SEASONAL DYNAMICS OF PACIFIC SALMON MIGRATION IN THE SOUTHERN KURIL WATERS OF THE PACIFIC OCEAN

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In recent years researches of salmons in North Pacific at their ways to spawning areas are being greatly developed. Of those researches on migrations with a huge distance off «native» coasts it is necessary to note a system of observations for species composition and biological indexes of salmons at control stations, where changes in number of fishes migrating through the observation site are estimated in the interyear aspect according to the size of catches per one drift gill net (Ishida et al., 1997). Of researches on peculiarities of further fish migrations to spawning areas the most systematic results were obtained during carrying out annual complex expeditions by TINRO, which embraced salmon migrations in the Okhotsk and Bering Seas and adjacent ocean area, including the one from the ocean side of Kuril Islands (Shuntov et al., 1993, 1995, 1997). In these studies biomass of salmons and their biological characteristics are estimated by catches during trawl surveys on vast areas. The present paper is based on materials, collected when catching salmons by gill nets. A long period of observations for each year within comparatively small site was a peculiarity of collecting, that allowed to examine salmons migration through the southern Kuril waters of the Pacific Ocean in its seasonal dynamics.

Materials and methods

Samples were collected from Japanese fishing vessels, that accomplished salmons' capture in research regime in the ocean along Kuril Islands between 45° and 48° N from the middle of May to July 20 in 1994-1997. Seasonal dynamics of salmon catches is given for a zone «A» near the Bussol Strait (Fig. 1), where the majority of carried out drift stations were concentrated. The zone «A» is restricted by the

boundary of territorial waters in the north-west, 153° E in the east and 45°30′ N in the south. During observed years in this zone 2.6 stations were being executed every 5 days at the average (Table 1). Observations in a zone «B» were used for biological characteristics of salmons as in 1994-1997 so in 1993.

Stock density was determined by the number index as a mean day fish catch per one standard net of 50 m long in hang. One line of nets with meshes of 111 mm and from 1 to 7 lines of nets with meshes of 127 to 135 mm were set at each station. The length of each line did not exceed 4 km. Verified differences of catches per effort and mean weight of various salmon species in dependence of a mesh size were ascertained. That is why to characterize pink salmon catches and its size and sex composition nets with meshes of 111 mm were used, and for other salmon species - nets with meshes of 127-131 mm. A standard period was usually about 10-12 hours.

The age of fishes was tested by their scales. When collecting the scale there was measured a standard body length and determined sex and stage of gonads maturity. An average weight of salmons was calculated on the base of groups weighing. Materials used here are presented in corresponding Tables.

Results

In the region of observations 5 species of Pacific salmon are met in catches.

Chum salmon, Oncorhynchus keta. To judge from dynamics of catches (Fig. 2), chum appeared in the area much earlier, than observations began. Thus, in the years of abundant runs (1994-1995) its catches, when water temperature on the surface was about 2° C exceeded 10 ind./net, remaining at the level of 10-15 ind./net up to the beginning of July. At small number runs, as in 1997, a period of the greatest catches was of short duration, and their size did not exceed 10 ind./net. As for 1997, data on catches in May in zone «A» are absent. However, it is possible to estimate chum number as low in this period according to its catches in May - the beginning of June in zone «B» (from 1 to 3 ind./net), where similar seasonal dynamics of its catches was usually marked. Data presented testify to the tendency of chum stock number reducing on a researched area in May-July 1994-1997.

Seasonal changes in fish body length are registered. In May fishes were larger, than in the first half of June. During 2-3d decades of June fishes distinguished themselves by the least variability of size composition. Further, with catches reducing the average fish length, as a rule, was increasing again, and variability of size composition became the highest for the period of observations (Table 2).

Decrease of the average fish body length in years of high number, as it deals with salmons, is not registered. In particular, this is viewed when comparing a body length of fish with the same age in 1994 and 1997 (Table 3). On the contrary, fishes of 4 years old in 1994 (high number) the most numerous in stocks were truly larger, than in 1997 (low number). For fishes at the age of 5 considerable differences in body length were not registered, though in contrast to those at the age of 4, they were rather larger in 1997. A comparison of fish body length in these years was made according to two schemes: 1- for fishes caught in zone «A», 2- independently of zones of catching («A» or «B»). In both cases the similar tendency in parameters change is noted.

