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NEW INFORMATION ON THE MARINE PERIOD OF LIFE AND THE MARINE FISHERY OF PACIFIC SALMON

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For many years the need of studying the marine period of life of the salmon had been realized but only in 1955 was systematically-planned work along these lines commenced by TINRO. Since then, expeditions have covered a good part of the region of the north-west Pacific known to be frequented by the salmon. The studies were of a very complex nature, involving the distribution, migration, feeding and other features of the biology of the salmon themselves, plankton studies and hydrological surveys. The extent of these operations was quite limited (usually made by one vessel) but nevertheless the information obtained and material collected contributed much new knowledge concerning the marine period of the salmons' life. The amount of material and of data obtained was quite considerable. This report will be restricted only to certain questions relating principally to the salmon of Kamchatka, since the latter without question predominate in all the waters which have been examined.

On the migrations and certain features of the dispersion of the salmon in the north-west section of the Pacific Ocean

The vast majority of the salmon which feed in the north-west area of the Pacific migrate to spawn in the rivers of the Kamchatka Peninsula. Concerning the routes of these migrations we have had up to the present time extremely limited and in many respects quite erroneous knowledge. It was the general understanding, for example, that the chums, pinks and sockeye returned to the Kamchatka coast along two routes: in small numbers from off Hokkaido along the Kurile Island chain, and in large numbers - past the Aleutian-Komandorsky Islands to Cape Kronotsk on the east coast of Kamchatka. It was assumed that only the West Kamchatka salmon used the first-named route and that the second was used both by those fish which, spawning in the rivers of West Kamchatka, turned southward at Cape Kronotsk to Kurile Strait and by those returning to the East Kamchatka coast. In other words, it was thought that, firstly, there were present in the north-west Pacific two separate regions in which the salmon spent the winter: one, in the vicinity of Hokkaido and the southern Kurile Islands, and another, lying south of the Aleutian Islands, and secondly, the salmon migrations from these regions to the Kamchatka coast confined to the above-mentioned routes.

For the West Kamchatka pinks, as also for the other salmon, the first migration route - from Hokkaido - was considered the minor one [p. 152] and the second - from the Aleutians - the main one, i.e., that region of the Pacific, lying south of the Aleutian Islands chain, was considered as the main wintering area for the Kamchatka pinks in general. Thus, between the chums, pinks and sockeye there was assumed to be no distinction, neither in regard to the route of migration nor consequently, in regard to the dispersion throughout the period of ocean residence. But actually certain differences do occur. The picture of the dispersion and migration of salmon in the north-west Pacific differs considerably from that as presented above.

Observations reveal that along the east coast of Kamchatka and the Kurile Islands the salmon of all species migrate in a wide front, the extent of which (Fig. 1) closely corresponds to the general expanse of the designated land regions and emphasizes the vast magnitude of the initial region of migration.

The pinks, in the period preceding their concentration in coastal waters east of Kamchatka and the Kurile Islands, are distributed in the ocean north of the Kurosio drift and the North Pacific current almost from the coast of Japan itself to the Rat Islands where their zone of occurrence overlaps, apparently, that of American pinks. Therefore, the view must be rejected as not conforming to the facts, that there exist in the north-west Pacific two regions where the pinks spend the winter: one to the south-east of Hokkaido and the other south of the western part of the Aleutian chain. As a matter of fact there exists, extending right along the Kurosio drift and the North Pacific current, but one region where the pinks spend the winter, the outer parts of which lie in the designated area.
Without going into detail at present, it can be said that the West Kamchatka pinks spend the winter in the western half of this district, and the East Kamchatka ones - in the eastern. Thus the routes of the spawning migrations of these stocks in the main are separate.

The great majority of West Kamchatka pinks migrate in a wide front from the south-east and from the south directly to the Kurile Islands area. And those fish which appear in the north Kurile area on the East Kamchatka side approach this same part of the southern area of the coast also from the south-east and not from Cape Kronotsk.

It is necessary to take into consideration the fact that in the waters of the north Kurile Islands the catch of pinks with set nets begins, as a rule, in the third 5-day period of June, when neither at Cape Kronotsk nor in the adjacent sections of the east coast of Kamchatka are pinks ever present in any appreciable numbers.

In the Cape Kronotsk area heavy concentrations of pinks occur only after June 20th and they are migrating not to the south but to the north. This is indicated, firstly, by the fact that, off Capes Kamchatka, Kronotsk and Shipunsky, in the latter part of June (viz. 26, 27 and 30) pinks which are caught in the drift nets set at right angles to the coast are headed northward. Secondly, the catches off Capes Kamchatka and Kronotsk consist mainly of males, but to the south, off Cape Shipunsky, females occur in considerable numbers. In this regard it is well known that a complete absence of females or a large predominance of males characterizes, generally, the early foremost schools of pinks. This means that the pinks are actually moving, not from Cape Kronotsk to Cape Shipunsky but, on the contrary, from Cape Shipunsky to Cape Kronotsk.

