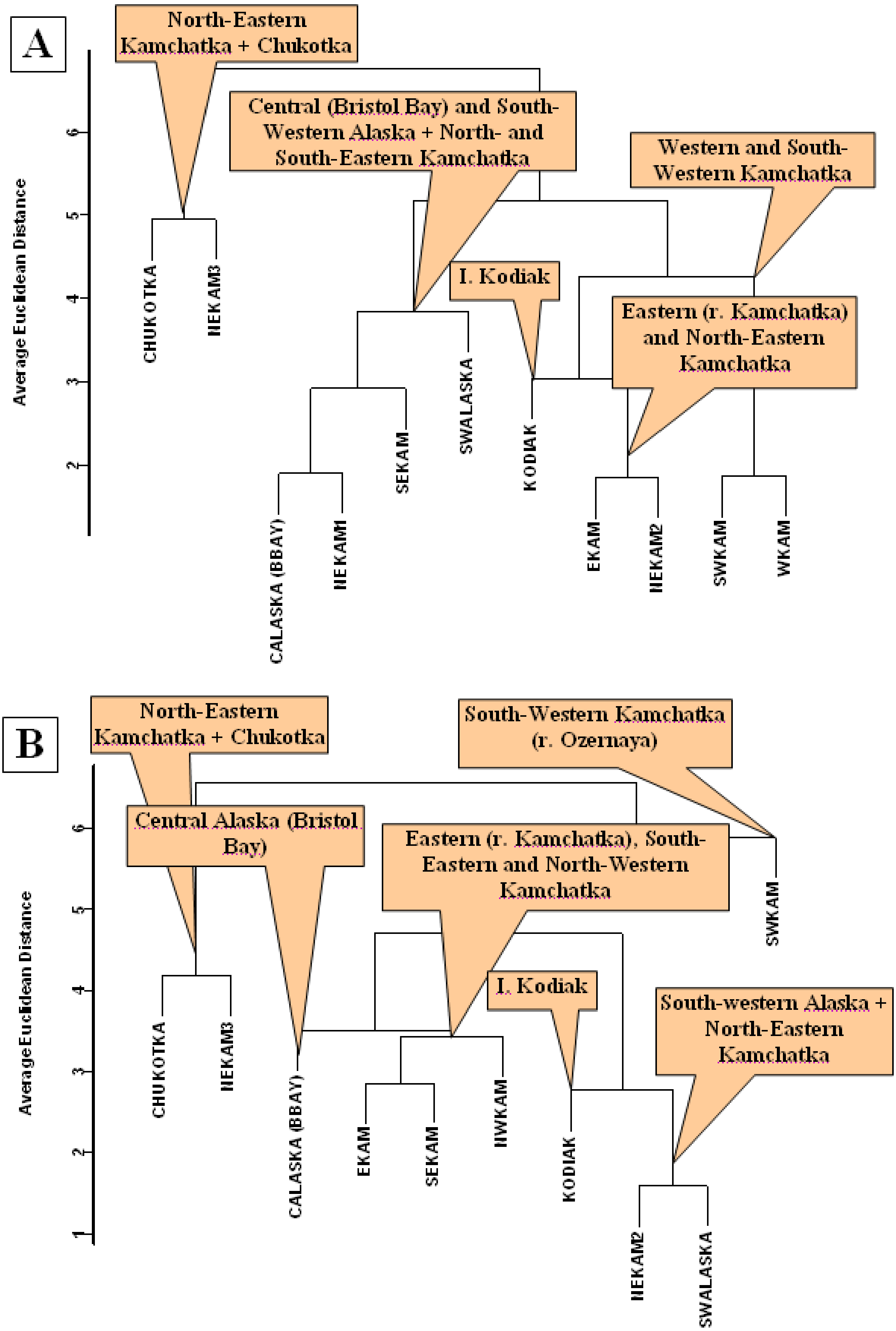


Fig. 8. The hierarchical cluster dendrograms of stock centroids of sockeye salmon from the standardized scale-pattern variables by the age groups 1.2 + 1.3 (A) and 2.2 + 2.3 (B) on the data of 2003

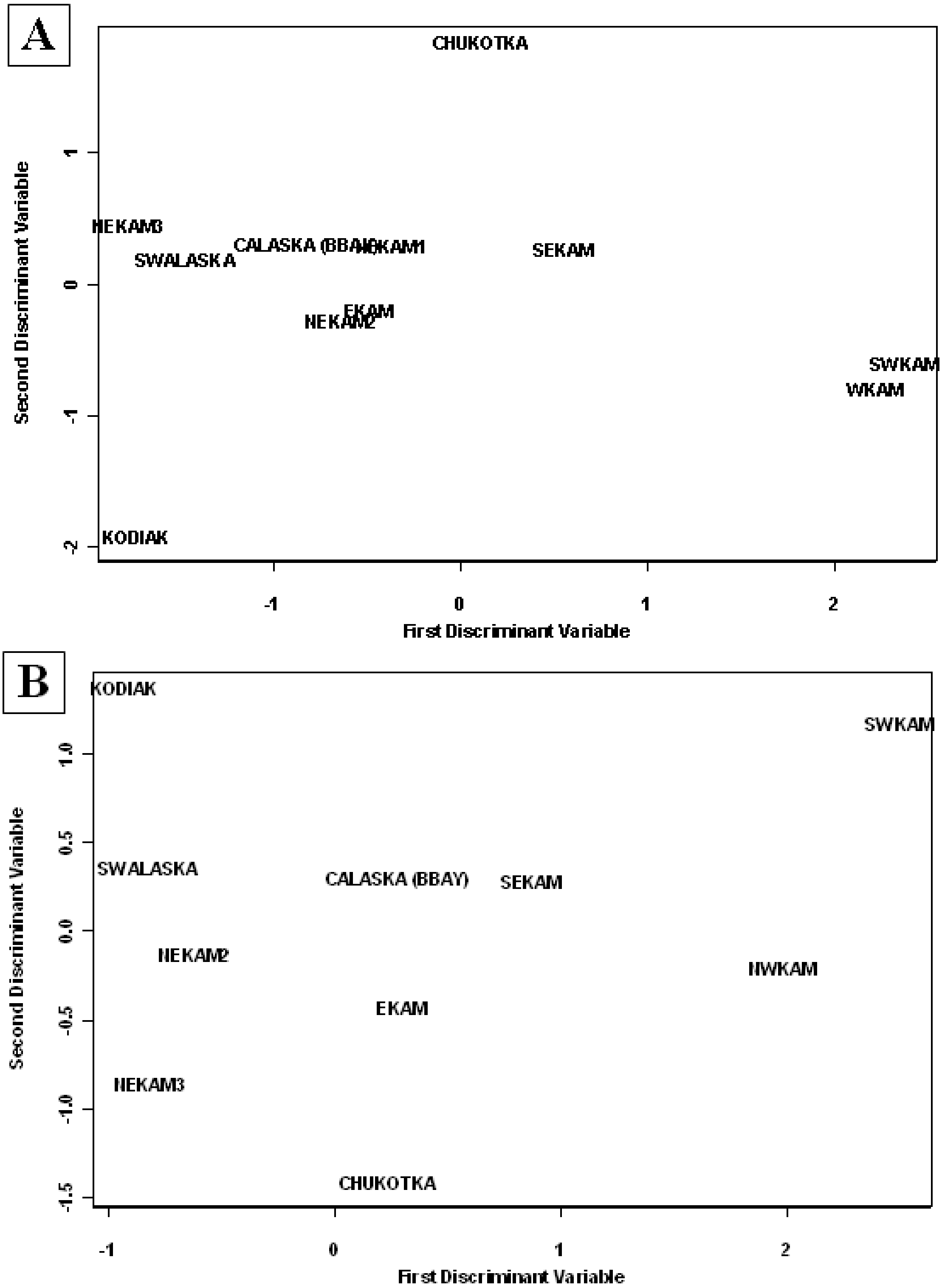


Fig. 9. The multivariate stock centroids of sockeye salmon scale criteria by age groups 1.2 + 1.3 (A) and 2.2 + 2.3 (B) relatively to the first and second canonical discriminate variables on the data of 2003

