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A REVIEW OF INVESTIGATIONS ON THE FAR-EASTERN SALMONS

By I. F. Pravdin

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Preliminary translation by W. E. Ricker

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Translator's Foreword

Professor I. F. Pravdin's review of Russian Pacific salmon investigations provides a conspectus of work done through 1938, and sheds interesting light on the situations that prompted it and the conditions under which it was carried out. For these reasons I have gradually completed and revised this translation, which was begun several years ago when searching for information concerning pink salmon. The Fisheries Research Board of Canada Biological Station, Nanaimo, B. C., has provided the means to make it available to a wider circle of salmon biologists.

The English names used here for the various salmons are those recommended in the American Fisheries Society's list, but their constant repetition in the text has been relieved a bit by frequent substitution of the Russian gorbusha and keta for pink and chum salmon; these names are familiar from their scientific use, and in fact keta is used commercially for some grades of chum salmon. Gorbusha means humpback, which was formerly the usual English name for this species, before it was banned because lacking in sales appeal. It is interesting to read (page 49) that large numbers of chinook salmon ran into the Kovycha River; this must be a variant of chavycha, a word adopted from one of the Kamchatkan languages to be the Russian name for the chinook, and used by Walbaum as its scientific name (tshawytscha).

Describing the ages of salmon has been a source of confusion. In ordinary English, as in Russian, the phrase "4 years old" means an individual that has completed a full 4 years of life and is in his 5th year. If a viviparous animal is concerned, age is measured from birth. Applied to fish, age is usually measured from time of hatching, though this is seldom specifically stated. In America, however, Pacific salmon in their last year of life are commonly assigned the age that they will achieve at functional maturity, measuring age in the Chinese manner from time of fertilization of the egg. This is even true of fish that are caught and killed, and which of course will never have a chance to reach the full age designated. Thus a coho salmon caught in the sea, 3 months before its likely spawning time, is called a "3-year-old" or "age 3" even though its actual age is only about 2.5 years from the time it hatched, or 2.75 years from the zygote. In Russian the same fish is usually called 2 years old, age 2 years, or 2+ years. However in this paper there is ambiguity in designating age: expressions such as vozrast 5 let, 5-letni͡ai͡a ryba, and 5-letka are all used, in different places, to mean either a fish which has completed 5 full years or a fish which is in its 5th year. In many instances it has been possible to obtain the correct interpretation only by referring to the tabular material presented, or to Table 48 of Krokhin and Krogius's Lake Kuril monograph (no. 41 in the references).

A feature of Soviet salmon management are the Control Points or Management Stations. These are variously named in the Russian text (rybovodnyĭ punkt, kontrolnyĭ punkt, kontrolno-reguliruiūshchii punkt), and also in the translation. I believe all these names refer to the same type of establishment--a base from which catch statistics are compiled, where the numbers of fish in local spawning runs are counted or estimated, and where information is collected concerning the success of spawning, etc.

An effort has been made to get the geographical names into their simplest form and in the nominative case. Sometimes this is not easy: for example, the Ichinskii fishery region takes its name from the Icha River, but it might just as easily have been the Ichi River, or the name could have been derived from a (hypothetical) village of Ichinsk. Also, non-Russian names tend to be declined if they end in a letter that is usual for Russian nouns (a, o, and most consonants), and to be left undeclined if not; but there are many exceptions, and the nominative form of an unfamiliar name is often in doubt. For ease in locating geographical features on an atlas I have refrained from translating descriptive Russian names, though it would have brightened the text to refer to the Big, Swift, Straight, Mossy, Hot, Mad and Sinful Rivers, for example.

As usual, there were a few words or expressions for which I could not locate English equivalents, so have let the Russian stand. Other doubtful or imprecise translations are followed by the Russian words in brackets. There are certain to be still other phrases that I have mistranslated, and for which apologies are tendered in advance. Corrections or improvements are always welcome.

Nanaimo, B. C.
October 1, 1962

W. E. Ricker

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INTRODUCTION

The present article is sponsored by the Pacific Research Institute for Fisheries and Oceanography (TINRO), and comprises a short review of the scientific results obtained by TINRO, during the 13 years of its existence (1925-1937), which can shed light on the important question of the condition of the stocks of far-eastern salmon of the genus Oncorhynchus: pink salmon (O. gorbuscha), chum salmon (O. keta), sockeye salmon (O. nerka), coho (O. kisutch), masu (O. masu) and chinook (O. tshawytscha).

The original fishery for far-eastern salmon consisted of a certain degree of utilization by the indigenous population for food for themselves and their dogs; and in spite of the primitive sparseness of population in the Far East, there is reason to think that even at that early time the fishermen did not always have at their disposal unlimited supplies of salmon, in particular rivers and tributaries. Actually it could not have been otherwise, for we now know for sure that in salmon the instinct of return to the native stream is strongly developed, what in American terminology is called the homing instinct. A reduced stock of salmon in some particular stream requires time to re-establish its numbers by natural means. In the old descriptions of Russian travellers in the Far East, we find quite a number of accounts of decrease in the catches of salmon in certain regions.

N. M. Przhevalsky (1871, 1), in the book concerning his travels in the Ussuri region, speaking of the copious run of chum salmon in the Ussuri River says that the local inhabitants--the goldy (nanaïtsy, I. P.)--told him of a decrease in the abundance of this fish. V. Margaritov (1899, 2) testifies that among the Kamchatka peoples it was not uncommon to hear reports of a change in the location of their habitations because of depletion of the fish supply. Closer to our own times, we have reliable evidence that the stocks of far-eastern salmon have declined in certain regions, but nevertheless on the whole the landings of these fish continue to be very large. In recent years, along the Soviet coast of the Pacific Ocean, they comprise more than 2 million centners, or more than 100 million pieces per year (marketed production).

The annual catches of salmon in the Soviet Far East for a 10-year period (1928-1937) are shown in Table 5 on page 8. I must point out that the data presented on the salmon catches (Tables 1-5), which have been put together from the data of the Far-eastern Fisheries Administration (Dalryba) by TINRO workers G. A. Pikharev and A. I. Lykhin, are not wholly accurate, since there is as yet no single correct compilation of the catches of salmon in the Far East. In spite of the inexactness of the figures, they nevertheless provide not a bad picture of the general condition of the catches, and they give a comparative commercial picture of each species of salmon for the whole Far East and for the individual fishery regions, which is very useful for evaluating the salmon stocks.

[page 6] At the present time commercial exploitation of salmon is greatest in Kamchatka waters (average annual landings there are more than 80 million pieces); in the Amur estuary and the Amur River more than 13 million pieces are caught; more than 10 million pieces are taken in the Okhotsk region; and finally, more than 3 million pieces of salmon are caught in the Maritime Province. Thus Kamchatka waters provide 76%, the Amur 12%, Okhotsk 9%, and the Maritime Province 3% (by numbers).

Kamchatka. Along the western and eastern coasts of the Kamchatka peninsula and in the Bering Sea regions the average annual landings of salmon by the Soviet fishing industry in 1927-1936 was more than 88 million pieces. In individual years catches have exceeded 147 million pieces; and during this period there were violent fluctuations in the numbers of salmon caught resulting from fluctuations in the catches of pink salmon (up to 1935 there were more in the even-numbered years and fewer in the odd-numbered years). The principal commercial salmon in Kamchatka are: pink salmon, 70.3% on the average; chum salmon, 17.0%; sockeye, 11.0% (by numbers). Catches of salmon in Kamchatka waters are shown in Table 1.

Along the Kamchatka coast alone (western and eastern) more than 80 million pieces of salmon are caught, on the average, and 7-8 million are taken along the coasts of the Bering Sea.

Table 1 shows, on the one hand, the general primary importance of pink salmon in the catches, and on the other hand, the sharp variations in the landings of that species of salmon. Up to 1935 the larger catches of pink salmon in Kamchatka have been made in the even-numbered years.

Amur estuary and Amur River (the former Nikolaevsk fishery region), which not so long ago occupied the top position in salmon landings, has yielded first place to Kamchatka. We recall that the Nikolaevsk region has experienced a drastic decline in the catch of summer keta, which began as early as 1914 and as a result of which, by a decision of the Far-eastern Revolutionary Committee (of April 3, 1925, No. 17), a 5-year closure (from 1925 to 1929) of commercial fishing for summer keta was proclaimed, and in even-numbered years even subsistence fishing by the local population was prohibited from Khabarovsk downstream along the Amur River, including the region of the Amur estuary. In addition, in the Nikolaevsk region, beginning in 1915, there was a marked decrease in pink salmon in the odd-numbered years; which is the reason for the 8-year closure of pink salmon fishing in the odd-numbered years by the Far-eastern Revolutionary Committee beginning in 1925.

The size of the salmon catches in the Nikolaevsk region is shown in Table 2.

On the average the Nikolaevsk fishery region is most productive of autumn chum salmon (50.3%), after which come pink

Table 1. [page 7] Catches of salmon (in thousands of pieces) in Kamchatka (Penzhin Gulf, and the west and east coasts of Kamchatka) and on the coast of the Bering Sea including the Anadyr Gulf.

	1927	1928	1929	1930	1931	1932
Pinks	17,307	91,770	9,420	84,193	29,937	99,115
Chums	8,485	16,074	18,921	17,932	14,489	11,250
Sockeye	9,779	15,297	11,029	12,448	9,606	8,863
Chinooks	106	87	109	179	115	128
Coho	1,321	1,313	1,127	2,706	961	594
Total	36,998	124,541	40,606	117,458	55,108	119,950

[Table 1 continued]

	1933	1934	1935	1936	10-year total	Yearly average	Per-cent-age
Pinks	36,830	118,938	80,449	53,908	621,867	62,186	70.3
Chums	8,526	15,626	12,155	26,648	150,106	15,011	17.0
Sockeye	5,747	12,261	4,722	7,757	97,509	9,751	11.0
Chinook	51	92	144	142	1,153	115	0.1
Coho	489	878	1,065	3,221	13,675	1,367	1.5
Total	51,643	147,795	98,535	91,676	884,310	88,431	99.9

Table 2. [page 7] Catches of salmon (in thousands of pieces) in the Nikolaevsk fishery region (Amur estuary and the rivers of the Soviet part of Sakhalin and the Amur River).

	1927	1928	1929	1930	1931	1932	1933
Pinks	194	17,840	?	9,664	345	10,079	111
Autumn chum	5874	5,273	4580	871	12,229	7,609	6492
Summer chum	392	109	72	2,372	2,005	613	100
Total	6460	23,222	4652	12,907	14,579	18,301	6703

[Table 2 continued]

	1934	1935	1936	10-year total	Yearly average	Percent-age
Pinks	8,400	341	4,730	51,704	5,170	39.3
Autumn chum	7,076	8,780	7,458	66,242	6,624	50.3
Summer chum	5,018	2,445	542	13,668	1,367	10.4
Total	20,494	11,566	12,730	131,614	13,161	100.0

Table 3. [page 7] Catches of salmon (in thousands of pieces) in the Okhotsk fishery region (from the Amur estuary to Penzhin Gulf [but not including these two regions]).

	1928	1929	1930	1931	1932	1933	1934
Pinks	2264	80(?)	2,204	296	5,651	980	9,013
Chums	4332	5169	8,205	3972	7,739	6746	7,072
Sockeye	73	156	?	72	143	166	248
Coho	45	39	?	72	182	77	69
Total	6714	5444	10,409	4412	13,715	7969	16,402

[Table 3 continued]

	1935	1936	9-year total	Yearly average	Percentage
Pinks	6,693	13,234	40,415	4,491	41.5
Chums	5,134	6,685	55,054	6,117	56.5
Sockeye	35	98	991	110	1.0
Coho	31	180	875	97	0.9
Total	11,893	20,197	97,335	10,829	99.9

salmon (39.3%). The catches of masu are inconsiderable, and they are included with the pink salmon catches. Pink salmon landings have been larger (during the period mentioned) in the even-numbered years.

Okhotsk region. Rather small catches of salmon are taken in the Okhotsk region (from the Amur estuary to Penzhin Bay). This huge region, which contains large salmon stocks, is as yet little exploited by the fishery.

Chum salmon occupy first place in the catches (56.5%), pink salmon (41.5%) are caught more abundantly in even-numbered years. Catches in the Okhotsk region are shown in Table 3.

[page 8] The Maritime Province (from the Tumen-Ula River to the Amur estuary), which has never had any very great salmon industry, now yields only a small catch of salmon because there the whole attention is directed to the ivasi [sardine] fishery, and, in addition, in rivers of the southern part of the Maritime Province salmon begin to appear in very small quantities. Data on the salmon catches in the Maritime Province for 1932 have been excluded because they do not seem reliable.

In addition to pink salmon (88.1%) and chums (4.9%), masu salmon are taken in appreciable numbers in the Maritime Province (7%). We notice that pink salmon in the Maritime Province region during these years were more numerous in the odd-numbered years, the reverse of what occurs in the Amur region.

Total landings of the individual species of salmon in the whole Far East are shown in Table 5. Pink salmon occupy first place (65.7%), chum salmon are in second place (24.7%), sockeye are third (8.1%), coho fourth (1.2%), masu fifth (0.2%) and chinook last (0.1%). In weight, of course, the relative roles of the various species of salmon are different.

[page 9] Among the manuscripts which are on file in the Pacific Research Institute for Fisheries and Oceanography, there is a review of the fishing industry of the Far East, put together from statistics of Dalryba and Glavryba by V. V. Yanson, in which salmon catches are shown differently than those given in our tables. Inasmuch as there is no unified compilation of the catches of salmon of the Far East, as I have already indicated, I have tried to collect data which are closer to the true figures, and have checked them, as far as possible, with the Dalryba statistics. In the TINRO data there are indications that the Japanese fisheries in waters adjacent to the coasts of the Soviet Union catch from 910,000 to 1,633,000 centners of salmon. Thus we may consider that in waters (continental and oceanic) which are adjacent to Soviet territory, the annual catch by the Soviet and Japanese industry averages 4 million centners [400 million kg] or more than 220 million pieces of

Table 4. [page 8] Catches of salmon (in thousands of pieces) in the Maritime Province.

	1928	1929	1930	1931	1933	1934
Masu	246	235	392	231	104	212
Chum	31	20	41	93	444	52
Pinks	927	5366	4020	6291	2558	1333
Total	1204	5621	4453	6615	3106	1597

[Table 4 continued]

	1935	1936	8-year total	Yearly average	Percentage
Masu	319	244	1,983	248	7.0
Chum	40	671	1,392	174	4.9
Pinks	3215	1154	24,864	3108	88.1
Total	3574	2069	28,239	3530	100

salmon. I will return to these catch figures when we are speaking of the condition of the salmon stocks, but for the moment will only point out that the contemporary salmon fishery of the Far East is a large one, and deserves careful attention from industry and from scientific organizations.

I believe that the Soviet landings of salmon can be increased, since there are regions where salmon fisheries are not yet developed. We may expect also that the effort in fish culture, which must certainly be increased, will contribute to an increase in our landings. Scientific studies too will assist the development of the salmon industry; these will be expanded and must solve for the industry many questions associated with the biology of salmon, with their production and the size of the stocks. In all this, we must not forget the bitter experiment which was made, in the recent past, in the development of the salmon industry in the former principal salmon region (Nikolaevsk), where the apparently inexhaustible wealth of salmon in the Amur was markedly depleted by excessive catches during pre-revolutionary years.

The construction of a plan for rational utilization of salmon, including provision for their increase, must operate primarily on the basis of quantitative and qualitative information about the stocks of these fish. Naturally, similar information is desirable about the fishery for every other kind of fish too; but for the far-eastern salmon, where more and more frequently and more and more definitely we see signs of a gradual decline in catches, along with an alternation of good and poor catches which greatly upsets the normal functioning of the industry--the study of salmon stocks has become a primary objective, even from the commercial point of view. However, we must acknowledge that up to the present time we have not had such materials as would provide complete answers to the question posed.

In the more than 10 years of its existence, the Pacific Research Institute for Fisheries and Oceanography has included among its numerous investigations work in the study of salmon. A great deal of material has been collected on the fishery biology of the salmon of the Maritime Province, the Amur estuary, the Amur River and its watershed, the rivers of Kamchatka and other waters of the Far East. Much has been done, but much more lies before us. Large new salmon investigations are planned both for the rivers and the seas, the number of investigators is to be increased, and [page 10] only after the completion of this cycle of work will it be possible to have a full and deeper understanding of the stocks of far-eastern salmon, and to find methods for increasing their production. Therefore these preliminary conclusions, although they have required no little expenditure of time and effort in working up the materials collected by our Institute, nevertheless must be considered as far from complete and not necessarily free from errors; in addition, part of the

Table 5. [page 8] Catch of salmon (in thousands of pieces) in the Far East[1].

	1928	1929	1930	1931	1932	1933
Pinks	112,801	14,866	100,081	36,869	114,845	40,479
Chums	25,819	28,762	29,421	32,788	27,211	22,308
Sockeye	15,370	11,185	12,448	9,678	9,006	5,713
Chinooks	87	109	179	115	128	51
Coho	1,303	1,127	2,706	961	594	489
Masu	246	235	392	231	13?	104
Total	155,626	52,284	145,227	80,642	151,797	69,344

[Table 5 continued]

	1934	1935	1936	10-year total	Yearly average	Percentage
Pinks	137,684	90,698	73,026	952,940	72,135	65.7
Chums	34,844	28,554	42,004	271,711	27,171	24.7
Sockeye	12,509	4,757	7,855	88,721	8,872	8.1
Chinooks	92	144	142	1,047	105	0.1
Coho	878	1,065	3,221	12,344	1,234	1.2
Masu	212	319	244	1,996	200	0.2
Total	186,219	125,537	126,492	1,097,168	109,717	100.0

[1] I have not included in this table catches of salmon in the Maritime Province in 1932, since they are open to doubt.

collections, mainly those on age composition and on the young salmon, have not yet been worked up. The author of this article has used both published and manuscript materials and the accounts of individuals who have been and are occupied in the study of far-eastern salmon in Soviet waters; as well as studies of the salmon along the Japanese and American coasts of the Pacific.

The article consists of two parts: I--a general review of the results of investigations of far-eastern salmon, II--the status of the study of far-eastern salmon, and a consideration of their stocks, by individual species. At the end of the article there are conclusions, proposals are made for scientific work on salmon in the immediate future, and a list of manuscript and published materials used is presented. The main part of the work is founded on the materials of the Pacific Research Institute for Fisheries and Oceanography, which it has collected during the 13-year period of its existence. The review of all these materials (commercial and biological) is made with one general end in view--to picture, insofar as materials at our disposal permit it, the contemporary conditon of salmon stocks, and to direct scientific thinking toward determining and increasing the size of these stocks in the interest of their maximum utilization. The great volume of the manuscript material held in the Institute, in the form of accounts, records and articles, for a number of reasons has not permitted the author to carry out a more careful review of them, which undoubtedly will detract from the value of this article. I am particularly disturbed to realize that some articles, to which their authors have devoted much work, knowledge and care, could not be utilized completely in order to clarify particular questions; my only excuse is the knowledge that some of these manuscripts will be published themselves and others will serve as valuable material for the work of future investigators.