In accordance with data received earlier by Birman (1968) in May-June a growth zone of the new year on chum scale only began to appear, more young fishes had the appearing of annual rings earlier. Thus, in catches of 1997 there were not observed fishes at the age of 2, because every species had a small growth zone of the next third year of life on scales. The share of fishes with the third annual ring to be watched along the edge of scales among the total number of fishes, that had the beginning of fourth year of growth on scales, made up 21.2 % in the second half of May, 5.5 % - in the first half of June, and 1.6 % - in the second half of June. At the same time the share of fishes with the fourth annual rings along the edge of scales was still higher in the total mass with fishes, that had the beginning of the fifth year of growth, and made up in this period 41.5 %, 35.1 % and 3.3 %, respectively. Fish age adapted to the time of spawning is presented in Table 4. A similar phenomenon in dynamics of chum age structure is shown. At the beginning of observation period fishes at the age of 5 prevailed in catches, but by the beginning of June the first place was occupied by fishes at the age of 4, whose number continued to increase as observations were lasted.

For chum stocks the smallest in numbers there was registered a more broad representation of fishes of young (3 years) and old (6 and 7 years) age groups in 1997.

To take into consideration gonads appearance, the share of more mature fishes gradually increased from the beginning up to the end of observation period. For example, in 1997 for the period from May 18 to June 18 fishes with gonads at maturity stages 2-3 (from 40 to 62 %) prevailed in catches, and further - at stage 3 (from 44 to 66 %). In relationship between males and females there was observed the tendency of increase of females' share from the beginning up to the end of observation period.

Pink salmon, O. gorbuscha. The first specimen of pink salmon appeared in nets at the end of May - the beginning of June. During June the appreciable increment of catches did not take place. And what is more, in the fourth and fifth 5-days of June there was registered even some decrease of them, after which pink number increased abruptly and kept itself at comparatively high level up to the end of observation period (Fig. 2). It is curious, that in even years fish individuals were at the average larger in June, than in July, and in odd years, on the contrary, in July - larger, then fishes from catches in June (Table 5). In odd years not only some increase in size of pink body is evident in July, but also considerable increase of fishes variability as for body length (except one small catch at the beginning of June 1997).

Using the example of correlation between pink and its gonads at various maturity stages in catches of 1997 three groups of values can be distinguished (Table 6). In the third decade of June the share of individuals with gonads at 2-3 maturity stages was comparatively high, then their number decreased greatly and kept at a low level up to finishing the observations. In the first decade of July fishes with gonads at the maturity stage 3 were exclusively dominant, as for their number, because by this time the share of more mature fishes rather decreased. From the middle of June the share of fishes with gonads at stages 3-4 increased greatly. It is important to note a spasmodic change of indexes when passing from one group of values to another, but not a smooth change in correlation between fishes in catches and their gonads at various maturity stages, as it was observed with chum. To conclude the review on pink it is necessary to emphasize peculiarities in dynamics of sex structure. On the whole, for the period

of observations there was marked the correlation of males and females characteristic for salmons, when at the beginning of run males dominate, and at the end - females. However, at the end of June - the beginning of July «a confusion» was noted in this tendency, that was registered even at infrequent observations (1995): a short-term increase of males' share took place, further it smoothly decreased again (Fig. 3). Approximately equal correlation of males and females, set in catches by the middle of June, completely corresponded to pink catches fall to be likely in this period all over the years of observations (Fig. 2).

Sockeye salmon, O. nerka. A very long period of comparatively high catches of sockeye is characteristic for their seasonal dynamics. Their number at times decreased, at others increased practically for the whole period of observations (Fig. 4). From 1994 to 1997 the evident increase of sockeye number is registered. If in first two years its average catches on 5-days did not exceed 0.5 ind./net, then in 1997 at the end of June - the beginning of July they composed about 1 ind./net. In zone «B» its catches at this time were rather high (2-3 ind./net), so long as sockeye migration to a great extent adapted to northern latitudes. In catches fishes of 5 age groups were presented, where specimen of the age 1.3 dominated (Table 7). Practically in all cases, except the 3d decade of June 1994, fishes in southern latitudes were larger, than in northern ones (Table 8).