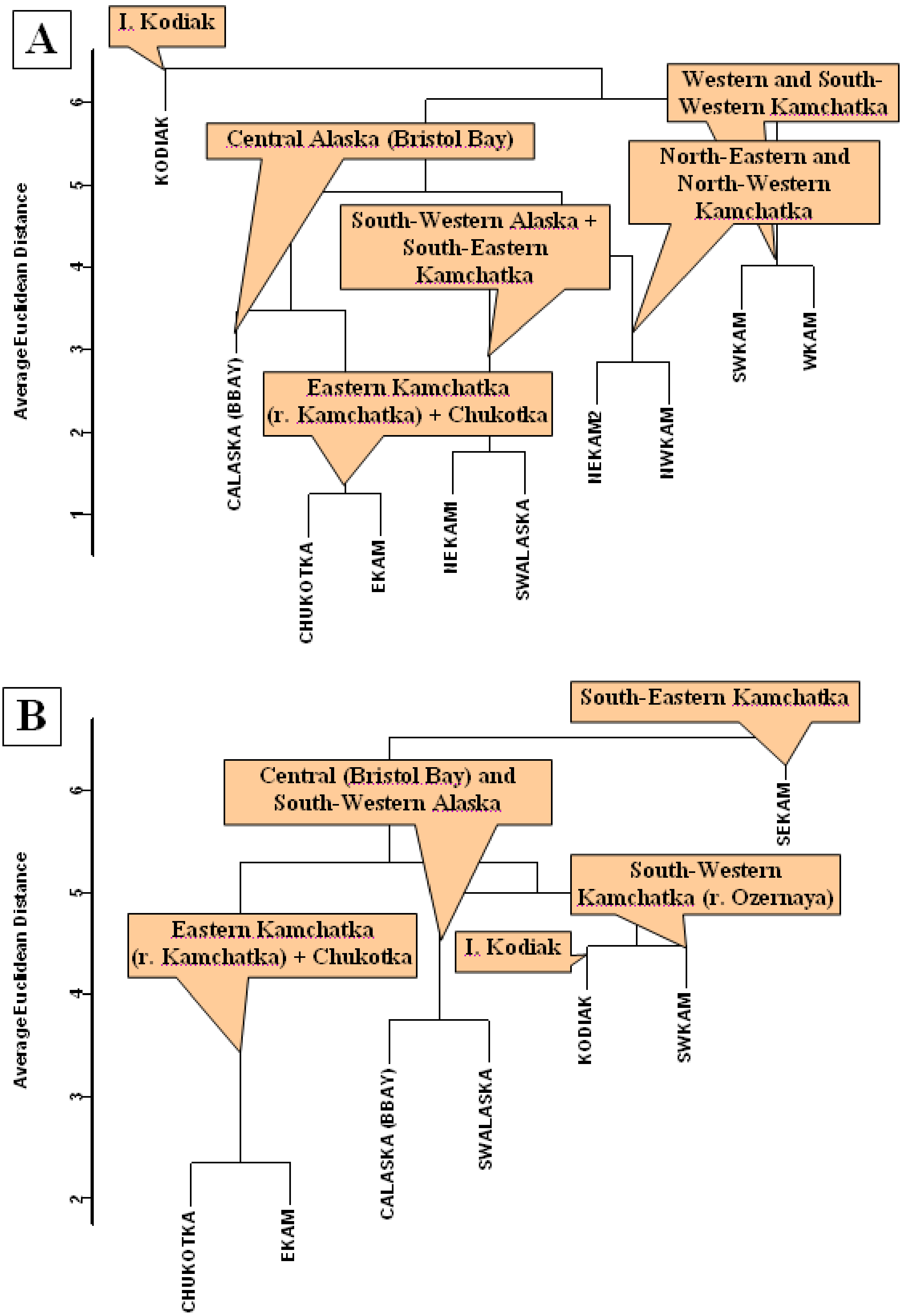
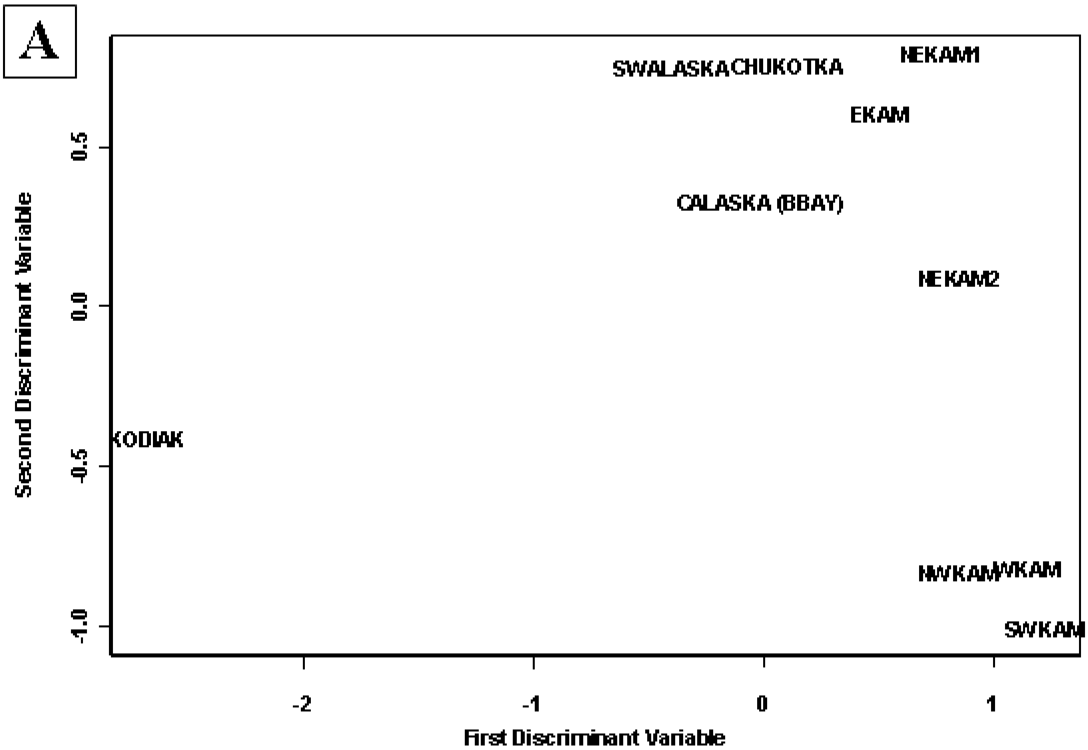


Fig. 10. The hierarchical cluster dendrograms of stock centroids of sockeye salmon from the standardized scale-pattern variables by the age groups 1.2 + 1.3 (A) and 2.2 + 2.3 (B) on the data of 2004.



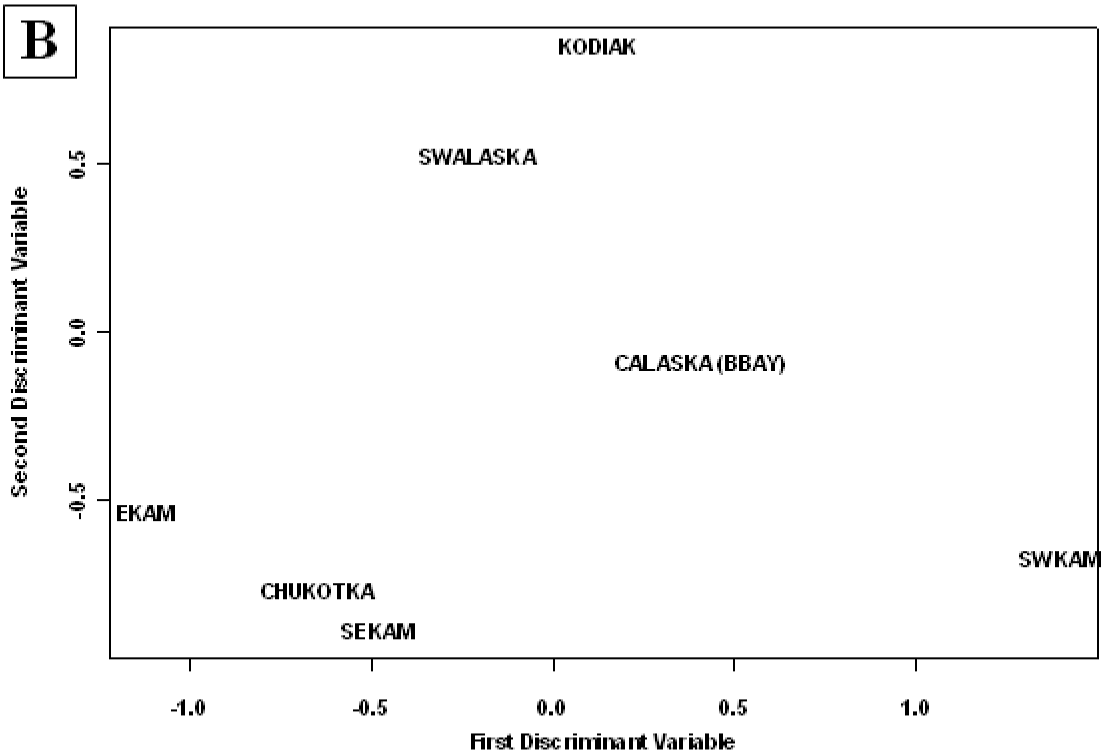


Fig. 11. The multivariate stock centroids of sockeye salmon scale criteria by age groups 1.2 + 1.3 (A) and 2.2 + 2.3 (B) relatively to the first and second canonical discriminate variables on the data of 2004