In addition to this, the author deeply regrets that it has been impossible for him to analyse, or even to give a more careful and detailed summary of, the salmon catches by individual species and in the different parts of the commercial fishing regions for recent years; for the available statistical data have proven to be, on the one hand, of very varied reliability, and on the other hand, in some places they do not even seem credible. For example, some sources speak of a quantity of masu salmon caught on the eastern coast of Kamchatka, and others mention commercial quantities of sockeye in the Maritime Province; whereas these species do not occur in commercial quantities in these regions (there are no masu in Kamchatka and no sockeye in the Maritime Province). We must have a large and authoritative work by economists and biologists which will indicate by regions (and even by particular bodies of water) the distribution of salmon production, since this information is quite indispensable both for a planned economy and for scientific studies [page 11] concerning the present condition and future increase of salmon stocks. Hence, in using the catch figures which we present, it is necessary to have reservations.

The content of this article was presented by me to the first Conference on the Study of Far-eastern Salmon, held at the Pacific Research Institute for Fisheries and Oceanography in Vladivostok in 1938 (from the 15th to the 19th of March); the planning of future investigations of far-eastern salmon was the subject of a special article by the author at that Conference; the text of the latter article is included in the conclusions of the present review, and on the basis of the decisions of the Conference the program of investigations has been drawn up.

A list of works (published and manuscript) bearing on the questions considered here is given at the end of this review, and in the text after the author's name the year of publication or year of compilation is given, along with the serial number by which the work in question is designated in our list.

In working up the materials used for this review on the age of salmon, their size, fecundity, spawning migrations, condition factors and other questions of their fishery biology, the following have taken part: I. O. Baranovsky, N. N. Guseva, D. A. Kanevets, A. V. Klimova, I. P. Kozyrev, A. I. Lykhin, I. A. Piskunov, G. A. Pikharev, I. F. Pravdin, M. A. Pravdina, A. G. Smirnov, A. Ya. Taranets, V. K. Cherni͡avskai͡a, and certain others. I have obtained especially valuable information from the numerous reports unfortunately not yet published, compiled by I. I. Kuznetsov and preserved at TINRO.

February-March 1938
Vladivostok

I. GENERAL REVIEW OF THE RESULTS OF INVESTIGATIONS OF FAR-EASTERN SALMON [page 13]

Information on the far-eastern salmon in the XVIII-XIX centuries

Without attempting to present a complete history of investigations of far-eastern salmon in pre-Soviet times, we must nevertheless take note of the important works which shed light on both the strong and the weak aspects of the investigations that have been made up to the present.

The earliest work, which nevertheless in some of its aspects is quite modern, containing useful information on the far-eastern Kamchatka salmons, is the book by S. Krasheninnikov (1755, 3) and his talented companion G. Steller (1774, 4); the materials presented by these investigators have been used by all later authors: Walbaum, Bloch, Schneider, Pallas, Richardson, Suckley, Günther, Jordan, Smitt and many others, both living and dead.

Information is available concerning the far-eastern salmon in numerous works of well known scientists who made journeys in the Far East during the 19th century: Middendorf, Schrenk, Maak, Mitsul, Dybovsky and others.

At the end of the 19th century there was published the work of A. M. Nikolsky (1889, 5) "The island of Sakhalin and its fauna of vertebrate animals". Nikolsky and I. S. Poliakov in 1881, and Poliakov alone in 1882, conducted investigations on Sakhalin. In Nikolsky's book some attention is given to the migrations of chum and pink salmon. In 1881 the chum salmon in the Tym River began to run on August 8, old style (August 20, new style); at the height of the run the catches per fishing site amounted to 1000 fish (weighing from 7 to 15 funty[1]). Toward the middle of September (old style) the chum salmon migration ended; it was also observed (according to data of Mitsul) that the chum salmon began to run first in the rivers of the northern part of the island, and then entered those of the southern part. "This circumstance," says the author, "makes me think that the chum salmon migrate along the coast of Sakhalin from north to south." We may recall that in 1898 in Japan there appeared the paper of Niwa Heitaroo "A report on an investigation of the fish stocks on the Island of Sakhalin".

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[1] [A Russian funt was 0.902 English lb (1 pud = 40 funty = 36.07 lb = 16.36 kg).]

Only quite recently have far-eastern salmon been studied from the point of view of the scientific aspects of the fishery. V. K. Brazhnikov (1900, 6) initiated such study with his investigation of the autumn fishery for Amur chum salmon, made in 1898. Already at that time the author made it his objective to relate the biological characteristics of this fish to the environmental conditions that prevail in its environment. The author presents a number of conclusions and hypotheses which must still be taken into consideration, and which require new studies along the lines which Brazhnikov suggested. For example, he observes that "the place of abode of the Amur division of the chum salmon is apparently the Sea of Okhotsk, and in particular its southern part, close to the estuary; it is certain that near Langra Island (now Baidukova Island - I. P.) [page 14] and Cape Golovachev (in northern Sakhalin - I. P.) the chum salmon appear from the north out of the Sea of Okhotsk; however, chum salmon also enter the Amur from the south, near Cape Dzhaore and Cape Pronge (and in general along the coast close to the southern channel), but these can scarcely be schools arriving from the Sea of Japan by way of Nevelsky Strait". These words have not lost their significance even today: up to the present time this question remains fundamentally undecided, in spite of its great scientific and commercial importance. The author suggests also that the stocks of chum salmon of different rivers remain grouped together in separate parts of the sea. This question too is important and, like the other, it is as yet not finally resolved. As far back as nearly 40 years ago Brazhnikov appealed for regulation of salmon fishing. In his book there are many biological and fishery data. Some of the author's questions have been solved by later investigators, for example the question of the death of fish of the genus Oncorhynchus after spawning.

In the numerous articles and books of L. S. Berg (1932, 7) there are descriptions (systematics, distribution, and basic information on the biology and the fishery) of all the far-eastern salmons. But the fundamental broad study of the far-eastern salmons from the biological and fishery points of view is a book by V. K. Soldatov. Soldatov, continuing the work begun by Brazhnikov, conducted uninterrupted investigations of the Amur salmon for a year and a half (from July 1907 almost to the end of 1908), continued to give attention to the project in subsequent years, and then wrote his excellent book (1912, 8) which down to the present time has served as the best handbook for all who are engaged in salmon investigations. The book contains a wide assortment of information on the biology of the chum and pink salmons: their migrations from the sea into the river, their distribution in the river, the size of the fish, their fecundity, spawning, mortality after spawning, size of the eggs and fry, and also information on the artificial culture of these fish. In conclusion, the author gives his opinion of the stability of the stocks of far-eastern salmon, and foresees the possibility of a decline in the fishery on the

Amur (of which we have become eyewitnesses). Thirty years ago Soldatov steadily urged that these stocks should not be exploited only, but that some consideration should be given to their production. His call to investigators for a long time remained unanswered; the salmon fishery on the Amur grew rapidly, but before the beginning of the imperialistic war the salmon fishery in this district fell off sharply. Fish-cultural measures on the Amur, which then consisted of the work of a single small hatchery (at Cape Bolshaîa Chkhil, below the city of Nikolaevsk), could have no appreciable effect in preventing, or in reducing, the harmful effects of overfishing of the salmon stocks. In 1914 two small hatcheries were opened in Kamchatka (on the Bolshaîa and Kamchatka Rivers). In 1915 the fact became well known that the salmon stocks, especially the summer keta, in the Nikolaevsk fishery region had become depleted; the total removal of salmon in 1915 was less than 8 million pieces, whereas in previous years (1909 to 1914) landings had commonly exceeded 20 million pieces.

After the investigations of V. K. Soldatov and up to the time of the establishment of Soviet rule in the Far East, that is for more than 20 years, no one was occupied in studying salmon either on the Amur or in Kamchatka, let alone the other regions of Russian far-eastern waters.

However it is well known that our neighbours across the Pacific Ocean--the Americans--in the interests of developing their salmon industry have conducted [page 15] investigations on salmon and have done work to increase their stocks. In the United States of America by the end of 1912 there were already more than 100 well equipped fish-cultural establishments and stations. In Alaska regulatory measures were introduced in the salmon fishery. Investigators in Canada have always worked assiduously. In 1925, the individual states adjacent to the Pacific Ocean, and the federal governments of the United States of America and of Canada united in carrying out systematic and comparative investigations on Pacific salmon. The well-known scientist Rich was appointed to head up this work. Japan also has constructed about 10 fish-cultural establishments, has introduced the prohibition of salmon fishing on the spawning grounds, and has organized studies in the ocean, including fish which are migrating to our Kamchatka rivers. Up to the 1930's there have appeared numerous works by American and Japanese investigators concerning the Pacific salmons (Chamberlain, Rich, Cobb, Gilbert, Davidson, Pritchard, Clark, Foerster, Marukawa and others).

STUDIES OF SALMON IN 1918-1924

With the establishment of the Soviet rule in the Far East a new epoch began in the investigation of the salmon riches of the Soviet waters of the Pacific Ocean. In 1918 on the river Praure, I. I. Kuznetsov, indefatigably continuing the work of

V. K. Soldatov, began his experiments in rearing artificially the fertilized eggs of salmon in the gravel; these experiments which have attracted the deep interest of Soviet fish culturists, were continued by Kuznetsov on a wide scale in 1923-1924 on the Amur River and on the Bystraîa (in Kamchatka). Kuznetsov's experiments showed that as a foundation for fish culture a careful study must be made of the interrelationships of all the physical and chemical factors which have an influence on reproduction (Kuznetsov, 1928, 9); therefore, far-eastern fish-culturists began (starting in 1925) the study of the natural reproduction of salmon, and have themselves contributed much new and valuable data to our knowledge of salmon biology. The results of this work are in Kuznetsov's book "Some observations on the reproduction of the Amur and Kamchatka salmons" (1928, 9). The author submits a mass of observations made by himself and his colleagues on spawning and on the actual process of deposition of the eggs of the Amur and Kamchatka salmon.

Kuznetsov's main conclusions are as follows. On the spawning grounds of all species of salmonids there is observed a preponderance of females: only when there are very few fish on the spawning grounds can an excess of males be observed. When there are weak runs of pink salmon (and to some extent, of autumn chum salmon) linear dimensions and weight of the fish are greater, as is also their absolute fecundity. On the Amur, pink salmon spawning is observed from July 20-27 to September 15-20, of summer keta from July 27 to September 20-25, of autumn keta from September 19 to the end of December; on the Bolshaîa River in Kamchatka the spawning of pink salmon is from August 15 to the end of September, that of chum salmon is from August 3 to the end of October, of sockeye from August 13 to the beginning of October, of coho from September 1-5 to January, of chinook from July 15 to August 20; on the Kamchatka River for chum salmon spawning is from August 1 to the end of October, for sockeye August 1 to the end of October, chinook from June 15 to September 15, and coho from September 1 to March 16. The eggs of salmonids are laid in the gravel; "pink salmon deposit their eggs on loose gravelly-sandy bottom in a rather slow current at a maximum depth from 22 to 28-30 cm., or in a coarse gravel bed at a depth from 13 to 17 cm. The autumn keta deposits its eggs in a [page 16] weak current in spring creeks [kliûchi], and also on loose fine gravel bottoms to a maximum depth of up to 35 cm, or rarely 40 cm. The sockeye deposit their eggs at a depth of 29-30 cm." When spawning grounds are overpopulated the fish may die before spawning; in addition, in these cases many additional eggs die which are unceremoniously excavated from the bottom. The total loss of eggs and young for autumn keta is 29.5% and for sockeye 31.5% of the total eggs produced. The principal enemies of the eggs of salmon in rivers of the Okhotsk-Kamchatka coast, the Amur estuary, and the Amur basin, are the Dolly Varden, the lenok [Brachymystax], the grayling and minnows [golîany]. In the work mentioned Kuznetsov urges that a policy of protection of natural reproduction of salmon be instituted, and also recommends artificial propagation "which, when there is an excess of spawners on the grounds, can provide a real addition to natural reproduction". In Kuznetsov's book we can find the necessary information about all the salmon of the Amur (masu, pink salmon, summer and autumn chums) and about the salmon of Kamchatka (chinook, sockeye, chum, pinks and coho).

I. I. Kuznetsov, having begun his work on the investigation and management of salmon with V. K. Soldatov (starting in 1907), was forced to interrupt it only under very difficult circumstances (the World War and the intervention), and resumed his studies again with the final establishment of Soviet rule in the Far East. In the Far-eastern Fisheries Administration [Dalnevostochnoe Upravlenie Rybolovstvo] there was established, at that time, a Scientific Bureau which took over and continued the interrupted work.

In 1923 an examination of the condition of the salmon stocks of the Amur River was undertaken by N. P. Navozov-Lavrov (1927, 10) who published the results he obtained. Of greatest interest are his studies on the age and rate of growth of the summer and autumn chum salmon. According to his data the growth of the summer and autumn chums is different, as indicated in Table 6.

Both these groups of chums ascend the Amur for spawning in their fourth year of life for the most part, but they differ in body size. These conclusions [page 17] are of very great importance, because they for the first time demonstrated the different rates of growth of these two groups of chums (called infraspecies in L. S. Berg's terminology). It is possible that this author is also correct when he says that the autumn form of chum salmon now prevails on the Amur, whereas in the Okhotsk-Kamchatka regions the summer chum salmon is more important (according to Marukawa's data), and that in general the summer chums are characteristic of the more northern parts of the Pacific Ocean. After L. S. Berg pointed out the distinction between the summer (vernal) and autumn (hiemal) forms of salmon (and other fishes) information concerning the summer and autumn chum salmon had a greater significance. The males of both the summer and the autumn chums are ordinarily larger than the females (that is, the males have a larger annual growth). In Navozov-Lavrov's article a description is given also of the Amur salmon industry which sprang up after the intervention (which ended only in 1922), and he gives information on the catches of pink salmon, summer chum salmon and autumn chum salmon for 17 years (from 1907 to 1923). N. P. Navozov-Lavrov proposes a series of measures directed toward rehabilitating the Amur salmon stocks. The most important of these proposals are the following: to permit the ascent to the spawning grounds of at least 25-30% of the whole stock which reaches the river; to introduce a closure of fishing on the spawning grounds themselves; to establish closed areas on some of the principal spawning rivers, and so on.

In 1924 the Scientific Bureau at Dalryba continued to occupy itself (in its salmon fishery section) with questions of fish management, including under this term the protection of the spawning grounds and question involved in establishing a standard rate of exploitation for salmon. The most important work along these lines was carried out by Kuznetsov himself.

SALMON INVESTIGATIONS IN 1925-30

In 1925 there was founded under the leadership of K. M. Deriugin, with the close participation of the author of this article, the Pacific Fishery Research Station, which later developed into the Pacific Fishery Institute. The Station was founded for the purpose of making a systematic study of commercial fishes and of the conditions of their life, and to make studies of the fishing industry in both its fishing and processing branches. Included in the make-up of this Station was the fish management section of Dalryba headed by I. I. Kuznetsov, together with the workers of the Scientific Bureau. Salmon studies were given a great deal of attention.

I. F. Pravdin (1926, 11) in 1925 did some work on the salmons in the Nikolaevsk Fishery Region, and on the basis of the materials collected he published an article. In the same year on the Amur, with the cooperation of the Pacific Station, A. V. Babaskin (1926, 12) worked on salmon and wrote a work on the age of the Amur chums. Kuznetsov occupied himself with the organization of fish management centres in the Amur basin and on Kamchatka. These centres have continued their work right up to recent years.

In 1926, salmon investigations on Kamchatka were extended to the Bolshaia River, and their study occupied I. F. Pravdin and A. G. Kaganovsky, thanks to whom some work was published on the fishery, biology and systematics of the pink salmon (Pravdin, 1928, 13; 1929, 14). Studies of the salmon fishery in the Amur estuary in 1926 was continued by V. E. Rozov (1926, 69), who collected data on the age of the pink and chum salmons. Age material was collected also by other workers. In 1926 there appeared a work of an associate of the Leningrad Ichthyological [page 18] Institute, M. I. Tikhy (1926, 15), in which he showed that pink salmon fished in Kamchatka are two years of age, that is, he confirmed the conclusion earlier arrived at by the American investigator Gilbert (1912, 79) and the Japanese investigator Marukawa (in his 1917-1918 article). Later I. F. Pravdin (1932, 16) came to the same conclusion with reference to the age of the Amur pink salmon (from 1928 data) and of the Bolshaia River pinks on Kamchatka (from 1926 data).

G. D. Dulkeit (1927, 17), writing about the freshwater fishes of southern Sikhote-Alin, referred to the pink salmon. According to Dulkeit the pinks in the Maikhe River, flowing into Ussuri Bay, ascend 35 and more kilometres. In earlier

Table 6. [page 16] Growth of Amur chum salmon (according to Navozov-Lavrov).

	Growth [size attained] in cm					
	1	2	3	4	5	6
Summer chums	27.95	43.10	55.35	61.40	69.10	78.00
Autumn chums	31.01	49.78	64.21	75.26	81.22	86.26

[Table 6 continued]

	Increment in cm					
	1	2	3	4	5	6
Summer chums	27.95	15.15	12.25	6.05	4.10	-
Autumn chums	31.01	18.77	14.45	11.40	8.47	6.33

times many pinks ascended as far as the Tsimukhe River; in 1919 the first wave of pink salmon appeared there during the first days of June. Pink salmon enter all the rivers of the Gulf of Peter the Great and the Suchan River.

Later the attention of the Pacific Institute was diverted away from systematic effort in the study of salmon, although in many regions materials on salmon biology and the fishery were collected from time to time. At the same time Kuznetsov's work on salmon management was not stopped; starting in 1932, it was separated from the plant of the Pacific Institute and transferred to Dalryba, to which Kuznetsov also was transferred. Up to 1937 all the work of observation on the spawning grounds of Amur salmon was carried out exclusively by Dalryba. Only beginning in 1937, when TINRO again began to expand its salmon investigations, did the staff of this Institute give attention to the spawning grounds in the Nikolaevsk region. It is true that throughout this period TINRO collected field information on salmon in many regions of the Soviet Far East, including the Amur. In 1928, 1929 and 1930 the Pacific Research Institute for Fisheries and Oceanography was organized through the instrumentality of the Kamchatka Stockholders Society (AKO). It did scientific work in several sectors of far-eastern waters, primarily along the coasts of Kamchatka and the Sea of Okhotsk, with the result that materials were collected relating to salmon investigations. We will briefly review the material in question.

