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Scale Pattern Analysis Estimates of Age and Stock Composition of Chinook Salmon *Oncorhynchus tschawytscha* in R/V *TINRO* Trawl Catches in the Western Bering Sea and Northwestern Pacific Ocean in Summer-Autumn 2003

by

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ABSTRACT

Identification of continental complexes of immature (1.1 and 1.2 , what is approximately 90% of the total catch) Chinook salmon local stocks in the western Bering Sea for the summer-fall period 2003 has been carried out on the base of structure of scale from the R/V “TINRO” trawl catches. Scale standards (the ages 1.2, 1.3 and 1.4) of the most abundant Asian (the Kamchatka River in Kamchatka) and North American (the Kuskokwim R., Nushagak R. and Yukon R. in Alaska) stocks were used for the identification. The percent of these stocks takes over 79-80% in average of the total removal of this species by the off-shore and river fisheries in the areas mentioned above. Resolution ability of the basis data line used provides the identification of the scale standards inside the simulation with the accuracy of 89% approximately. Nevertheless, the results obtained are still preliminary and can be final only behind 2005/2006, when the basis scale lines of adult Chinook salmon would have got a similar age structure to the fishes from mixed trawl catches.

The results of the identification have demonstrated a rather obvious volume of the Alaskan complex in summer and fall 2003 in the western Bering Sea, what was 47% (June-August) and 37% (September-October). The volumes of the Asian complexes were 53 and 63% in summer and fall respectively. It should be noted that the scales from the trawl catches are of a low quality what can cause some distortion in the results. However, as the basis scale line has been represented only by the most abundant stocks of Asia and North America, than at the level of a tendency we can suggest a high percent of American Chinook salmon in the Economic Zone of RF in the Bering Sea. That has been also indicated by high meanings of Chinook salmon stock abundance assessment from the data of trawl surveys on the R/V “TINRO” in the western Bering Sea in the summer-fall period 2003.

Additional preliminary data on the quantitative distribution of continental complexes of stocks of immature Chinook salmon separate by two periods have been obtained on the base of these meanings. In summer the abundance of 1.1 and 1.2 Asian stocks was 20.39 million fishes, in fall – 14.41 million fishes. The abundance of the same age groups of North American stocks was 18.09 and 8.46 million fishes in summer and fall respectively. The assessments obtained indicate of a high stock abundance of Kamchatkan and Alaskan Chinook salmon. That probably relates to the methodical errors in the course of the identification mentioned above. Although that can be related to ecological transformations of migration patterns too, as well, as to a high level of mortality of immature Chinook salmon over the early marine period of life. A requirement of additional studies of Chinook salmon population structure in the Economic Zone of Russia to undertake with different identification methods should be emphasized in the whole.

INTRODUCTION

This work is a component of the Bering Sea-Aleutian Salmon International Survey comprehensive research plan (BASIS). The data we demonstrate here are the data on identification of Chinook salmon local stocks in the R/V “TINRO” trawl catches from the Western Bering Sea for summer and fall 2003. A similar work we have carried out in 2002 (Bugaev 2004). In 2003 there were obtained the results illustrating two stages of the survey. The first stage was in summer (July-August), the second one – in autumn (September-October). In the course of the survey there were obtained Chinook salmon stock abundance and biomass assessments for each stage (NPAFC 2004). That became a basis for assessment of stock abundance of Asian and American stocks of immature Chinook salmon for the stages of the survey in the Western Bering Sea. It should be noted however, that for today all the assessments obtained can be reckoned only as preliminary, because further researches using another methods of identification and providing more accuracy of the results are required.

The objective of this work is identification of Asian and American stocks of immature Chinook salmon on the base of scale structure analysis in principal bio-statistic areas within the Bering Sea part of the Economic Zone of Russia.

MATERIAL AND METHODS

A mixed material consisted of Chinook salmon scale samples, collected by staff of TINRO-center from the R/V «TINRO»’s trawl catches in the western Bering Sea in summer and autumn 2003. In this work we have used the system of division into districts accepted for biocenological studies of commercial fishery zone of Russia in the Far East (Shuntov 1986; Volvenko 2003) (Fig. 1). . The volume of the scale mixed material is demonstrated in the Table 1. The sample size used for age composition estimation is 731 specimens, including 406 identified ones.