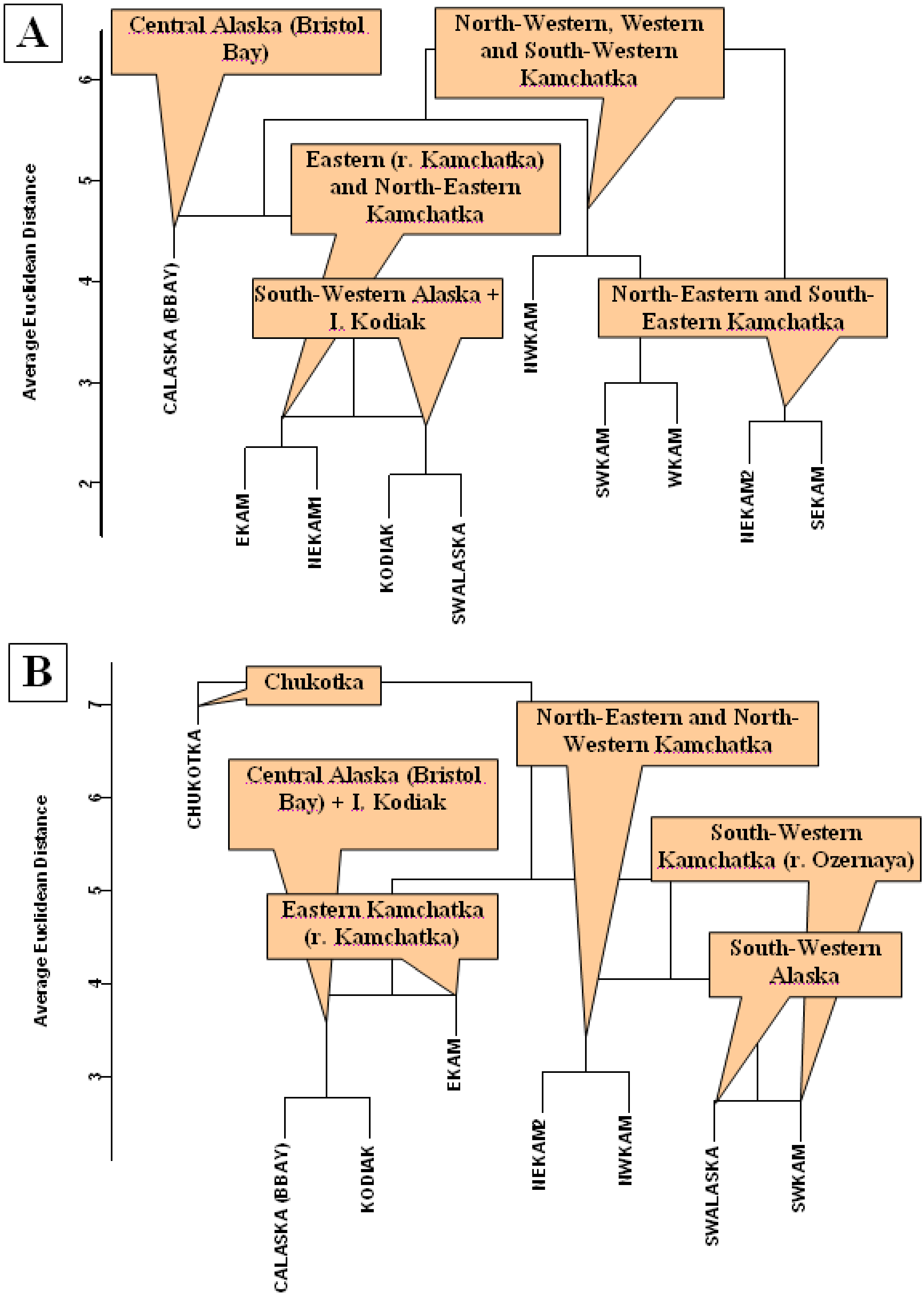


Fig. 12. The hierarchical cluster dendrograms of stock centroids of sockeye salmon from the standardized scale-pattern variables by the age groups 1.2 + 1.3 (A) and 2.2 + 2.3 (B) on the data of 2005.

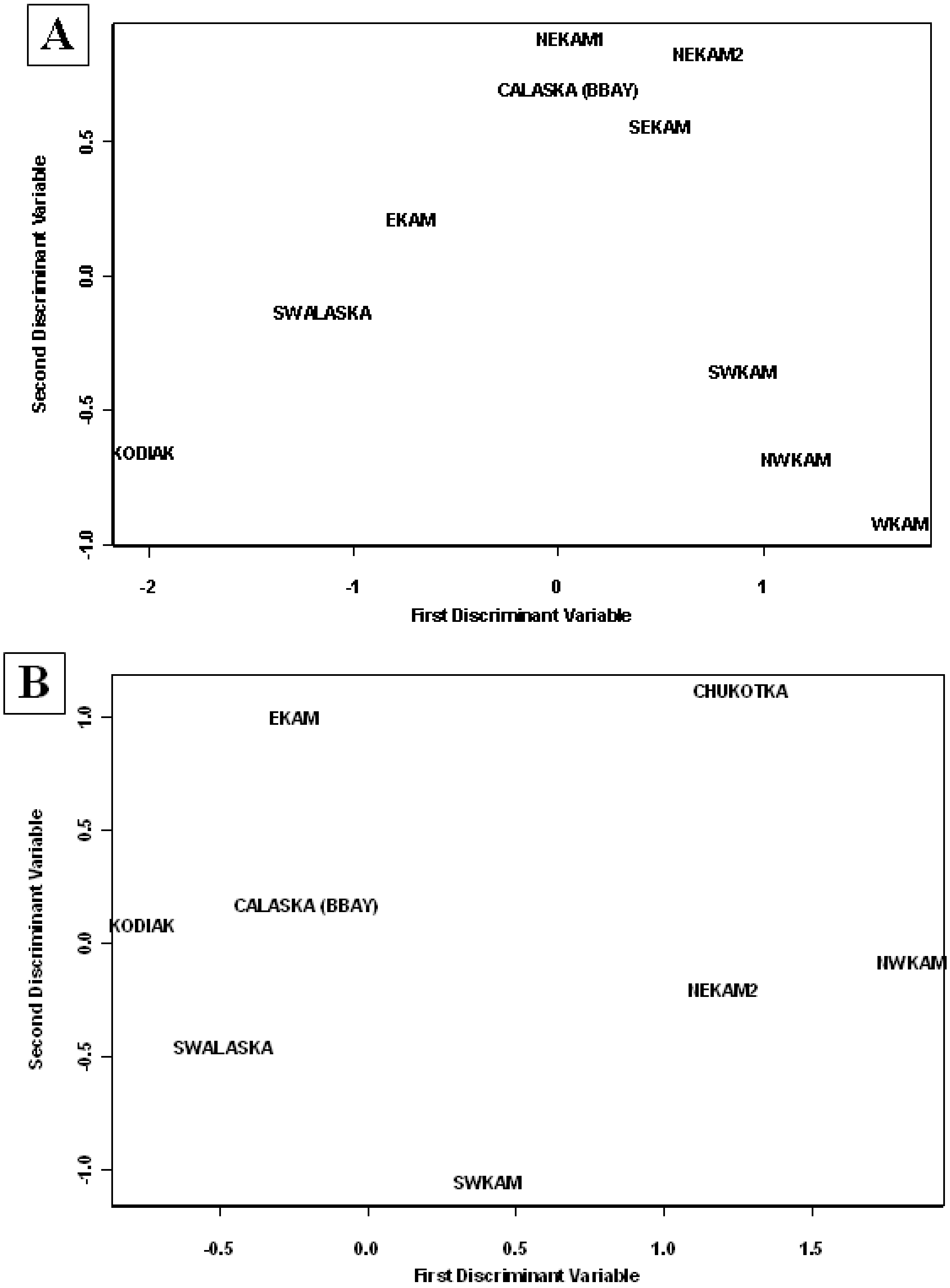


Fig. 13. The multivariate stock centroids of sockeye salmon scale criteria by age groups 1.2 + 1.3 (A) and 2.2 + 2.3 (B) relatively to the first and second canonical discriminate variables on the data of 2005

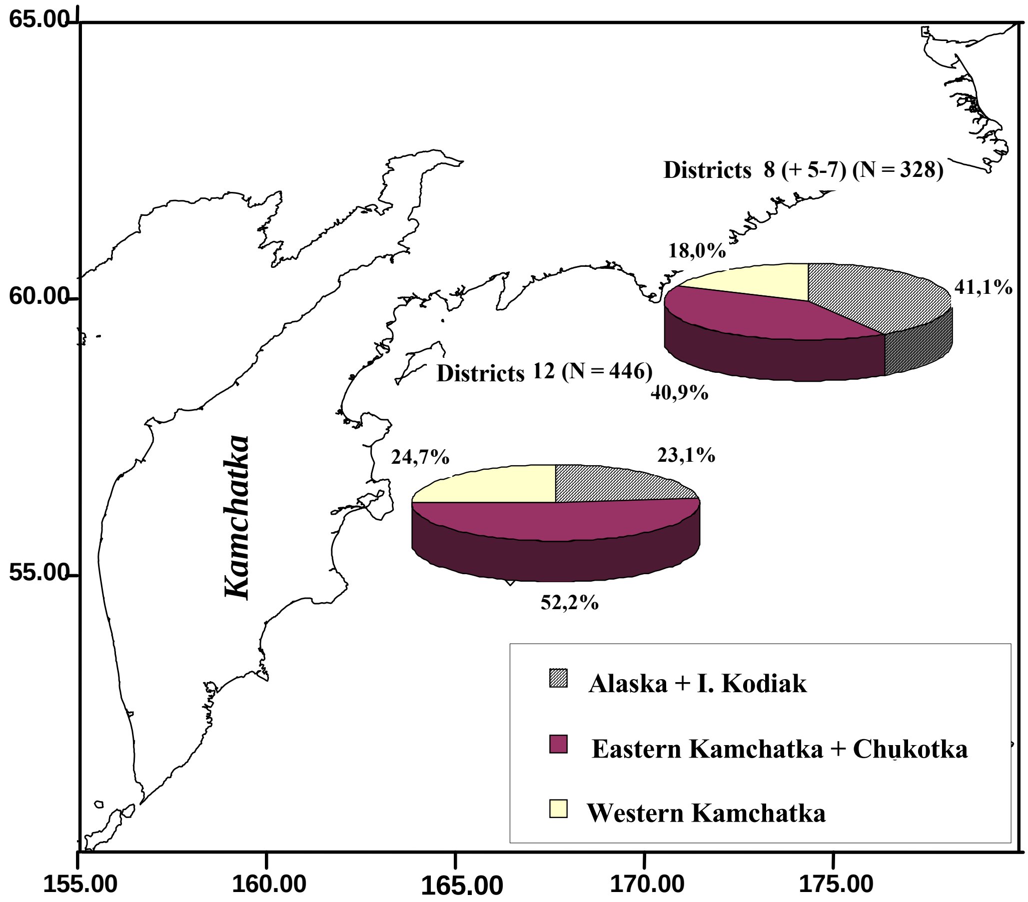


Fig. 14. The distribution of the stock complexes of immature sockeye salmon (the age group 1.1 + 1.2 + 2.1 + 2.2) on the data of trawl catches of the R/V «TINRO» in the Western Bering Sea in September-October of 2002