Studies of the salmon in the Okhotsk region. In 1928-1929 V. E. Rozov (1931, 86) along with Comrades Golovanov (1931, 85), Gromov, Deulin, Kaganov, Shidlovsky and Pavlov made a fisheries survey of the Okhota and Kukhtui Rivers (on the northwest coast of the Sea of Okhotsk). From June 21 to October 15, 1928, the expedition made observations on the migration and capture of salmon in the lower reaches of the Okhota and Kukhtui Rivers. From the 1st to the 11th of August Rozov conducted studies in the Kukhtui River for more than 300 km upstream, making a map of this section of the river and indicating the spawning places of the salmon. The expedition's associate Shidlovsky was left there for the winter to continue the scientific work, and the other members of the expedition returned to Vladivostok. In 1929 in June the work of the Okhotsk expedition was resumed; V. E. Rozov (1930, 88), Gromov and Kaganov again participated. During the summer (from August 7 to October 10) they surveyed the regions of the Okhota River for more than 400 km upstream; the whole section was mapped and [page 19] the spawning grounds of chum salmon and sockeye were located both on the main stream and also throughout its watershed (in tributaries and lakes).

Their conclusions include the following: the Okhota and Kukhtui Rivers can be included in the list of salmon-producing rivers: using the tidal currents the following salmon enter it for spawning--chum, pink, sockeye and coho. V. E. Rozov discovered a lake form of sockeye in the Okhota-Kukhtui region.

In 1929 the run of chums in the Okhota River began during the first days of August; these fish did not remain on the lower spawning grounds but went farther upstream. The expedition estimated that about 5 million chum salmon spawners enter the Okhota River. The run of keta continued into early October. Sockeye spawn in the tributaries of the Okhota River which contain lakes. One of the largest spawning grounds for this fish is Lake Aglikit, which receives more than 100,000 spawners.

The organization of artificial propagation in the region of these spawning grounds presents great difficulty, for the spawning areas are subjected to great fluctuations in water level, and the upper spawning grounds cannot be utilized for artificial propagation because there are no roads there. All the same, the expedition indicated the possibility of working toward construction of a fish-cultural establishment on the spring creeks of the Arka River, a tributary of the Okhota. This expedition gave serious attention to the need for protection and improvement of the natural spawning grounds: which are subjected to fishing, are clogged up by log or brush jams, and which do not have enough water for the spawning fish to reach them in dry years.

In passing, we may notice that in 1937 V. E. Rozov (1937, 20) presented complete data on the salmon of the Tuguro-Chumikansk region; from this article we find that chum and pink salmon enter the basins of rivers flowing into the Shantar Sea; the majority are chums (average weight 3.2 kg); pink salmon in this region are quite scarce but nevertheless the pink catches are greater in the even-numbered years. The spawning of pink salmon begins in the second half of July and ends at the middle of September; the chums begin to spawn during the first half of August and finish spawning at the beginning of October. The landings of salmon are small here (4000-5000 centners) in spite of the fact that the stocks of salmon would permit an increase in landings up to 24,000 centners. G. D. Dulkeit, during his sojourn on the Shantar Islands (1924-1926), observed there near the shores of Yakshina Bay toward the end of July and in August of 1925 a run of chum and pink salmon, of which the pinks entered the Yakshina River and spawned there. In 1925 the pinks began to enter the Yakshina River on August 8. The number of chum and pink salmon entering the rivers of the Shantar Islands is not large. Coho apparently are almost absent: only in Lake Bolshaia (on Great Shantar Island) were 2 specimens of young coho taken ("apparently age 1+ [godovichki]").

<u>The Taui Bay region</u>. In 1928 G. D. Dulkeit (in connection with his work on the arctic fox industry) visited Ola Island which lies in Taui Bay in the Sea of Okhotsk, and came to the conclusion that among the salmon caught around the island there, pinks and chums occurred (in small numbers). Taui Bay itself is richer in salmon: about 500,000 pieces of salmon are caught there (Dulkeit does not mention the species). In 1930 observations were made in Taui Bay itself. Observers made a

count of the salmon caught, collected [page 20] biological material, made meteorological observations, and learned (by making enquiries) something of the abundance and quality of the salmon spawning grounds in the Yarman, Yane and Taui Rivers.

The run of pink salmon in 1930 in the marine sectors began during the first days of July and continued to the 1st of August. The total catch of pink salmon was 737,832 pieces. Chum salmon appeared from July 15 and were caught in the marine area up to September 10. The main run took place from July 20 to August 15. The keta caught in 1930 numbered 448,576 pieces. The run of coho lasted from August 15 to September 20. It was caught in small numbers. The Yane, Taui and Arman Rivers have good spawning grounds for keta and gorbusha.

D. N. Taliev in 1930 collected data on the age, food and fecundity of chums and coho on the Ola River. The average size of the chums was 63 cm and their average weight 2.5 kg, the average length of the coho was 70 cm and their weight 3.7 kg. In surveying the fish fauna of the Ola River there was found a new form of the sockeye. By making enquiries, the time of the salmon runs was determined. The pinks come first; the beginning of their main run can be taken as July 1; the sockeye run almost concurrently with them; the chum run begins July 10; latest of all is the run of coho which begins August 2-5. In addition to these salmonids, in spring a very limited number of chinook salmon run into the Ola River, and in autumn a small number of ovech (a new form of sockeye). A considerably larger number of these latter enter the Yana and Siglan Rivers. This form has been described by Taliev (1932, 22) under the name of _Oncorhynchus nerka ovetsh_ Taliev.

Taliev surveyed the spawning grounds of the chums, pinks and to some extent the coho. He made an expedition on foot along the middle and lower parts of the Ola River, and partially surveyed the Malyi Magadan River which is situated south of the Ola River, and into which there run mainly pink salmon, with a very limited number of chums. Concerning the salmon of Gizhiga Bay, there is information in an account by G. A. Pikharev (1928).

The Penzhin Gulf region. In observations made at the Penzhin [Observation] Station in 1930 the first specimens of chum salmon appeared in the Penzhin Gulf on July 4-6, and from July 19 they began to appear in the traps by hundreds. The commercial fishery began July 25 and continued to the 19th of August; by the end of August the run of fish had almost completely ceased.

In July the greater part of the fish were caught in the southern portions, while in August they were caught in the northern portions. In the southern portions the fish appear several days earlier. The run of keta in 1930 was good, and the failure to fulfill the plan by 43.7% was the result of a number of miscalculations, and other causes. In addition to chum salmon, occasional pink salmon are caught by the fishery; during the whole season they amount to about 200 pieces in all.

A. A. Danilov worked in the region of the River Icha in 1929; he collected materials concerning the salmon of this region, including information on the young salmon. In his account Danilov gives data concerning the times of the salmon runs and their sizes.

In 1929 the main run of summer keta near Icha began July 13; the run was very intensive: in the marine regions the Kamchatka Stockholders Society (AKO) landed 398,736 fish. Examination of the stomachs of the summer keta revealed that they had eaten capelin, shrimps and mysids. The run of pink salmon was weak and lasted from June 22 to August 11. The sockeye ran from July 20 to August 20. Danilov observes that the contents of the digestive tracts of the sockeye were the same as of the chums. [page 21] Chums, sockeye, pinks, chinook and coho run into the Icha River. The author gives the average size of male pinks as 52.5 cm, and of females 49.2 cm, while the average weight of the males is 1.82 kg and of females 1.67 kg. The average fecundity is 1888 eggs. The average length of sockeye males is 64.5 cm and of females 58.5 cm; the average weight of males 3.39 kg, of females 2.99 kg; the fecundity on the average is 4218 eggs. Concerning the run of chum salmon Danilov writes that he observed two runs of this fish: a spring run (when smaller individuals occurred) and an autumn run.

In 1930 the observer Griniuk worked on the Icha River. Measurements of salmon, made at the Icha [Control] Point, gave the following results: average size of pink salmon, 47 cm; of keta, 59.5 cm; of coho, 60.75 cm. In the regions northward from Icha the salmon appeared much earlier than in those to the south.

Vorovskaia River region. In 1930 Maksimov made observations on the Vorovskaia River. His place of work was the marine fishing sector 18 km northward from the Vorovskaia River. The observer made measurements of the fish and meteorological observations. The following data concerning the stocks were obtained: the weight of 100 pink salmon was 133.8 kg, and of 100 chum salmon 275.0 kg. Sockeye were caught throughout the whole season. Coho began to be taken at the end of August. The first specimens of chum salmon were taken July 1. The main run of the chum salmon and also of the pinks began after a storm on July 2. Along with the pink salmon masu salmon were taken, to the number of several specimens, which species had previously never been observed at all in this region. This information concerning the masu requires verification.

The number of sockeye taken during the season was 4404, and of keta 76,261, of gorbusha 602,319--which was 397,681 less than expectation, which observers explained by the poor qualifications of the workers; only 49 chinook salmon were captured.

The Kikhchik River region. From April 16 to September 13, 1929, G. V. Belavin worked at Kikhchik, and observed that the chinook salmon ended their migration into the Kikhchik River toward the middle of June. The chum salmon were taken in June and their migration continued to September; the most intensive migration fell during the period from July 19 to August 5. 480,000 fish in all were taken. The average weight of the chum salmon was 3.44 kg, the average length was 68.5 cm. The weight varied from 1.9 to 5.3 kg and the average length from 54 to 80 cm. The pink salmon run began July 20 and ended August 12-14. Pink salmon were caught to the number of 500,000. At the beginning of the run, up to July 23-24, mostly males ran, and in the second half of the run, females. The average weight of the pink salmon was 1.7 kg (from 990 g to 3 kg). The average size was 57 cm (45-67 cm). Pink salmon ascend the Kikhchik River 60-65 km up to a large obstruction; which in the opinion of the local inhabitants is insurmountable for pinks (chums, chinooks and sockeye go up over the obstruction). The sockeye begin their mass migration July 18, and end August 10. The weight of the sockeye varies from 1.8 kg to 5 kg and their size from 58 to 75 cm. The catches of coho (in autumn) were small. Chinooks are caught in spring, and in March and April sёmga and mikizha [Salmo penshinensis and S. mykiss].

In 1930 observer Belavin made a collection of young salmon on the Kikhchik River, and made measurements of chum salmon, sockeye, pinks, chinook and coho, and collected batches of eggs. Throughout the season he made hydrometeorological observations.

The run of pink salmon began in the middle of July and continued to the beginning of September. The main migration took place from July 20-29 up to August 15. [page 22] In June 19,099 pink salmon were captured, in July 2,469,204, and in August 4,473,740, the total for the season being 6,962,043.

Chum salmon occur from the first half of July to the beginning of September. The main migration lasted from the second decade of July to the second decade of August. 550,263 chums were taken altogether.

The sockeye run took place from the third decade of July to the middle of August. 66,576 sockeye were taken during the season.

The chinook salmon run occurred from June 13 to July 19. During the whole season 944 were taken.

The run of coho began in the second decade of August and ended in September. 148,014 were taken during the season.

Bolshaia River region. M. N. Krivobok (1930, 21) worked on the Bolshaia River in 1929 and made observations on the salmon both in the ocean sector and in the river sector. In his account Krivobok discloses that the main migration of chum salmon in the sea in 1929 began July 5; up to July 29 the number of chums in the catches increased and it reached its maximum on July 22-23-24. After July 24 the run of keta fell into a decline. The end of the main run can be taken as August 13, but occasional specimens were caught up to September 5. In the later catches the fish were mainly spawned out. We must observe that the run of chum salmon in the Yuzhno-Bolsheretsk region, situated southward from the mouth of the Bolshaia River, differs sharply from that in the northern part. Of the total catches of chum salmon in the different sectors along the whole west coast, the region of the Bolshaia River occupies first place; both northward and southward from there the size of the catches decreases, with only this difference, that northward this decrease occurs gradually, while to the south it is abrupt. The chum salmon run in the river is later. The main run to the river began July 21, that is, about 16 days after it began in the sea. The maximum fishery coincided in time with the fishery on the sea coast. The further run of the fish in the river is a perfect reflection of the run of the fish in the sea. The delay of the run of fish is to be explained, possibly, by the fact that before they enter the river the fish wait a certain time in the region just off its mouth, their entry into the river being perhaps hindered by the seals. The average size of chum salmon is 63 cm and their weight is 3.4 kg. The maximum size which the fish attained was 76.5 cm and the minimum was 50.5 cm. From an analysis of the sex composition of the catches it is evident that at the beginning of the season males predominate, comprising 70% of the catch, then gradually females increase and from the middle of the run they are a majority.

The sockeye begin to be caught during the first days of July. The main run is from July 19 and the greatest run July 24. The end of the run is referred to the 10th of August, but occasional specimens of sockeye are encountered up to September 5. The total size of the sockeye [?catch] of the different sectors decreases in the direction from south to north. The catches of sockeye in the river are considerably less than in the sea. Occasional specimens are caught there up to September 20. Of the grand total of fish measured a high percentage were males. The average size of the sockeye was 61 cm and 2.9 kg; the maximum size was 73 cm and the minimum 52 cm.

The migration of pink salmon in the Bolsheretsk region was not great in 1929. Occasional specimens were caught starting during the first days of July; the main run began July 16 and reached its maximum July 23. Afterwards the catches decreased and at the 1st of August reached a second maximum, after which [page 23] the catches quickly fell off and by August 18-20 the pink salmon run subsided completely. The catch of pink salmon in 1929, as just mentioned, was very small. As for the chum salmon, an unusually large catch of them was made, so that the 1929 landings exceeded all previous years since 1910. In addition, beginning in 1926 the number of keta caught has increased every year.

The run of coho was very weak. The total catch at individual fishing sites did not exceed 2000-3000 pieces. The first coho was captured in the river July 25. A more sustained run of coho began August 8; the maximum catches were observed August 20-29 and in some sectors up to 300-400 fish per day were caught. Then the catches again fell off, but right up to the time the traps were removed, that is, to September 5, coho were being caught at an average rate of a hundred a day.

M. N. Krivobok observed young salmon throughout the whole season, along the whole bar ["koshka"] right to the mouth in uniformly large numbers; from spring right to the middle of July a massive migration of pink salmon fry occurred, which species later completely ceased running. During the first days of September sëmga [Salmo penshinensis] were observed in the Bolshaia͡ River.

The total salmon caught during the season in the eight marine and two river sectors was 1,860,000 pieces, of which 1,523,000 (81.9%) were chum salmon, 204,000 were pink salmon, 46,000 sockeye, and 6000 coho.

Ozernaia͡ River region. F. A. Kochmarev worked in 1929 on the Ozernaia͡ River, and obtained data on the catches and size of the salmon. The sockeye weighed 2.5 kg (on the average) at the beginning of the run; and on the average [for the whole run], 2.6 kg. The average weight of the chum salmon was 3.4 kg, and of the pink salmon was 1.7 kg. In 1930 observer Anoshin made collections of fry of salmon and made 1850 measurements; he collected materials on age, fecundity, and biology, and made meteorological observations.

The sockeye fishery on the Ozernaia͡ River began June 17 and continued to August 25; the pink salmon run took place from July 28 to August 20. The catch of fish for the season 1930 was 770,871 sockeye, 707,078 pinks, 41,568 chums and 1176 coho.

Kamchatka River region. Work was performed on the Kamchatka River by Agafonov from May to the end of September in 1928, and starting in May, 1929; the seasonal [observation] point was changed the second year. The run of sockeye, which here is the principal commercial fish, began on June 2 in 1928; at the start of the run males predominated and at the end females. Large catches were made in June, when 3,892,513 pieces were taken (83% of the total landings in the marine and river sectors which equalled 4,683,000 pieces).

The average weight of the sockeye in 1927 was 2.68 kg. In

1929 the sockeye run was poor: 2,345,000 pieces were landed altogether, of which 72% were taken in the marine sectors. The average weight of sockeye was 2.80 kg.

From the materials available at the Institute (1926-1929) pertaining to the sockeye of the Kamchatka River, we can see that the commercial catches of sockeye consist of four age-groups: 4-, 5-, 6- and 7-year fish; the main bulk consists of 5- and 6-year fish (more of the former). The general condition of the stock of sockeye entering the Kamchatka River is in a condition of decline, and requires the adoption of strict measures to increase it by increasing reproduction; the decline in the sockeye catch is a result of the fact that more than 70% of the sockeye arriving at the mouth [page 24] of the Kamchatka River are caught, and only 27% of the stock enters the river for spawning.

At the observation point it was found that the average size of the salmon caught was as follows:

	1928	1929
Coho	2.79 kg	3.45 kg
Chums	3.22 "	3.29 "
Chinooks	10.31 "	9.59 "

In the report it is pointed out that Agafonov was able to observe the penetration of pink salmon in 1928 up to 36 km above the mouth of the Kamchatka River into one of its southern tributaries, the so-called Second River [Vtoraia͡ rechka].

Karagin Island. The rivers of Karagin Island were studied in 1928 (from July 6 to September 23) by two scientific workers of the Pacific Institute, Razumovsky and Kanachin. In the Untsindaem River spawning of chum salmon and pinks was observed. In 1929 Razumovsky and Li͡ubimov continued their studies on the rivers of the island.

Korf Bay region. In 1929 and 1930 V. T. Bogaevsky (1931, 96), working in the Bay of Korf, collected data on the run of sockeye which began to appear (in the Bay of Skryta) starting June 3, on the chinook salmon (the run began June 13), and on the chum and pink salmon which were caught between the 3rd and 13th of June. The migration of sockeye and chinooks ended at the close of June, while the keta and pinks went on to the end of July. Of chinooks they captured 231 pieces, 17,455 sockeye, 97,466 chums, and 973,988 pinks. A light run of coho lasted from the beginning of August to the middle of September. Bogaevsky also located the spawning grounds of the chum, pink and sockeye along the Rybnaia͡ River, and the spawning grounds of sockeye on the Kultuchnaia͡ River.

The beginning of the main run of pink salmon in 1930 was in the middle of July, though in sectors situated close to the mouth of the Vivinskaia͡ River it was during the first days of July. Sockeye, chums and chinooks are caught in smaller numbers. These run in commercial quantities from the end of June almost to the end of July, without marked fluctuations in abundance of the fish running. All four species of salmon approach the coast of the bay almost at the same time. In 1930 the runs of fish were normal:

Salmon caught in	1929		1930		1931	
Pinks	973,988	pieces	2,121,850	pieces	3,422,419	pieces
Chums	97,466	"	271,011	"	271,973	"
Sockeye	17,455	"	75,091	"	17,429	"
Chinooks	231	"	857	"	122	"
Cohoes	...		...		42	"

Among the rivers flowing into Korf Bay, salmon are distributed, by species, in the following manner:

Kultuchnaia͡ River	-- mainly	pinks and sockeye
Rybnaia͡ River (Avia͡)	"	pinks and chums
Vivinskaia͡ River	"	pinks, chums and chinooks
Notean River	"	pinks and sockeye
Buvaem River	"	pinks, sockeye and chums

Oliu͡torka region. M. L. Alperovich worked on the Oliu͡torka River in 1929 and 1930. His work began June 4. The sockeye fishery in 1929 began in the river on June 12, and in the sea on June 19; the maximum catches were taken June 18-25, and the run ended July 24. The average size of the sockeye was 59.6 cm. Chum salmon were caught in the river from June 19 to August 25; the maximum catch was July 8. The average size of the chums was 63.3 cm. Pink salmon were caught from June 23 to August 12; the maximum landings were on July 6-9. Cohoes were in insignificant numbers. During the season 1929 64,774 sockeye were taken in the river sectors [page 25] of this region; 277,383 chums were taken in the river and marine sectors; and 805,609 pink salmon were taken in the river sectors.

