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Interannual Changes in Anadromous Migrations of Salmons in Waters of the Sakhalin-Kuril Region

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Abstract

The paper is based on data of detailed complex survey carried out in July-August, 1993,in the southern Sea of Okhotsk (to 53° N) and Pacific waters off Kuril Islands. Biomass of all salmons was determined at 184.4 thousands tons that is much less than similar estimates in 1991 (330 thousands tons).
The peculiarities of distribution of particular salmon species are considered against a background of anomalous oceanological situation. It is assumed that approximately one-half of pink salmon accounted in the Sakhalin-Kuril region (150 thousands tons) has been redistributed during anadromous migrations to the north-eastern Sea of Okhotsk and Bering Sea. This fact is interpreted in favour of fluctuating stocks idea of Glubokovsky -Zyvotowsky. According to that hypotesis,pink can numerously redistribute into other spawning grounds under influence of considarable environmental changes.

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INTERANNUAL CHANGES IN ANADROMOUS MIGRATIONS OF SALMONS IN WATERS OF THE SAKHALIN-KURIL REGION

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The features of anadromous migrations of salmon in the Southern Sea of Okhotsk and Kuril waters of the Pacific Ocean under anomalous oceanological conditions of 1993 are considered. In the Sea of Okhotsk, the redistribution of pink salmon to more northern waters has been found. In the Pacific Ocean, on the contrary, marked concentrations of this species were only in the waters near middle and southern Kuril Islands.

Total biomass of salmons in the region under consideration has decreased 1.8 times in comparison with that during analogous period in 1991.

The present paper continues the analysis of features of anadromous migrations of Pacific salmons under anomalous oceanological conditions in 1993. The first report dealt with analysis of the salmon distribution and migrations in the eastern Kamchatka region using data of the complex expedition of PRIFO on the research ships "TINRO", "Professor Kizevetter", "Professor Soldatov" during June-July, 1993 (Shuntov et al., 1994). The present paper considers the results of studies at the second stage of expedition when the survey has been carried out in the southern Sea of Okhotsk and Kuril waters of the Pacific Ocean at the distance of up to 350 miles from Islands.

Methods of the survey carrying out and processing of data obtained has been described in the previous report (Shuntov et al., 1994). Investigations have been carried out from July 13 to August 17, 1993. A grid of trawlings and background stations can be seen in Figures presented in this paper. Biostatistical information has been averaged for 12 regions, the limits and numbers of which are shown in Fig.1. As to periods and areas, the expedition in 1993 has almost completely repeated similar expedition in also odd 1991. This facilitates the comparisons of data obtained under conditions of marked interannual differences in the oceanological environment.

Because of synchronous operations of three ships which were coordinated by the first author of this paper, 8 areas of 12 were three times investigated. This allowed to trace some details of the salmon migrations which could not be traced when carrying out single surveys (Shuntov et al., 1992). At the same time, it should be reminded that trawlings have been made by otter trawl of 108/528 type, the vertical opening of which is 50 cm, with speed of 4.5-5.0 knots. When trawling, a trawl lifted to the surface and catching took the upper 50-m layer, i.e. basic layer of salmons habitat. A coefficient of the trawl catchability for salmons, as before, was taken equal to 0.3.

RESULTS

From Table 1, it can be seen that in 1993 in the Sakhalin-Kuril waters, 184.4 thousands tons of Pacific salmons were accounted for and this figure proved to be 1.8 times less than in 1991. A similar situation has also taken place in the eastern Kamchatka region (Shuntov et al., 1994), and this fact, in our opinion, has confirmed the conclusions that in 1990s, the epoch of reduced level of the salmon number and reproduction in connection with change of climato-oceanological conditions in the North Pacific has begun (Chigirinsky, 1993; Beamish, Bouillon, 1993). However, as for the Sakhalin-Kuril region, additional explanations are here needed. In this region, a reduction of total ichthyomass of salmons is largely related to two-fold decrease of the number of pink salmon (Oncorhynchus gorbuscha) (Table 1). Apart from other reasons here, a factor of density could also play a part. In 1991, when the parents of the pink salmon posterity coming in 1993 for spawning have spawned, the pink salmon approaches were extremely heavy. At that time, its catch in this region was record (about 121 thousands tons). As to other species, when comparing 1991 and 1993, the picture does not appear equally unambiguous. In this sense, it is to bear in mind that foraging in waters of the Sakhalin-Kuril region Siberian salmon (O. keta), sockeye salmon (O. nerka), king salmon (O. tschawytscha) and silver salmon (O. kisutch) represent only particular part (different for different species) of overall number of each species. But major reproduction regions of all of these species are outside the Sakhalin-Kuril region. Therefore, comparisons of data for different years for these regions are more expressive if the estimates of biomass in the eastern Kamchatka region (including the western Bering Sea) which are given in our first report (Shuntov et al., 1994) are kept in mind. In case of such analysis of data, all species reveal decreasing total biomasses: Siberian salmon - 142.5 thousands tons in 1991 and 78.9 thousands tons in 1993, sockeye salmon - 47.5 and 29.4 thousands tons respectively, king salmon - 11.4 and 7.1 thousands tons respectively and silver salmon - 6.5 and 5.0 thousands tons respectively.

As in the Bering Sea, the oceanological situation in the Sakhalin-Kuril region in 1993 was extraordinary. As compared with 1991, the surface temperature was here lower by 1.0-1.5°C that manifested itself as delay of some seasonal phenomena including migrations to the Kuril waters of species of subtropical nekton complex: saira (Cololabis saira), Japanese anchovy (Engraulis japonicus) and Pacific squid (Todarodes pacificus). However, it is of interest that these changes in the temperature conditions were not reflected in the salmon migration terms. For example, pink salmon began the active entrance to rivers of Sakhalin from end of July, i.e. by ten days earlier than in 1991. On the other hand, its movement near the Kuril Islands has begun in third ten-day period of August that was also typical for previous years.