As the scale sample size collected and available for identification was insufficient to carry out a differentiation analysis by particular bio-statistic districts, we have got summary results for the Bering Sea part of the Economic Zone of Russia. It should be noted, that the scale is reckoned as available for analysis if it 1) is taken from a dominant age group in the catches (in this case 1.1 or 1.2) and coordinated with scale in the basis lines and 2) went minimum deformation what depends on the place of body where from the scale has been sampled. As for the scale sampling places it should be noted that in the world practice of the Pacific Salmon studies the places have been systematized quite long ago (Davis et al. 1990). This systematization does not work well for scale sampling from the trawl catches, therefore in the most cases the scale has been taken not from the «preferably» places, but from the places where sampling is still possible. The places are often covered ones, near the caudal or pectoral fins. This is why a visual estimation of scale availability for analysis is very important, i.e. the less deviation from scale basis line - the better. Unfortunately, it is impossible to escape the deviation, or else majority of scale from the trawl catches has been lost. The risk of methodical error always occurs in the research like this, what has been demonstrated in the world practice of the Pacific Salmon identification in the pelagic or bottom trawl by-catch (Patton et al. 1998; Myers et al. 2003).

The basis scale lines were collected by staff of KamchatNIRO and Fish & Game Service Alaska from the river and off-shore catches in the Asian and American sides of Pacific Ocean in June and August 2003 (Fig. 2). The sample size and the composition of the basis lines is demonstrated in Table 2. The total sample size of the basis scale lines takes 834 Chinook salmon individuals.

In the case of poor abundant species, in particular Chinook salmon, having a complicated age structure, forming the basis lines always runs into the problem of lack of sample sizes. That makes impossible forming authentic statistical basis lines by particular dominant age groups 1.2, 1.3 and 1.4. It is mostly characteristic for the Asian stocks, which are low abundant in their majority. Although the problem is quite characteristic for the North American stocks too. Therefore a combinatory approach, uniting all age groups mentioned above, has been frequent in forming the basis lines (Myers et al. 1987, 2003). Thus, the sample size of the basis lines has got statistically substantial (about 100 specimens and more).

Analyzing all Kamchatkan scale basis lines one can see that substantial samples to provide formation of the basis lines by dominant age groups have been collected every year only in the system of the Kamchatka River. The stock mentioned provides 70-80 % of the off-shore and shore harvest in Asia, what is compatible to the abundance of particular principal North American stocks, for example in Alaska. Therefore, taking into account the none simple (questionable) quality of scale from mixed trawl samples, we tried to operate with the most abundant stocks. In the Asian part of Chinook salmon areal the stock was Kamchatka River stock, in the North American part they were Kuskokwim R., Nushagak R. and Yukon R. stocks. In principal, the selection allows leveling some uncertainties, relating to a pertly interception of mixed samples by several minor stocks and displacing an assessment to the level of a continental stock complexes distribution trend. Moreover, taking into account a permanent deficiency of different data, as volumetric, as annual composition, for the minor stocks basis lines, the approach in the case of poor abundant species allows a more considerable analyzing of year-to-year dynamics of distribution processes for Asian and American Chinook salmon in the course of ocean feeding.

We outline, that the basis data line in this work was formed *via* a combinatory approach, i.e. through unification of the age groups 1.2, 1.3 and 1.4. In this context it is quite substantiated, because mixed marine samples in general are represented by the fishes 1.1 and 1.2 only. Therefore all the results obtained are preliminary yet; the finally conclusions require using the basis lines 2005 and 2006. The results obtained for today can be specified to some extent in a feature work. It is advisable moreover to get Chinook salmon stocks distribution assessments for the Western Bering Sea using another methods of identification for an objective analysis of situation.

We do not give a detail description of the scale criteria operation method we always used in the process of research like this, since we have it published before as a methodical basis for identification of local Chinook salmon stocks in the Economic Zone of Russia (Bugaev 2004; Bugaev et al. 2005). Resolution ability of the basis data lines formed and of identification of mixed marine samples was found from the maximum likelihood estimation (MLE) (Millar, 1987, 1990). A confidence interval for the likelihood assessments got with a given accuracy 95% (CI – 95%) was calculated with the boot-stripe method (500 repetitions) (Efron, Tibshirani, 1986).

RESULTS AND DISCUSSION

Age structure

Complete age composition of post-catadromous juvenile and immature Chinook salmon in the trawl catches 2003 is demonstrated in Table 3. It is seen from the data demonstrated that juveniles were not observed in the catches for this period. In autumn the percent of juveniles increases up to 53.54 (the ages 0.0, 1.0 and 2.0), what relates directly to the seaward migration from the off-shore. Remembering that in this case exactly immature individuals, i.e. the individuals spent in the sea not less than a year and migrated pretty far from the places of emergence, are the major interest for identification we analyze the age composition of this pool of fish apart (Tables 4 and 5, Fig. 3). We should note, that immature Chinook salmon .1 was absolute dominance in the trawl catches in summer 77.43 % and fall 81.25 %. The next frequent was .2 group to take 19.72 % in summer and 13.19 % in fall. In the essence, these two groups are principle age groups (PAG) of identification scale pool. The summarized contribution of these groups to the pool takes more than 90 %, what allows getting representative data in the course of identification using scale criteria. The other minor age groups (MAG) fluctuated as 6-7 %.