Apparently, then, this is one of the chief directions of migration of pinks to the north-east Kamchatka rivers: They approach the coast from the south-east in the vicinity of the Gulf of Avachinsky and from Cape Shipunsky follow the coast to the north, toward Bering Sea.

[p. 153] In 1955 the migration pf pinks past the Komandorsky Islands in the direction of Cape Kronotsk was extremely poor. Single individuals and small groups (almost entirely males) began to show up around the Blizhnee (Near) Islands and on the way toward Cape Kronotsk only in the third 5-day period of June, when surface water temperatures were, in these areas, 4-5°. Up to the end of June the run of pinks in this direction remained about the same (Fig. 2). Consequently, from this general area there was no important run of pinks to Cape Kronotsk, at least prior to mid-July. It is thus even more improbable that any large runs of pinks, bound for West Kamchatka rivers, would go by this route.

[p. 154] But in years which are warmer than 1955, the migration in this direction is much stronger and commences earlier. Naturally, a great deal depends on the magnitude of the runs migrating along these routes.

A considerable or even a large part of the run of pinks in the Oliutorsky-Karaginsky region migrates across the deep-water areas of the Bering Sea, but, apparently, in normal years - not earlier than the second half or third decade of June. Prior to this time the surface water temperatures in the open and offshore areas of the Bering Sea (usually less than 4°) are still too low for pinks - at such temperatures pinks in any appreciable numbers are seldom encountered.

Thus, the distribution and migrations of East Kamchatka and West Kamchatka pinks are basically separate. This conclusion has been confirmed, by the way, by the results of the tagging of salmon by American investigators in 1957; 20 tagged fish, a number of which had travelled, without any doubt, over the Bering Sea deeps, were caught a second time in the waters of the East Kamchatka and Oliutorsky areas and not one was found on the west coast of Kamchatka (Fig. 3).

The East Kamchatka stocks of pinks, as is well known, are much smaller than the West Kamchatka (in some years scarcely one tenth as great), therefore, for the Kamchatka pinks as a whole the east and west sections of their marine feeding zone are by no means equal in importance. This is apparent, for example, from the results of the fishery. In the Blizhnee Islands region the pinks made up not more than 7% of our catches, or 2-3 fish in a 500-metre drift set. Further west, however, between 155° and 165°N and 250-300 miles from the Kurile Islands, in the same decade of June and at the same water temperatures, the proportion of pinks fluctuates between 60 and 96%, or, in the same 500-metre drift set, from 20 to 40 fish.

A similar relationship is found when data from the Japanese salmon fishery are analyzed. East of 170°N the Japanese [p. 155] usually catch less than 10% of all the pinks taken which amounts to not more than 10% of the total catches of salmon in the region. Meanwhile, near the southern part of the Kurile Islands in 1955, for example, the proportion of pinks was more than 35% of the total catch. In a word, the region of the Pacific, contiguous to the Kuriles and Hokkaido, is of much more importance for Kamchatka pinks, as a feeding and wintering place, than the regions adjacent to the Aleutian Islands. The situation is quite different for chum and sockeye salmon.

The zone of residence of all these salmon in the north-west Pacific is without any question one and the same but for chums and sockeye the eastern part of this zone, adjacent to the Aleutians, is appreciably more important than the western. Here, as distinct from the pinks, winter many chums and sockeye not only from East but also from West Kamchatka. The region occupied, in the north-west Pacific, by the West Kamchatka population of chums and sockeye extends to the east further than the limits of the area occupied by the West Kamchatka pinks. In any case, the migrations of chums and sockeye to the west coast of Kamchatka from the area lying south of the Aleutians had been determined over a period of 13 years of Japanese investigations and not further back than the summer of 1957 were two chums caught on the west coast of Kamchatka which had been marked in Aleutian waters by the Americans (Fig. 3).

But throughout this region, lying to the south of the Aleutians, the chums and sockeye of East Kamchatka predominate, apparently. If a comparison be made of the relative importance of this geographical region as a feeding and wintering area for each of the three species in question, it will be found that it is of greatest value to the chums and sockeye, in conformity to the relative importance [p. 156] of the rivers of East Kamchatka for spawning in comparison with the rivers of West Kamchatka. In the rivers of East Kamchatka, in the majority of cases, there spawns not more than one-fifth of the annual commercial stock of pinks, but of chums and sockeye, roughly speaking, just about one-half of the stock. The already-described features of the pre-migratory distribution of the chums and sockeye clearly govern the time of migration. The front along which both these species approach the east coast of Kamchatka and the Kurile Islands is as wide as for the pinks but the main direction of travel is different. For the chums and sockeye the region of greatest concentration during the winter and the main direction of the spawning migration is shifted to the east and north-east in comparison with the pinks. Most of the chums and sockeye migrate along a front several hundreds of miles wide to various parts of the east coast of Kamchatka, from where a good part of the fish proceed southward along the coast to the north Kurile Strait and then up along the west coast of Kamchatka. But quite a few chums and a certain number of sockeye come up the north Kurile Strait from the south and south-east, i.e., directly from the open ocean (see Fig. 1).