Coho salmon, O. kisutch. In catches coho appeared later, than other salmon species, usually at the end of June - the beginning of July (Fig. 4), when water surface was warmed to 5-6°C. As a rule its catches increased little by little by the end of observation period. Only in 1996 the abrupt increasing of coho number was registered already at the beginning of July, with some next decreasing. Maximum catches in 1994-1995 did not exceed 1 ind./net, in 1996 they achieved 1.5 ind./net, and in 1997 - 3 ind./net. Fish age was determined by samples collected in 1993; in catches of zone «B» two age groups - 1.1 (45.7 %) and 2.1 (54.3 %) were registered. As the object was of smaller number during the period of observations, samples were collected synchronically in zones «A» and «B» only in 1997. It was found that according to its mean body length coho was considerably small in northern latitudes (56.2 ± 0.67 cm),

than in southern ones (60.8 ± 0.98 cm). For coho compared to other salmons, the earlier obtaining secondary sex signs is characteristic; as a result in catches sex dimorphism is clearly seen in the outward appearance.

Chinook salmon, O. tschawytscha. Chinook catches for the whole period of observations were very small. In May - the first half of June they usually composed 0.01-0.02 ind./net, further increased a little up to 0.01-0.04 ind./net. Catches increase was accompanied by the reducing of mean length of seining fishes. For example, in May 1994 the mean length of fish was 86.3 cm (at fluctuation of individual values from 59 to 119 cm), and in July - 79.7 cm (from 65 to 91 cm). Changes of body weight characterize gradual decrease of fish size in catches more brightly. In the last decade of May the average weight was 11.4 kg, in the middle of June - 8.0 kg, and in the second decade of July - 5.2 kg. Chinook age composition was presented by six groups, among which fishes of age 1.3 (48 %) dominated. Specimen of age 1.4 and 2.3 occupied the second place as for number, composed 36 % in sum. Relative number of other age groups (1.2, 2.2 and 2.4) varied from 4 to 8 %.

Thus, according to the relative number, pink and chum salmons, whose catches always exceeded 10 ind./net at the highest density of stock, dominated among Pacific salmons in the southern part of Kuril waters of the Pacific Ocean. The second place as for relative number was occupied by the couple sockeye - coho with maximum catches up to 2-3 ind./net. Chinook meeting in net catches is so low, that when estimating salmons stock density these values may be used as casual.

If the time of appearing of sockeye (seasonal forms are taking into consideration), pink and coho stocks corresponds to the migration order of these fishes for spawning, then chum, migrating into rivers after pink, runs in mass number to the straits of Kuril Islands and enters the area of the Okhotsk Sea first of other salmons. In addition it may be mentioned that average weights of sockeye (3.03 kg), coho (2.52 kg) and pink (1.24 kg) in catches of the ocean do not appreciably differ from the average weight of these fishes before their entering the rivers of spawning, as compared to chum (2.42 kg). So migration of first-mentioned fishes into the Okhotsk Sea may be considered as feed-spawning and as feeding for chum.

We suppose that fishes of the same species but caught in various time or various areas have differences in some biological indexes, which associate with the character of migration. Apparently chum migrates for spawning to the Okhotsk Sea by a united stock, without isolating in large fish groups accordingly to spawning areas (Kaev, 1996) with dominating of 5-years fishes at the head. A clear spatial divergence on body length was observed at coho and sockeye in contrast to chum. In particular, at an average more large specimen of sockeye have been in catches of southern latitudes near Iturup and Urup Islands, in the lakes of which fishes of local populations spawn. Dynamics of biological indexes of pink testifies the presence of fishes in catches of at least two different groups too.

Conclusion

Five species of Pacific salmons were represented in catches of the southern Kuril waters of the Pacific Ocean, pink and chum dominated among them in number. According to the peculiarities of distribution and biological indexes of fish, chum migrations to the Okhotsk Sea ought to be considered as feeding ones for the first turn. Divergence on either these or those parameters associated, probably, with partial isolation of fish groups in accordance with areas and terms of spawning is characteristic for other salmon species, that allows to determine their migrations to the Okhotsk Sea as feed-spawning.