Identification local stocks

A resolution ability of the baseline model was assessed with the method of dependent simulation before starting the process of identification itself (Table 8). On the base of the data obtained there was estimated the differentiation accuracy of scale standards among the standards. The resolution ability found was 88.85%. In principle, that is a rather high level of identification, although it should not be neglected, that the population diversity in mixed marine samples can be much more higher being compared to that in the baseline model suggested. Therefore the accuracy is relative. Nevertheless, since we discuss only the most abundant stocks, the level of trend assessment can be reckoned as rather high.

Continental complexes of local Chinook salmon stocks in the Western Bering Sea were identified on the base of represented baselines (Table 7, Fig. 4). Judge by the results obtained the part of American Chinook salmon took 47% in July-August and 37% in September-October 2003. The Asian stocks took 53% and 63% time respectively. A decrease of contribution of Alaskan stocks in September-October probably relates to the cyclic character of migration of immature fish .1 and .2 in the Western Bering Sea. Than in the second half of summer we could observe a massive drop in of this stock complex into the Economic Zone of Russia, also in autumn a high sea ward migration to the area off the Aleutian Islands took place for wintering. Theoretically, a reduce of immature Chinook salmon stock abundance in the Western Bering Sea revealed in the course of autumn survey in the R/V “TINRO” is an evidence of that (NPAFC 2004).

Stock abundance

The data of the R/V “TINRO” trawl catches for 2003 provided an assessment of abundance and distribution of post-catadromous juvenile and immature Chinook salmon in the Bering Sea part of the Economic Zone of Russia (Table 8, Fig. 5). It follows from these data that principal summer aggregations are situated in the biostatistical district 8, in autumn a consequent reduction of immature fish abundance has been observed, also at that the frequency of post-catadromous juveniles in the off-shore has been increased evidently. Generally in summer the abundance of immature fish in the Western Bering Sea was 4101 million spec. to be in autumn 24.76million specimens. The post-catadromous juvenile Chinook salmon was observed in the catches only in autumn, the abundance was 2.01 million spec. approximately.

These data became a basis of preliminary assessment of immature Chinook salmon abundance, continental stock complexes identified, in the area of studies (Table 9). The assessment got was provided only for mayor age groups 1.1 and 1.2. Summer abundance of Alaska Chinook salmon complex was estimated as 18.09 million spec., autumn – as 8.46 million spec. The complex of Asian stocks in summer was 20.39 million spec. and in autumn – 8.46 million spec.

Lets make a note, that the level of estimated abundance of Asian and American stocks is very high. It is so even for Alaska complex, which is visibly more abundant than Asian, these assessments are set very high. If to make analysis of Chinook salmon abundance dynamics of Kamchatka and Alaska, several moments can be figured out. In the Asian part of areal the harvest of Chinook salmon by coastal and river fisheries on the data for late 1990th and early 2000th took about 500 tons, what is less than 70 thousand individuals being recalculated for the average weight 7.5 kg (Karpenko, Rassadnikov 2004). With that, in 2003 and 2004 the catches have got visibly reduced to 200-300 tons. Same time the level of Alaska Chinook salmon catches in 2000-2004 was quite high and varied in average in range 400-700 thousand spec., what is 6-10 times higher, being compared to the catches of Asian Chinook salmon catches (www.cf.adfg.state.ak.us).

Lets make a note, that the assessments of Asian Chinook salmon abundance cannot be assumed, just judging by official statistics data, as monosemantic. If analyze packing the spawning grounds in Kamchatka it turns that for the period 2000-2004 about 140 thousand fishes spawned averagely, i.e. 70% of total run to the coast (Karpenko, Rassadnikov, 2004). Hence, the volume of fishery gets officially of 30% approximately, what is absolutely irreal, taking into account commercial value of Chinook salmon. Usually a pretty different situation has been observed on Pacific Salmon. That nonsense appeared especially evident in 2004, when packing the spawning grounds took about 200 thousand fishes, but the harvest on the official data was about 40 thousand fishes, what is less than 20%. Thus, it is clear, that a real Chinook salmon stock abundance is visibly higher than official statistical. Just to remark at last, that we don't provide here the data on Chinook salmon drift net harvest in the Economic Zone of RF, where the situation is similar. The problem of pouching is not a new in Russia, also it turns to be especially urgent in the case of relatively poor abundant species.