Recall that some influence on the migration terms can be made by the number of salmons with which the sizes of fishes correlate in some regions. So, average weight of pink salmon in 1991, i.e. when its number was very high, was 1.16 kg in the Sea of Okhotsk and 1.13 kg in the Kuril waters of ocean. In 1993 (first survey), pink salmon was much larger:1.38 kg in the Sea of Okhotsk and 1.45 kg in ocean. Therefore, the forage conditions in 1993 must be also considered more favourable by this index. At least, such conclusion can be drawn for Sakhalin pink salmon bearing its early run in mind. But as we will see below, especially large pink salmon migrated to the southern Kuril Islands where great deviations in terms of its run were not noted. Thus, the above data characterizing some peculiarities of the anadromous pink salmon migrations in 1993 do not fall in full measure into the concept established, and this indicates evidently complex and multifactorial character of the phenomena considered.

However, a specificity of anadromous migrations of salmons in 1993 was still largely related to not negative anomalies of the surface temperature and considerable reduction in their number. As in the Bering Sea, in the Sakhalin-Kuril region, the significant changes in water circulation have taken place, and this, most likely, has left its imprint on the forming migration paths and quantitative distribution of salmons. In this regard, the following features of water circulation in the region under consideration are first of all worthy of notice. As shown in Fig.2, a flow of oceanic waters to the Sea of Okhotsk through the northern Kuril passages was slightly noticeable. Here, the West-Kamchatka Current is usually originated which was also weakened. In the ocean before the passages there was at this time the highly dynamical stationary gradient zone which was formed by fast flows and omnidirectional water gyres. When analyzing the situation in the eastern Kamchatka region, we noted already (Shuntov et al., 1994) that oceanic branch of the West Subarctic gyre south of Komandor Islands and Blizhny Strait was not pronounced in 1993. In addition, in this region, the south-westward water motion has been well pronounced. The scheme of currents (data of our expedition) in Fig.2 explains the absence of north-eastward inflow of waters to the Blizhny Strait. The oceanic branch of the Kamchatka Current which usually forms oceanic branch of the West Subarctic Gyre has propagated from the middle Kuril Islands to the east, to the ocean, rather than to the north-east (1991).

In the Sea of Okhotsk, in addition to the West Kamchatka Current, the East Sakhalin Current was a quite weakened and/

moreover, it pressed itself to the shore. Over the most part of the East Sakhalin shelf (north of Terpeniya Cape), a northward water flow has predominated. This flow included waters of the southern Sea related to the warm Soya Current (Fig.2). Bearing the foregoing in mind one can say that there are highly essential changes in the oceanological background on the ways of salmon migrations.

We have already called attention to the fact that salmons move during anadromous migrations as a wide echeloned migration and do not follow some narrow values of different oceanological factors and freely cross the cold water spots, countercurrents and cross currents (Shuntov, 1993, 1993a). However, this is not to say that they must not respond to large-scale landscape changes related to change in the water circulation schemes over vast water areas. Summer distribution of all species of salmons in the Sakhalin-Kuril region in 1993 confirms this conclusion.

As indicated in Fig.2, pink salmon, when it runs through the Kuril passages, has basically avoided the north Kuril region through which it usually migrates in quantity (Shuntov et al., 1993; Takagi et al., 1981; Heard, 1991). Similar picture has been also observed for 2nd and 3rd surveys. In accordance with the catches distribution, the pink salmon coming from the ocean (from the east) to the middle Kuril passages has been clearly traced. It is evident that pink salmon rounded the north Kuril highly dynamical zone from the south. Further to the south, spreading of pink salmon has been limited by warm northern branches of the Kuroshio System.

As the distribution character of the pink salmon catches in the Sea of Okhotsk (Fig.2) implies, its motion to the northwest and, likely, to the north was predominant in July. As a result, "accumulation" of pink salmon within waters near the Sakhalin has first taken place in the vicinity of the Terpeniya Cape and further north. This is also evident from the increase in given direction of average coefficients of females maturity: 10.2-10.7% in waters to the east and north of the Terpeniya Cape and only 9.4-9.8% near the south-eastern Sakhalin shore. By the way, unlike the Bering Sea, in the Sakhalin-Kuril region, the spatial dynamics of the pink salmon maturity coefficient had quite traditional form (Shuntov et al., 1993), i.e. in open ocean, it was minimum (4.8-6.7%) and comparatively gradually increased in the shoreward direction. From Fig.2 we notice also that, in addition to the north-west tendency to the Sakhalin shores, some increase of maturity coefficient has been observed toward the southern Kuril Islands and Hokkaido.

Other species of salmons have also responded to non-typical oceanological situation but each species had, in this sense, its peculiarities in distribution. King salmon (exclusively non-pubescent individuals of 58-85 cm (largely 65-75 cm) in length), much like pink salmon, avoided the highly dynamical zone off the northern Kuril Islands. In 1991, it was here not incommon

(Fig.3). On the contrary, in the central part of the Sea of Okhotsk deep-water hollow where none of king salmon has been caught in 1991, it was very abundant in 1993 (Fig.3). The number of king salmon in 1993 in waters off the Sakhalin was less than that in 1991 (and, by the by, during the similar survey in 1992). During all years of investigations including autumn period (Shuntov, 1989), king salmon has been regularly found in the catches in the southern Kuril region.