Table 1. Number of stations , executed in zone «A» in 1994-1997

Months	Days	1994.	1995	1996	1997
May	16-20	0	3	0	0
	21-31	3	14	4	0
June	1-10	6	8	2	4
	11-20	4	4	3	7
	21-30	5	5	3	6
July	1-10	6	4	2	8
	11-20	5	2	4	7

Table 2. Chum salmon body length and its variability in zones «A-B», cm

Period	1994			1996			1997		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
05.16-20	-	-	0	-	-	0	59.3	3.93	50
05.21-31	59.8	3.51	98	57.6	3.08	50	57.9	4.04	100
06. 1-10	59.3	3.43	102	56.8	3.55	50	56.3	3.25	50
06.11-20	56.8	2.33	150	56.9	2.73	101	57.4	3.38	100
06.21-30	56.4	2.60	70	58.9	3.26	100	57.9	3.03	50
07. 1-10	56.4	3.29	100	60.2	4.09	50	56.9	4.15	100
07.11-20	60.7	5.36	141	62.9	4.61	100	57.2	3.99	50

Table 3. Statistic indexes of chum salmon body length (cm) at the age of 4 and 5 years in 1994, 1997.

Age	Years	Mean	S.D.	CV	n
June 21 - July 18, zone «A»					
0.4	1994	57.9 ± 0.37	4.55	7.86	148
	1997	56.2 ± 0.25	3.04	5.41	147
0.5	1994	60.1 ± 0.60	4.76	7.92	62
	1997	61.2 ± 0.62	4.04	6.59	42
May 16 - July 18, zones «A-B»					
0.4	1994	57.4 ± 0.21	4.00	6.97	373
	1997	55.9 ± 0.17	2.92	5.23	290
0.5	1994	59.5 ± 0.25	3.94	6.61	256
	1997	59.7 ± 0.25	3.30	5.53	171

Table 4. Chum salmon age composition adapted to the period of spawning in zones «А-В» in 1994, 1997

Period	Fishing area	Age (years)					N
		0.3	0.4	0.5	0.6	0.7	
1994							
05.21-31	А	-	37.5	56.3	6.2	-	48
	Б	-	39.1	56.5	4.4	-	46
06. 1-10	А	-	52.5	41.6	5.9	-	101
06.11-20	А	0.7	52.0	47.3	-	-	150
06.21-30	А	-	67.2	32.8	-	-	67
	Б	2.0	67.4	28.6	2.0	-	49
07. 1-10	А	2.1	64.6	33.3	-	-	48
07.11-20	А	3.0	71.7	24.3	1.0	-	99
1997							
05.16-20	Б	-	28.0	50.0	22.0	-	50
05.21-31	Б	-	43.0	49.0	8.0	-	100
06. 1-10	Б	-	62.0	34.0	4.0	-	50
06.11-20	Б	3.0	55.0	38.0	3.0	1,0	100
06.21-30	А	-	66.0	30.0	4.0	-	50
07. 1-10	А	4.0	77.0	18.0	1.0	-	100
07.11-20	А	8.0	74.0	18.0	-	-	50

Table 5. Pink salmon body length and its variability in zone «A», cm

Period	Mean	S.D.	N	Mean	S.D.	N
Even years	1994			1996		
June 11-20	-	-	-	47.4	2.32	50
June 21-30	46.8	2.69	50	-	-	-
July 1-10	45.5	2.69	50	46.0	2.36	50
July 11-20	46.1	2.05	50	-	-	-
Odd years	1995			1997		
June 1-10	-	-	-	45.0	2.50	50
June 11-20	46.8	2.53	100	45.3	2.30	202
June 21-30	46.0	2.71	51	45.7	2.32	250
July 1-10	47.6	2.85	41	46.3	2.39	519
July 11-20	47.2	2.94	50	46.4	2.40	831

Table 6. Correlation of fishes with gonads at various stages of maturity from catches of pink salmon in zone «A» in 1997 (%)