Anyway a real volume of Chinook salmon harvest and packing the spawning grounds in Asia and North America, including Canada, is approximately as 10-20 times as less than the abundance assessed on the data sampled by R/V "TINRO" in the Western Bering Sea in summer and autumn 2003. Therefore the methodical errors notified for Chinook salmon identification cannot play a decisive role. There are two interrelating factors perhaps, allowing to give explanation of the dilemma. The first is ecological transformation of directions of Pacific Salmon feeding marine migrations in the whole and Chinook salmon, both, Asian and North American stock complexes, migrations in particular, as a result of transformation of climate and ocean conditions. The very high catches appear due to the displacement of principal feeding aggregations to the Economic Zone of Russia. The second factor is a very high level of natural mortality, especially for the initial stage of early marine period of Pacific Salmon. In favour of this suggestion says the fact, that among immature fishes in the trawl catches more than 80% were .1 individuals. Further researches hopefully could clarify the dilemma.

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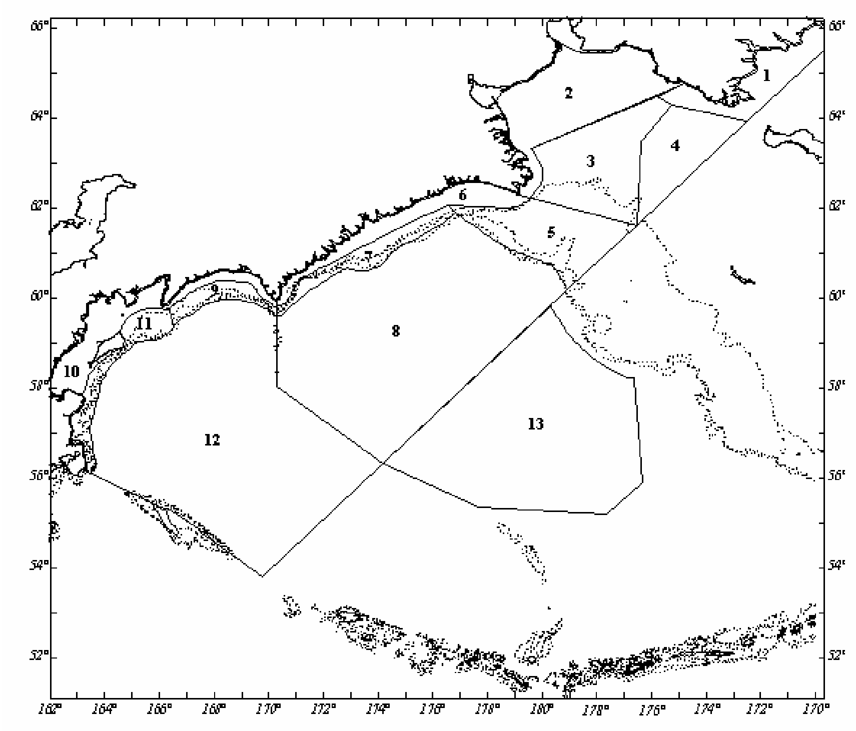

Fig. 1. Scheme of biostatistical districts in the Western Bering Sea used by TINRO-center for ecosystem researches (Shuntov 1986; Volvenko 2003)