Inclination of pubescent silver salmon to the Kuril waters (Fig.4) is most typical for its distribution in the region under consideration during anadromous migrations. In literature, it was repeatedly noted that silver salmon is the most heat-loving species of Pacific salmons. It was indicated that it inhabits in sea at temperatures of 7.2-15.6°, and 5°C is lower temperature limit of its occurence (Birman, 1985; Sandercock, 1991). Such conclusions are likely based on the late silver salmon run for spawning and the most southern position among salmons of northern limit of its occurence in winter. However, as seen from Fig.4, during anadromous migrations across the north-western Pacific Ocean, silver salmon not only did not avoid the cold zone of upwellings in the middle part of Kuril range but gravitated towards it. Powerful upwellings off middle Kuril Islands are stationary on the interannual basis. In summer, the water temperature directly within zones of upwelling can drop up to 2-3°C. It is no mere chance that they are for a long time known as "Kuril refrigerators". The above outlined picture of summer distribution of silver salmon was not here uncommon in 1993. More often, it was also found in given region in 1991.

The waters of the Sakhalin-Kuril region on the whole are south-western periphery of marine part of the sockeye salmon range. In the southern part of water area under consideration, it was occasionally found within narrow belt along the middle and southern Kuril Islands (pubescent and large fry). In the vicinity of the northern Kuril Islands, sockeye salmon was more common and, in so doing it, unlike pink salmon and king salmon, did not avoid the above highly dynamical zone located before the northern Kuril passages.

Siberian salmon has freely migrated across the northern Kuril zone. However, the extension of this species was less wide than that of pink salmon (Fig.5). In connection with absolute predominance of autumnal form of Siberian salmon (including high number of autumnal Siberian salmon from the Japanese fish-breeding factories) in the southern part characterizing by comparatively late spawning migration, it was still absent in the warm south-western Sea of Okhotsk during first survey. On the basis of catches distribution (Fig.5), one can conclude that Siberian salmon has gone down to the southern Kuril region from the north within the belt of more cold waters. This conclusion does not contradict the known conceptions that Siberian salmon in all or nearly all Asiatic stocks crosses, in its marine migratory cycle, the Bering Sea and adjacent waters (Neave et al., 1976;

Salo, 1991).

The Siberian salmon distribution shown in Fig.5 is only one of the stages of its seasonal displacement. In particular, during first survey, Siberian salmon was common before the Sakhalin shelf, north of the Terpeniya Cape. During second survey (first half of August) its number has here appreciably decreased, that is, one can conclude that it has passed to the northern part of the sea. In spite of this, total quantity of Siberian salmon within the limits of the Sea of Okhotsk regions considered in this paper has increased from 12.9 thousands tons (11.2 thousands tons of pubescent individuals) to 16.8 thousands tons (15.5 thousands tons of pubescent individuals) that is undoubtedly related to coming of fish from the ocean.

In July, in the extreme southern Sea of Okhotsk and roughly 200-mile belt along the Sakhalin, 12 individuals of salmon trout fry of 14.7-31.0 cm in length were caught. In August, it continued to be found in the same regions. 18 individuals of 16-33 cm in length were caught.

On July 20, nearly at equal distances from the south-eastern Sakhalin shores and southern shores of Kuril Islands (46°29' N, 145°58' E), 187 fingerlings of pink salmon of 7-16 cm in length were caught. All other fingerlings caught in July in open waters of the southern part of the sea have falled into size range. In August, they have been found in the same regions but their sizes increased and were 10-18 cm. Judging from distribution of catches, scattering of pink salmon fingerlings to the open waters during our observations occurred largely from the Sakhalin. This was also typical for much more numerous fingerlings (on July 23, east of the Terpeniya Bay in one trawling, 381 individuals of Siberian salmon have been caught which have begun to be found in catches in the open sea from July 22. In July, they were 8.5-22 cm in length while 12-22.2 cm in August. Data on the pink salmon and Siberian salmon fingerlings given here are consistent with similar data of our expeditions in the last years.

CONCLUSION

During anadromous migrations including arrival to the shores, the salmons continue to intensively feed on (Birman, 1985; Shuntov et al., 1993). As in previous expeditions, in the course of depicting salmons from catches of each trawling, the samples of feed have been taken as well as plankton catching within layers of 0-200 m and 0-50 m has been carried out. Special publications will be prepared on data of these surveys. Here, we note only one circumstance. As earlier (Shuntov et al., 1993, 1993a) when comparing the quantitative distribution of salmons, plankton and small nekton, some clear relationships fail to be identified. This idea is also confirmed by data of Fig.1 from which we notice that salmons can be numerous (or small in numbers) in both poor and rich in plankton and nekton regions.

For identification of real relations in this sense, the resolving ability of macrosurveys with total cathchings of plankton is obviously inadequate.

As in respect of the Bering Sea (Shuntov et al., 1994), in our opinion, there is good reason to proceed from general picture of oceanological and hydrobiological environment when explaining the features of quantitative distribution of salmons during anadromous migration in particular year. Our first report indicated already that we are inclined to believe the deviations in the water circulation being in 1993 as confirmation of conclusions about epochal realignment in the climatic-oceanological conditions and pelagic associations of the North Pacific (Shuntov et al., 1993). These realignments started since early 1990s and already were embodied in the composition and productivity of plankton and nekton associations, and some tendencies which have become apparent in 1990 and 1991 have further strengthened in 1993. So, an average biomass of nonpredatory (largely, copepods and euphausiids) plankton within 0-200 m layer in the southern Sea of Okhotsk was 206 t/sq.km in 1980s, 138 t/sq.km in 1990-1992 and 136 t/sq.km in 1993. Biomass of predatory plankton during these years has changed in the opposite direction: 50, 74 and 71 t/sq.km respectively. We have no comparable data about the summer plankton of the Kuril oceanic waters for 1980s. However, in accordance with available data, here, similar dynamics has also taken place: in 1991, biomass of nonpredatory plankton has been 139 t/sq.km and one of predatory plankton was 120 t/sq.km while in 1993 87 and 120 t/sq.km respectively. Biomass of nekton has also drastically decreased after 1991. In 1991, biomass of fishes and squids within 0-50 m layer in the Sea of Okhotsk has been 1.7 t/sq.km while in Kuril oceanic waters it has been 1.5 t/sq.km (Shuntov et al., 1993b). In 1993, it has decreased to 1.2 and 0.9 t/sq.km respectively, first of all, due to decrease of quantities of Alaska pollack (Theragra chalcogramma), Pacific sardine (Sardinops sagax melanosticta) and pink salmon.