In 1930 the first to arrive were, as always, the sockeye, whose run lasted from June 12 to July 1; at the beginning of the run mostly females[1] were running, and at the end of the run males[1]. The average length of the sockeye was 61 cm, the weight of the males[1] was 2-3 kg and the fecundity 5623 eggs. In all 523,757 pieces of sockeye were taken in the region during 1930. The principal spawning grounds of sockeye are in Lake Batat Gegetkhen.

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[1][Apparently the words female and male are accidentally interchanged here.--W.E.R.]

Second in order of appearance in the river are the chum salmon. Their main run takes place from July 14-15 to August 15. The maximum [daily] landings in 1930 were 10,000-14,000 pieces, the total landings were 76,261 pieces. Among the salmon captured in Oliutorka Bay chum salmon amounted to 15-18%. The weight of the chums was 3-4 kg.

The pink salmon run takes place from July 1 to August 1; it was most intensive at the middle of the month. In landings pink salmon occupy first place among the commercial fishes of the region, comprising 81%, and each year the number of pink salmon increases. In 1930 the run of gorbusha was especially large; total landings amounted to 6,279,534 pieces.

Anadyr region. A. G. Kaganovsky in 1928-1929 led and took part personally in the Anadyr expedition, whose complement also included Comrades Chapsky and Magonin; this group of associates worked in the autumn of 1928, and Kaganovsky spent the winter of 1928-1929 on the Anadyr; he was also on the Anadyr estuary in 1927. Concerning commercial salmon in the Anadyr estuary, Kaganovsky (1928, 81) reports the occurrence of chums, pinks, sockeye, chinook and coho. The average size of chums (1927) was 63.3 cm for males and 59.4 cm for females; the weight of the males was 3.3 kg and of the females 2.9 kg. In July the males were in a majority, while in August it was the females. In 1927 pink salmon were scarce in the estuary; the run began at the beginning of July. The average length of pink salmon was 50 cm and their average weight 1.2 kg. The sockeye also occurred in insignificant numbers; the first individuals were caught July 3; their size was 58-59 cm and their weight 2.5 kg. Chinooks were very scarce, and no cohoes were actually seen by the author; apparently their numbers are very small and they migrate at the beginning of September. The commercial fishery for salmon in the Anadyr estuary began in 1910, when the river fishery caught 633,196 chum salmon; in 1911, 710,475 keta and 35,542 gorbusha were taken; in 1912, 335,093 keta; in 1926, 49,670 keta were taken, while the local population prepared for their own use 14,640 pieces; in 1927 in the Anadyr estuary 471,164 keta were landed and 57,729 gorbusha; and in addition, in the Gek region--17,604 keta, 6020 gorbusha and 199 sockeye. Thanks to the successful work of the Anadyr expedition it has been possible to learn approximately the stocks of the anadromous and sedentary fishes. Kaganovsky believes that the catch of keta in the Anadyr estuary and River should not exceed 1-1.2 million pieces. Pink salmon in that region are not utilized[1], in spite of the fact that there is opportunity to organize a fishery for this species.

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[1] [This statement appears to conflict with the account of pinks taken in 1911 and 1927, a few sentences earlier--unless these were all for domestic use.--W.E.R.]

In addition to the Anadyr River, Kaganovsky studied also the estuary of the Tumana River, which is situated 25 miles south from the entrance of the Anadyr estuary. Sockeye enter the Tumana River for spawning and 150,000 pieces can be caught in a season.

INVESTIGATIONS IN THE AMUR RIVER BASIN [page 26]

In 1931 TINRO once again gave attention to studies on the Amur salmon. In 1931 A. N. Taliev studied the lower reaches of the Amur; his report (1931, 23) contains information concerning chum and pink salmon. The summer keta were 59.5 cm in average length and weighed 2.7 kg; the autumn keta were 73.2 cm and 4.6 kg.

The run of summer keta in the Amur estuary begins in the first half of July and ends at the beginning of August. At the end of August the run of autumn keta begins and continues to the middle of September. The summer and autumn keta are in evidence along the left bank [of the estuary] where the main mass of the fish run; this is the reason for postulating that the keta are coming in from the Sea of Okhotsk by way of the northern channel.

The average size of pink salmon was 47.2 cm, and their weight was 1.6 kg. It was found that the gorbusha appear from the direction of the south coast of the estuary, from the south channel, and they appear to reach the left bank of the estuary through the Sakhalin channel.

The Amur masu were 55.6 cm long and weighed 2.32 kg. It was observed that the masu also appear from the direction of the Sea of Japan and migrate through the southern channel of the estuary.

In 1932 the Pacific Institute sent an expedition to the lower Amur. Among the objectives of the expedition were: to determine the dynamics of the chum salmon catches, and to get information on the composition of the migrating stocks in respect to sex, age, size, rate of growth, and fecundity. The work was conducted at 3 observation points--at Ozerpakh, in the region of Pronge, and at the village of Bogorodsk. A report was prepared by A. A. Emelīanov (1933, 24). In the course of Emelīanov's visit to the spawning grounds of the Kamor River on July 31, 5 pink salmon were taken whose sexual products were in stage IV of maturity. In 5-6 hours' stay on this little river, up to 30 dead spawned out pink salmon were counted. Emelīanov indicates that the run of gorbusha into the lower reaches of the Amur began about June 20; it had fallen off to stragglers by August 20. The summer keta appeared July 5, [and later on] specimens occasionally were caught with the autumn keta. The total catch of pink salmon in the Nikolaevsk region in 1932 was 118,199.5 centners or approximately

10 million pieces. More pink salmon are caught along the right bank of the Amur than along the left.

The sum total of summer keta landings was 15,773.2 centners, or more than 600,000 pieces. These figures are not entirely accurate, because from some of the fisheries catch statistics were not obtained. The poor run of summer keta in 1932 is explained by some representatives of the fishing organizations as a result of the relatively high level of the water in the Amur that year, according to Emelianov. In the region of Bogorodsk, in August and September, the water still stood about 4 m higher than usual. Fish manager Azbelev considered that another possible cause was the ice, which had remained in the vicinity of the Island of Langra up to the middle of August.

Occasional specimens of autumn keta began to be caught on August 15-17 at Nizhnii Pronge and at Ozerpakh; on August 30 at Langra Island 18,000 keta were taken, and at Puir about 20,000, while at Nizhnii Pronge by this time [only] 5-10 pieces were taken per 24 hours, and at Ozerpakh also there were very few. It was supposed that because of the high water the keta travelled in the channel, but experimental fishing there gave negative results.

At the Dudi fishery, situated above Bogorodsk, chums [page 27] arrived September 5. From the 5th to the 10th of September 2400 pieces were caught, while on September 15 there were only 7 pieces. The total catch of autumn keta up to September 14 from all fisheries in the lower Amur was 64,617.7 centners, which comprised 27.1% of the plan. Only the Tyvlin fishery fulfilled its plan to the extent of 105%, having caught itself and received from other fishermen 3728.1 centners of autumn chums.

The report points out that, according to local fishermen, in recent years the run of masu salmon on the Amur has been continuously increasing.

In the course of Emelianov's visit to the Naleo River he discovered that it was mainly pink salmon that spawned in it. The run of pinks into the Naleo in 1932 began June 20, and scattered individuals were running up to August 19. The chum salmon appeared about July 5 and continued to run up to August 19--up to the time the trap nets were removed. The migration of masu took place in the Naleo River from the beginning of May up to July 17. 227,000 pink salmon, 200 masu and 500 summer keta were put into the river past the Control Point. The spawned-out pink and chum salmon began to move downstream about August 10, and the masu during the first days of July.

At the end of September A. A. Emelianov undertook a journey of inspection to the spawning grounds of Georgiev Kliuch[1], which enters a tributary of the Khor River that is

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[1] [A kliuch is a slow-flowing creek with numerous springs in its bed or from the surface nearby. Often it is situated in an abandoned flood-plain river channel, and often it has lake-like expanses. Here kliuch is sometimes translated as "spring creek".]

called "Ryba-mamka" [mother of fishes]. There were almost no fish in the Georgiev Kliuch; on the night of September 24 only 23 autumn keta were passed through an experimental trap net. In following days the number of fish running was only a few tens. On the Khor River at this time about 60-100 fish were being caught at each fishing site.

The temperature of the water in Georgiev Kliuch at the time of Emelianov's visit, that is, at the end of September, remained between the range 6.4 and 7.0°C, and in the tributary "Ryba-mamka" it varied from 7.6 to 13.0°C. In the Georgiev Kliuch one nest was opened and the number of eggs laid in it was counted; 921 were counted, of which 49 were dead. The nest had been dug to a depth of 34 cm. Emelianov observes that the Georgiev Kliuch, and especially the tributary "Ryba-mamka", was grown up with water vegetation over much of its extent and requires cleaning out.

Emelianov also observed among the spawning males and females of autumn keta a marked increase in the size of the gall bladder (30 × 20 mm). The hind portion of the intestines were full of blue-green fluid. Emelianov makes the suggestion that an increased secretion of bile is associated with the great loss of fat by the fish up to the moment of spawning.

The report of A. A. Lovetskaia (1934, 25) gives some information concerning work done on the Amur salmon in 1933. Work was conducted at the fishery of Nizhniaia Gavan from August 27 to September 17. This fishery is on the lower Amur, 171 km from the town of Nikolaevsk, on the right bank of the Amur, at the foot of some bald hills [or, small volcanoes]. Into the left bank of the Amur flows the tributary Ukhtinskaia which is joined to Lake Udyl. Both banks of the Amur are mountainous in the region of Nizhniaia Gavan. The right bank has a large shoal which extends far down the Amur.

In the 1933 season the kolkhozes caught 141,795 kg (38,681 pieces) of autumn keta, of which 7461 kg (1864 pieces) belonged to the goslov [?state fisheries], while 52% were the share of the kolkhozes. The catch of the kolkhozes in 1932 was 27,354 pieces of keta, while a one-man share of the catch [ulov edinolichnovo sektora] was 142 pieces. In the 1933 season there were no pink salmon at all. The summer keta also were represented only by occasional examples; hence [page 28] they caught only autumn keta. The first autumn keta appeared in the seines August 26, whereas in 1932 it was August 28. By September 2 the first run began. Three maxima were observed throughout the keta run: (a) there was a maximum September 2-3 lasting 2 days; (b) one September 10 which lasted only 1 day (at one fishing point several thousand pieces were caught); and (c) September 14-15. Between these maxima the chums were caught in small numbers--a few tens or hundreds at each fishing point: the catches of the second run were the largest, when the kolkhozes caught 71,915 kg (18,254 pieces) or 48.2% of the total catch for the season. The third run came next in size of landings. The greatest catch per day was 11,989 kg (3388 pieces) or 8% of the total catch. The first run was the least important.

In 1932 the run of keta was somewhat delayed: the first run began September 11, the second was on September 13, while the third (September 19) was rather weak and lasted longer--up to September 22, whereas in 1933 the third run had finished September 16; occasional specimens of keta were caught even later. The character of the different runs in 1932 was somewhat different. Then the largest run was the first, when the greatest catch per day was 5358 pieces (19.5% of the total catch), the next in size was the second, with 1963 pieces (7.1% of the total catch), and the third was very insignificant, its greatest catch being 139 pieces (0.5% of the total catch).

In view of the low level of the water in the Amur in 1933, all the chum salmon migrated by way of the channel and the left bank, where it is considerably deeper. The catches also show this: on the left bank chum salmon were caught by thousands per seine, but on the right bank only by tens or rarely by hundreds (first and second runs). At the time of the third run keta were caught uniformly and in small numbers near both banks, single specimens being taken.

In 1932, in spite of the high water on the Amur, the fish also travelled by way of the channel. Near shore few were caught, and the plan of the seine fishermen near shore was fulfilled to the extent of only 27%. In this (1932[1]) year the plan also was not fulfilled: instead of 3700 centners 1492.6 centners were taken, or 40.3% of the plan.

The speed of the chum salmon migration is approximately 57 km per 24 hours. From analysis of the schools of autumn keta throughout the course of the fishing season, it was discovered that their sex ratio was not constant: at the beginning of the run males predominated, towards the end of the run the ratio was reversed. On the average, out of 1100 pieces of keta studied in 1933, 563 specimens were females (51.2%) and 537 were males (48.8%). A similar ratio was observed in 1932. The size of the female autumn keta, on the basis of 440 measured, was as follows for the 1933 fishing season. The greatest length was 76.5 cm, the least was 52 cm, and the average was 64.78 cm.

Male autumn keta (403 specimens) had a maximum length of 88 cm, a minimum of 49.5 cm, and the average was 68.46 cm. The greatest weight of the females was 5.5 kg, the least 1.9 kg,

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[1] [Probably 1933 was intended here.--W.E.R.]

average 3.4 kg; and for males the maximum weight was 10 kg, minimum 1.4 kg, and average 4.3 kg. From a table of length frequencies of autumn keta for 1932 we see that the maximum number of females occurred in the size class 63-69 cm, and the maximum number of males at a size of 67-73 cm.

Comparing the average size of the autumn keta of the even-numbered (1932) and odd-numbered (1933) years, we can say that their size in the even year was somewhat greater than in the odd year; this was especially true of the males.

Throughout the run of the autumn keta their size gradually decreased. [page 29] In the first run the maximum number of individuals occurred in the 67-68.9 cm group, in the second run it was 63-64.9 cm; and in the third run the maximum occurred at the same size (63-64.9 cm).

A decrease in the size of autumn keta during the run was observed both for males and females. Along with their size, the keta decreased proportionally in weight as the run progressed:

First run,	av.	weight	of	males,	5.3 kg,	of	females,	3.5 kg
Second	"	"	"	"	4.0 kg,	"	"	3.4 kg
Third	"	"	"	"	3.9 kg,	"	"	3.1 kg

The qualitative composition of the stock, in respect to degree of assumption of breeding dress [brachnyĭ nariad] also changes throughout the chum salmon run. At the beginning the percentage of coloured(?)[loshälye] individuals is not great (12%), and the individuals running have only weak traces of colour [loshanie]. In the second run the percentage of coloured fish increases to 29.4%, and the number of fish with well developed breeding dress is larger. In the middle of the second run the percentage of coloured individuals falls off, and then it increases again toward the end of the second run, reaching 35.4%. The third run is like the second run: at the beginning the percentage of coloured individuals is large, then it decreases, and toward the end of the run it again increases. The cause of this alternation is not clear.

An analysis of age data has shown that chum salmon attain sexual maturity and migrate for spawning at ages from 2 to 7 years. The schools of autumn keta in large part consist of individuals maturing in the fourth year of life; these amount to 84.6%. The remaining smaller percentages are distributed among the 2-year-olds (1.7%), 4-year-olds (12.4%), 5-year-olds (1.0%) and 6-year-olds (0.3%).

The average size by ages is as follows:

2-year-olds, 61.4 cm	5-year-olds, 74.0 cm
3-year-olds, 65.87 cm	6-year-olds, 88.0 cm
4-year-olds, 71.19 cm	

Analysis of the age composition of the autumn keta catches for males and females separately has shown that the percentage of females in the catches in their fourth year comprises 48.5 out of the total [of 84.6% which are of this age], and males comprise 36.1. In this case the females exceed the males. In the other age groups there is a preponderance of males over females; the percentage of males is relatively large in the fifth and third years [of life]. Males are heavier than females in all age groups: mean sizes in cm are as follows:

2 years of age,	males,	60.0	females,	62.0
3 " " "	"	67.7	"	64.2
4 " " "	"	74.1	"	69.7
5 " " "	"	78.0	"	72.0
6 " " "	"	86.0		

The schools of chums running in 1932 were characterized by a somewhat different age distribution. The maximum number of chum salmon ran in the fifth year of life (4 years old--57.3%) and in the fourth year of life (3 years old--36.7%); in the third (2 years old--0.9%) and sixth (5 years old--5.1%) years smaller numbers of chums were running.

[page 30] In a right bank tributary of the Amur, the Gavan River, salmon formerly entered for spawning; but now apparently they do not spawn in this river. In the Kenzhu (a right bank tributary of the Amur) which enters near Bogorodsk, salmon also enter (mainly autumn keta); at the present time this small river is badly polluted with sawdust from a sawmill. Other spawning rivers for salmon are the Ukhta which flows into the Ukhta channel, and the rivers flowing into Lake Udil, though the number of salmon entering them is not great.

In the same year 1933 a paper was written by N. V. Milovidova-Dubrovskaia͡ (1933, 26). This article contains essential information. The author depicts the biological characteristics of pink salmon of the Amur River and Maritime Province in the even-numbered and odd-numbered years. Data for 1927, 1929, 1930 and 1931 served as a basis for the article, data which had been collected at control points along the Amur, on the Chomi, Khuzi, My, Beshenaia͡, Khilko and Naleö Rivers, at Cape Lazarev and Iski, and from the Tumnin River in the Maritime Province.

The length of the pink salmon run is subject to fluctuations. The time of the fishery for the Amur River begins in the second half of June [and lasts until] the end of July, with the most intensive run in the first 20 days of July. The first pink salmon forerunners appear at the end of May or during the first few days of June. In the Tumnin River of the Maritime Province, which flows into the Bay of Datta, pink salmon appear during the last days of May, and up to the middle of June they are sparsely represented in the commercial catches of masu salmon. The main run is during the first 20 days of July, and about the first of August the pink salmon fishery ends. From available material for an even-numbered year (1930), concerning the Beshenaīa and Khilko Rivers, a large percentage of the catches consists of males. In the catches of the estuarine rivers of Cape Lazarev and the Iski River, the percentage of males is less than that of females. The My River is an exception, where the percentage of males again exceeds the percentage of females. The ratio of the sexes in the pink salmon catches throughout the Amur River system in even-numbered years (according to available material consisting of 670 specimens) is 49.1% males and 50.9% females. The percentage sex composition in odd-numbered years is given only for the Khuzi River in 1927 and 1929, from which it appears that the number of females significantly exceeds the percentage of males, comprising 64.2% in 1927 and 61.2% in 1929. The sex ratio in gorbusha catches is not constant, and depends to a considerable extent on the time of year: at the beginning of the year males usually predominate; at the peak of the run (July 14-15) the number of males and females is almost the same, and toward the end of the run females are significantly in the majority (about 70%). Male pink salmon in the Amur tributaries situated above the town of Nikolaevsk, such as the Beshenaīa and Khilko Rivers, have a size greater than 50 cm, but in the other places where they have been studied, except the Chomi River, the males are smaller than this.