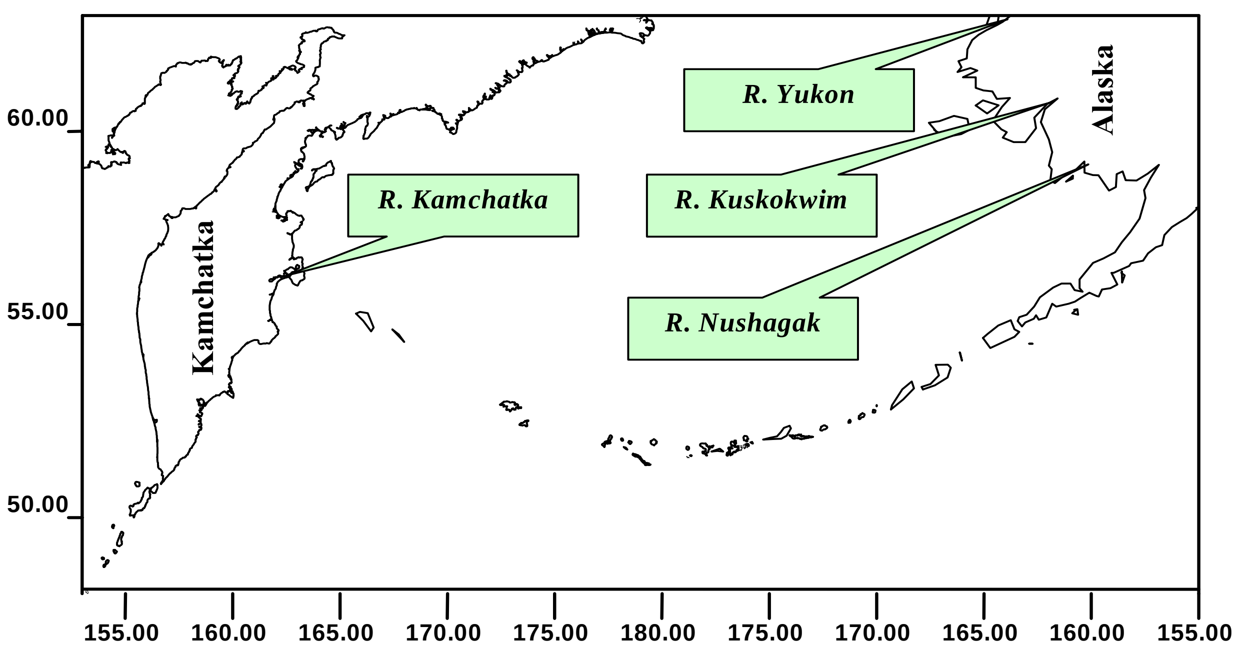

Fig. 2. Sampling area of Chinook salmon scale used for the baseline 2003

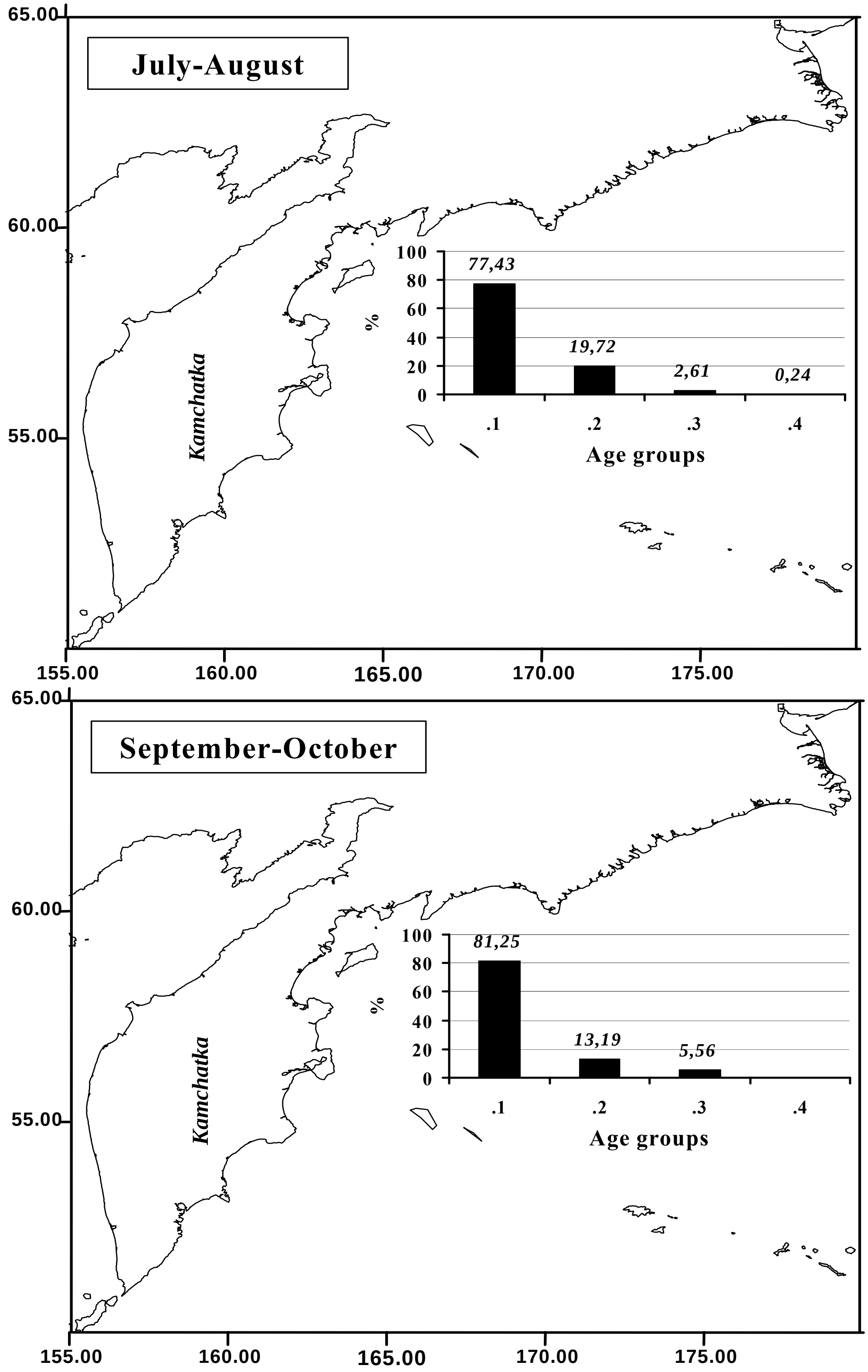

Fig. 3. Distribution age groups of immature chinook salmon in the western Bering sea from trawl catches R/V "TINRO" in summer-autumn 2003