Changes in the abiotic and biotic environment occurring in the recent years could not but reflect in the salmons number and distribution. And some such peculiarities of 1993 were already above emphasized: the number of all species decreased and marked redistribution took place as compared with 1991. Here, a pink salmon is worth special mentioned for which not only changes in migration paths within the Sakhalin-Kuril region but also large-scale redistribution between regions have been observed.

In the process of the July survey, biomass of pink salmon in the Sakhalin-Kuril region was about 150 thousands tones, at the beginning of August it decreased to 74 thousands tones while in mid-August - to 30 thousands tones. First of all, this decrease has been related to entrance of fish to the Sakhalin rivers as since the end of July, a quite active catching of pink salmon began in the Terpeniya Bay. Even in July, it was evident that more small fish was orientated towards the Sakhalin. At the time, an average weight of pink salmon in the Sea of Okhotsk was 1.38 kg while in the Pacific Ocean 1.45 kg. As more small fish entered the Sakhalin rivers, its average weight in the sea began to grow and was in early August 1.58 kg in the Sea of Okhotsk and 1.65 kg in the ocean. In the course of third survey, i.e. in mid-August, when the pink salmon catching season in the Sakhalin was largely finished, the south Kuril and Hokkaido groups have mainly remained in the sea, the spawning run of which takes place within second half of August and September. Its average weight was at the time 1.71 kg in the Sea of Okhotsk and 1.9 kg in the ocean. Judging from sizes (weights), reduced maturity coefficient and general predominance of males*, the south Kuril and Hokkaido pink salmon, at final marine stage of anadromous migrations, fed not only in the Pacific waters but also throughout the southern deep-water hollow of the Sea of Okhotsk. Its biomass was determined at 30 thousands tons. A reality of this estimate is confirmed by data of fishing off the south Kuril Islands and Hokkaido: 9.0 and 13.0-15.0 thousands tones respectively. With consideration for some quantity of pink salmon approaching the spawning-grounds as well as the fact a part of catch is not reflected in the official statistics (South Kuril Islands), we can be assured that the figures presented are almost consistent with each other.

A distinctly different picture has been found for the Sakhalin region. Here, only 27 thousands tones of pink salmon have been caught and about 21 thousands tons of pink salmon have been accounted in the spawning-grounds according to data of Sakhalin branch of PRIPO. The question is reasonable: where are additional 72 thousands tons of pink salmon (150 thousands tones less 30 thousands tones of the south Kuril and Hokkaido pink salmon and 48 thousands tons of Sakhalin one). In our first report (Shuntov et al., 1994), we already discussed about 20 thousands tons of "surplus" pink salmon in the east Kamchatka region and related it presumably to run of fish in August from the Kuril waters. If this version is taken, there are additional 52 thousands tons of pink salmon "vanished" from the Sakhalin-Kuril region.

Our version of possibility of the pink salmon part redistribution to other regions is to same degree confirmed by statistics for the northern Sea of Okhotsk. In this region, about 9 thousands tons of pink salmon have been caught, and, according to data of the Magadan branch of PRIPO, its unprecedentedly great quantity - 46 thousands tons - has approached the spawning-grounds. Especially striking picture has been observed in the north-eastern part of the Sea of where, in accordance with the PRIPO prediction, coming of 8 thousands tons of pink salmon has been expected but 45 thousands tons of pink salmon have approached there.

* Permanent predominance of males in the south Kuril group is one of characteristics features of this group (Chupakhin, 1973).

A total balance of offshore and coastal accounts of pink salmon in 1993 is presented in Table 2. Near-total coincidence of general data of coastal and offshore accounts requires additional explanation. Offshore accounts have not covered the northern half of the Sea of Okhotsk where, as known, run of pink salmon starts even earlier than in the Karaginsky Bay. Therefore, one can safely suggest that during first survey of the Sakhalin-Kuril region, not less than 20-25 thousands tons of pink salmon ran towards the north. Thus, its total biomass could attain 230-240 thousands tons. Nevertheless, for such ratio, data of coastal and offshore accounts do not contradict one another. The point is that coastal estimates do not without question include large losses of pink salmon in the northern part of the sea from marine mammals (especially white whale (Delphinapterus leucas) as well as neglected catch (including a quite large-scale poaching). Our expert estimate determines these losses to be equal to 20-25 thousands tons.

Thus, data on anadromous migrations of pink salmon in 1993 confirm the M.K. Glubokovsky and L.A. Zhivotovsky (1986) hypothesis for fluctuating stocks of this salmon. From this hypothesis it follows that in some years pink salmon, under the effect of drastic and considerable change in the environmental conditions, can redistribute to other regions in large quantities. As indicated above, year of 1993 has differed from previous years in oceanological conditions. Changes in water circulation were especially essential. It is apparent that additional deep investigations are needed to draw the final conclusions about dynamics of the population system of pink salmon. At the same time, it has become evident that new interesting aspects have arisen in studying marine life period of pink salmon.