In odd-numbered years both the males and the females are larger than in even-numbered years. In absolute figures, the average size of males in odd-numbered years is 51.6 cm, and of the females 49.5 cm, and in the even-numbered years the males average 46.2 cm and the females 44.6 cm. This makes the average difference 5.4 cm for males and 4.9 cm for females. Being longer than the females, the males also exceed them in weight. In odd-numbered years pink salmon weigh more than in even-numbered years: 1589 g as compared with 1128 g; for each sex separately the comparison is: males 1774 g vs. 1208 g, and for females 1486 g vs. 1062 g.

[page 31] An analysis of the sex composition of the pink salmon in the Tumnin River shows that the percentage of females exceeds the percentage of males in the odd-numbered years by 9.4%, and in the even years by 6.4%; females predominate throughout the whole time of the fishery, and only at the peak of the run (July 16) is the sex ratio almost the same. Here we have not observed any such sequence of changes in sex ratio with time of run as is found among the Amur gorbusha. Regarding the length and weight of the Maritime Province gorbusha, males have been larger than females in all years of observation; in addition, in odd-numbered years the pink salmon are larger in size than in the even years. The average size and weight of the pink salmon of the Maritime Province in the Tumnin River in odd-numbered years is 51.7 cm for males and 47.5 cm for females, while the males weigh 1950 g and females 1516 g; in an even-numbered year (1930) the males were 47.5 cm

long and weighed 1538 g, and the females were 44.5 cm long and weighed 1210 g. The main bulk in the catches (74.9%) in an odd-numbered (1929) year consisted of individuals 1001-2000 g, and in an even-numbered year (1930) the great bulk (65.3%) were in the range 1001-1600 g.

It is well known that pink salmon make their spawning migration in the second year of life, after having remained one year in the sea. The scales of pink salmon do not have clear winter rings. Outside the winter ring, in a majority of scales, a narrow ring with closely set sclerites can be detected, or something that appears like a band with slightly narrowed sclerites. This circumstance is the reason for postulating that there is no winter fast in pink salmon. The number of sclerites laid down in each period of life of the pink salmon varies considerably, both in respect to the number in each annulus and also on the whole scale. The average number of sclerites laid down in the first summer of life of pink salmon is almost the same in both sexes: at that time also they are almost the same for all the different fishing areas. During the winter period a larger number of sclerites is observed on scales of the Maritime Province gorbusha, and during the following vegetative period (the second summer) there are more, although very few more, on specimens from the Khuzi River (Amur system). The rate of growth of pink salmon from the catches of the Khuzi and Tumnin Rivers is greater in odd-numbered years than in the even-numbered years. (The rate of growth in the Khuzi River in the odd-numbered years is 30.1 cm and in the Tumnin 29.6 cm; in even-numbered years it is 26.1 cm for the Khuzi and 27.5 for the Tumnin.)

Regarding the rate of growth of pink salmon from the Khuzi River, as compared with those of the Tumnin River, no marked differences in increase within the same year have been observed either for males or for females. The gorbusha of the odd-numbered years achieve an average size of 30 cm in their first year of life (in both rivers), and at the time of sexual maturity they average 50 cm. In even-numbered years yearling gorbusha from the Khuzi River have grown 26.2 cm and those from the Tumnin River 27.5 cm, having achieved in a year and a half in both waters an average size of 45-46 cm. In making these comparisons, it is necessary to understand that the growth of the Amur gorbusha in individual years is subject to some year-to-year fluctuation, as a result of which there can be important differences in the rate of growth of pink salmon of the two commercial regions being compared.

In the catches of the Khuzi River, which enters the Amur estuary, and of the Bolshaia Di͡uanka River, which enters into the closed and brackish portion of Silantev Bay (in the Strait of Tartary) a so-called "fingerling annulus" [malkovoe koltso] is observed, which reflects the period of life of the young fish in the estuary; while on the scales of pink salmon from catches in the Tumnin River, which enters the open water of [page 32] Datta Bay, and those from other Maritime Province rivers, this estuarine annulus is not observed--with rare exceptions.

From all of the biological characteristics of the Amur and Maritime Province pink salmon given above, certain conclusions may be drawn, in my opinion: (1) there is agreement in the time of maturity in the sexual products of the pink salmon of the two regions; (2) the males of both populations exceed the females in size, and the former are more variable in size; (3) the composition of the Amur and Maritime Province pink salmon catches in even-numbered years is very close in respect to length; in the odd-numbered years, while their average sizes are comparatively close, in the Amur catches a large percentage of heavy specimens is observed; (4) the number of sclerites laid down in odd-numbered years by the Amur and the Maritime Province gorbusha is very close; (5) gorbusha of the odd-numbered years grow more rapidly than gorbusha of the even-numbered years.

In 1935 and 1936 studies of the Amur salmon were conducted by I. O. Baranovsky, N. N. Guseva, I. P. Kozyrev, V. N. Cherniavskaia and S. P. Shapkin; the material which they have collected has been worked over. Migration of the autumn keta at Cape Puir in 1935 began August 30 (somewhat later than in the previous year). Guseva and Cherniavskaia (1935, 27), comparing the run of keta with the wind, show that a northwest wind is favourable for the approach of chum salmon to the left coast of the Amur estuary. This conclusion seems very logical, if we remember that the chum salmon are mostly in the upper layer of water. The migration of keta in 1935 lasted only 23 days, ending September 23. The observers discovered that 3 peaks could be detected in the run. Having inspected a large number of fish (about 10,000) for the determination of sex ratio, the authors present a very informative table showing that at the beginning of the run males (67%) predominate, and at the end, females (up to 80%). The average size (by length and weight) is also illustrated by a large body of material (1682 specimens); the average weight of the males (for the whole fishing season) was 4.49 kg (the greatest weight was 12.34 kg and the least was 1.74 kg); the average weight of females was 3.43 kg (maximum 7.01 kg, minimum 1.49 kg). Thus the difference in weight between the males and females averaged 1.06 kg. Keta of the first run had an average weight of 4.38 kg, of the second 3.63 kg, and of the third 3.16 kg. The average fork length of males was 69.5 cm, and of females 64.8 cm. Supplementary material concerning the autumn keta of 1936 is given by Baranovsky and Kozyrev (1936, 28); fundamentally it supports the work of Guseva and Cherniavskaia.

S. P. Shapkin (1935, 29), working on the Amur and the Nizhnii Gavan, supplemented the information obtained by A. A. Lovetskaia. The first autumn keta in the N. Gavan in 1935 were observed on August 25; on the Amur, as in its estuary, the females in general were larger than males[1]; the average weight of males was 4.01 kg, and of females 3.19 kg, that is, fish running up the Amur had a smaller weight than keta studied in the estuary. The average size of males was 67-68 cm and of females was 64 cm. The mean fecundity of autumn keta is given by Shapkin as 3034 eggs, and the average weight of the ovaries was 244 g. Shapkin observes in his article that the migration of keta into the local streams is now very inconsiderable.

I. O. Baranovsky and I. P. Kozyrev (1936, 28) conducted observations at Dzhaore. The run of pink salmon in 1930 was protracted: from June 5-6 through August (and later). The average weight of the males was 1.7 kg and of females 1.3 kg; these [page 33] figures show that the pink salmon were large, but the size of the catch had declined in comparison with other even-numbered years; in 1932 at Dzhaore 1,027,000 pink salmon were caught, in 1934 it was 426,147, and in 1936 it was 235,647. The average fecundity was 1213 eggs. Later Baranovsky (1937, 30) made a special study of the pink salmon question, and came to the conclusion that as a result of the decrease in the catch of the even-numbered years, the catch of gorbusha in odd-numbered years was increasing. Summer keta at Dzhaore were caught during the last days of June; the main run began July 10 and reached its greatest height July 17, while about August 10 the run of summer keta ceased. In all, 12,000 pieces of summer keta were caught at Dzhaore in 1936. The average weight of the summer keta males was 2.73 kg and of the females 2.34 kg; the males had an average body length of 61 cm, and the females 58 cm. The fecundity of the summer keta was from 1277 to 3075 eggs, average 2051. Spawning of gorbusha and summer keta was observed in the My River on July 24 and 25.

In 1937 TINRO undertook special studies of salmon spawning on the Iski River. The expedition for the study of the spawning grounds on the Iski River, consisting of the ichthyologist A. Ya. Taranets (1938, 40) and the hydrobiologist A. V. Ulitcheva worked from August 17 to October 1, 1937. The Iski is a rather small mountain river, about 50 km long, flowing into Schastia Bay, which opens into the Amur estuary on the northwest. The expedition enumerated and studied the spawning grounds of the salmon entering the Iski River--keta and gorbusha.

The spawning grounds of keta and gorbusha in the basin of the river studied are divided into two groups in respect to their location. The first group is situated along the lower reaches of the river and in its right tributary, the Little Iski, which enters 4-5 km from the mouth of the Big Iski. A large number of gorbusha and summer and autumn keta run into

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[1] [Apparently the reverse was actually intended.--W.E.R.]

the Little Iski; the summer keta which enter the Iski River are fully comparable to the summer keta of the Amur.

The second group of spawning grounds is situated in the upper course of the Iski River, and it is mainly autumn keta which go up to them. The middle course of the Iski River is not favourable for spawning because of its unsuitable bottom (large stone).

In 1937 a very abundant run of salmon was observed on the Iski River, causing a great overpopulation of the redds by the spawners. Nests with deposited eggs were repeatedly dug out by spawners which had arrived for spawning later. A number of nests of keta and gorbusha were opened up [for examination]; and a number of sample areas were established for estimating the density of the eggs deposited.

In addition to the observations on the spawning grounds, the expedition collected data on the age of the keta (about 400 samples) and on their fecundity. It also made estimates of the number of unspawned eggs retained in the fish.

The characteristics of the spawning grounds were determined for the period of observation, in respect to hydrobiology, hydrology and water chemistry. A change in the chemical composition of the environment was indicated. The environment changes in relation to the intensity of spawning and the influence of the bottom vegetation. The quantity of dissolved mineral substances decreases going downstream, as a result of inflowing tributaries having humic waters and changes resulting from human settlements. The fauna consists mainly of insect larvae; the dominant group was the caddis flies.

Similar biological studies of the spawning grounds of salmon were made on the Amur River also, specifically, in its tributary the Khivanda (430 km above Nikolaevsk). The expedition included A. G. Smirnov (1938, 39), [page 34] K. P. Stamburskaia͡ and A. M. Smirnova. In the period from August 20, 1937 to January 12, 1938 studies of the region were conducted to the extent and along the lines indicated below. Brief data were collected for a physiographic description of the lower course of the river, in which region the principal spawning places are situated. Stamburskaia͡ worked over the observations of Dalryba on fluctuations of the level of the water of Lake Khivanda, obtained in 1937 during the period of the movement of the salmon. The size of the landings by the fishery was determined over the course of the last 5 years. Similar information for 3 years was obtained also for the whole Komsomolsk region. The catches of salmon in the Khivanda River sector, village of Nizhneilinovsk, were compiled, with notes on how they were graded as a commercial product; which latter is a basis for judging the degree of maturity of the migrating individuals.

For the purpose of discovering peculiarities of the salmon run, and equally for supplementing other samples of biological series, an observation point was established at the village of M. Gorky (below the mouth of the Khivanda River), which operated from the beginning to the end of the run of these fish. Analogous observations were taken concurrently in the region of the principal spawning grounds, where the salmon ascending the river are passed through special traps. In the investigations at the second point special attention was given to the condition of the gonads of the fish, the degree of their maturity, the distribution of the spawners throughout the spawning regions, and finally the process of egg deposition itself. Opening of nests after fixed intervals of time took place from the end of October 1937 to the 12th of January 1938. Sixteen nests in all were examined. From these, samples were taken for determination of the initial percentage fertilization of the eggs and, later, the number of dead eggs (in different stages of embryonic development). In the places where the nests were opened samples were taken of the plankton and benthos for qualitative examination. Analyses of the water for gases and dissolved solids were limited by the time available. Observations on temperature were made throughout the season. The hydrogen ion concentration was determined. The materials collected from the Iski River and the Khivanda River have not yet been completely worked up.

WORK ON SALMON REPRODUCTION (1925-1933)

If general ichthyological research work on far-eastern salmon for a long time did not achieve any broad development, the same cannot be said about work concerned with fish management. Since 1923 I. I. Kuznetsov has uninterruptedly carried out work on management, giving much attention to studies of the biology and ecology of the salmons, their spawning, and the life of the young salmon--which we have already referred to in the brief review of his book on the reproduction of the Amur and Kamchatka salmons (1928, 9). Later, in 1937, Kuznetsov published a book (31) on the reproduction of chum salmon, compiled from articles and papers written by Kuznetsov himself and by other people who have been occupied with the study of spawning, spawning grounds and fry. We must dwell a little on some of Kuznetsov's conclusions.

Data on counts of eggs in nests, and their mortality there, have led Kuznetsov (1928, 12) to the following conclusions: the number of fertilized eggs in a redd, among gorbusha of the even years (1924 and 1928), was 822 on the average (16 nests were opened, in slow and fast currents); among summer keta there were 2205 eggs (from inspection of 3 nests); autumn keta, 2428 eggs (from inspection [page 35] of 192 nests); spring sockeye, 3079 eggs (60 nests opened). The loss of eggs in spawning of the salmon amounts to: gorbusha, 26.65%; summer keta, 14.9%; autumn keta, 15.4%; sockeye, 18.2%.

The number of dead eggs in a nest depends primarily on the spawning conditions. Mortality of eggs on the nest increases when fish must spawn in the same areas. Among gorbusha spawning in even years, the mortality of eggs in individual nests was up to 50-70%; on the average for 1928 on the Amur, at the start of the spawning period dead eggs amounted to 16.5%; and on the Bolshaia River (where the fish had been put through to the number of 1 female per 2 square metres), at the end of spawning the egg mortality was 29.1%. With normal population of the spawning grounds the following egg mortalities were determined in the nests: gorbusha in 1927, 6.7% (6 nests opened); autumn keta, 5.3% (192 nests opened); summer keta, 11%; sockeye, 2.5%; coho, from 3 to 6.5%.

The mortality of eggs and fry during the course of the whole process of development was determined as follows: (a) for keta on the Bolshaia River in 1926, 29.6%, and in 1927, 28.8%; (b) for sockeye in 1923 and 1926, 16.7% on the average (175 nests opened); and in 1927, 14.6% (47 nests opened); (c) for autumn keta (on the Amur), on the basis of 364 nests opened, 18.4%.

In the spawning kliuches, which have a weak current, salmon prefer to make their nests in places where there is an upwelling of ground water; and the greater such upwelling, the more successfully does normal development of the eggs take place. Mortality occurs during low water levels in winter, when part of the nests perish from drought or freezing.

The general mortality in natural reproduction of salmon, as a fraction of the total egg production, is: for gorbusha in even years, from 40% to 60%; for summer keta, 25.9%; for autumn keta, 33%; for keta on the Bolshaia River, 29%; and for sockeye on the Bolshaia and Kamchatka Rivers, 33.58%; on the average for all the fish cited, 34.45%.

A check of the nests in the Georgiev kliuches (Khor River) showed that 20.7% were lost from drying out or freezing. If we take the mortality from drought and freezing for all nests as 15.55% on the average, then the eggs and fry produced by natural spawning is 50%, of which 20% is referable to losses during spawning, and 30% to mortality during the process of development.

Control Points [Kontrolno-reguliruiushchie punkty]. In the 1930 season fish management measures consisted, as Kuznetsov's (1931, 33) work shows, of the following: 1) the work of the Control Points in the protection and study of natural spawning of salmon; 2) artificial propagation and release of young salmon; and 3) experiments in the acclimatization of Kamchatka sockeye on the Amur.

Ten summer Control Points functioned on the Amur in 1930: Beshenaia, Khilko, Lake Orël, Khuzi, My, Fomi, Uda, Im, Iski and Naleo; and there were 9 autumn Points, on the Rivers Beshenaia, Naleo, Aniui, Bidzhan, Bolshaia canal, Georgiev Kliuch, Tsangali, Tatibe Kliuch, and Chichiveĭza; in addition to the Amur, there were 2 Points on the Bolshaia River (on Kamchatka) in the region of Okaian and Karimaĭ Kliuches; 2 Points on the Okhota River; one Point on the Diuanka River (Maritime Province) and 2 Points in the basin [page 36] of the Kamchatka River: on the Nikolka and Andrianovka Rivers. In all, 26 Points functioned along our far-eastern coast.

In relation to the geographic location of these Points, the runs of salmon in 1930 at different Points were observed at different periods of time. The earliest run was the masu run in the Nikolaevsk region; the start of the run in the lower river was during May 20-29, and it continued to the individual rivers up to July 8; the end of the run occurred from about July 15 up to August 8.

The run of gorbusha began approximately on the same days, but was more protracted at several Points (up to August 30).

The run of summer keta started much later, beginning June 20-29, and its end coincided with the end of the pink salmon run.

The number of fish put up to the spawning grounds in the various streams of the Amur was very large in comparison with previous years (the period from 1925 to 1929). In all, the following numbers of fish were let past the Amur Points: 2535 masu, 3,097,208 gorbusha, and 571,432 summer keta. Regarding the autumn keta it may be said that, in spite of their massive run up the Amur, they arrived in very limited numbers on the spawning grounds of the principal spawning rivers. In comparison with 1926, which is the biggest year for the population of the spawning grounds, in 1930 only 7% of the number of autumn keta spawned, or 6692 pieces; of this number males were 3187 and females were 3505 pieces. We should observe that the deficiency of autumn keta in the Amur tributaries and the Ussuri was caused, in I. I. Kuznetsov's opinion, by overfishing in the Amur near the approaches to the spawning grounds, and also by the low level of the water in the Amur River which persisted throughout the whole chum salmon run. The Amgun River was an exception among the Amur tributaries, for there the autumn keta arrived on their spawning grounds in numbers sufficient for the reproduction of the stock. At other passage points, such as the Diuanka, Okhota, Bolshaia, Kamchatka, Nikolka and Ushki Rivers, Lake Aglikit, Gromova Kliuch, Karimaĭ Kliuch and Okaian Kliuch, more chum salmon were let through.

An especially large number of pink salmon (up to 190,000 pieces) was let into the Diuanka River; at the other points where keta, sockeye and coho were let past, the number of gorbusha passing was limited to hundreds and never exceeded 10,000.