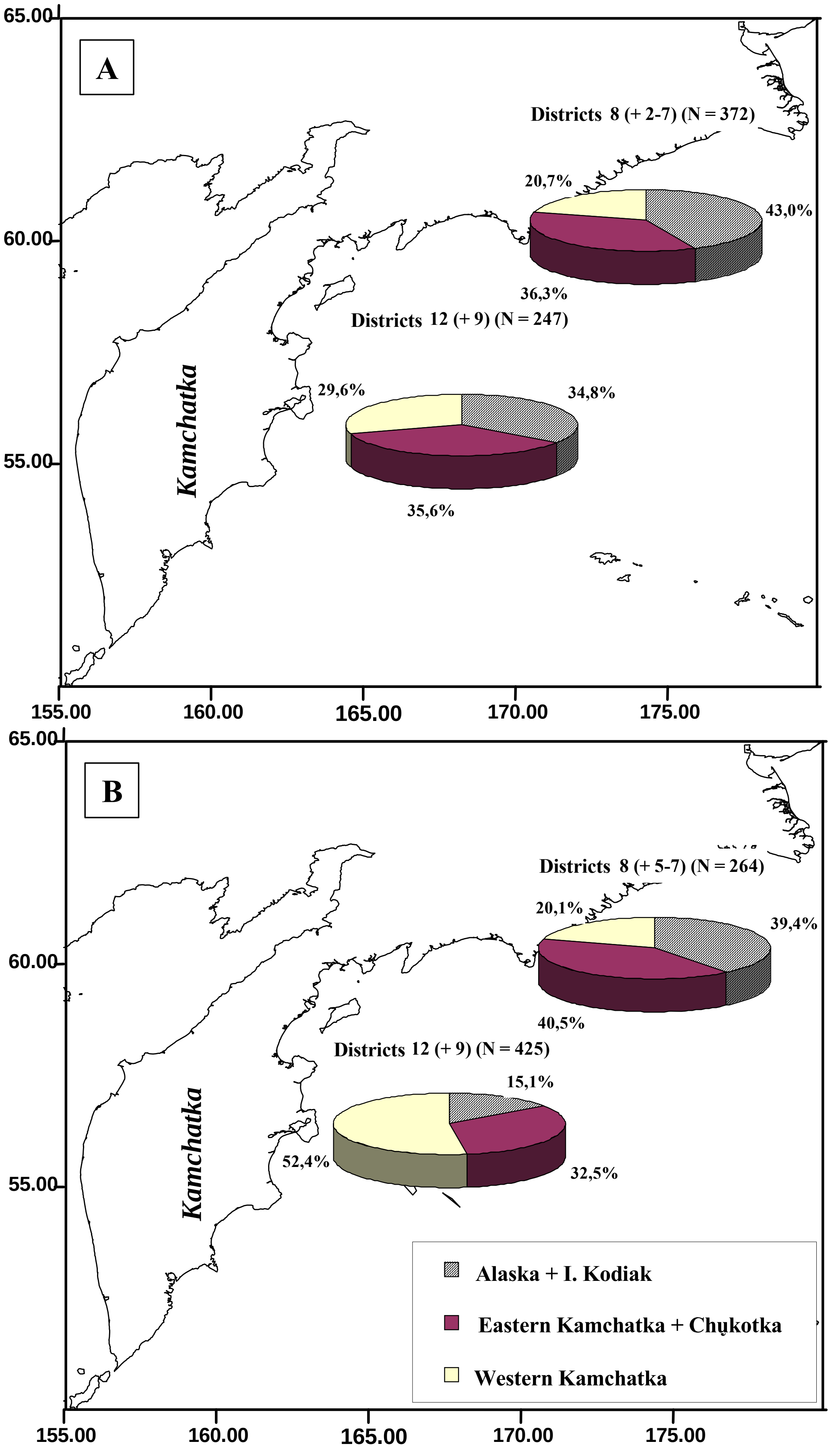


Fig. 15. The distribution of the stock complexes of immature sockeye salmon (the age group 1.1 + 1.2 + 2.1 + 2.2) on the data of trawl catches of the R/V «TINRO» in the Western Bering Sea in July-August (A) and in September-October (B) of 2003

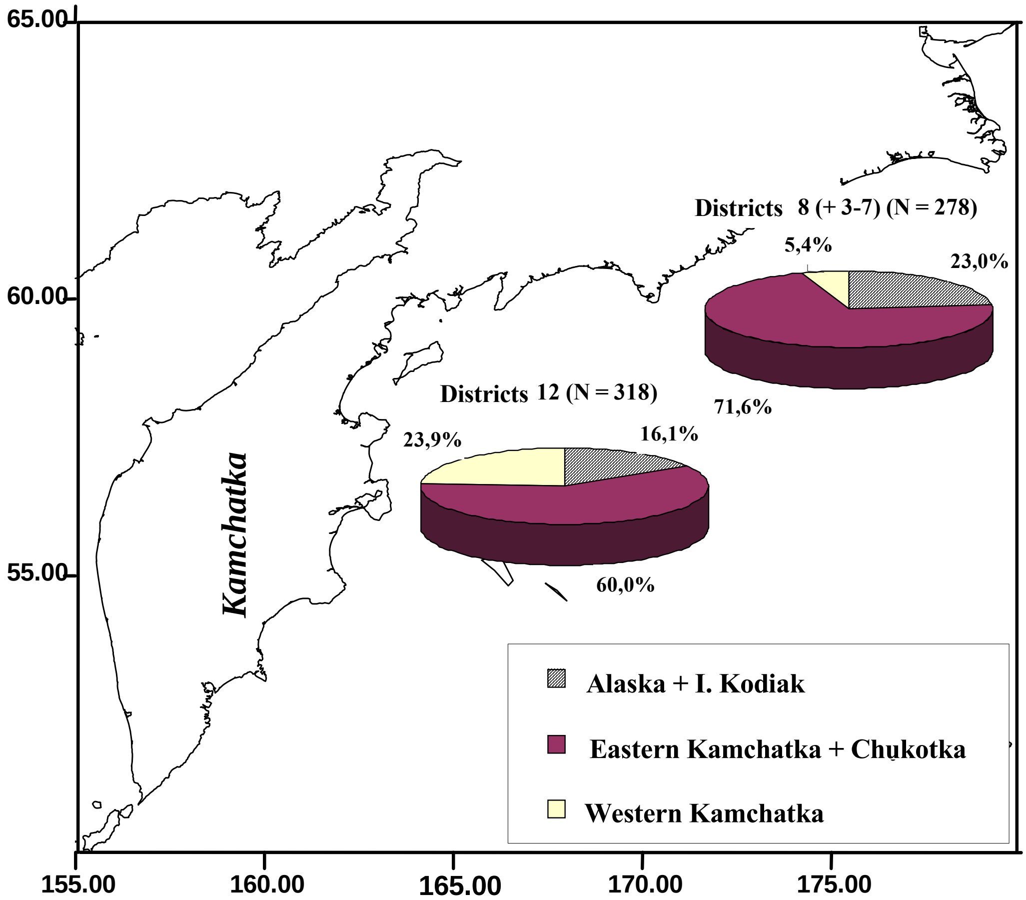


Fig. 16. The distribution of the stock complexes of immature sockeye salmon (the age group 1.1 + 1.2 + 2.1 + 2.2) on the data of trawl catches of the R/V «TINRO» in the Western Bering Sea in September-October of 2004