Table 2

Pink salmon biomass (thousands tons) in 1993 according to data of coastal and offshore accounts

Region	Catch	Within spawning-grounds	In all, from coastal accounts	Offshore accounts
East Kamchatka (including the Karaginsky and Olyutorsky Bays)	51.6	30.0	81.3	63.0
Sakhalin-Kuril -Hokkaido	50.6	22.3	72.9	150.3
Northern Sea of Okhotsk	9.0	46.0	55.0	
Total	111.2	98.3	209.5	213.3

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CAPTIONS TO FIGURES OF PAPER:

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Figure 1. Diagram of regions of the biostatistical information averaging (boundaries of regions are dotted lines, numbers are digits within squares). Biomass of macroplankton within 0-50 m layer: 1 - less than 30; 2 - 30-60; 3 - more than 60 t/sq.km; biomass of squids within 0-50 m layer: 4 - less than 0.26; 5 - 0.25-0.5; 6 - 0.5-1.0 t/sq.km; biomass of salmons: 7 - less than 0.1; 8 - 0.1-0.3; 9 - more than 0.3 t/sq.km

Figure 2. Distribution of salmons' catches in the Sakhalin-Kuril region, July 13-28, 1993.
1 - 0; 2 - less than 10; 3 - 10-50; 4 - 50-100; 5 - more than 100 specimens/hour of trawling.
Isolines - generalized diagram of currents; digits underlined - average coefficient of maturity of females.

Figure 3. Points of king salmon catching in the Sakhalin-Kuril region in July-August, 1991 and 1993.
1 - 1993; 2 - 1991.
Isolines - generalized diagram of currents in 1993.

Figure 4. Points of the pubescent coho salmon catching in the Sakhalin-Kuril region in July-August, 1993.
1 - 1993; 2 - 1991.
Isolines - surface temperature in 1993.

Figure 5. Distribution of the chum salmon catches in the Sakhalin-Kuril region, July 13-28, 1993.
1 - 0, nonpubescent chum salmon; 2 - less than 5; 3 - 5-10/hour of trawling, pubescent chum salmon; 4 - less than 5; 5 - 5-10/hour of trawling.

Table 1.

Biomass (thousands tons) of salmons in the Sakhalin-Kuril waters, July 13-28, 1993

Regions	Pink	Chum		Sockeye		King	Coho	Salmon trout	All species (thousands tons)
		pubescent	nonpubescent	pubescent	nonpubescent	nonpubescent	pubescent	nonpubescent	
1	0.16	0.30	0.09	-	-	-	-	-	0.55
2	12.14	3.33	0.59	-	-	0.27	0.41	0.06	16.80
3	9.56	2.20	0.20	-	-	-	0.20	-	
4	2.35	-	-	-	-	-	-	-	2.35
5	29.16	3.32	0.40	-	0.01	1.01	-	-	33.90
6	4.11	2.08	0.36	0.23	-	-	0.07	-	6.85
7	2.08	-	0.07	-	-	-	-	-	2.15
In all 1-7	59.56	11.23	1.71	0.23	0.01	1.28	0.68	0.06	74.76
8	24.04	4.21	0.49	1.18	-	0.63	1.10	-	31.65
9	34.56	1.62	1.23	0.12	-	0.54	1.62	-	39.69
10	17.33	0.41	1.85	-	-	0.18	0.38	-	20.15
11	10.59	1.38	-	-	-	0.22	0.08	-	12.27
12	4.18	0.96	0.49	-	-	-	0.25	-	5.88
In all 8-12	90.70	8.58	4.06	1.30	-	1.57	3.43	-	109.64
In all 1-12 (1993)	150.26	19.81	5.77	1.53	0.01	2.85	4.11	0.06	184.40
In all (1991)	297.2		20.1		2.5	6.1	3.8	0.4	330.1

UDK 597.553.2 (265.53) Ichtyology

INTERANNUAL CHANGES IN ANADROMOUS MIGRATIONS OF SALMONS IN WATERS OF THE SAKHALIN-KURIL REGION

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Abstract

The paper is based on data of detailed complex survey carried out in July-August, 1993, in the southern Sea of Okhotsk (to 53°N) and Pacific waters off Kuril Islands. Biomass of all salmons was determined at 184.4 thousands tons that is much less than similar estimates in 1991 (330 thousands tons). The peculiarities of distribution of particular salmon species are considered against a background of anomalous oceanological situation. It is assumed that approximately one-half of pink salmon accounted in the Sakhalin-Kuril region (150 thousands tons) has been redistributed during anadromous migrations to the north-eastern Sea of Okhotsk and western Bering Sea.