Fish hatcheries in 1930. In 1930, when a Fish-cultural Bureau was established at the Pacific Institute of Fisheries and Oceanography, 3 fish hatcheries came under the supervision of the Institute: the Sakhalin hatchery on the Tym River, the Amur hatchery on the Bira River (Lake Tëploe) and the Kamchatka hatchery on Lake Ushki. The Sakhalin hatchery was discontinued, as it did not meet the requirements of fish-cultural practice, and in its place a new one was constructed at the Adatymov Kliuches, having a capacity of 10 million eggs.

The Amur and Kamchatka hatcheries are located close to nursery areas in which artificially fertilized eggs in Atkins trays [ramki] are reared directly on the bottom of the unfrozen springs, in special sections of the bottom marked out by horizontal timbers. The Ushki fish rearing station is rated at 20 million eggs of sockeye, chums and coho.

At Lake Tëploe at that time 3 nurseries were constructed with a total capacity of 20 million autumn keta eggs, but prior to 1930 only one nursery, carrying 10 million eggs, had been completed. In 1930 during the entire run of chum salmon of Lake Tëploe [page 37] 12,103,432 eggs were collected, of which 6,987,556 were laid down in nursery No. 1, 3,139,763 in nursery No. 2 and 1,976,113 in nursery No. 3. The mortality of the eggs was large: in the first nursery it was 17.5%, in the second 31.5%, and in the third 51%. The increased mortality in the two latter nurseries was the result of technical imperfections: the right volume of flow of water was not available, and rearing was done on imperfect trays, from which the eggs spilled out onto the bottom in two layers. Of the total number of fertilized eggs in the nurseries of the hatchery, an average of 26.8% perished. The mortality of the hatched fry of the chum salmon was not great--about 5%.

With a view to establishing a new commercial fish in these spawning waters experiments were made in 1930 in transporting Kamchatka sockeye to the Amur River. About 2½ million sockeye eggs were collected; these were transported in isothermal boxes and Atkins apparatuses. In all, 1,504,233 eggs were delivered to the Tëploe hatchery, and of the total number of eggs collected only 1,073,730 fry were released, or 43% of the collection.

Thus the count of fry hatched from the eggs shows that in the season 1930/31 a total of 9,447,453 eggs of keta and sockeye were hatched. However the total number of young salmon of the various species, including the estimate of the number of young which went out past the control points and those which were released from the Teploe hatchery, is as follows (in pieces)[1]:

1) gorbusha	895,891,320	4) autumn keta,	15,832,287
2) masu	2,036,500	5) sockeye	26,150,555
3) summer keta	333,731,448	6) coho	4,943,025
		Total	1,278,585,135

There should be an accounting made of the results of the experiment in acclimatizing sockeye on the Amur, up to the present time, even though Kuznetsov (1937, 31) has already reported on a part of this experiment, as have other workers, for example N. N. Belov (Belov's article is in the Arkhiv TINRO, No. 42, 1931).

Studies on the Amur in 1931. From the observations made in 1931 by Kuznetsov on the Naleo River and Korenev Kliuch, the following was discovered.

Korenev Spring Creek enters the Naleo River from the right side. The channel of the creek is narrow and meandering, it has a rather low bank, and in its lower reaches the bottom is covered by large boulders and stones. In winter the kliuch freezes. According to the observations of fish cultural technicians, in the season 1930 only about 700 autumn keta entered the Naleo River, and they spawned for the most part in the region of the "Labazy", about half a kilometer below the mouth of Korenev Spring Creek. The Labazy are the principal spawning grounds for autumn chum salmon in the Naleo River; above and below them only occasional individuals spawn.

The enumeration of autumn keta in the Naleo River in 1931 showed that about 800 fish arrived for spawning, in spite of the tremendous run of this fish all along the Amur. In even-numbered years gorbusha enter the Naleo River in large numbers. Summer keta, masu, and in odd-numbered years gorbusha, enter the Naleo River in limited numbers. Data on the count of these fish in the Naleo River from 1925 to 1931 have shown that from 6 to 315 summer keta have entered, from 39 to 1593 masu, and from 494 to 2963 gorbusha (in odd-numbered years). Gorbusha, masu and summer keta begin to lay their eggs [page 38] first about 4-5 km above the mouth of the Naleo. Because of the unavailability of the eggs of local fish to the hatchery, the work of the hatchery on the Naleo River must be concerned either with acclimatizing Kamchatka salmon (sockeye, coho and chinook) on the Amur, or with the rearing in the hatchery of Amur salmon which have been transferred as eggs from other spawning tributaries.

Observations on the Beshenaia River showed that the river has become very shallow, which is associated, Kuznetsov believes, with the systematic cutting of the forest and

[1] [These figures evidently are the totals for quite a number of years, since 26 million sockeye are included.]

floating the logs downstream. In the tributaries there was either almost no water at all or it flowed in them as tiny, almost dried out rivulets. There are no non-freezing spring creeks in the lower course of the Beshenaiā River. The tributaries are situated far from its mouth.

Along the Beshenaiā River there are important spawning grounds of summer keta, which come there in some years in numbers up to 100,000. These spawning grounds are exceeded in importance only by those of the Ud River. In view of this fact, and also because it is possible to construct a hatchery close to the mouth of the river, and because of the favourable conditions for transporting eggs from other spawning rivers, Kuznetsov proposed that as quickly as possible a fish hatchery should be constructed on the Beshenaiā River, where there is an opportunity for mass rearing of masu, summer and autumn keta, and in the odd-numbered years pink salmon.

On the journey up the Sutari River the Talyi Spring Creek was examined. It is situated on the left side of the Sutari River 35 km above its confluence with the Kuldur River, and approximately 50 km from Lake Tëploe. The length of the creek is 7 km, its breadth is from 4 to 6 m. In 1930 there were no autumn keta at all in Talyi Spring Creek, and in 1931 they entered the kliuch in inconsiderable numbers. Five kilometres below the mouth of Talyi Creek the Tunguzka Spring Creek enters the Sutari River; its length is about 10 km. This creek does not freeze for a distance of 2.5 km above its mouth, but above that it dries out or freezes. The autumn keta in this creek are even fewer than in Talyi Creek. From 1000 to 2000 autumn keta enter both creeks (in years of good runs).

In his article, I. I. Kuznetsov indicates that the Khor River occupies first place among the spawning tributaries of the Amur system in its size and the abundance of the autumn keta which enter it. Numerous tributaries flow into the Khor River, which at high water can scarcely be distinguished from the main channel of the Khor in strength of current and the extent of the overflow of the water, but at low water a large number of them dry out in their upper reaches. When the water in the tributaries rises, keta begin to run into them, to rest in their numerous deep holes, and to spawn. A continuous system of spawning tributaries and spring creeks begins below the village of Sviātogoriā, in whose neighbourhood the Kaplunovsky Kliuch rises; according to unofficial information, in this part of the Khor River up to 10,000-12,000 autumn keta are fished out of the deep holes and spring creeks every year. In the deep holes they catch fish which are not yet mature, but in the kliuches almost all that are taken have ripe sexual products. A check of the fish has been made in Privalov Spring Creek and on the Bolshaiā tributary, which are situated about 12-15 km apart. The estimates of keta at these control points gave the following results (in pieces).

1925 ...	1000	1929 ...	640
1926 ...	700	1930 ...	440
1927 ...	2400	1931 ...	7000
1928 ...	578		

[page 39] The splitting up of the channel of the Khor River takes place also about 25-30 km above Bicheva, in the region of Yumo-Tsangali Spring Creek. The fish here spawn more abundantly than in the region of Georgiev Spring Creek. But the region of the Yumo-Tsangali Kliuch is hard to get to, especially in summer time, when there frequently are floods on the Khor River; therefore Kuznetsov considered it most practical to construct a fish hatchery in the region of Georgiev Spring Creek.

Studies in the Maritime Province in 1931. In 1931, I. I. Kuznetsov (1932, 35) inspected the Mongurai River in order to select a place for the construction of a hatchery. The information about the Mongurai River, obtained by his personal observations and enquiries among the local population, revealed the following facts.

The Mongurai River is subject to very high floods, in which the current becomes so strong that meadows and ploughed fields are washed out down to the gravel, to a depth of 70-100 cm. After a flood the river in many places has occupied new overflow channels. At low water, sand banks in the Mongurai River begin approximately 2 km from the mouth; travel by boat is not possible farther upstream.

Chum, pink and coho salmon enter the Mongurai River. According to the local people, about 10,000 of these fish enter the river. Throughout the whole extent of the river, salmon are fished intensively by the local inhabitants.

In view of the frequent and extreme fluctuations in water level and the weak gradient of the terrain in which the Teplyi Kliuch flows, conditions for construction of a fish hatchery on the river with a direct gravity feed of the water system are not favourable.

The Suifun River was also inspected. Kuznetsov learned that all the left tributaries of the Suifun freeze, and are either completely uninhabited by salmon or else the entry of salmon into them is very limited. Among kliuches that seldom freeze, the author indicates that one of these exists on the right-bank tributary of the Suifun, the Chukhvon River, and there is one in the Suifun itself in the neighbourhood of the village of Borisovka (situated 12 km from the town of Voroshilov); in addition, there is another such kliuch on the Sandagou River in the region of the village of Nezhino. Inspection of these kliuches showed that they were not suitable for construction of a fish hatchery. On the Suifun River 5 km above Borisovka, there is a side-channel that is used for spawning, called the Khambalabe. This channel does not freeze and has rather transparent water, which comes from the main channel of the Suifun. But when there is even a small rise in the water level the kliuch is drowned and the water becomes muddy. In the upper and lower parts of the Khambalabe channel the bottom is gravelly, but in the middle course the bottom is covered with a thick layer of mud. The spawning area is not great.

The right tributaries of the Suifun River in the region below and above the Sandagou River--First Brook, Second Brook, Elduga and others--are tundra streams and for a considerable distance from the mouth they are inundated during big floods. Chum salmon enter these streams in small numbers. Kuznetsov comes to the conclusion that these streams could be used only as secondary points for fish-culture purposes.

Studies in Kamchatka in 1930. In 1930, in connection with the project to construct two fish hatcheries in the Kamchatka River basin, I. I. Kuznetsov was sent by the Pacific Fisheries Institute to reconnoitre the Kamchatka River from [page 40] a fish-cultural point of view; the results of this reconnaissance were presented in a report (Kuznetsov, 1931, 34).

On the 1st of August the fish-cultural expedition set out on the River Nikolka. At the mouth of the Big and Little Nikolka no live fish were observed. A few spawning sockeye were encountered only at a distance of 7-8 km from the mouth of the Big Nikolka. Spawned-out sockeye were encountered very seldom. Kuznetsov believes that the run of sockeye here was many times less than in 1929.

While visiting the Milkovo Inspection Point, it was found that the maximum number of females with running eggs occurred toward the end of the run; at the beginning of the run there were considerably fewer. At this Point 700 sockeye were measured and examined in 5 days, from the 25th to the 29th of July. Out of 382 female sockeye, those with running eggs amounted to 57 pieces (15%), and out of 333 males the mature ones amounted to 154 pieces (46%).

Coho salmon, according to information of the local inhabitants, are caught mainly in the region of Verkhnekamchatsk in the main channel of the Kamchatka River, which at this point does not freeze. About 50% of all the fish are caught in Stage V of maturity.

On the journey from the village of Milkovo to the village of Pushchino a great deficiency of sockeye in 1930 was observed, and there was an intensive fishery for these fish using barrier nets [zapory]. From data collected in 1929 at the village of Sharoma, during the period 1925 to 1929 from 13,740 to 40,858 sockeye were caught in the barrier nets. In the region of Pushchino a systematic deficiency of sockeye was observed; in

1930, according to the testimony of the local inhabitants, only about 3000 sockeye were caught altogether. According to the official statistics, from 1925 to 1929 on the average about 16,000 pieces were caught yearly.

In all the other kliuches and brooks seen during our journey inadequate numbers of fish for more than one year had frequently occurred; the fish arrive here for spawning in quite small groups. These kliuches and brooks flow through a region having a very slight gradient. The most favourable point for artificial rearing of fish was found in the region of Verkhne-kamchatsk. In the Verkhnekamchatsk region a large concentration of spawning coho was found. Not far from this village there are two rivers, the Andrianovka and the Kovycha, which all species of salmon enter in large numbers every year. In the Kovycha River chinook salmon enter in largest numbers, while in the Andrianovka it is sockeye.

The Andrianovka River, which is a left-bank tributary, enters the Kamchatka River by two mouths which are 2 km apart. The Kovycha River enters the Kamchatka on the right bank, at a point several hundred metres upstream from the mouth of the Andrianovka. Both rivers have a very fast current, and in the wintertime they become very shallow. There are some good non-freezing kliuches at a considerable distance from the Kamchatka River; they are not very large, and in winter they become very shallow, so that in some parts they freeze to the bottom and dry up.

The Eleninsk kliuch was selected for construction of a hatchery. It enters the Poperechnaia River on the left side, approximately 500 m from its mouth. Eleninsk kliuch has numerous underground springs.

A journey up the Kirganika River to the Mokhovaia River and the kliuches adjacent to it--Kakhanok, Toplochnyi and others, situated 8-12 km from the village of Kirganik--made possible the following observations. On the Mokhovaia River, Perfilev Kliuch, and the Kakhanok and Toplochnyi Kliuches, which usually are well seeded by salmon, sockeye spawning scarcely occurred at all in 1930 [page 41]; only near the mouth of the Mokhovaia River and in the Kakhanok and Toplochnyi Kliuches were a few sockeye and chums observed.

Finally, Kuznetsov characterizes the results of the above expedition in a series of short conclusions, and he indicates the principal measures which are necessary for the management of the salmon fishery on the Kamchatka River. Kuznetsov shows that the catastrophic decline of sockeye on the Kamchatka River requires the most serious consideration of the fate of this fish. In 1929 the spawning grounds of the Bolshaia River basin were 20% filled on the average, and in 1930 only 5%. One of the principal causes of the catastrophic reduction in these stocks is the extremely intensive fishery for sockeye by

Japanese vessels before they enter the mouth of the river. Kuznetsov believes that it is impossible to reestablish the stocks of these two year-classes using just one artificial fish-cultural station; what is necessary is to take measures for getting the sockeye to the spawning grounds, and for the protection of spawning.

To preserve and reestablish natural stocks of salmon on the Kamchatka River, sockeye above all, Kuznetsov proposes: a) to restrict the fishery for sockeye in the sea before they enter the river, b) to increase the escapement of sockeye to the spawning grounds by putting strict quotas on the fishery in the proestuarine regions, c) to increase the protection of all spawning grounds in the Kamchatka River basin and d) to encourage the use of other less valuable kinds of fish for feeding sledge dogs.

Studies in Kamchatka in 1931. Survey of the spawning grounds of the Kamchatka River valley at the time it was full of sockeye during the 1931 season was carried out under the auspices of Dalryba and under the leadership of V. A. Agafonov (1932, 36). In the upper part of the Kamchatka River 18 rivers and kliuches were inspected. The inspection showed that some very good spawning areas were very weakly occupied by sockeye in 1931, on the average only to the extent of 14-15%.

The Greshnaia̐ River, which enters the Kamchatka about 15 km from the village of Pushchino, has clean transparent water and gravelly bottom; its depth is up to 10 cm in the riffles and up to 1 m in the pools. The whole area in the river from its mouth to its source is a spawning area. Sockeye used to play an important role in the system of spawning grounds of the Greshnai͡a River, but gradually the number of sockeye entering to spawn in this river has decreased. In 1931 its spawning area was filled to the extent of not more than 25% of capacity.

The Malai͡a Kliukvennai͡a River has transparent cold water with a rapid current; the bottom is of gravel and in places sand; spawning grounds occupy approximately 60% of the total area of the river. The spawning grounds of sockeye were occupied to the extent of not more than about 15%.

The Bolshai͡a Kliukvennai͡a River is broad and has a slow current; its bottom is gravel covered by sand and mud. The spawning areas are situated only in the upper parts of the river--in kliuches; while in the middle course of the river sockeye were not observed.

The Polovinnyi Kliuch has a rapid current, clear transparent water, and a clean gravel bottom. The whole extent of the kliuch is a spawning ground. In 1931 it was occupied to not less than 70% of capacity.

The Nakazov Kliuch, whose length does not exceed 2 km, also has transparent water, a swift current and gravel bottom. The whole area of the kliuch is a spawning bed; in 1931 it was approximately 50% filled.

The Pervai͡a River, situated 4 km from the village of Verkhnekamchatsk, has excellent spawning areas. This river has a rapid current, clean [page 42] transparent water, and a clean gravel bottom. The breadth of the river is 3 to 6 m, its depth from 0.6 to 1 m. The spawning area was about 40% full.

The Zhupanka River has a strictly gravel bottom, without any sand or mud, and clean transparent water. The run of sockeye in it in 1931 was very inconsiderable.

The Sigachik River which enters the Kamchatka River near the village of Milkovo, is rather shallow with a swift current and a gravel bottom. In 1931 very few sockeye entered it; its spawning area was not more than 10% occupied.

The Karakovai͡a River is a tributary of the Kozyrevka; its upper portions have a gravel bottom and clear water. The local people asserted that a very few sockeye, chum, chinook and coho salmon enter this river. In 1931 there were no sockeye at all; utilization of the spawning grounds by the chinooks amounted to no more than 1%, and by chums about 3%.

The Krutoberegovai͡a [Steepbank] River has transparent water with a current speed of 4 km/hr, and a depth from 16 cm to 10 m. The bottom is of gravel and sand. According to local informants, sockeye, chinooks, chums and cohoes entered this river.

The Kirpich-Sokarin side-channel, which is up to 5 m wide and 2.5 m deep, has a gravel bottom, transparent water and medium current speed. Only two specimens of sockeye were found. The Kirpich-Sokarin River is up to 8 m wide and 3 m deep. The water is transparent, and the bottom clean gravel; the current is of moderate speed. The spawning areas of this river were not more than 20% filled in 1931. According to the local people, in previous years fish had entered the Kirpich-Sokarin River and its side-channel in great numbers.

The Bystrai͡a River is a tributary of the Kozyrevka. From testimony of the inhabitants of the village of Srednekamchatsk, large numbers of sockeye and other salmon used to enter the mouth of the Bystrai͡a River. In 1931 sockeye and all other salmon were completely absent from the Bystrai͡a.

The kliuch which enters the Kamchatka River below Srednekamchatsk is up to 3 m wide and about 5 km long. Its current is slow. The bottom in the lower portion is sandy, and in the middle and upper portions gravelly. At the head of the kliuch the spawning ground was approximately 15% filled.

At the end of his account, V. G. Agafonov states that salmon are captured in the spawning rivers; that sockeye are fished out for dog food; that in some places there are weirs across the whole river; and that at the time of the salmon run rafting of logs downriver takes place.