The sockeye complete (and probably commence) their migration from off Hokkaido along the Kurile Chain much earlier than the chums. In August, 1956, in a direction along the Kurile Chain to the south, mature sockeye were encountered only up to the southern end of the Onekotan Islands, the chums likewise, although in much fewer numbers - almost up to Diana Strait (Fig. 4). This circumstance in combination with the presence of the spring run of sockeye and its more northerly distribution with respect to the Asiatic and American Pacific coasts is indicative, as we interpret it, of a somewhat unequal reaction of both fishes to temperature conditions. The sockeye are more cold-loving than the chums. As indicated below, this is confirmed by the allocation of these salmon to summer feeding areas. Another important difference between them is the fact that for Kamchatka [p. 157] the Hokkaido area is of relatively less significance than for the chums. As for the Aleutian area, however, the reverse can be said: the main mass of sockeye proceed to the rivers of the Kamchatka Gulf mainly from here. What has just been said conforms to the established distribution of sockeye in the Pacific basin from west to east: they are absent in the Japan Sea and are very scarce on the west and north coasts of the Okhotsk Sea; in Kamchatka their numbers suddenly increase, as indicated by the series of years (1936-1947) when on the east coast of the peninsula the catch was much greater than on the west; a greater number of sockeye are caught in American waters, where they, as is well-known, surpass the number of chums.

But the Hokkaido and Aleutian areas of the wintering chums and sockeye are not as isolated one from the other as formerly was thought and they represent only extreme sections of the region within the boundaries of which these fish winter. The broad extent of this region corresponds with the wide front of the spawning migration of both species, which are headed simultaneously to different points along the east coast of Kamchatka and the Kurile Islands.

A study of the salmon in the wintering areas was carried out in January, 1958, and April, 1959. In the latter case it corresponded with the commencement of the spawning migration. Chinooks and spring sockeye were migrating. The main mass of pinks, cohos, summer sockeye and the bulk of the chums and Kamchatka Atlantic salmon were still, apparently, in the area where they had spent the winter. The distribution of the various species is established by the following temperature boundaries: sockeye - from 1.5 to 6, chums - from 1.5 to 10, pinks - from 3.5 to 8.5, coho - from 5.5 to 9, Atlantic salmon - from 5° to 8° (Fig. 5).

[p. 158] When we speak of the spawning migration of salmon, we cannot represent the situation by assuming that each group of the fish, reaching sexual maturity, separates itself from all the remaining mass of salmon which had been wintering in the ocean and proceeds to spawn, while the remainder continues to feed, carrying on its own feeding migration, quite separate from the first-named group. Actually, with the coming of spring, in accord with the warming of the surface ocean waters, the whole mass of feeding salmon, together with the fish which are maturing, leave their wintering areas and migrate to the north, shifting to the summer feeding areas. As the surface ocean waters warm up the migrations of these fish become more and more extensive. In August and September, i.e., at the period of maximum warming of the surface waters, the southern boundary of dispersion of the feeding sockeye in the north-west Pacific is the surface isotherm 12°, for chums - 13.5-14°. The position of this boundary in different years may naturally change in accordance with the Kurosio current. In August, 1956, it passed 150-300 miles east of the northern part of the Kuriles, 400 miles south of the Komandorskys and approximately 200 miles south of the Blizhnee Islands. In the zone of displacement of the moderately cold and subtropical waters, where a temperature range of 15°-17° in the surface stratum was observed, feeding salmon never occurred in the period mentioned.

In short, the salmon carried out in the sea, within the limits of the above-mentioned isotherms, seasonal migrations of approximately the same character as we found among sardines, saury, scomboroids, anchovies and a number of other pelagic-feeding species in the Pacific. During the spring and summer they occur in the north, extending into the northern regions of the Bering and Okhotsk Seas and, with the approach of autumn and winter cooling, the fish which do not reach maturity in that year proceed back to the south. In other words, it seems that the spring-summer salmon migrations display, in informal fashion, that common tendency to move north which, along with the warming of the water, is observed in the many different forms of animals, inhabiting the subtropical-boreal region of the northern part of the Pacific.