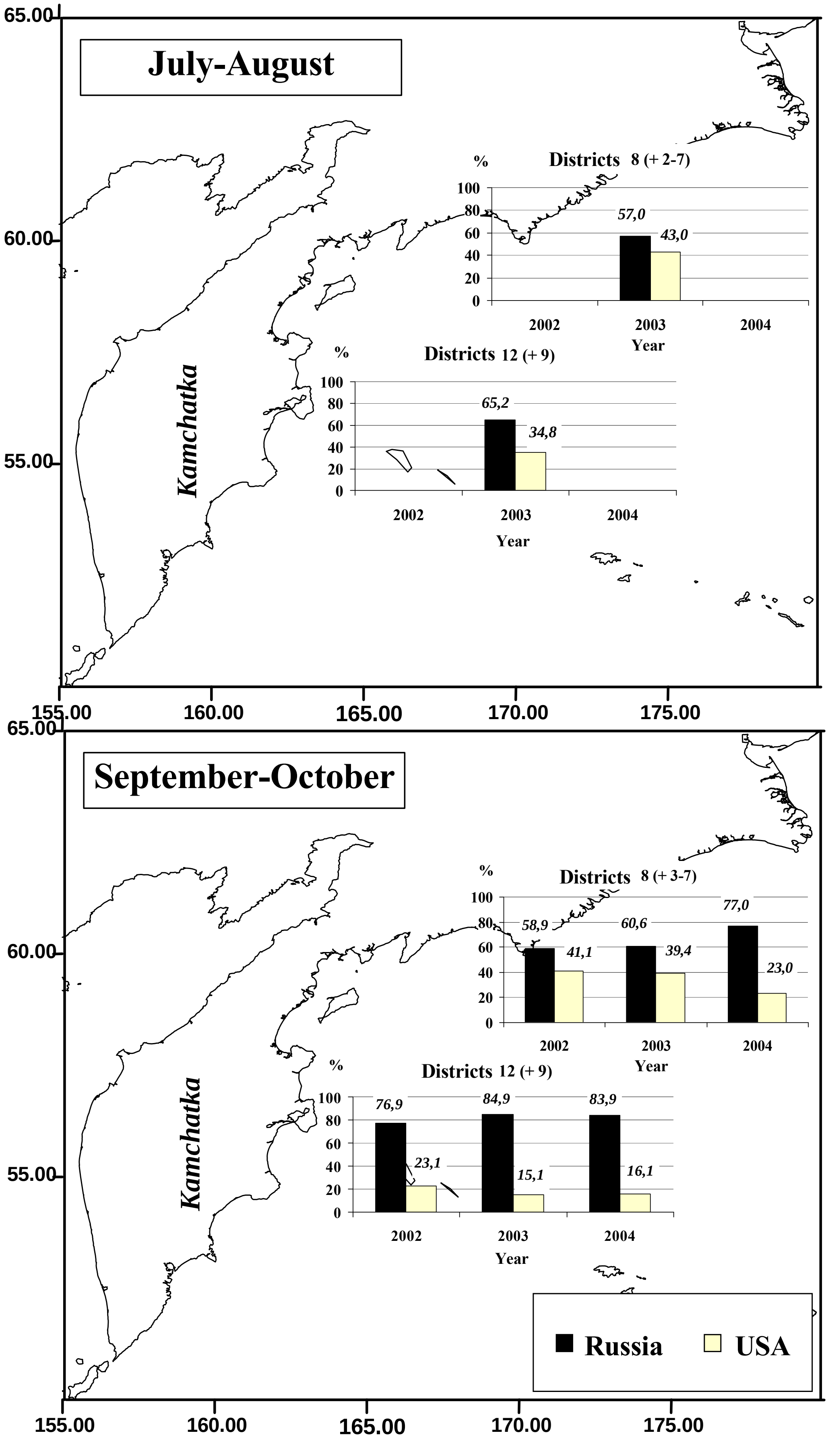


Fig. 18. The distribution of Asian and North American stocks of immature sockeye salmon on the data of trawl catches of the R/V «TINRO» in the Western Bering Sea in the fall in 2002-2004

Table 1. The total size of the mixed samples of sockeye salmon used in the work, ind.

Year	Season	Biostatistical districts	Period	Coordinates	Determine age	Identification
2002	Autumn	8 (+ 1-7)	13.09-30.09	56°36' - 61°01' N 170°58' - 179°49' E	438	328
		12 (+ 9)	03.09-14.10	53°28' - 59°57' N 164°00' - 175°04' E	642	446
2003	Summer	8 (+ 1-7)	02.08-23.08	56°59' - 64°59' N 169°07' - 179°32' E	527	372
		12 (+ 9)	17.07-05.08	54°01' - 60°00' N 163°45' - 171°59' E	447	247
	Autumn	8 (+ 3-7)	05.10-22.10	56°57' - 63°15' N 171°00' - 179°37' E	310	264
		12 (+ 9)	23.09-05.10	53°55' - 58°59' N 163°45' - 172°59' E	566	425
2004	Autumn	8 (+ 3-7)	05.10-23.10	56°59' - 63°03' N 171°02' - 179°35' E	295	278
		12	26.09-11.10	53°52' - 59°58' N 163°56' - 172°59' E	466	318
TOTAL					3691	2678

Table 2. The size of the scale baselines of sockeye salmon used in the work, ind.

Region	Stock/river	Code	AGE														
			2003					2004					2005				
			1.2	1.3	2.2	2.3	Total	1.2	1.3	2.2	2.3	Total	1.2	1.3	2.2	2.3	Total
RUSSIA																	
North-Western Kamchatka	r. Palana	NWKAM				100	100	-	-	-	-	-	-	-	-	100	100
	r. Khairuzova		-	-	-	-	-	-	100	-	-	100	-	27	-	-	27
Western Kamchatka	r. Vorovskaya	WKAM	-	45	-	-	45	-	37	-	-	37	-	100	-	-	100
	r. Icha		-	42	-	-	42	-	100	-	-	100	-	100	-	-	100
	r. Krutogorova		-	-	-	-	-	-	57	-	-	57	-	71	-	-	71
South-Western Kamchatka	r. Bolshaya	SWKAM	-	100	-	-	100	-	100	-	-	100	-	100	-	-	100
	r. Kikhchik		-	94	-	-	94	-	55	-	-	55	-	55	-	-	55
	r. Ozernaya		-	-	-	100	100	-	-	100	102	202	-	-	50	100	150
	r. Utka		-	20	-	-	20	-	-	-	-	-	-	-	-	-	-
South-Eastern Kamchatka	r. Avacha	SEKAM	-	-	-	20	20	-	-	-	32	32	-	-	-	-	-
	r. Jupanova		-	100	-	-	100	-	-	-	-	-	-	45	-	-	45
Eastern Kamchatka	r. Kamchatka	EKAM	-	100	-	100	200	-	100	100	100	300	50	100	50	100	300
North-Eastern Kamchatka (Karaginsky district)	r. Dranka	NEKAM1	-	21	-	-	21	-	-	-	-	-	-	68	-	-	68
	r. Ivashka		-	25	-	-	25	-	100	-	-	100	-	57	-	-	57
	r. Karaga		-	40	-	-	40	-	-	-	-	-	-	-	-	-	-
	r. Kichiga		-	21	-	-	21	-	-	-	-	-	-	36	-	-	36
	r. Khailulya		-	70	-	-	70	-	100	-	-	100	-	100	-	-	100
North-Eastern Kamchatka (Olutorsky district)	lag. Anana	NEKAM2	-	-	-	100	100	-	-	-	-	-	-	-	-	-	-
	r. Apuka		-	-	-	-	-	-	100	-	-	100	-	-	-	-	-
	r. Getyrgyryvayam		-	-	-	-	-	-	-	-	-	-	-	75	-	22	97
	r. Kultushnaya		-	31	-	34	65	-	-	-	-	-	-	-	-	-	-
	r. Pakhacha		-	100	-	50	150	-	-	-	-	-	-	100	-	20	120
North-Eastern Kamchatka (Navarinsky district)	r. Kaichimmovayam	NEKAM3	-	25	-	50	75	-	-	-	-	-	-	-	-	-	-
	r. Severnaya		-	50	-	100	150	-	-	-	-	-	-	-	-	-	-

Chukotka	lag. Amaam	CHUKOTKA	-	92	-	55	147	-	42	36	-	78	-	-	40	36	76
	lk.-r. sys. Meinypilgyn		-	45	-	100	145	-	100	64	-	164	-	-	-	-	-
	r. Tumanskaya		-	91	-	32	123	-	53	25	-	78	-	-	-	-	-
USA																	
Central Alaska (Bristol Bay)	Port Moller	CALASKA (BBAY)	50	100	50	100	300	100	95	100	43	338	50	100	50	100	300
South-Western Alaska	r. Nelson	SWALASKA	-	-	50	50	100	-	45	100	30	175	-	-	50	45	95
	r. Bear		-	-	50	50	100	-	-	50	50	100	34	53	50	50	187
	lk.-r. sys. Chignik		-	50	-	-	50	38	49	-	50	137	-	50	-	-	50
Kodiak Island	lk. Karluk	KODIAK	-	-	50	50	100	-	-	50	44	94	-	-	50	50	100
	lk. Red		-	-	-	-	-	50	-	50	-	100	21	43	50	50	164
	lk. Saint Olga		50	-	50	-	100	100	-	99	-	199	-	50	50	-	100
	lk. Spiridon		50	50	50	-	150	50	50	-	-	100	50	50	-	-	100
	lk. Frazer		-	-	-	-	-	30	-	50	-	80	-	50	-	50	100
TOTAL			150	1312	300	1091	2853	368	1283	824	451	2926	205	1430	440	723	2798

Table 3. The abundance and the biomass of immature sockeye salmon in the epipelagic zone of the Western Bering Sea in 2002-2004

Year	Season	Biostatistical districts												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Abundance, millions of fish														
2002	Autumn	-	-	-	-	0.51	-	0.10	76.57	-	-	-	75.30	152.48
2003	Summer	-	0.32	5.75	0.57	13.07	-	0.89	50.08	1.06	-	-	39.98	111.72
	Autumn	-	-	-	-	0.15	-	2.53	30.14	0.23	-	-	68.23	101.28
2004	Autumn	-	-	0.08	-	0.73	-	0.08	72.91	-	-	-	48.15	121.95
Biomass, thousands ton														
2002	Autumn	-	-	-	-	0.61	-	0.20	91.55	-	-	-	86.06	178.42
2003	Summer	-	0.22	3.78	0.44	8.82	-	0.67	39.14	0.64	-	-	30.14	83.85
	Autumn	-	-	-	-	0.11	-	2.27	26.34	0.22	-	-	61.68	90.62
2004	Autumn	-	-	0.07	-	0.52	-	0.12	63.89	-	-	-	44.30	108.90

Note. Coefficient of trawl catch – 0.3.

Table 4. The age structure of immature sockeye salmon in the trawl catches of the R/V «TINRO» in the Western Bering Sea

Year	Season	Biostatistical districts	N	AGE, %													AAG, %
				0.1	0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3	3.1	3.2	4.1	
2002	Autumn	8 (+ 5-7)	438	1.40	2.05	-	23.08	30.38	3.23	-	14.17	19.65	1.83	0.98	3.23	-	87.28
		12	642	2.83	2.94	0.11	22.63	20.59	2.15	-	22.63	19.00	2.94	3.28	0.90	-	84.85
2003	Summer	8 (+ 2-7)	527	2.65	0.95	0.38	36.81	11.39	0.19	-	38.90	5.50	0.38	2.09	0.57	0.19	92.60
		12 (+ 9)	447	5.14	1.56	0.67	29.53	16.11	1.79	-	26.85	14.32	0.45	2.24	1.34	-	86.81
	Autumn	8 (+ 5-7)	310	2.90	1.61	-	51.61	10.97	1.61	-	20.97	7.42	0.65	1.94	0.32	-	90.97
		12 (+ 9)	566	5.48	0.88	-	31.98	13.96	1.06	0.18	29.15	12.01	0.88	3.36	1.06	-	87.10
2004	Autumn	8 (+ 3-7)	295	1.69	0.68	-	42.71	16.27	-	-	29.83	5.77	-	2.71	-	0.34	94.58
		12	466	6.44	1.29	0.42	36.91	10.52	-	-	39.48	3.22	-	1.29	0.43	-	90.13

Note. AAG - available age groups for identification by scale pattern analysis.