5 Figures, 2 Tables, 16 References.

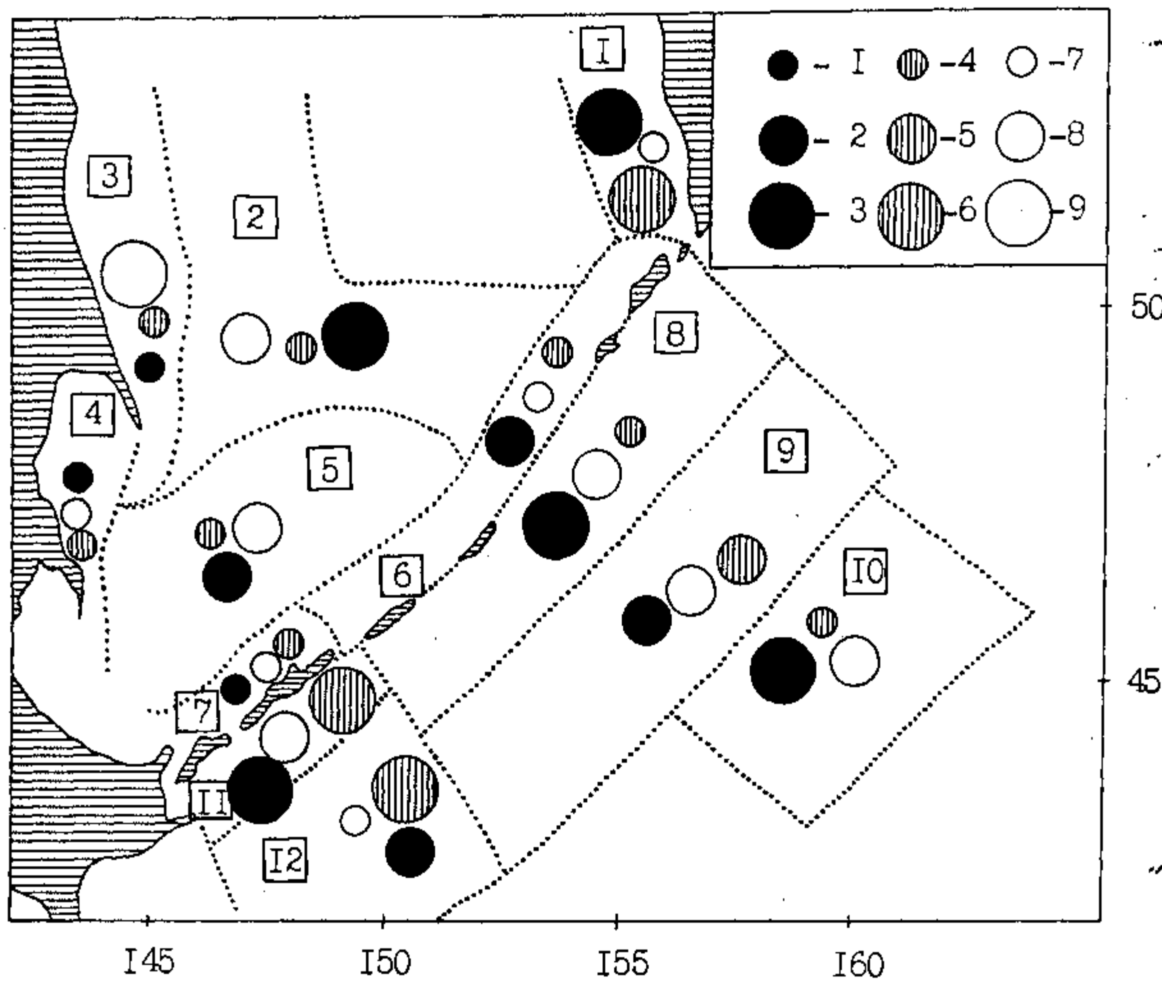

Fig 1

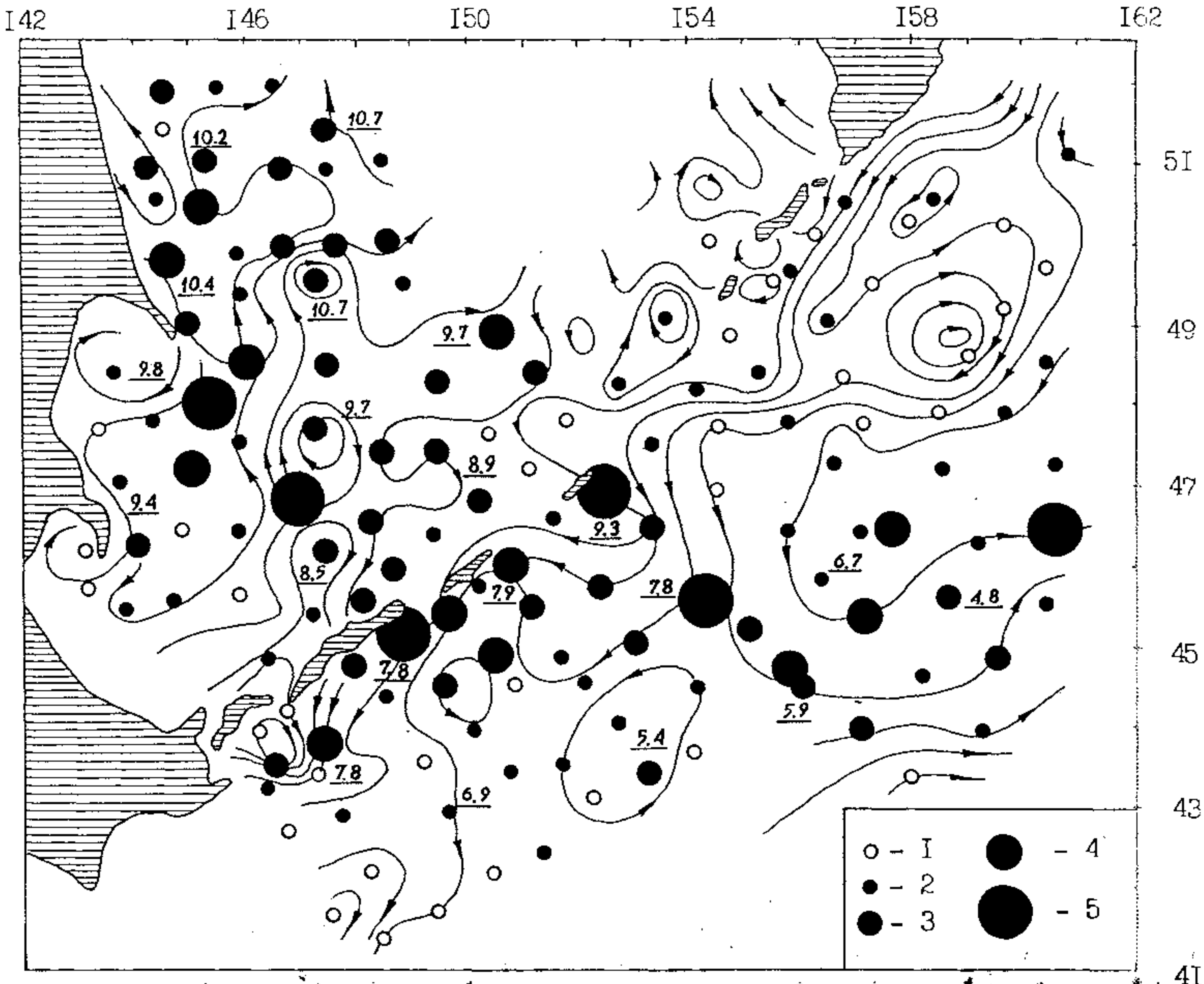
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Fig 2