[p. 159] At the beginning of August immature chums, chinooks and sockeye are concentrated in large numbers directly off the south-east coast of Kamchatka, the north half of the Kurile Islands and the Aleutians (Fig. 6). Since at this time the run of mature fish of these species is almost over, the proportion of immature fish in the catches increases appreciably. Observations indicate that around 50% of all sockeye and 80% of all chums, caught in Kurile Island waters and off the East Kamchatka coast in August, had not yet reached maturity (Table 1; from data collected by the expedition).

Table 1. Condition of the gonads of chum, chinook and sockeye salmon, in different parts of the catch area

Species	Number of fish	Per cent with gonads in stage of maturity I	II	II-III	III	III-IV	V
Blizhnee Islands (Aleutian region), 13-18-VI, 1955							
Chums	157	2.5	5.7	54.8	37.0	-	-
Sockeye	31	-	6.7	83.6	9.7	-	-
Waters of the east coast of Kamchatka and north Kurile Islands, 26/VI-18/VII, 1955							
Chums	176	5.7	18.8	18.8	29.0	42.5	-
Sockeye	73	-	8.2	47.9	30.2	13.7	-
Aleutian area (from 170°W to 180°), 25/VIII-5/IX, 1956							
Chums	114	-	64.0	34.2	0.9	0.9	-
Sockeye	8	25.0	37.5	37.5	-	-	-
Chinook	5	-	20.0	80.0	-	-	-
Waters of the east coast of Kamchatka and north Kurile Islands, 26/VII-9/IX, 1956							
Chums	296	16.9	63.6	3.0	5.4	7.4	3.7
Sockeye	130	12.3	36.4	-	26.9	22.2	2.2
Chinook	6	-	66.6	16.7	-	16.7	-

The sex products of these fish were found to be in the early stages of development (I, II, II-III). As a rule, only the females were in the II-III stage. Some of them were in this stage as winter approached and, possibly, spent the winter in stage III. This may explain perhaps why in May and early June in the Pacific area, 500-700 miles from the nearest coast, there were sometimes chum and sockeye females with fully developed sex products.

Neither in the regions of concentration of immature chums and sockeye nor south of them, as far as the Kurosio front, did we encounter any pinks which would seem to suggest that in this year there were none going to spawn: in August all the pinks where we were able to see them (and we did find them only on the coast) had ripe sex products and were without question proceeding to the river. Thus, the hypotheses suggested by A. P. Vedensky of a 4-year life cycle for pinks was not confirmed.

[p. 160] Brief note on the feeding of salmon in the sea.

The rapid growth of salmon in the sea and their early maturing attests to the extremely intensive and effective utilization by them of the food resources of the sea. Salmon continue to feed up to the time of the spawning migration. Perhaps it would be correct to say that the migration of those fish that, in the current year, go to the rivers for spawning commences at the same time when also the rest of the fish move, i.e. shift, to the summer feeding grounds. Only the attainment, during the process of migration, of a certain degree of maturity of the gonads brings about the spawning migration. But up to the arrival in the brackish zone of the inshore waters the salmon do not cease to feed.

The composition of the food of these fish is very varied. In the stomach contents of salmon, migrating from different regions of the Pacific to the coast of Kamchatka, more than 60 forms of animals were noted, namely: over 14 species of fish, among them young cod, Alaska pollack, flounders, lingcod, cottids, ocean rockfish, agonids, liparids, cyclopterids, eel blennies, dolphins, silver anchovy, saury, sandlance, Japanese anchovy (Engr. japonicus Schl.) and others; more than 22 species of pelagic crustaceans, among them 5 species of euphasiids, 10 species of hyperiids and 7 species of calianids; 2 species of pteropods (Clione limacina and Limacina helicina); young squid and octopus; hydroid medusae, salps, holothurians and a series of other organisms.

For chums in June-July up to 40% of all their food was made up of pteropods. In the food of the pinks, pteropods are much less common, whereas the pinks consumed fish and their young (30%) in much greater numbers than chums. In this regard they surpass the sockeye but like them they feed to a considerable extent also on euphausiids and hyperiids (Table 2). Each species of salmon has, thus, certain favourable food organisms but in general these fish [p. 161] have also a considerable food plasticity. Therefore, it will not be easy to link the distribution of salmon to the migration routes by means of the distribution of certain food organisms.