Table 5. The pair t-test for the averages of identified cluster complexes of sockeye salmon stocks on the basis scale lines of 2003-2005

Year	Age	Cluster/regional complex stocks	N	By average means (M)		By coefficients of variation (CV)	
				t-test	p-level	t-test	p-level
2003	1.2 + 1.3	North-Eastern Kamchatka + Chukotka	303	3.78	< 0.01	1.74	0.104
		Central (Bristol Bay) and South-Western Alaska + North-Eastern and South-Eastern Kamchatka	477				
		North-Eastern Kamchatka + Chukotka	303	1.24	0.234	2.91	< 0.05
		I. Kodiak	150				
		North-Eastern Kamchatka + Chukotka	303	0.93	0.369	1.10	0.292
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	231				
		North-Eastern Kamchatka + Chukotka	303	0.44	0.665	3.12	< 0.01
		Western and South-Western Kamchatka	301				
		Central (Bristol Bay) and South-Western Alaska + North- and South-Eastern Kamchatka	477	2.02	0.063	10.76	< 0.001
		I. Kodiak	150				
		Central (Bristol Bay) and South-Western Alaska + North- and South-Eastern Kamchatka	477	2.56	< 0.05	6.78	< 0.001
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	231				
		Central (Bristol Bay) and South-Western Alaska + North- and South-Eastern Kamchatka	477	0.94	0.362	6.10	< 0.001
		Western and South-Western Kamchatka	301				
		I. Kodiak	150	1.31	0.210	2.83	< 0.05
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	231				
		I. Kodiak	150	0.57	0.578	1.22	0.243
		Western and South-Western Kamchatka	301				
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	231	0.09	0.926	1.19	0.252
		Western and South-Western Kamchatka	301				
	2.2 + 2.3	North-Eastern Kamchatka + Chukotka	337	3.93	< 0.05	0.40	0.692
		Central Alaska (Bristol Bay)	150				
		North-Eastern Kamchatka + Chukotka	337	2.55	< 0.05	1.94	0.073
		Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	220				
		North-Eastern Kamchatka + Chukotka	337	0.95	0.356	2.59	< 0.05
		I. Kodiak	200				
		North-Eastern Kamchatka + Chukotka	337	0.10	0.920	1.21	0.245
		South-Western Alaska + North-Eastern Kamchatka	384				
		North-Eastern Kamchatka + Chukotka	337	0.06	0.949	5.12	< 0.001
		South-Western Kamchatka (r. Ozernaya)	100				
		Central Alaska (Bristol Bay)	150	0.92	0.371	1.02	0.325
		Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	220				
		Central Alaska (Bristol Bay)	150	2.18	< 0.05	2.74	< 0.05
		I. Kodiak	200				

		Central Alaska (Bristol Bay)	150	2.53	< 0.05	0.61	0.549
		South-Western Alaska + North-Eastern Kamchatka	384				
		Central Alaska (Bristol Bay)	150	0.79	0.443	4.71	< 0.001
		South-Western Kamchatka (r. Ozernaya)	100				
		Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	220	1.91	0.077	2.57	< 0.05
		I. Kodiak	200				
		Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	220	1.82	0.089	1.05	0.312
		South-Western Alaska + North-Eastern Kamchatka	384				
		Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	220	1.33	0.204	4.28	< 0.001
		South-Western Kamchatka (r. Ozernaya)	100				
		I. Kodiak	200	1.46	0.165	2.80	< 0.05
		South-Western Alaska + North-Eastern Kamchatka	384				
		I. Kodiak	200	0.60	0.557	2.67	< 0.05
		South-Western Kamchatka (r. Ozernaya)	100				
		South-Western Alaska + North-Eastern Kamchatka	384	0.09	0.933	5.74	< 0.001
		South-Western Kamchatka (r. Ozernaya)	100				
2004	1.2 + 1.3	I. Kodiak	279	1.36	0.194	1.96	0.069
		Central Alaska (Bristol Bay)	195				
		I. Kodiak	279	1.37	0.194	0.03	0.977
		Eastern Kamchatka (r. Kamchatka) + Chukotka	295				
		I. Kodiak	279	2.04	0.061	4.07	< 0.01
		South-Western Alaska + North-Eastern Kamchatka	333				
		I. Kodiak	279	1.31	0.211	0.08	0.994
		North-Eastern and North-Western Kamchatka	200				
		I. Kodiak	279	0.48	0.636	0.53	0.606
		Western and South-Western Kamchatka	349				
		Central Alaska (Bristol Bay)	195	0.55	0.591	1.69	0.114
		Eastern Kamchatka (r. Kamchatka) + Chukotka	295				
		Central Alaska (Bristol Bay)	195	2.28	< 0.05	2.42	< 0.05
		South-Western Alaska + North-Eastern Kamchatka	333				
		Central Alaska (Bristol Bay)	195	1.09	0.296	2.21	< 0.05
		North-Eastern and North-Western Kamchatka	200				
		Central Alaska (Bristol Bay)	195	0.74	0.471	1.02	0.326
		Western and South-Western Kamchatka	349				
		Eastern Kamchatka (r. Kamchatka) + Chukotka	295	4.20	< 0.001	6.90	< 0.001
		South-Western Alaska + North-Eastern Kamchatka	333				
		Eastern Kamchatka (r. Kamchatka) + Chukotka	295	0.52	0.610	0.04	0.965
		North-Eastern and North-Western Kamchatka	200				
		Eastern Kamchatka (r. Kamchatka) + Chukotka	295	0.81	0.432	0.87	0.400

		Western and South-Western Kamchatka	349				
		South-Western Alaska + North-Eastern Kamchatka	333	1.24	0.235	5.59	< 0.001
		North-Eastern and North-Western Kamchatka	200				
		South-Western Alaska + North-Eastern Kamchatka	333	1.64	0.122	7.73	< 0.001
		Western and South-Western Kamchatka	349				
		North-Eastern and North-Western Kamchatka	200	2.14	< 0.05	0.78	0.448
		Western and South-Western Kamchatka	349				
	2.2 + 2.3	Eastern Kamchatka (r. Kamchatka) + Chukotka	325	1.10	0.288	0.38	0.709
		Central (Bristol Bay) and South-Western Alaska	423				
		Eastern Kamchatka (r. Kamchatka) + Chukotka	325	1.87	0.082	1.00	0.336
		I. Kodiak	293				
		Eastern Kamchatka (r. Kamchatka) + Chukotka	325	0.80	0.439	3.58	< 0.01
		South-Western Kamchatka (r. Ozernaya)	202				
		Eastern Kamchatka (r. Kamchatka) + Chukotka	325	4.21	< 0.001	2.94	< 0.05
		South-Eastern Kamchatka	32				
		Central (Bristol Bay) and South-Western Alaska	423	2.82	< 0.05	1.33	0.205
		I. Kodiak	293				
		Central (Bristol Bay) and South-Western Alaska	423	0.30	0.765	4.60	< 0.001
		South-Western Kamchatka (r. Ozernaya)	202				
		Central (Bristol Bay) and South-Western Alaska	423	2.02	0.063	0.43	0.672
		South-Eastern Kamchatka	32				
		I. Kodiak	293	0.86	0.406	3.59	< 0.01
		South-Western Kamchatka (r. Ozernaya)	202				
		I. Kodiak	293	2.45	< 0.05	0.83	0.422
		South-Eastern Kamchatka	32				
		South-Western Kamchatka (r. Ozernaya)	202	1.37	0.193	3.52	< 0.01
		South-Eastern Kamchatka	32				
2005	1.2 + 1.3	Central Alaska (Bristol Bay)	150	3.76	< 0.01	0.07	0.944
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	411				
		Central Alaska (Bristol Bay)	150	2.03	0.062	1.90	0.079
		South-Western Alaska + I. Kodiak	401				
		Central Alaska (Bristol Bay)	150	1.49	0.158	0.51	0.618
		North-Western, Western and South-Western Kamchatka	453				
		Central Alaska (Bristol Bay)	150	2.94	< 0.01	0.11	0.911
		North-Eastern and South-Eastern Kamchatka	220				
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	411	1.40	0.184	3.29	< 0.01
		South-Western Alaska + I. Kodiak	401				
		Eastern (r. Kamchatka) and North-Eastern Kamchatka	411	0.79	0.440	0.59	0.562
		North-Western, Western and South-Western Kamchatka	453				