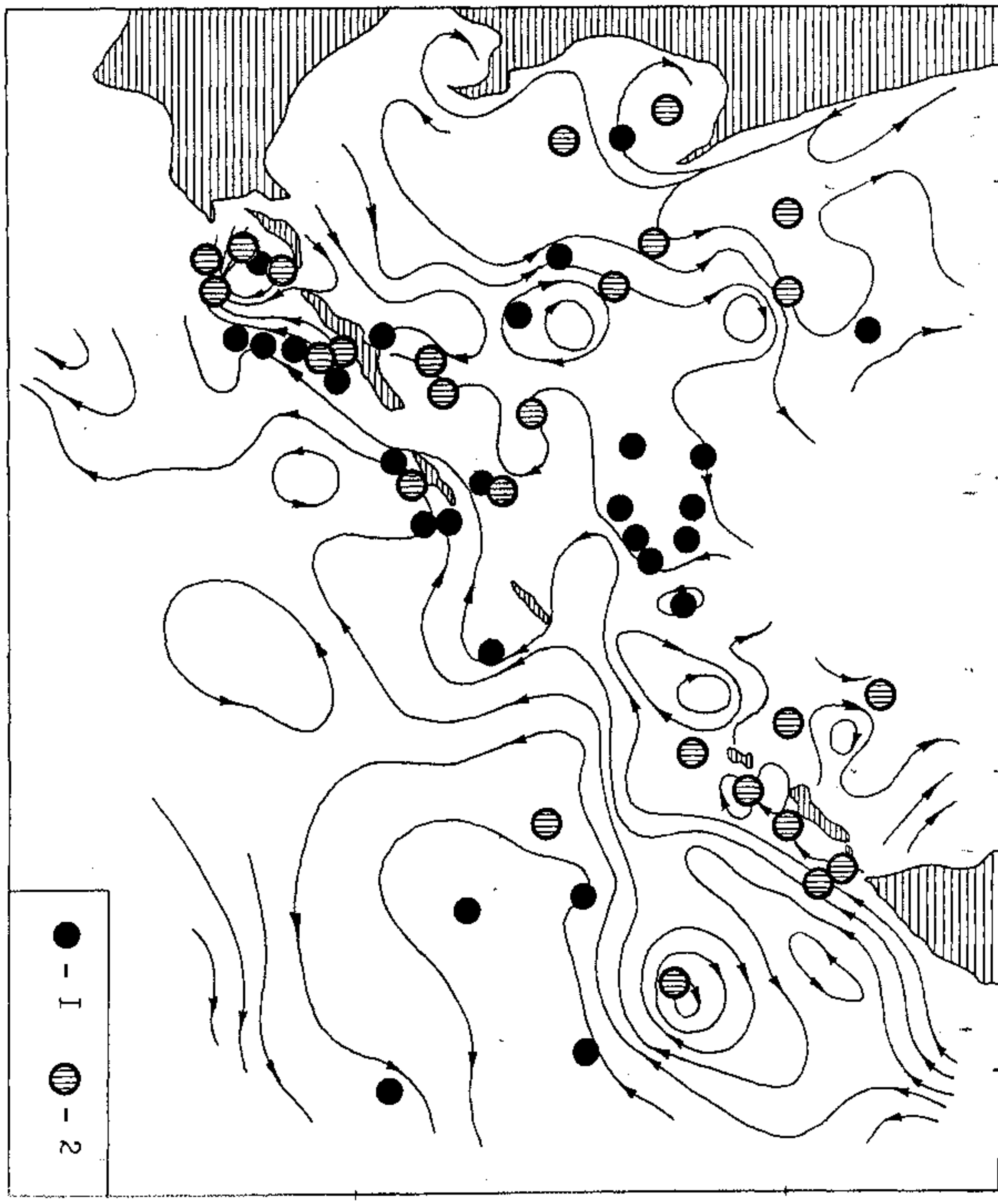

Fig 3

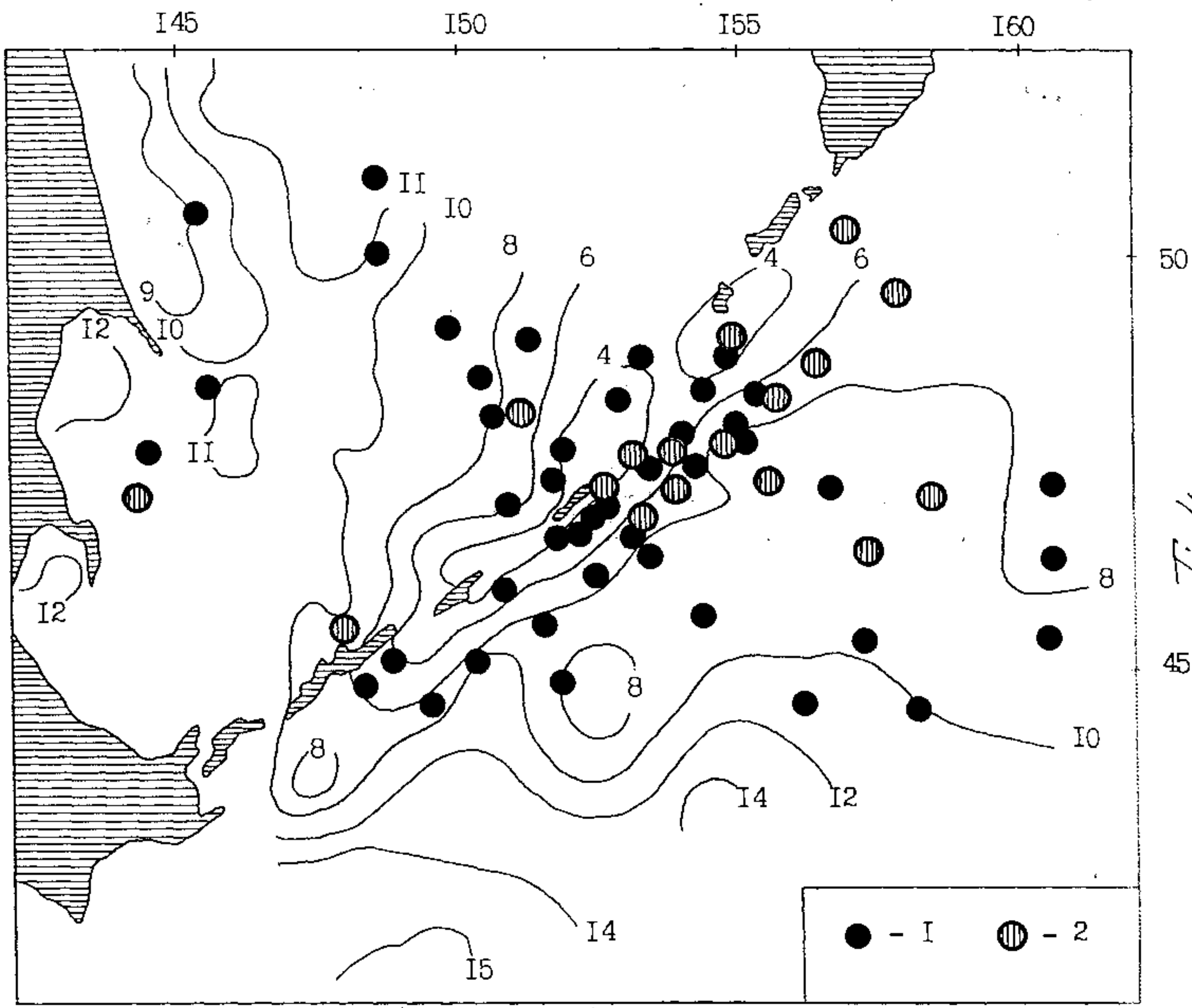

Fig 4