Dates of analysis	Stages of maturity			N
	2-3	3	3-4	
June 21	26.0	64.0	10.0	100
June 23	19.0	67.0	14.0	100
July 3	1.0	94.0	5.0	100
July 8	3.0	93.0	4.0	100
July 14	4.2	53.8	42.0	119
July 18	2.6	54.2	43.2	118
July 19	2.5	56.7	40.8	120

Table 7. Sockeye salmon age composition from catches in zone «B» in 1993, 1996 (%)

Dates of analysis	Age (years)					N
	1.2	1.3	1.4	2.2	2.3	
1993.07.07	6.2	60.4	2.1	12.5	18.8	48
1996.06.02	7.2	60.3	1.2	3.6	27.7	83
1996.06.25	17.4	47.7	1.2	16.3	17.4	86
1996.07.17	14.3	49.3	1.3	10.4	24.7	77

Table 8. Sockeye salmon body length (cm) and its variability from catches in zones «A» and «B» in 1994-1997

| Period	Zone «A»			Zone «B»		
	Mean	S.D.	N	Mean	S.D.	N
1994						
05.21-31	62.3	3.68	50	61.8	3.60	48
06.21-30	61.7	3.58	58	63.2	3.11	50
07. 1-10	61.9	2.59	58	59.9	3.25	25
07.11-20	63.2	3.76	59	62.4	4.24	50
1995						
05.16-20	60.2	2.92	50	-	-	-
06.11-20	56.9	3.38	50	-	-	-
06.21-30	-	-	-	54.9	3.42	50
07. 1-10	-	-	-	58.0	3.38	50
1996						
05.16-20	-	-	-	60.1	2.87	50
05.21-31	61.1	3.12	34	59.2	2.38	20
06. 1-10	-	-	-	59.0	3.48	70
06.11-20	60.5	3.48	24	-	-	-
06.21-30	-	-	-	60.3	3.29	100
07. 1-10	-	-	-	59.4	3.38	50
07.11-20	-	-	-	59.9	3.60	100
1997						
05.16-20	-	-	-	58.7	2.51	80
05.21-31	-	-	-	58.8	3.49	52
06. 1-10	60.2	2.91	20	-	-	-
06.11-20	62.3	2.43	55	58.4	3.38	60
07. 1-10	60.5	2.76	52	-	-	-
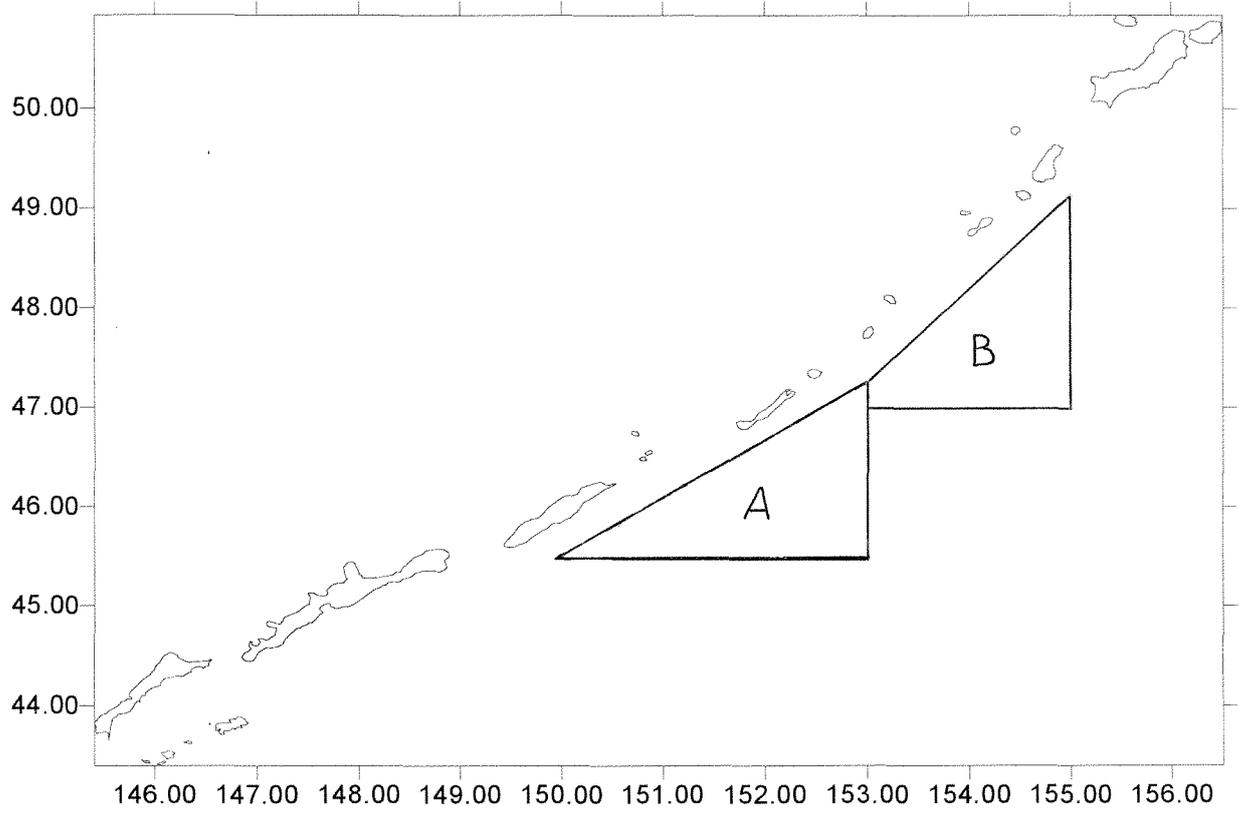
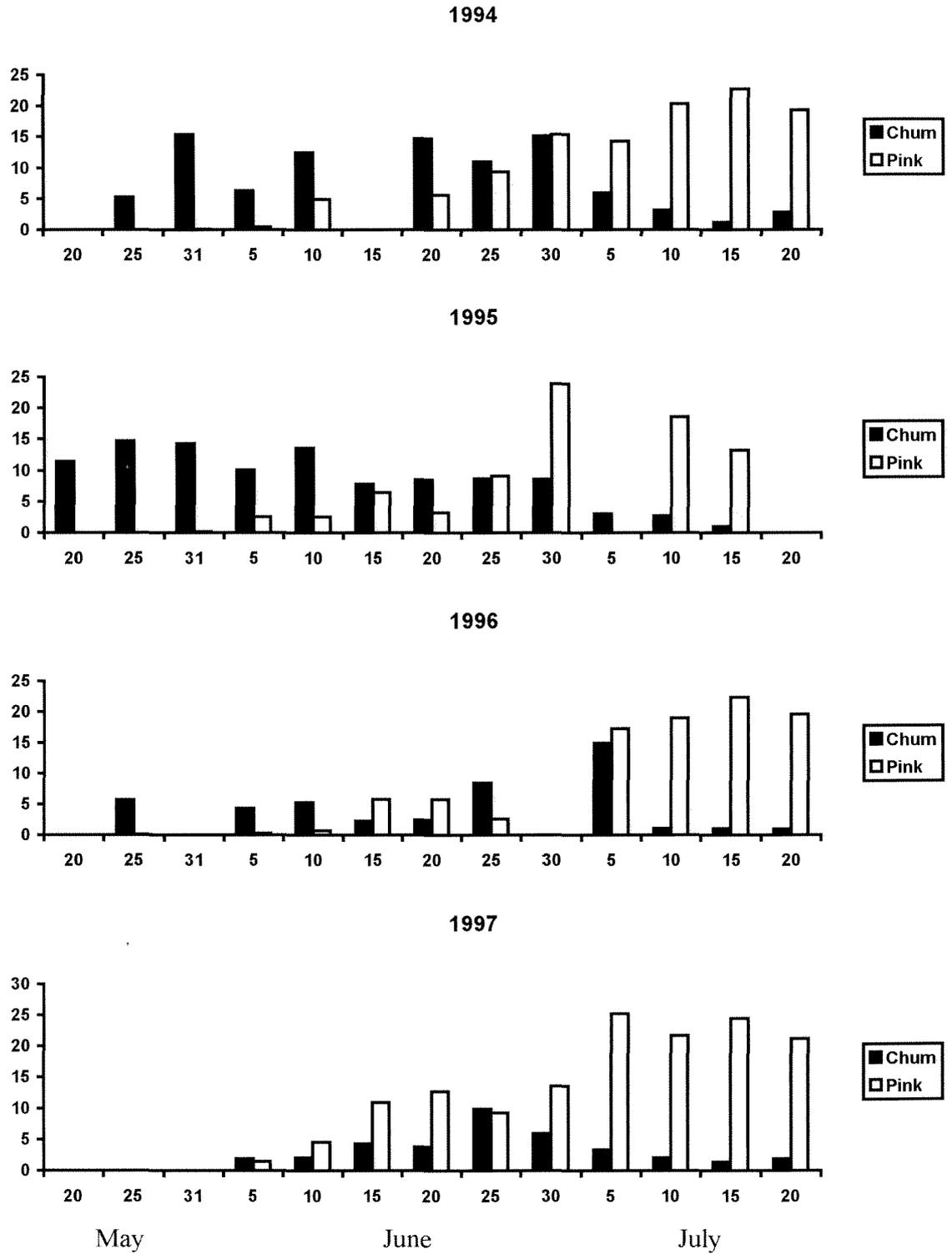**Fig. 1.** Sites of salmon catching by drift gill nets.