The feeding, as referred to above, is carried on not only by the salmon going to spawn but by the immature fish occurring with them in June-July. The feeding of the latter in late summer and autumn was marked by a marked increase in the percentage of fish in the diet (Table 3). The cause of this is simply, apparently, that the heavily-feeding spawning schools of salmon and to a certain degree other fish too (e.g. pollack) eat heavily during summer on the available zooplankton and by autumn its biomass is severely reduced. Thus, for example, according to the calculations of B. M. Mednikov, the biomass of the crustacean Calanus cristatus 100 miles off the Kamchatka coast decreased in 1956 from 100-110 mg/m^3 in the second half of May to 8-10 mg/m^3 in the first 10 days of September, i.e., about 90% (90-100 mg/m^3) were eaten. Furthermore these figures must be considered minimal since in September the plankton catches were from a depth of 500 m. while in May the copepod biomass was computed only from 200 m.

Table 2. Percentage composition of the food components of salmon and the number of species of individual zoological groups (June-July, 1955, according to L. D. Andrievsky).

Food component	Keta		Pink		Sockeye	
	Number of species	%	Number of species	%	Number of species	%
Fish and their young	8	8	14	30	10	8
Pteropods	2	40	2	9	2	11
Euphausiids	5	16	5	27	5	31
Hyperiids	8	5	4	23	7	22
Calianids	5	6	7	5	5	13
Hydroid medusae	1	+	1	+	1	5
Salps	1	10	1	+	1	3
Holothurians	1	5	-	-	1	+
Miscellaneous	-	10	-	6	-	7
Total index of fullness in June-July, °/ooo	55		62		24	

Table 3. Percentage composition of food of chums and number of species of individual zoological groups (1956, according to L. D. Andrievsky).

Food component	May-June		August	
	Number of species	%	Number of species	%
Fish and their young	4	2.05	4	52.38
Pteropods	2	17.03	1	5.95
Euphausiids	1	60.04	1	0.45
Hyperiids	4	9.27	4	6.16
Calianids	1	2.22	3	0.51
Octopi	2	1.83	2	7.91
Polychaetes	-	-	1	25.93
Miscellaneous	8	7.56	3	0.71
General index of fullness, °/ooo	35.7		17.0	

In 1957 the biomass of Calanus cristatus in a standard tow south of Petropavlovsk was reduced from 10,650 in July to 3,160 mg/m^3 in September. The general decrease in biomass of this copepod per square metre of surface of the ocean amounted, from June to September, to 7.9 g. The decrease in biomass of Calanus tonsus in the same period was 9.24 g per m^2, and Eucalanus bungii 7.05 g. Consequently the total decrease in biomass of these three chief species of Calanids amounted approximately to 24.19 T per km^2, which figure must be considered low since, because of the insufficiency of material, the August generations of Calanus tonsus and Eucalanus bungii were not counted.

It was impossible to obtain the essential data on the extent of consumption of other plankton forms, but it can be assumed that some of them would be eaten no less completely than the calanids. The euphausiids, for example, occupy in the feeding of salmon a much greater place; the percentage importance [p. 162] of euphausiids in the food of chums dropped from 60.04% in May-June to 0.45% in August (Table 3). Under these conditions it is extremely important to note that, with the salmon, certain other fish, in particular sauries and Japanese anchovy (Engraulis japonicus Schlegel), moved northward during the summer. The assumption of the amphi-Pacific dispersion of these fish hardly conforms to what actually is the case: undoubtedly these fish are of the open sea with a trans-Pacific distribution, i.e., schools of these fish do not occur in inshore coastal waters. In August and early September we found anchovies up to 175°W, i.e., 2400 km east of Honshu. In some southern regions of their dispersion the salmon consume both fish in quite large numbers.

The wide spectrum of the feeding of salmon must apparently be considered an indication that restricting the salmon schools to a few of the most favoured foods is too unsafe and that for these fish the pressure or strain of the intraspecific and interspecific competition for food is considerable. The food plasticity of salmon undoubtedly is a means of overcoming this competition: it represents an important adaptive feature. Moreover at the present time as a result of the appreciable decline in the stocks

of Far-Eastern salmon the supplies of food for these fish in certain areas of the ocean are to a great extent unutilized.

Some remarks on the high-seas fishery

Since 1952 there has been a quite intensive high seas fishery for Far-Eastern salmon. Suffice it to say that in 1957 salmon in the North Pacific were sought after by over 1300 Japanese vessels. Of these 863 operated south of 48°N and west of 160°E and were based at Hokkaido ports; the remainder fished north of 48°N in an area extending to the eastern section of the Aleutians, and on 16 factory ships more than 120,000 tons were processed. The fleet took, in all, 122 million salmon.

The condition and characteristics of the high-seas salmon fishery are determined by the special peculiarities of the runs and the distribution of the fish. One of these characteristics is the fact that in the offshore waters of the Pacific the salmon are not thickly congregated but move in small schools or singly. It is but natural, then, to imagine that the width of the migration front is quite broad. From May to June, 1957, for example, the Japanese drift-netters, operating from motherships, used, for a catch of 60,358,000 salmon, 7,158,000 net sets with a total length of 358,000 km. The average daily catch of one net, 50 m long, did not exceed, in consequence, 8.5 fish and in a gang of nets 1 km long - 170 fish. In the fishing areas the catch per net was as follows: Aleutian Islands (east of 170°E) - 7 fish; Pacific coast of Kamchatka and Kurile Islands - 8 fish; Okhotsk Sea (close to south-west coast of Kamchatka) - 18 fish.