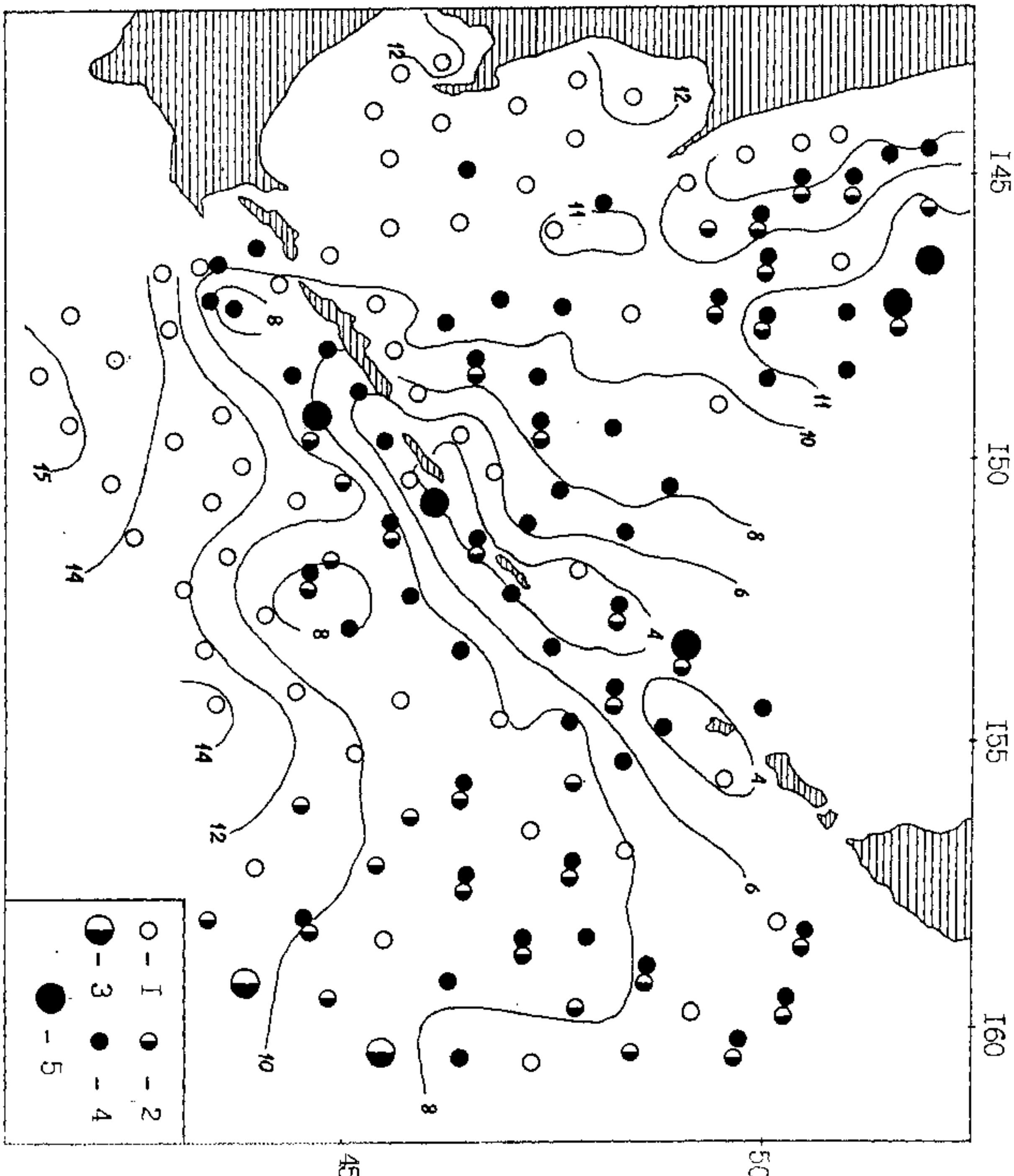

Fig 5

Рис. 5. [illegible]
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