Fig. 2. Dynamics of average for five days catches of pink and chum salmons in zone «A» in 1994-1997.

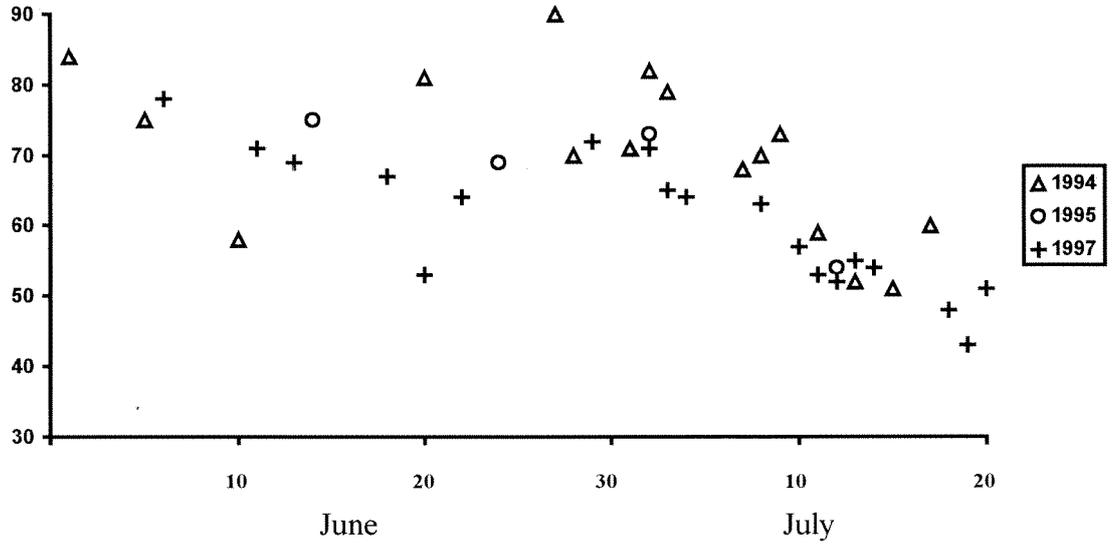Vertically: catch, ind./net; horizontally: dates.