Since, in their approach from the various sections of the ocean, the salmon concentrate in greater and greater numbers close to the coast, the Japanese annually direct a considerable number of their fishing vessels to the Okhotsk Sea, the south-west coast of Kamchatka and in July concentrate their factory ships, which are operating in the ocean, in the immediate vicinity of the east coast of Kamchatka and northern Kurile Strait. The congregating of several hundred vessels and a great number of drift nets close to the approaches to Kurile Strait and the mounts of the Kamchatka rivers, within [p. 163] the limits of a relatively small area, represent one of the most dangerous consequences of the Japanese salmon fishery for the salmon industry of Kamchatka. This has already been observed since the abundance of salmon in the afore-mentioned rivers has declined quite considerably.

Another extremely adverse feature of the high-seas fishery is the catch of immature fish. In 1956 and 1957 the Japanese fishery vessels caught in the offshore waters of the north-west Pacific and the adjacent waters of the Okhotsk and Bering Seas a large number of chums and sockeye of those age classes which would make up the main spawning runs in 1958.

Among the fish caught in immature state there are not usually any which have spent less than two summers in the sea. These fish are very readily taken in nets of 55-60 mm mesh.

But of fish of the same age the immature salmon, living together with the mature ones, are somewhat smaller than the latter, from which it follows that it is not of economic or biological advantage to catch such fish. Therefore, it is extremely desirable that the fishery for salmon on the high seas should be closed not later than the end of July, i.e., prior

to the concentration of the large mass of immature chums, chinooks and sockeye in the immediate vicinity of the coasts of Kamchatka and the Kurile Islands.

That section of the Pacific, lying north of the Kurosio drift and North Pacific current may be termed salmon water since the salmon occur here in predominantly commercial sizes and their dispersion here from west to east is practically uninterrupted. Moreover, such fishing pressure, as at the present time applied to the Asiatic stocks of salmon, can lead to a situation wherein, in the southern parts of these waters, the stocks of salmon become scarce.

At the present time the Asiatic salmon runs are being fished much more intensively than the American since, due to the present disposition of the Japanese commercial fishing fleet, it is operating almost exclusively on the salmon that are produced in our rivers. It is impossible to consider such a situation normal. The situation would be normal only if the exploitation by the Japanese salmon fishery were applied equally to both the Asiatic and American runs. This should be the goal.

The question of regulating the exploitation resulting from an active commercial fishery in the sea on the separate runs of Far-Eastern salmon is indeed a very important one. At the present time this exploitation is carried on quite without any regard for the condition of the runs being fished and their reproductive potentials. To regulate it is quite possible. In order to accomplish this it is necessary to determine the time and extent of the operations of the fishing fleet in the various parts of the fishing zone up to the time the commercial fishery in the several regions is closed. Some steps in this direction might be undertaken now. As far as the inshore coastal waters are concerned no special knowledge is required. It is abundantly clear that for the conservation and restoration of the depleted stocks of pinks in the south-western rivers of Kamchatka it is necessary at certain times to fully prohibit fishing along the west coast. But it is quite impossible to achieve this end by introducing protective measures in coastal waters, in the vicinity of the spawning streams. It is essential, therefore to protect the runs of salmon from the excessive fishing throughout the extent of their migration. But in order to accomplish this it is necessary to know clearly where the fish feed in the ocean and the migratory path of each main run of salmon and also the length of its stay in the different fishing areas. Meanwhile, we consider this our main problem and look for future studies to provide a practical solution to it. [p. 164]

Conclusion

An understanding of the series of very interesting and important features associated with the effective maintenance of abundant populations of salmon cannot be considered more than basic up-to-the-present assumptions, and these will not explain even in general outline the conditions of life of these fish in ocean waters. Most of the facts indicate that these conditions have an influence on the dynamics of the abundance of salmon much more strongly than was previously thought. To the study of the mechanism and extent of this influence attention must be seriously paid. It is clear that one must investigate each run of salmon whose feeding grounds in the sea and migratory paths have been studied only in a preliminary way.
Suffice it to say, as a basis for the study of this problem (the first step in its solution), it is again essential to understand the localization of the

various runs of salmon in the sea. In order to do this it is necessary to increase the actual field operations and the studies being made. No other fishery-biological studies can contribute as much knowledge of the water masses in the north-west Pacific, as a study of the marine period of life of the salmon, if the appropriate studies be carried on actively and with greater means than at present.