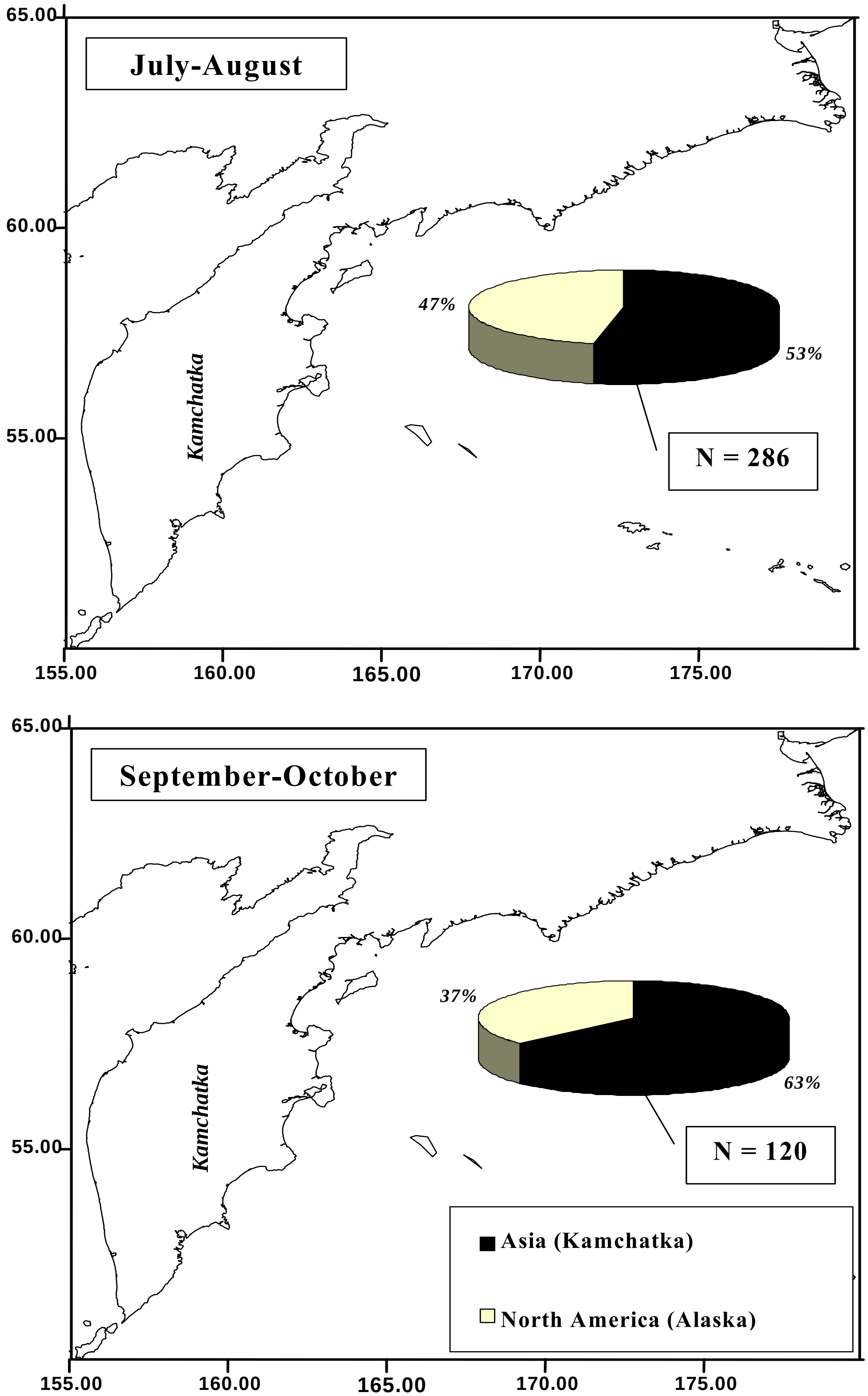

Fig. 4. Distribution Asian and American of immature chinook salmon in the western Bering sea from trawl catches R/V “TINRO” in summer-autumn 2003