		Eastern (r. Kamchatka) and North-Eastern Kamchatka North-Eastern and South-Eastern Kamchatka	411 220	1.66	0.119	0.31	0.758
		South-Western Alaska + I. Kodiak North-Western, Western and South-Western Kamchatka	401 453	0.10	0.920	2.56	< 0.05
		South-Western Alaska + I. Kodiak North-Eastern and South-Eastern Kamchatka	401 220	0.11	0.911	2.37	< 0.05
		North-Western, Western and South-Western Kamchatka North-Eastern and South-Eastern Kamchatka	453 220	0.05	0.964	0.88	0.394
	2.2 + 2.3	Chukotka Central Alaska (Bristol Bay) + I. Kodiak	76 450	2.92	< 0.05	0.96	0.353
		Chukotka Eastern Kamchatka (r. Kamchatka)	76 150	3.48	< 0.01	0.63	0.541
		Chukotka North-Eastern and North-Western Kamchatka	76 142	2.27	< 0.05	1.71	0.109
		Chukotka South-Western Alaska	76 195	0.67	0.511	1.74	0.104
		Chukotka South-Western Kamchatka (r. Ozernaya)	76 150	0.13	0.895	2.40	< 0.05
		Central Alaska (Bristol Bay) + I. Kodiak Eastern Kamchatka (r. Kamchatka)	450 150	1.69	0.113	1.95	0.072
		Central Alaska (Bristol Bay) + I. Kodiak North-Eastern and North-Western Kamchatka	450 142	0.38	0.708	1.84	0.087
		Central Alaska (Bristol Bay) + I. Kodiak South-Western Alaska	450 195	2.19	< 0.05	6.25	< 0.001
		Central Alaska (Bristol Bay) + I. Kodiak South-Western Kamchatka (r. Ozernaya)	450 150	1.16	0.265	6.32	< 0.001
		Eastern Kamchatka (r. Kamchatka) North-Eastern and North-Western Kamchatka	150 142	0.65	0.526	3.29	< 0.01
		Eastern Kamchatka (r. Kamchatka) South-Western Alaska	150 195	1.89	0.080	2.12	< 0.05
		Eastern Kamchatka (r. Kamchatka) South-Western Kamchatka (r. Ozernaya)	150 150	1.50	0.155	3.29	< 0.01
		North-Eastern and North-Western Kamchatka South-Western Alaska	142 195	1.21	0.246	6.08	< 0.001
		North-Eastern and North-Western Kamchatka South-Western Kamchatka (r. Ozernaya)	142 150	1.91	0.077	8.25	< 0.001
		South-Western Alaska South-Western Kamchatka (r. Ozernaya)	195 150	0.41	0.686	2.50	< 0.05

Note. Underlined meanings t-test with statistical probability ($p < 0.05$, $p < 0.01$, $p < 0.001$) or ($0.05 < p < 0.10$).

Table 6. The dependent simulation of the basis scale line of sockeye salmon of the age group 1.2 + 1.3 on the data pool of 2003, MLE/SD

Cluster/regional complex stocks	N	1.	2.	3.	4.	5.
1. North-Eastern Kamchatka + Chukotka	303	0.8889 0.0694	0.0642 0.0474	0.0028 0.0072	0.0381 0.0391	0.0035 0.0087
2. Central (Bristol Bay) and South-Western Alaska + North-Eastern and South-Eastern Kamchatka	477	0.0673 0.0686	0.8239 0.0831	0.0003 0.0024	0.0730 0.0779	0.0078 0.0146
3. I. Kodiak	150	0.0177 0.0204	0.0069 0.0139	0.9869 0.0215	0.0030 0.0089	0.0001 0.0010
4. Eastern (r. Kamchatka) and North-Eastern Kamchatka	231	0.0254 0.0336	0.0924 0.0762	0.0095 0.0201	0.8770 0.0832	0.0034 0.0084
5. Western and South-Western Kamchatka	301	0.0007 0.0023	0.0126 0.0180	0.0005 0.0029	0.0089 0.0125	0.9852 0.0171
Mean accuracy, %						91.24

Table 7. The dependent simulation of the basis scale line of sockeye salmon of the age group 2.2 + 2.3 on the data pool of 2003, MLE/SD

Cluster/regional complex stocks	N	1.	2.	3.	4.	5.	6.
1. North-Eastern Kamchatka + Chukotka	337	0.8144 0.0827	0.0234 0.0256	0.0096 0.0157	0.0047 0.0103	0.0830 0.0521	0.0002 0.0024
2. Central Alaska (Bristol Bay)	150	0.0092 0.0237	0.9321 0.0569	0.0180 0.0312	0.0043 0.0156	0.0959 0.0722	0.0003 0.0023
3. Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	220	0.0803 0.0527	0.0176 0.0310	0.9170 0.0463	0.0001 0.0009	0.0365 0.0370	0.0000 0.0000
4. I. Kodiak	200	0.0079 0.0126	0.0079 0.0194	0.0012 0.0040	0.8599 0.0817	0.0459 0.0506	0.0000 0.0000
5. South-Western Alaska + North-Eastern Kamchatka	384	0.0864 0.0726	0.0186 0.0374	0.0030 0.0114	0.1310 0.0829	0.7360 0.0971	0.0000 0.0000
6. South-Western Kamchatka (r. Ozernaya)	100	0.0018 0.0054	0.0004 0.0028	0.0512 0.0316	0.0000 0.0004	0.0027 0.0079	0.9995 0.0033
Mean accuracy, %							87.65

Table 8. The dependent simulation of the basis scale line of sockeye salmon of the age group 1.2 + 1.3 on the data pool of 2004, MLE/SD

Cluster/regional complex stocks	N	1.	2.	3.	4.	5.	6.
1. I. Kodiak	279	0.9586 0.0343	0.0037 0.0074	0.0109 0.0156	0.0043 0.0104	0.0017 0.0046	0.0031 0.0061
2. Central Alaska (Bristol Bay)	195	0.0302 0.0323	0.8038 0.1092	0.0374 0.0519	0.0873 0.0829	0.0396 0.0420	0.0053 0.0175
3. Eastern Kamchatka (r. Kamchatka) + Chukotka	295	0.0006 0.0040	0.0618 0.0580	0.8421 0.0974	0.0860 0.0785	0.0611 0.0503	0.0384 0.0357
4. South-Western Alaska + North-Eastern Kamchatka	333	0.0001 0.0017	0.0935 0.1012	0.0917 0.0910	0.8029 0.1102	0.0409 0.0522	0.0038 0.0150
5. North-Eastern and North-Western Kamchatka	200	0.0064 0.0112	0.0249 0.0343	0.0171 0.0268	0.0163 0.0315	0.8192 0.0793	0.0595 0.0644
6. Western and South-Western Kamchatka	349	0.0041 0.0094	0.0123 0.0232	0.0008 0.0057	0.0032 0.0098	0.0375 0.0520	0.8899 0.0734
Mean accuracy, %							85.28

Table 9. The dependent simulation of the basis scale line of sockeye salmon of the age group 2.2 + 2.3 on the data pool of 2004, MLE/SD

Cluster/regional complex stocks	N	1.	2.	3.	4.	5.
1. Eastern Kamchatka (r. Kamchatka) + Chukotka	325	0.9233 0.0602	0.0892 0.0593	0.0645 0.0542	0.0038 0.0089	0.0464 0.0585
2. Central (Bristol Bay) and South-Western Alaska	423	0.0155 0.0319	0.7835 0.1006	0.0345 0.0607	0.0098 0.0260	0.0090 0.0245
3. I. Kodiak	293	0.0369 0.0472	0.0923 0.0726	0.8870 0.0773	0.0030 0.0093	0.0034 0.0125
4. South-Western Kamchatka (r. Ozernaya)	202	0.0044 0.0103	0.0205 0.0318	0.0126 0.0217	0.9825 0.0280	0.0001 0.0012
5. South-Eastern Kamchatka	32	0.0199 0.0319	0.0145 0.0255	0.0014 0.0067	0.0009 0.0046	0.9411 0.0635
Mean accuracy, %						90.35

Table 10. The dependent simulation of the basis scale line of sockeye salmon of the age group 1.2 + 1.3 on the data pool of 2005, MLE/SD

Cluster/regional complex stocks	N	1.	2.	3.	4.	5.
1. Central Alaska (Bristol Bay)	150	0.9121 0.0852	0.1155 0.0875	0.0077 0.0175	0.0134 0.0275	0.0384 0.0501
2. Eastern (r. Kamchatka) and North-Eastern Kamchatka	411	0.0585 0.0836	0.7520 0.1150	0.0583 0.0501	0.0053 0.0155	0.0466 0.0658
3. South-Western Alaska + I. Kodiak	401	0.0000 0.0002	0.0392 0.0371	0.9259 0.0501	0.0058 0.0097	0.0085 0.0137
4. North-Western, Western and South-Western Kamchatka	453	0.0199 0.0267	0.0201 0.0242	0.0049 0.0095	0.8930 0.0677	0.0203 0.0301
5. North-Eastern and South-Eastern Kamchatka	220	0.0095 0.0218	0.0732 0.0658	0.0032 0.0080	0.0825 0.0638	0.8862 0.0805
Mean accuracy, %						87.38

Table 11. The dependent simulation of the basis scale line of sockeye salmon of the age group 2.2 + 2.3 on the data pool of 2005, MLE/SD

Cluster/regional complex stocks	N	1.	2.	3.	4.	5.	6.
1. Chukotka	76	0.8430 0.0641	0.0106 0.0157	0.0294 0.0253	0.0068 0.0182	0.0009 0.0041	0.0168 0.0188
2. Central Alaska (Bristol Bay) + I. Kodiak	450	0.0048 0.0165	0.6571 0.1505	0.0295 0.0485	0.0004 0.0030	0.1229 0.1186	0.0278 0.0399
3. Eastern Kamchatka (r. Kamchatka)	150	0.0460 0.0392	0.1349 0.0773	0.9344 0.0554	0.0417 0.0359	0.0148 0.0248	0.0000 0.0000
4. North-Eastern Kamchatka + North-Western Kamchatka	142	0.0702 0.0522	0.0051 0.0110	0.0002 0.0014	0.9045 0.0517	0.0004 0.0031	0.0185 0.0267
5. South-Western Alaska	195	0.0164 0.0296	0.1595 0.1252	0.0065 0.0190	0.0018 0.0064	0.8059 0.1288	0.0106 0.0329
6. South-Western Kamchatka (r. Ozernaya)	150	0.0196 0.0324	0.0328 0.0408	0.0000 0.0000	0.0448 0.0375	0.0551 0.0620	0.9263 0.0576
Mean accuracy, %							84.52