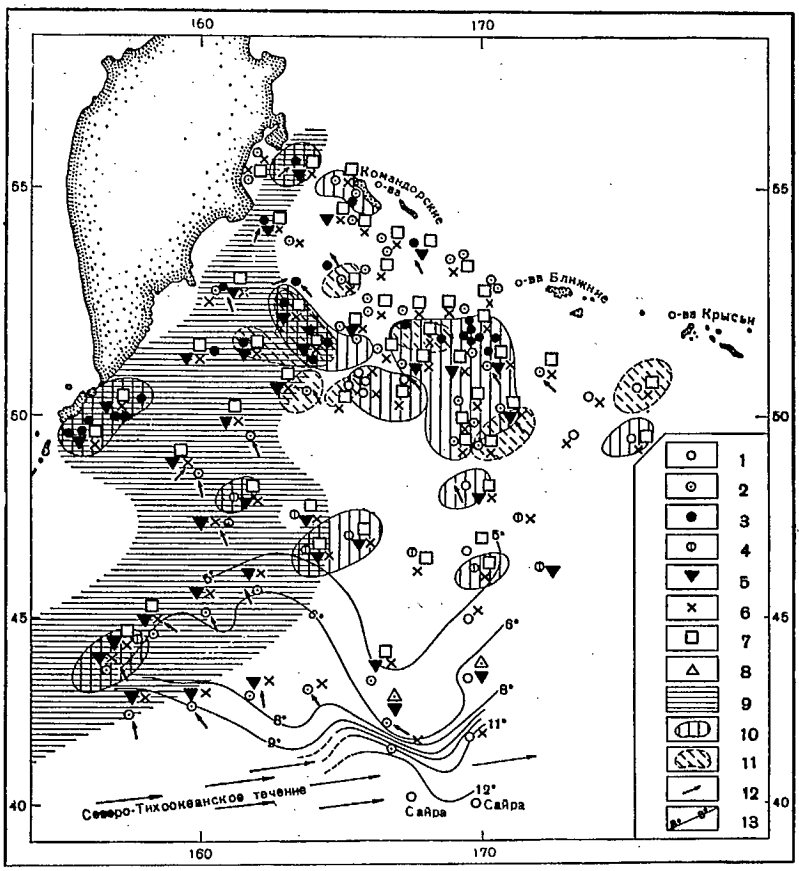

Fig. 1. Distribution of salmon in the northwest Pacific in May-June (from the 1955-1957 data). Drift net locations: 1 - in second half of May; 2 - in first half of June; 3 - in second half of June; 4 - at the beginning of June, 1956; 5 - pinks; 6 - chums; 7 - sockeye; 8 - coho; 9 - greatest concentration of pinks; 10 - the same for chums; 11 - the same for sockeye; 12 - direction of fish movement; 13 - surface isotherms at the end of May and in first half of June, 1957.

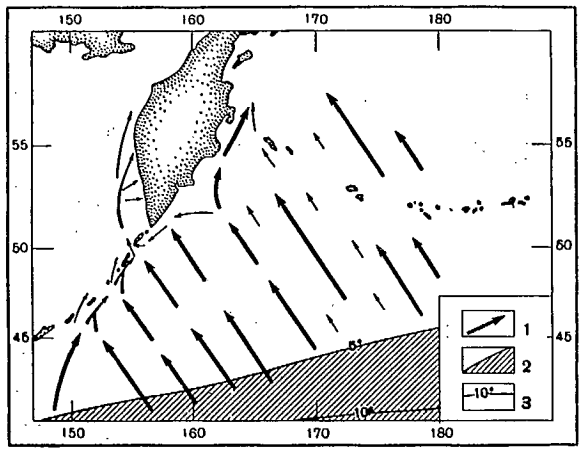

Fig. 2. Suggested route of spawning migration of Kamchatka pinks in the northwest Pacific. 1 - direction of migration; 2 - suggested area of ocean residence prior to migration; 3 - surface isotherms in February (from the Ocean Atlas).