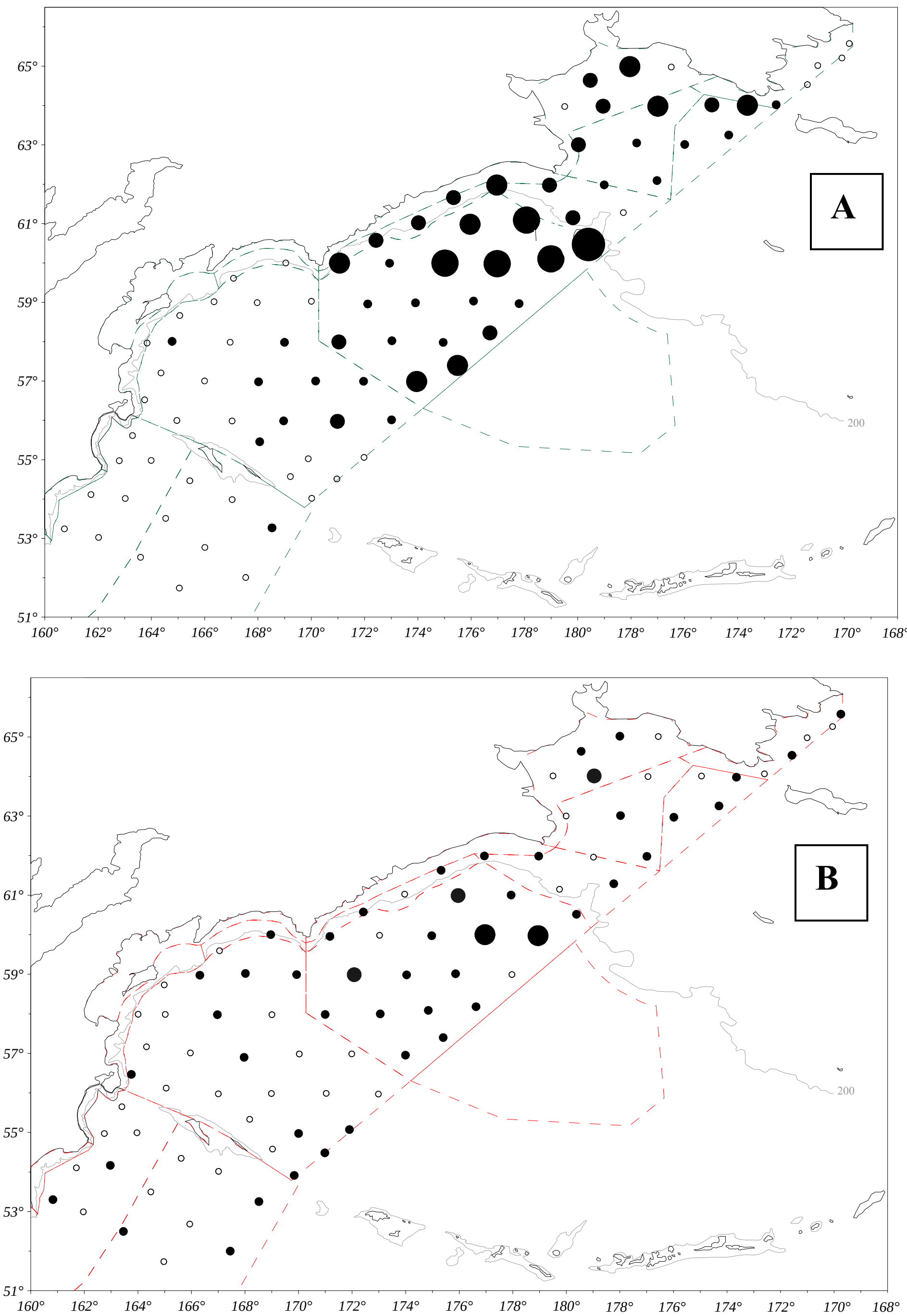

Fig. 5. Spatial distribution of relative abundance (spec./km^2) of juvenile and immature chinook salmon in the western Bering sea, July 15 – September 8, 2003 (A) and September 14 – October 25, 2003 (B). Designations: 1 – no catch; 2 - < 50; 3 – 51-100; 4 – 101-251; 5 – 251–500; 6 – 501-1000; 7 – > 1000 inds./km^2 (TINRO Center, Vladivostok, Russia)

Table 1

Size mixed samples of Chinook salmon from trawl catches R/V "TINRO" in the western Bering sea in summer-autumn 2003

Season	Period	Size scale materials, number of fish	
		Age	Identification
Summer	July-August	421	286
Autumn	September-October	310	120
Total	July-October	731	406