Table 12. The estimates of the maximal likelihood (ML), the standard deviation (SD) and the confidential intervals (CI – 95%) obtained in the identification of immature sockeye salmon local stocks in the trawl catches of the R/V «TINRO» in the Western Bering Sea in 2002-2004

Year	Season	Biostatistical districts	Age	N	Cluster/regional complex stocks	MLE	SD	CI - 95%
2002	Autumn	8 (+ 5-7)	1.1 + 1.2	193	North-Eastern Kamchatka + Chukotka	0.2696	0.0503	0.1656-0.3707
					Central (Bristol Bay) and South-Western Alaska + North-Eastern and South-Eastern Kamchatka	0.5167	0.0576	0.4003-0.6386
					I. Kodiak	0.0162	0.0140	0.0000-0.0467
					Eastern (r. Kamchatka) and North-Eastern Kamchatka	-	-	-
					Western and South-Western Kamchatka	0.1975	0.0336	0.1283-0.2692
			2.1 + 2.2	135	North-Eastern Kamchatka + Chukotka	0.1641	0.0504	0.0458-0.2278
					Central Alaska (Bristol Bay)	0.2355	0.0690	0.1003-0.3943
					Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	0.4408	0.0721	0.2919-0.5902
					I. Kodiak	-	-	-
					South-Western Alaska + North-Eastern Kamchatka	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.1596	0.0378	0.0983-0.2476
		12	1.1 + 1.2	214	North-Eastern Kamchatka + Chukotka	0.2466	0.0455	0.1473-0.3384
					Central (Bristol Bay) and South-Western Alaska + North-Eastern and South-Eastern Kamchatka	0.4537	0.0614	0.3198-0.5910
					I. Kodiak	-	-	-
					Eastern (r. Kamchatka) and North-Eastern Kamchatka	0.0581	0.0397	0.0000-0.1445
					Western and South-Western Kamchatka	0.2416	0.0356	0.1733-0.3218
			2.1 + 2.2	232	North-Eastern Kamchatka + Chukotka	0.1104	0.0316	0.0372-0.1441
					Central Alaska (Bristol Bay)	0.0264	0.0359	0.0000-0.1201
					Eastern (r. Kamchatka), South-Eastern and North-Western Kamchatka	0.6137	0.0548	0.4729-0.7077
					I. Kodiak	-	-	-
					South-Western Alaska + North-Eastern Kamchatka	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.2495	0.0361	0.1908-0.3667

2003	Summer	8 (+ 2-7)	1.1 + 1.2	192	I. Kodiak	0.0132	0.0114	0.0000-0.0419
					Central Alaska (Bristol Bay)	0.3437	0.0793	0.1607-0.5288
					Eastern Kamchatka (r. Kamchatka) + Chukotka	0.2858	0.0659	0.1531-0.4354
					South-Western Alaska + North-Eastern Kamchatka	0.3017	0.0798	0.1187-0.4675
					North-Eastern and North-Western Kamchatka	-	-	-
					Western and South-Western Kamchatka	0.0556	0.0354	0.0000-0.1358
			2.1 + 2.2	180	Eastern Kamchatka (r. Kamchatka) + Chukotka	0.4444	0.0617	0.3205-0.5913
					Central (Bristol Bay) and South-Western Alaska	0.1829	0.0609	0.0000-0.2246
					I. Kodiak	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.3727	0.0567	0.3095-0.5796
					South-Eastern Kamchatka	-	-	-
		12 (+ 9)	1.1 + 1.2	120	I. Kodiak	0.0085	0.0099	0.0000-0.0344
					Central Alaska (Bristol Bay)	0.1138	0.0699	0.0000-0.2583
					Eastern Kamchatka (r. Kamchatka) + Chukotka	0.1225	0.0708	0.0000-0.3013
					South-Western Alaska + North-Eastern Kamchatka	0.5800	0.0994	0.3445-0.7744
					North-Eastern and North-Western Kamchatka	0.0370	0.0442	0.0000-0.1369
					Western and South-Western Kamchatka	0.1382	0.0569	0.0227-0.2725
			2.1 + 2.2	127	Eastern Kamchatka (r. Kamchatka) + Chukotka	0.5471	0.0647	0.4179-0.6864
					Central (Bristol Bay) and South-Western Alaska	0.0088	0.0422	0.0000-0.0831
					I. Kodiak	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.4441	0.0654	0.2893-0.5709
					South-Eastern Kamchatka	-	-	-
	Autumn	8 (+ 5-7)	1.1 + 1.2	178	I. Kodiak	-	-	-
					Central Alaska (Bristol Bay)	0.5358	0.0650	0.3849-0.6654
					Eastern Kamchatka (r. Kamchatka) + Chukotka	0.3852	0.0600	0.2599-0.5126
					South-Western Alaska + North-Eastern Kamchatka	-	-	-
					North-Eastern and North-Western Kamchatka	-	-	-
					Western and South-Western Kamchatka	0.0790	0.0397	0.0000-0.1761
			2.1 + 2.2	86	Eastern Kamchatka (r. Kamchatka) + Chukotka	0.4370	0.0756	0.2876-0.5833
					Central (Bristol Bay) and South-Western Alaska	0.1094	0.0644	0.0000-0.2285

					I. Kodiak	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.4536	0.0745	0.3266-0.6241
					South-Eastern Kamchatka	-	-	-
		12 (+ 9)	1.1 + 1.2	225	I. Kodiak	-	-	-
					Central Alaska (Bristol Bay)	0.1766	0.0555	0.0509-0.2708
					Eastern Kamchatka (r. Kamchatka) + Chukotka	0.4085	0.0607	0.2616-0.5242
					South-Western Alaska + North-Eastern Kamchatka	0.0499	0.0564	0.0000-0.1865
					North-Eastern and North-Western Kamchatka	-	-	-
					Western and South-Western Kamchatka	0.3650	0.0485	0.2533-0.4716
			2.1 + 2.2	200	Eastern Kamchatka (r. Kamchatka) + Chukotka	0.2327	0.0477	0.1354-0.3478
					Central (Bristol Bay) and South-Western Alaska	0.0626	0.0442	0.0000-0.1385
					I. Kodiak	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.7047	0.0509	0.6030-0.8324
					South-Eastern Kamchatka	-	-	-
2004	Autumn	8 (+ 3-7)	1.1 + 1.2	163	Central Alaska (Bristol Bay)	0.2725	0.0764	0.0693-0.4306
					Eastern (r. Kamchatka) and North-Eastern Kamchatka	0.6508	0.0883	0.4355-0.8604
					South-Western Alaska + I. Kodiak	0.0767	0.0410	0.0114-0.1830
					North-Western, Western and South-Western Kamchatka	-	-	-
					North-Eastern and South-Eastern Kamchatka	-	-	-
			2.1 + 2.2	115	Chukotka	0.1239	0.0448	0.0211-0.2214
					Central Alaska (Bristol Bay) + I. Kodiak	-	-	-
					Eastern Kamchatka (r. Kamchatka)	0.5773	0.0726	0.4120-0.7185
					North-Eastern Kamchatka + North-Western Kamchatka	0.1114	0.0548	0.0000-0.2133
					South-Western Alaska	0.0567	0.0579	0.0000-0.1532
					South-Western Kamchatka (r. Ozernaya)	0.1307	0.0619	0.0255-0.2689
		12	1.1 + 1.2	155	Central Alaska (Bristol Bay)	0.2039	0.0706	0.0378-0.3372
					Eastern (r. Kamchatka) and North-Eastern Kamchatka	0.4822	0.1028	0.2603-0.6995
					South-Western Alaska + I. Kodiak	0.1239	0.0409	0.0484-0.2201
					North-Western, Western and South-Western Kamchatka	-	-	-
					North-Eastern and South-Eastern Kamchatka	0.1900	0.0706	0.0286-0.3498

			2.1 + 2.2	163	Chukotka	0.0552	0.0253	0.0000-0.0929
					Central Alaska (Bristol Bay) + I. Kodiak	-	-	-
					Eastern Kamchatka (r. Kamchatka)	0.2057	0.0460	0.1150-0.3130
					North-Eastern Kamchatka + North-Western Kamchatka	0.2744	0.0548	0.1709-0.3960
					South-Western Alaska	-	-	-
					South-Western Kamchatka (r. Ozernaya)	0.4647	0.0584	0.3526-0.5856

Table 13. The estimates of the abundance and biomass of identified Asian and American complexes of immature sockeye salmon local stocks in the Western Bering Sea on the data of trawl surveys of the R/V «TINRO» in 2002-2004

Year	Season	Biostatistical districts	Total abundance and biomass		Complex stocks					
					Russia			USA		
			Millions of fish	Thousands ton	*%*	Millions of fish	Thousands ton	*%*	Millions of fish	Thousands ton
2002	Autumn	8 (+ 5-7)	77.18	92.36	*58.9*	45.46	54.40	*41.1*	31.72	37.96
		12	75.3	86.06	*76.9*	57.91	66.18	*23.1*	17.39	19.88
2003	Summer	8 (+ 2-7)	70.68	53.07	*57.0*	40.29	30.25	*43.0*	30.39	22.82
		12 (+ 9)	41.04	30.78	*65.2*	26.76	20.07	*34.8*	14.28	10.71
	Autumn	8 (+ 5-7)	32.82	28.72	*60.6*	19.89	17.40	*39.4*	12.93	11.32
		12 (+ 9)	68.46	61.90	*84.9*	58.12	52.55	*15.1*	10.34	9.35
2004	Autumn	8 (+ 3-7)	73.80	64.60	*77.0*	56.83	49.74	*23.0*	16.97	14.86
		12	48.15	44.30	*83.9*	40.40	37.17	*16.1*	7.75	7.13