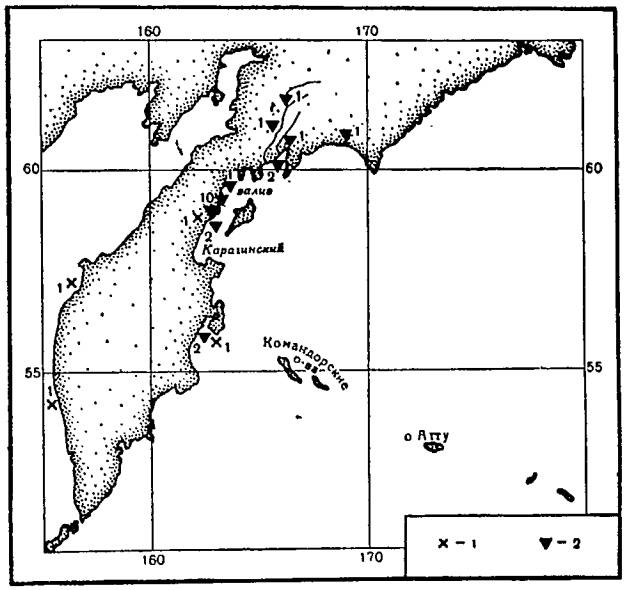

Fig. 3. Locations of catch of chums (1) and pinks (2), tagged by American scientists in 1957 in Aleutian waters.

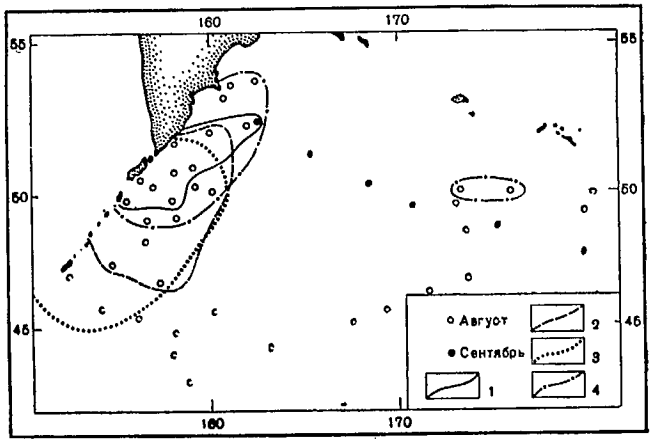

Fig. 4. Occurrence of mature salmon in the northwest Pacific in August, 1956. 1 - sockeye; 2 - chum; 3 - pink; 4 - coho.

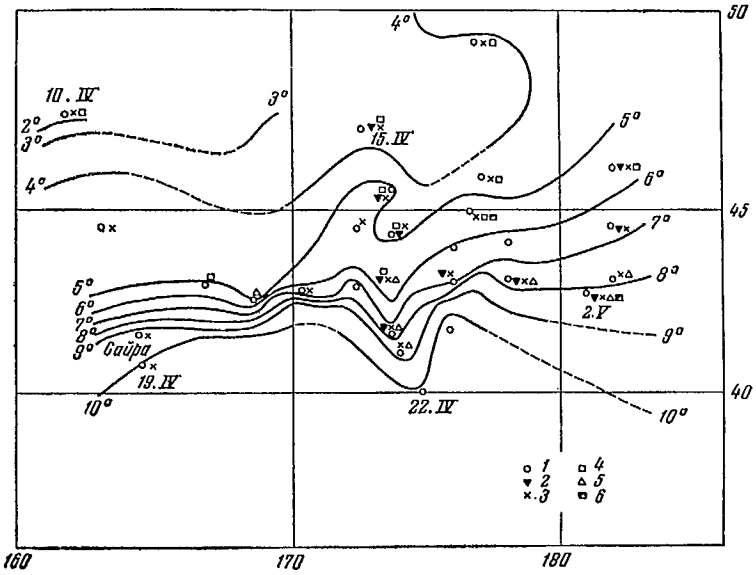

Fig. 5. Occurrence of salmon and surface temperatures in April-beginning of May, 1959. 1 - Station; 2 - pink; 3 - chum; 4 - sockeye; 5 - coho; 6 - Kamchatka Atlantic salmon. The absence of pinks in the catches west of 170° meridian is explained by the lack of necessary nets.

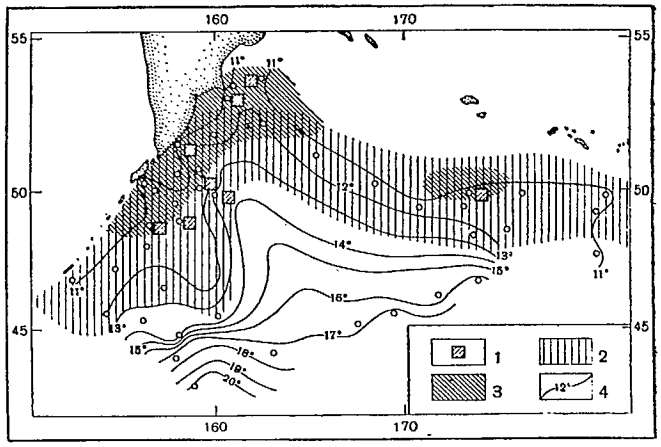

Fig. 6. Regions of concentration of immature salmon in August and early September, 1956. 1 - chinook; 2 - chum; 3 - sockeye; 4 - surface isotherms.