Fig. 3. Correlation of males and females from catches of pink salmon

in zone «A» in 1994,1995,1997.
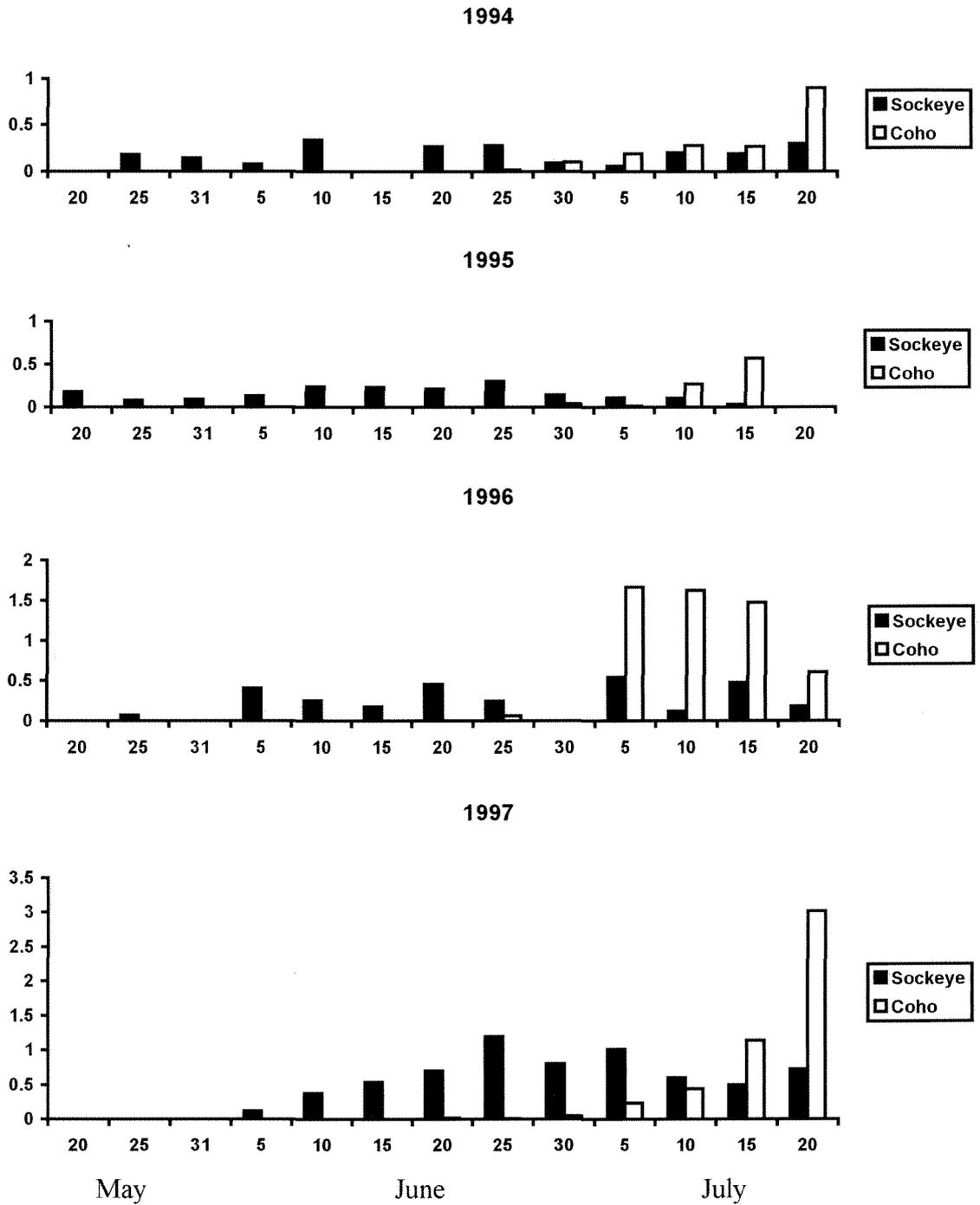
Vertically: share of males, %; horizontally: dates.

1994

1995

1996

1997

May   June   July

Fig. 4. Dynamics of average for five days catches of sockeye and coho salmons

in zone «A» in 1994-1997.

Vertically: catch, ind./net; horizontally: dates.

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Summary

Data on catches per 1 net and biological characteristics of 5 Pacific salmon species g. Oncorhynchus, encountered in catches by drift gill nets in the southern Kuril waters of the Pacific Ocean in 1994-1997 are presented. According to the peculiarities of distribution and biological indexes of fish chum migrations to the Okhotsk Sea ought to be considered as feeding ones for the first turn. Divergence on either these or those parameters associated probably with partial isolation of fish groups in accordance with areas terms of spawning is characteristic for other salmon species, that allows to determine their migrations to the Okhotsk Sea as feed-spawning.

Table 8. Fig. 4. Bibl. 6.