In a report by fishery manager A. P. Penzikov (1932, 37), he gives observations made in 1931 on the Bolshaîa River and on the Okaîan and Karimaĭ kliuches. Among these observations there is valuable information on the biology of the salmon. Hatching of sockeye and coho fry was observed after 139-147 days; the percentage of the eggs which died in the nests was not large (5-6%). The run of chinook salmon in the Bolshaîa River in 1931 began May 24, most were caught from June 20 to June 25, and by July 20 the run was over. The spring run of sockeye began to enter the Bolshaîa River May 29; pink salmon ran from the beginning of July, and the main migration fell in the period August 1-8; in 1931 the run of pink salmon into the Bolshaîa River was greater than expectation; cohoes began to enter August 17, but there was no large run. According to Penzikov's information, the fish entered the spawning grounds in poor condition(?) [ryba na nerestilishcha zashla plokho]. The downstream migration of young [page 43] pinks in the Bolshaîa River in 1931 was observed from the end of May to June 10-11.

In 1930, 1931 and 1932, A. Pavlov (1933, 38) did some work at the Control Station on Gromov Kliuch and on the Ulkhana River, and inspected the stocks which arrived on the following spawning grounds: the Kanaĭ and Goriachaîa Rivers, the Bakirka side-channel, the Romkin Kliuch, the Mankevich River, the Pavlov Kliuch, the Naakchen side-channel, and the Unchan, Nîaryn Bolshaîa and Nîaryn Malenkaîa Rivers, the Mashchichan side-channel, the Bumon, Muryldîa and Nashanku Rivers, Lake Namanuir and the Nîarykhan, Geramdandîa and Samutkich Rivers. All these rivers are tributaries of the Kukhtuĭ River. Inasmuch as we have little information concerning conditions in these rivers, I will present extracts from Pavlov's account.

The Kanaĭ River is 37 km long, 10 m broad; it has its origin in 3 kliuches in a volcano which is a continuation of the "Medveshîa Golov" [bear's head] volcano. In places the Kanaĭ River does not freeze; some of these open leads are 200-250 m long. Pavlov explains the presence of the open reaches by the existence of springs. Cohoes are the principal salmon that spawn in the Kanaĭ River (up to 25,000-30,000 individuals); chum salmon enter it in small numbers. The spawning grounds extend over a distance of 20 km.

The Goriachaîa River is 15 km long; its breadth averages 7-8 m. The bottom of the river is of fine gravel, strongly silted and grown up with moss and grass. Spawning grounds are situated in three places where the vegetation is not so luxuriant. Pavlov believes that if improvement measures were undertaken it would be possible to increase the spawning area. Few fish enter the Goríachaía River--up to 2000-3000.

The Bakirka side-channel is 10 km long, and averages 15 m broad. The bottom is of fine gravel. In places where springs enter, there are unfrozen reaches. The Bakirka channel is a good spawning ground for chum salmon. The fish enter it in large numbers.

The Romkin Kliuch is up to 5 km long and averages 10 m broad. It empties into a side-channel close to the Bakirka channel. The kliuch is badly silted and grown up with moss and grass, and fish can spawn only in its lower reaches. Chum salmon enter this kliuch to the number of 100-150 individuals.

Gromov Kliuch is a tributary of the Kukhtuĭ River. It is 7 km long and its channel averages 10 m wide. The current is slow. When the water level is 0.19 m [on the gauge] the volume of flow is 0.2385 m^3/sec, and at the 0.29 m level it is 0.4068 m^3/sec. The bottom of the kliuch is of fine gravel, much silted up in places, and almost continuously grown up with aquatic vegetation and mosses. The banks of Gromov Kliuch are rather high and precipitous. As a rule the kliuch does not freeze at all in its lower course. The spawning area of the kliuch is only about one-third used by spawning fish, because in many places the fish cannot clean out the channel, which is abundantly grown up with water vegetation. If improvement measures were carried out the fish could utilize the whole spawning area of the kliuch. At the mouth of Gromov side-channel chum salmon appeared on August 6 in 1930, and they entered the kliuch on August 7. The main migration of the fish was on September 11 (when 273 males and 229 females were passed through) and the migration ended September 19. The main migration of the fish occurred when there had been an increase in water level. In all, 3580 chums were put through the fence, of which 1902 were males and 1678 females; there were 33 pink salmon, including 23 males and 10 females. Determination of their stage of sexual maturity showed that the chums began to enter Gromov Kliuch in stage IV [page 44] of development of the sexual products. Cleaning of the nest sites by the fish began August 14, and the last nesting pair was observed October 6. The average fecundity of the chums was 2437 eggs, based on 64 counts.

On July 15 Pavlov captured fingerling chum salmon in the Kukhtuĭ River which were up to 6 cm long, and in Gromov Kliuch on July 20 he observed fingerlings which had not yet emerged from the gravel, and which still had large yolk sacs.

The whole extent of the Mankevich River was at one time used for spawning, but as a result of its drying out, the fish nowadays enter only the lower kliuch, in numbers up to 500 individuals.

The Ulkhan River is the largest spawning river of the Okhotsk region. It is 58 km long, and 25 m wide in its lower course, while in its middle and upper reaches it becomes as much as 150 m wide in places. The Ulkhan River has its source at the Soĭ volcano, and for 3-4 km it runs along as an inconsiderable little kliuch, then unites with two kliuches which are 40-50 m long each. From the place where the three kliuches combine, the Ulkhan River runs for 25-27 km among volcanoes of no great height. The bottom of the river here is of mud; throughout the remaining course of the river its bottom is of fine gravel.

When it rains hard the Ulkhan River overflows its banks and floods the tundra for 0.5-1 km. Then if the river freezes great layers of ice are observed covering the banks for up to 2 km. In its upper course the Ulkhan River freeze-up is late and the spring break-up is early, while at a distance of from 14-16 km from the mouth it freezes right to the bottom.

The Ulkhan River has 4 mouths. Fish enter it only by way of the two middle ones. At the time of high water there is an obstruction by trees which interferes with the migration of the fish. The spawning grounds on the Ulkhan River extend over a distance of 30 km, average 45-48 m broad and occupy an area of 1,440,000 m^2.

In 1931 fish on the spawning grounds of the Ulkhan River were 10-11 times scarcer than in 1930. In 1930 an approximate census of chum salmon showed 2.5 million spawned-out fish, while in 1931 244,094 chums were passed through a weir. Also put through the weir were 7156 cohoes and 212 pink salmon; in addition, Dolly Varden char, kundzha [Salvelinus leucomaenis], grayling, pestra [probably Salmo mykiss] and lampreys were found on the spawning grounds of the Ulkhan River. According to the local Tungus and Yakut inhabitants, the run of fish is greater in the even-numbered years. The start of the chum salmon run in the Ulkhan River was on July 13.

Three peaks in the chum salmon migration were observed. During the first run--July 28, 29 and 30--100,950 chums and 125 pink salmon were put through; in the second peak on August 7, 17,191 chum salmon, 4 cohoes and 3 pink salmon passed; the third peak occurred on August 15, 16 and 17, when 77,271 chums and 156 cohoes went upstream. The main run of cohoes began during the last days of August and continued to the middle of September. The end of the run was September 18.

Pavlov noted that the main runs of fish occurred at the time of a rise in the water level, but when the flood was very great, the fish were swept down with the current. The time of emergence of young fish from the nests was not observed. Up to the time of downstream migration Pavlov observed young fish along the backwaters in the middle current of the river, where there is much mud, water vegetation and even mosquito larvae.

The downstream migration of the fish began June 27. The peak of the downstream migration was from June 30 to July 5. On July 8 the run had ceased, but resumed again July 10. From July 15 to 20 there was a second mass migration, somewhat smaller [page 45] than the first. On July 25 the downstream migration of young fish finished for good. According to an approximate estimate, during the whole time 937,500,000 young fish went downstream.

The young fish which went downstream up to July 8 differed from those observed from July 10 through 28 in weight and in length. Pavlov suggests that during the first interval the young chum salmon went downstream, and during the second the cohoes. Among predators on young salmon there were observed Dolly Varden char, round whitefish, grayling, spotfin sculpins [Cottus poecilops], gulls, and several kinds of ducks.

The average fecundity of the chum salmon taken in the Ulkhan River in 1931 was 2461 eggs (from 46 determinations), and the average fecundity of pink salmon of the 1932 run was 1569 eggs (from 13 determinations).

In order to estimate egg mortality, in the spring of 1931 after the emergence of the fry Pavlov opened the nests over an area of 2 square metres and found 21 dead eggs. This insignificant egg mortality is explained by Pavlov by the fact that on the Ulkhan River spawning grounds the gravel is completely clean and well flushed by the water; in addition, on these spawning grounds the water never freezes. Pavlov's report shows that he took hydrometeorological observations from July 1 to November 1, 1931.

Pavlov Kliuch is situated opposite the mouth of the Ulkhan River. The kliuch is nearly 3 km long and averages 8 m in width. The bottom is of clean gravel. In winter the kliuch never freezes at all. The spawning area of the kliuch amounts to 10-12 km^2 [perhaps this should be 10,000-12,000 m^2--W.E.R.]. Chum salmon enter it for spawning to the number of 5000-6000.

The Naakchen side-channel is of exactly the same type as the Bakirka channel. The bottom is of fine gravel. In places small spring creeks flow into it. The length of the channel is 2.5 km and its width is up to 12 m. Up to 4000 chum salmon enter it.

The Bolshaía Níaryn River is about 26 km long and averages 8 m broad. The spawning grounds extend over 15 km, and occupy an area of about 40 km^2 [40,000 m^2?]. About 15,000-20,000 cohoes enter this river for spawning.

The Malaía Níaryn River is about 11 km long and 8 m broad. Its source is in the tundra. Spawning grounds extend for a length of 4 km; the spawning area amounts to 12 km^2 [12,000 m^2?]. Only cohoes spawn here, to the number of up to 8000 individuals.

The Mashchichan side-channel is 1 km long, and up to 10 m broad. The bottom is of clean gravel. In places where kliuches enter there are open leads during the winter. Chum and coho salmon spawn in the Mashchichan channel in the number of up to 6000 individuals.

In the mouth of the Bumon River there are some small coho spawning beds which are used by only a few hundred cohoes. The Nīăpkos side-channel is 4 km long and 10-12 m in average width. The bottom is fine gravel. Chum salmon and cohoes spawn in this channel to the number of up to 6000 individuals.

The Samutkich River is about 24 km long and 8 m wide. In its middle and lower course there are spawning grounds for chums and cohoes, of which up to 30,000 individuals enter.

The information collected by fishery guardians concerning the numerous previously unstudied rivers and streams unfortunately have not been published, and to a large extent have not yet been reviewed, but they constitute valuable primary data for evaluating spawning conditions and they will be of great assistance in completing these evaluations.

THE DEVELOPMENT OF SALMON INVESTIGATIONS ON KAMCHATKA [page 46]

Starting in 1932, studies of salmon in the Kamchatka region by the Pacific Fisheries Institute were broadened. Three observation points were established, at Ust-Kamchatsk, Bolsheretsk and Kikhchik. Material was collected by E. A. Lovetskaia at Ust-Kamchatsk and by V. B. Bool at Bolsheretsk, describing the composition of the migrating schools of sockeye, pinks, chums and coho, and in addition studies of sockeye spawning grounds were undertaken at Lake Kuril; the latter studies were continued in 1933 and have been described in the book by E. M. Krokhin and F. V. Krogius (1937, 41). A. S. Baranenkova in 1932 examined Lakes Nachikin and Sokoch in the upper waters of the Bolshaia River, and Paratunka Lake in the Avachin Bay watershed. As indicated in the report of the Kamchatka Division for 1932, M. V. Zheltenkova was able to carry out successfully experiments on accelerated maturation of the gonads of sockeye at the Ushkov Fish Hatchery, by means of subcutaneous injection of gravidana [possibly an extract prepared from mature fish--W.E.R.]. In 1932 the workers of the division had noted the presence of schools of young keta feeding in Kamchatka Bay (in 1933 the age of these fish was determined as 2, 3 and 4 years). It was established that there are three races of sockeye in the basin of the Kamchatka River. Studies of coho in winter showed that by the beginning of December more than 90% of the coho had already laid their eggs, but that the spawned-out fish remain alive for a long time, and food was observed in the stomachs of some of these fish.

In 1933, in addition to continuing the work of 1932, the young salmon were studied. A report by A. S. Baranenkova (1934, 42) was published in the hectographed publication Rybnoe Khoziaistvo Kamchatki, No. 2, 1934. The author gave a morphological description of the young of sockeye, coho, keta and gorbusha. This work has outstanding interest and can serve as a basis for further studies in this field. The author showed that the principal meristic characters (for example, the number of gill rakers) in the young in general coincides with the number of rakers in the mature fish. Studies of young sockeye (from Kamchatka rivers) showed that the young migrate downstream to the sea in their first, second, third and (very rarely) fourth year; the largest percentage migrate in the second year. Young coho migrate to sea when they are one year old, on the average. Chum salmon leave the river shortly after absorbing the yolk sac, rarely as fingerlings; pink salmon move downstream "as soon as they begin to swim freely"; young chinook salmon remain in fresh water sometimes more than 3 years. The time of downstream migration of the young salmon frequently coincides with the period of the spring high water, although migrating individuals are encountered right up to autumn; the first young to migrate are the pink and chum salmon. In this work a description is given of the physical and chemical characteristics of the places where the young fish stay up to the time they migrate to sea; and the question of the feeding and growth of the young is discussed.

In 1933 an experiment was carried out in marking young sockeye (by cutting off the adipose and left ventral fins); the size of the marked individuals varied from 8.5 to 18 cm. 5127 young fish were marked in this way, and in addition 100 young were marked with metal tags.

In 1933 a worker of the Kamchatka Division [of TINRO] V. I. Gribanov (1933, 43), put together a preliminary review of the fishing industry of Kamchatka including information on the history of the Kamchatka fishery and the current condition of the fishing and processing industries.

[page 47] In 1934 an experiment was made in catching salmon at sea with drift nets (near the west coast of Kamchatka); the presence of sockeye was discovered more than 56 miles from the coast (15-20 days before the beginning of the sockeye run in the river). Hydrological investigations were conducted in the same region and at the same time (by P. A. Moiseev).

At Nachikin Lake studies were made of the physical and chemical conditions on the spawning grounds of the spring and the summer sockeye: spawning of the former took place in rivers, and of the latter in lakes and kliuches. The work on the Bolshaîa and Paratunka Rivers was continued, and the first experiment was performed in acclimatizing sockeye in fresh waters; also, work was continued on the study of young salmon (the results were utilized in the article by A. S. Baranenkova mentioned above).

In 1934 F. V. Krogius, Z. E. Bool and A. S. Baranenkova (1934, 44) prepared an account of the biology of the salmon of Kamchatka based on materials of the Kamchatka Division, together with certain data concerning the fishery. In 1931 565,000 centners of salmon were caught along the east coast of Kamchatka, and in 1932 487,000 centners; along the west coast the catch was 1,015,000 centners in 1931 and 1,798,000 in 1932. Pink salmon were most important in the catches, while cohoes and chinooks were last.

On the west coast more pink salmon were caught in even years, and on the east coast in odd years, but the west coast catches greatly exceeded those of the east. The pink salmon of large runs are smaller than those of small runs. In the even years pink salmon ascend to the very uppermost portions of rivers and brooks, while in odd years they spawn only in the lower portions.

In Kamchatka waters, in addition to the summer chum salmon, autumn chums and the so-called "monako" are distinguished; the latter are smaller in size than the first two kinds, and enter the rivers earlier. The Oliutorsk region is especially rich in chum salmon, and there too the weight of the chums is greatest. In the northern portions of the west coast of Kamchatka chums have a small average weight.

There are several races of sockeye which differ principally in their time of migration to the spawning grounds: (a) spring sockeye enter the mouth of the Bolshaia River in May and June, and spawn in the tributaries of Lake Nachikin from the end of June to the beginning of August; (b) summer sockeye spawn in lakes, where springs enter; (c) the azabach, which has a later time of migration (at the end of September); (d) the arabach, which has small eggs and is smaller than ordinary sockeye in body size. In northern regions sockeye are usually of larger size.

There is interesting information on the rate of growth of sockeye. The young migrate out of the river in different years of their life: some in the first year, some in the second, and some in the third. The fish which go to sea in the first summer reach 20-25 cm at the start of their second year of life; while fish which remain in the river up to 1.2 years of age are only 8-10 cm long at the end of their first year of life (in fresh water); nevertheless at 4-5 years of age both types are of approximately the same length. It is mentioned that young sockeye of the Kikhchin and Bolsheretsk regions go to sea earlier than those from the Ozernaia River. As a rule the catches of sockeye on the west coast of Kamchatka are greatest in the Ozernovsk region, while on the east coast they are most numerous near Ust-Kamchatsk. The most favourable spawning grounds for sockeye are those which have an emergence of ground water with a temperature of 5-6°C and with a weakly acid reaction (pH = 6.6) and a considerable content of CO_2; the bottom is usually of gravel with some mixture of sand. Mortality of sockeye eggs in the nests is high [page 48] averaging about 37% (of the eggs deposited), and varies from 5 to 100%. Young sockeye 3-4 cm long are covered with scales having 2-3 sclerites.

The coho goes up to spawn from its second to its fifth year, but mainly in its third year, and spawns from September to January. On the east coast of Kamchatka summer cohoes and autumn cohoes are distinguished; the former spawn principally in October, and the latter in November and December.

Spawning of cohoes takes place in kliuches and rivers, partly in the same sectors where chums and sockeye also spawn; by digging out the nests of these latter fish the cohoes cause great damage. The fecundity of the chinook salmon averages 8100 eggs. Young chinooks remain in the rivers 1 or 2 years, more rarely 3-4 years. In Kamchatka, chinook salmon provide only inconsiderable catches in comparison with the other salmons; they are most frequently encountered in the Kamchatka River and the Bolshaia River. Chinooks go up to spawn at 5 years of age (rarely 7) [v vozraste 5 (redko 7) let].

Since 1935 special investigations of the spawning grounds of the basin of the Paratunka River have been undertaken.