Table 2

Composition and size of scale standards used for baseline in 2003

Region	River/stock	N
Asia (Kamchatka)	r. Kamchatka	176
North America (Alaska)	r. Kuskokwim	239
	r. Nushagak	233
	r. Yukon	186
Total		834

Table 3

Age composition of juvenile and immature chinook salmon from trawl catches R/V "TINRO" in summer-autumn 2003

Season	N	0.0	0.1	0.2	0.3	1.0	1.1	1.2	1.3	1.4	2.0	2.1	2.2
Summer	421	-	1.66	1.19	0.24	-	75.5	18.3	2.37	0.24	-	0.24	0.24
Autumn	310	0.65	0.32	0.32	0.32	51.6	37.4	5.48	2.26	-	1.29	-	0.32

Table 4

Age composition of immature chinook salmon from trawl catches R/V "TINRO" in summer-autumn 2003

Season	N	0.1	0.2	0.3	1.1	1.2	1.3	1.4	2.1	2.2
Summer	421	1.66	1.19	0.24	75.5	18.3	2.37	0.24	0.24	0.24
Autumn	144	0.69	0.69	0.69	80.6	11.8	4.87	-	-	0.69

Table 5

Relation principal (PAG) and secondary (SAG) age groups of immature chinook salmon from trawl catches of R/V "TINRO" in summer-autumn 2003

Season	N	PAG		Total	SAG
		1.1	1.2		
Summer	421	75.53	18.29	93.82	6.18
Autumn	144	80.56	11.81	92.37	7.63

Table 6

Homogenous-mixture baseline-dependent simulation results for the based used for identification continental complexes stocks of immature chinook salmon in 2003, MLE/SD

River/stock	N	r. Kamchatka	r. Kuskokwim	r. Nushagak	r. Yukon
r. Kamchatka	176	**0.9611**	0.0301	0.0217	0.0225
		0.0414	0.0434	0.0280	0.0335
r. Kuskokwim	239	0.0333	**0.7438**	0.0476	0.0244
		0.0393	**0.1100**	0.0592	0.0422
r. Nushagak	233	0.0009	0.0613	**0.9148**	0.0188
		0.0050	0.0644	**0.0625**	0.0344
r. Yukon	186	0.0047	0.1648	0.0159	**0.9343**
		0.0138	0.0944	0.0272	**0.0576**
Mean accuracy, %					**88.85**

Table 7

Maximum likelihood estimates (MLE), standard deviations (SD) and confidence intervals (CI – 95 %) derived for results of identification local stocks of immature chinook salmon from trawl catches R/V "TINRO" in the western part of Bering sea in summer-autumn 2003

Season	River/stock	N	MLE	SD	CI - 95 %
Summer	r. Kamchatka	286	0.5306	0.0478	0.4063-0.6338
	r. Kuskokwim		-	-	-
	r. Nushagak		0.3055	0.0418	0.2007-0.3886
	r. Nushagak		0.1639	0.0459	0.0678-0.2993
Autumn	r. Kamchatka	120	0.6306	0.0737	0.4662-0.7562
	r. Kuskokwim		0.0796	0.1040	0.0000-0.3666
	r. Nushagak		0.2898	0.0871	0.0805-0.4265
	r. Nushagak		-	-	-

Table 8

Abundance (millions individuals) of chinook salmon in the upper epipelagic layer of the western Bering sea by data trawl catches R/V "TINRO" during summer-fall in 2003

Season	Maturity	Fishing efficiency	Biostatistical districts										Total
			Pacific Ocean	Bering Sea									
				12	9	8	7	5	4	3	2	1	
Summer	*Immature*	0.3	0.15	2.36	-	30.11	1.20	2.18	1.43	2.08	1.63	0.02	41.16
	Juvenile	-	-	-	-	-	-	-	-	-	-	-	-
Autumn	*Immature*	0.3	1.29	3.44	0.09	15.60	0.10	1.13	1.83	0.50	1.59	0.48	26.05
	Juvenile	0.4	-	1.55	0.10	0.33	0.02	-	-	0.01	-	-	2.01

Table 9

Abundance of immature chinook salmon from Asia and North America by principal age groups (PAG) in the western Bering sea for data trawl catches R/V "TINRO" during summer-fall in 2003

Season	PAG (1.1 + 1.2)		Complexes stocks				SAG	
			Asia		North America			
	%	млн.экз.	%	Million of fish	%	Million of fish	%	Million of fish
Summer	93.82	38.48	*53*	20.39	*47*	18.09	6.18	2.53
Autumn	*92.37*	22.87	*63*	14.41	*37*	8.46	7.63	1.89