In 1936 the Kamchatka Branch [of TINRO] established 5 observation points along the west and east coasts of Kamchatka; at these points biological and commercial data concerning salmon are collected continuously. In that year the times of migration of salmon in the Ozernovsk region were as follows:

	Beginning of the run	End of the run
Pinks	June 5-10	September 25-30
Sockeye	June 20-25	September 25-30
Chums	May 1-5	September 1-5
Coho	July 5-10	September 25-30

At the Bolsheretsk Observation Point observations were made on the spawning and development of the eggs. In 1936 F. V. Krogius and E. M. Krokhin completed a work on the biology and abundance of the sockeye stock in the Paratunka River basin. In their article these authors (1936, 45) come to numerous conclusions, and it is not out of place to mention the more important ones here. The places where sockeye spawn in the Paratunka basin are Lakes Dalnee and Blizhnee. In winter these lakes do not become very cold (at depths of about 5 m they do not cool below 2°C; in summer the upper layers become warmed to 16° and higher, and in the lower layers--at a depth of 40 m--throughout the whole summer temperatures less than 4° are maintained). In the Paratunka basin sockeye arrive first at Lake Dalnee (from the end of May to the end of August); later they enter Lake Blizhnee (from the middle of June to the middle of September); the azabach migrate in July and August. It is reported that the sockeye usually enter a river which is characterized by the higher temperature and the more alkaline reaction. From the time of the entry of sockeye into a lake up to the time of spawning one to two months elapse; the azabach enter a kliuch in breeding colour and immediately begin to spawn.

As typical hydrochemical characteristics for spawning grounds of sockeye the authors cite a free CO_2 content of about 10 mg per litre, and pH from 6.6 to 6.8. In 1935 there were 4.7 square metres of spawning area per female. The age composition of the spawning sockeye is not the same in different years: sometimes the 4-year-old group predominates, sometimes the 3-year-old group. Young sockeye, after absorbing their yolk sacs, feed on insect larvae and adults. The authors separate the azabach [page 49] as a separate form, as L. S. Berg had previously done (the azabach has larger fins and a shorter caudal peduncle).

Supplementing the work of Krogius and Krokhin on Lake Paratunka are the investigations of Gorogodsky and Orlova (1934, 46), who have presented a detailed account which includes very important data on the biology of the sockeye. Their

Table 7. [page 49] Catch of pink salmon by regions, as percentage of the total catch.

Name of the region	1930	1931	1932	1933	1934	1935	6-year average
Icha	19.8	3.6	17.4	4.8	21.8	1.8	11.5
West Kamchatka	63.7	46.7	79.0	27.8	71.6	60.7	58.3
East Kamchatka	0.4	1.5	0.6	1.0	0.4	0.6	0.7
Karagin	7.5	34.6	2.6	39.3	2.9	30.6	19.7
Oliutorka-Anadyr	8.6	13.6	0.5	27.1	2.3	7.4	9.8

account also contains information on young cohoes; especially useful is their working up of material on the food of young cohoes (255 digestive tracts). Bottom fauna and various insects (adult and larval) predominated in their food, and in addition small pieces of fish flesh and fish eggs were found in the digestive tracts of the young fish. The downstream migration of young cohoes to the sea takes place from the end of June to the beginning of October; the main migration is from August 1 to September 25. The main body of cohoes goes down at the age of 1 and 1+, when they are about 11 cm long; a certain number of 2-year-old fish also migrate, at an average size of 11-15 cm.

In 1937 R. S. Semko (1937, 47) wrote a work on the biology of the Kamchatka pink salmon; this work is a very complete account of the results of previous investigations, and of materials collected by the author himself. During the 5-year period from 1931 to 1935 the Kamchatka fishery produced an average annual catch of up to 85.5 million salmon, of which pink salmon comprised more than 70%. The author's table of the distribution of the Kamchatka pink salmon catch among the various fishery regions is given in our Table 7, where the catch of each region is expressed as a percentage of the total catch of this fish.

The Table gives a picture not only of the distribution of the catches, but also of the distribution of the commercial stocks of pinks. Semko, after reviewing the pink salmon catches for over 28 years (1909 through 1936) comes to the conclusion that the alternation of catches (larger catches in even-numbered years and smaller in odd-numbered years) in west Kamchatka can be considered to have its beginning in 1913[1], since prior to that time large catches were obtained in the odd-numbered years (1909, 1911, 1913, 1917). He points out that along the west coast in recent years there has again been an increase in the catches of the odd-numbered years.

Fluctuations in the catches have also occurred in east Kamchatka. He gives new information concerning the times of the run of pink salmon during the years 1931-1935. In the stomachs of marine pink salmon there are found herring, capelin and crustaceans. The age of pink salmon entering the river is determined by Semko, as by other investigators, as two years (on the basis of materials from the Bolsheretsk, [page 50] Kikhchin, Ust-Kamchatsk and Korf sectors). The size of pink salmon depends on whether the fish are more numerous or less numerous in a particular year; in years of abundant runs the pink salmon are smaller in length and in weight--the difference in average size in particular years (1927-1932) can amount to 11.5 cm. In even-numbered years (up to 1934) the average length of the pink salmon was 45.9 cm and in odd-numbered years

[1] [This is evidently a misprint for 1918.--W.E.R.]

it was 51.9 cm. The author presents a great deal of material on the condition of pink salmon at different times and in different sectors. Study of average weight and condition factor brings the author to the conclusion that different rivers there are inhabited by stocks of pink salmon that differ in respect to condition [weight at a given length]. The article also gives information on hydrochemical conditions in the Bolshaîa River estuary and on the spawning grounds.

The author's information concerning the mass mortality of pink salmon in 1932 and 1934, immediately prior to spawning, deserves careful attention; he identifies the cause of this mortality as the fact that when pinks fill small streams in massive numbers it is possible for a marked decline in the oxygen content of the water to occur. Pink salmon spawn in most places where the current speed is between 0.3 and 0.5 m/sec; large individuals can also spawn in swifter currents (0.6-0.8 and even up to 1 m/sec). The spawning grounds of pink salmon must be adequately supplied with oxygen, must not have too high a free carbon dioxide content (most often 4 to 5 mg/litre and pH not less than 7.0); emergence of ground waters on the spawning grounds of pink salmon is not essential and is even superfluous. The absolute fecundity of pink salmon on the average is 1454 eggs (1169 in even years, 1656 in odd years). In 1934, spawning near the source of the Plotnikova River lasted from the beginning of August to the middle of September, while in the Bolshaîa River in the same year spawning did not begin until September 3-6 and lasted to the end of September (Dvinin's data). The article includes observations by V. V. Azbeleva on the spawning process in pink salmon. The average length of young pink salmon obtained in the river at the time of downstream migration was 3.2 cm, with an average weight of 0.21 g. Copepoda and a comparatively small number of Chironomidae were found in the digestive tracts of the young fish migrating downriver.

Here we may recall certain other works done by the Kamchatka Division, although in part they have already been utilized in other communications from the same Division. The following works are of interest: E. A. Lovetskaîa's (1933, 48) account of her observations on the salmon of the Bolshaîa River; P. A. Dvinin's (1935, 49) account of observations he made on the lower reaches of this same Bolshaîa River; a report by P. A. Dvinin and R. S. Semko (1936, 50) concerning hydrological and hydrochemical studies at the time of the salmon migration in the regions off the mouth of the river and at the entrance to it; an article by E. M. Krokhin (1935, 51) concerning work done at Lake Kronotsk, where he discovered an indigenous form of sockeye; V. I. Gribanov's (1937, 52) general account of the work of the Kamchatka Division in 1936; and others.

The investigations of sockeye on the Kamchatka River, begun by M. P. Somov and previously by I. I. Kuznetsov, have been continued with great success by F. V. Krogius, E. M. Krokhin and other workers of the Kamchatka Division: for example R. S. Semko (1935, 54) made a study of the racial composition of the sockeye of Lake Nachikin.

It is well known that in 1929 there was a catastrophic failure of the sockeye in the Kamchatka River basin. M. P. Somov has published an article in which this question is given scientific scrutiny. Somov's conclusions (1930, 95) are of great interest. The author studied the age [page 51] composition of sockeye in 1926, 1927, 1928 and 1929, and came to the conclusion that in the years before 1929 the main mass of the sockeye catches consisted of fish entering the river in the 5th year of their life; in the first 3 years mentioned 5th-year fish [piatiletnie ryby] averaged 65% (4th-year fish--2%, 6-th year--25%, 7th-year--8%), while in 1929 the principal age-group in the catches were the 6th-year fish (71%), while 5th-year fish amounted to only 13%, 4th-year 2%, and 7th-year 14%. Somov recognizes the cause of the decline of the sockeye catch in 1929 in the spawning conditions in 1924, when the migration of sockeye was less than average and few fish arrived on the spawnibg grounds. Later Somov (1930, 53) again returned to this same question of the condition of the sockeye stocks, calling attention to a method of estimating the numerical composition of a run of sockeye.

A large and very fundamental work by E. M. Krokhin and F. V. Krogius has been devoted to the study of sockeye spawning in the basin of Lake Kuril. These investigators have published the detailed materials (1937, 41) on ecological conditions during spawning and egg development, and conditions of life for the young sockeye. In this they have given a physical and geographical sketch of Lake Kuril, have accumulated data on the temperature, transparency and hydrochemical characteristics of the lake, have described the spawning grounds in detail (in kliuches, rivers and lakes); they have given an account of the abundance of spawned-out fish and the number of eggs per unit spawning area; they have accumulated observations on sockeye fry and fingerlings, and have also given an analysis of age and growth, the weight of the fish and the sex ratio, and have determined the fecundity of the sockeye.

The conclusions of these authors deserve very great attention, as does their comparison with data on sockeye in other places and particularly with materials concerning other species of Pacific salmons. We may observe with much satisfaction that the comprehensive program of study of Pacific salmons which was planned in 1932 at a scientific conference in Moscow is beginning to be realized in the works of the Kamchatka Division of TINRO. Let us take a look at some of the conclusions of these authors, which are extremely important for understanding the biology of sockeye. "Spawning grounds of sockeye in the basin of the Ozernaia River are situated (1) in the littoral region of lakes, (2) in small streams entering a lake, (3) in kliuches which empty into the tributaries of a lake, (4) in the outlet of the Ozernaîa River, in the upper 4 km of the river." The total area of all the spawning grounds was determined as 322,000 m^2, of which more than half is in the lake littoral, while the smallest spawning area is that in the kliuches. Sockeye spawning lasts from the beginning of October to the end of December. In 1932 about 240,000 females spawned, or 480,000 of both sexes combined (on the basis of a 6-fold turnover of spawning fish in the lake, in its outlet, and in rivers, and a 4-fold turnover in the kliuches). Per unit area, a greater number of fish laid their eggs in the spawning grounds of the kliuches, where on the average 3200 eggs were enumerated per square metre, whereas in the lake spawning grounds it was 2010 eggs per m^2, and in the outlet spawning grounds of the Ozernaîa River 2458 per m^2; the average degree of utilization was 2230 per m^2. These figures led the authors to believe that the spawning grounds of Kuril Lake in 1932 were overpopulated with fish, for they considered (following I. I. Kuznetsov) that an area of 2½ to 3 m^2 is necessary for one spawning female, whereas on the Kuril spawning grounds each female had only 1.4 m^2. The greatest egg mortality was observed in the kliuches (39-40%), in the lake it was 30%, and in [page 52] the outlet river 37%; average mortality was 35.7%. The eggs died principally at the beginning of development when their nest was worked over again by later-spawning females, and also from unfavourable environmental conditions. Very few eggs died in the later stages of development or during the period of emergence of the fry.

The waters of the spawning sectors contained larger than usual quantities of oxygen and free carbon dioxide; their active reaction was 7.2-6.3. Eggs are buried to a depth of 10-40 cm. The eggs do not all develop at the same rate in a nest, and the larvae hatch on different days. One curious phenomenon was observed: the sockeye spawning in the kliuches were smaller than those spawning in the lake, although they were of the same age. The average absolute fecundity of the sockeye was 3750 eggs. Young sockeye usually remain 1 year in fresh water and then leave for the sea, but a part of the young stay in fresh water for 2 years; in general, the young sockeye of the Ozernaîa River basin remain longer in fresh water than sockeye of other regions. The sockeye came back to spawn principally in their 5th year of life [na 5-m godu zhizni], but part of them returned in their 4th or 6th year; in 1932 fish in the 6th year predominated. Sockeye grow most intensively in their first year of life in the sea; generally speaking, in the authors' opinion the rate of growth of sockeye of the Ozernaîa basin must be regarded as good.

In 1937 a book by these same investigators appeared--Krokhin and Krogius (1937, 55)--concerning the spawning beds of salmon in the Bolshaîa River basin. This work contains a physical and geographical description of the Bolshaîa River, gives the hydrochemical characteristics of numerous rivers and brooks, describes the spawning grounds of the salmon, and contains information on the biology of the salmon. Since this work has been published I will not dwell here on its contents; the important conclusions from this work will be used below in the description of the spawning of the individual salmon species.

STUDY OF SALMON AT SEA

In studying salmon stocks it is impossible to avoid problems of the life of the salmon at sea. This is just as important a job as the study of spawning grounds and young salmon; but it has been attacked by the Pacific Institute on a wholly inadequate scale because of the very great technical efforts which are needed in such researches. But nevertheless the Pacific Institute in 1933 began independent studies of salmon in the sea when an experimental salmon fishery was begun off the west coast of Kamchatka (the Yavina River region) and also off the east coast. M. L. Alperovich and I. I. Rassokhin (1934, 56) were among those who worked with the west Kamchatka group. Since the fishery was conducted with floating gill nets under extremely unfavourable conditions, during July 17-19 only 2 specimens of pink salmon, 12 sockeye and 7 chums were caught. The experiment did not succeed; but we know that at the same time the Japanese fishing industry was carrying on a commercial salmon fishery in this region; their fishing was conducted in July with fixed and floating gill nets just outside the 3-mile coastal zone, approximately at a depth of 20 m; the nets were set out in gangs several kilometres long.

Off the east coast of Kamchatka drift-net fishing for salmon was done from August 18 to 30, but without result, apparently because the salmon had already entered the mouths of the rivers by that time.

[page 53] In the same year (1933) experimental salmon fishing with floating gill nets was conducted in the Maritime Province and in Sakhalin Gulf; this has been reported in an article by N. V. Dubrovskai͡a-Milovidova (1933, 57). The purpose of these experiments was to discover the routes by which salmon approach the coast near the rivers and to see what prospects there were for commercial gill-net fisheries in these regions. Fishing was done with cotton and linen nets of 12/12 twine and 65-70 mm mesh; the length of the nets along the cork line was 31 m and their depth was either 100 or 50 meshes. The work began with a drift on August 31, when the commercial fishery for autumn keta started. The earliest of the autumn keta had begun to run at the beginning of the second half of August. During the night of August 29-30 the keta began to run in schools. The first catch was made at Nizhniĭ Pronge.

The first effective drift was made 14 miles from Ud Island. The depth was 25.67 to 27 m; water temperatures where the net was set were 10.3° at 5 m and 5.0° at 10 m, while where the net was lifted temperatures were 10° at 5 m and 6.8° at 10 m. The net drifted [oblov proizvodilsi͡a] 1.8 km in the course of 24 hours and 30 minutes. There was no catch.

Additional fishing was conducted in the Sea of Okhotsk, in the region of the northeastern part of the tip of Sakhalin Island, from which direction, according to hypotheses put forth in the literature, chum salmon must come to the Amur River. A second drift was made on the traverse from Cape Marii͡a along the Sakhalin coast to the Amur estuary, where several experimental catches were made. At the time of the second drift 3 female chum salmon were captured in the nets, of which 2 had approached from the ocean side 3-4 m below the cork line and were in stage 3 of maturity, while one of them approached it from the opposite side. The depth was 34.8 m, the wind SE, wind force Beaufort 4, current NNE, and water temperature was 14.5° at 5 m, 6.6° at 10 m, and 2.2° at 15 m.

After this they moved closer to the coast in the direction of Ush Island (Baĭkal Bay) where 4 chum salmon were taken at depths of 3 and 5 m. The temperature at the place the net was emptied was 14.5° at 5 m. Judging by the quantity caught, the fish were not moving in a definite direction, since 2 individuals entered the net from the sea side and 2 from the estuary side. The size of the catch, and also the way in which the fish entered the net suggests that the fish caught were "wanderers" [bluzhdai͡ushchie], that is, for some reason or other they did not form a part of a migrating school. In this region, from Baĭkal Bay up to the Amur estuary, the main mass of autumn keta move close to the shore, and at a majority of the fishing stations they are fished with drag seines 500-700 sajenes long [1170-1490 m].

The place the 4th drift was made was a little southwest of the third one. The depth was 22.0-23.6 m; and the surface current here, which judging by its colour was fresh Amur River water, was toward the southeast; while the current deeper down was of Okhotsk Sea water moving in a direction opposite to the other. The water temperature here indicated the presence of a cold current at no great depth (it was 10.5° at 5 m, 8.7° at 10 m and 2.9° at 15 m). The catch of this drift consisted of 6 chum salmon: 4 came from the sea side and were entangled 1.5 m below the cork line and about mid-way along the net, while 2 came from the estuary side and were caught at 0.5 m and 1 m depth; the majority of females among them were in stages III and III-IV of maturity. This dispersed character [of the catch] reflects an absence of accumulations of fish in the region fished.

Finally, the last drift was carried out along the west coast, in the region of the Kol River; the depth was 18-20 m, water temperature was 10.7° at 5 m, 9.7° at 10 m, and 5.8° at 15 m. When the net was hauled it contained 9 chum salmon, of which 6 came from the sea side and 3 from [page 54] the shore side, [they were usually] at a depth of 2-2.5 m below the cork line, only one being near the lead line. The chums caught were in stages III-IV and IV of maturity, which indicates that these fish had been delayed and would have to proceed into the river without remaining in the region off its mouth. The sizes of the fish caught varied from 54.0 to 67 cm and their weight from 1900 to 4450 g; the maximum length of the females was 67 cm and weight 4450 g, and for males it was 63.0 cm and 3500 g; the minimum length for females was 58 cm and weight 2610 g, while for males it was 54 cm and 1900 g. The individuals studied were almost all in their 5th year [4-letki]; those in their 4th and 6th year were almost absent.

This expedition did not solve the question of how schools of autumn keta approach the estuary, and did not make [sufficient] observations on temperature and currents. From published data it is known that Amur River water, after discharging into the Sakhalin Gulf, is directed to the coast of Sakhalin and constitutes a brackish warm current in the upper layers of water, while at the same time in the layers near the bottom there is a cold current carrying water from distant parts of Sakhalin Gulf and the Sea of Okhotsk into the Amur estuary. Temperature data at different levels were taken at the places drifts were made; these confirm this picture and show that the limits of the warm current lie at a depth of about 15 m and of the cold current from that level and deeper. This is apparent from the table of water temperatures at various depths which is published in the article.

Judging by the drifts, the movement of the upper layers of water (Amur water) in the southeastern part of Sakhalin Gulf is in a NE direction, while in the eastern part it is NNE. Concerning the water of the western shore of Sakhalin Gulf which Brazhnikov designated as water of an "Arctic Sea character", we can say that it must occur north of the Kol River, for in the drift described a higher temperature was observed. The direction of the currents here is much influenced by the wind and the strength of the tidal currents.

In characterizing the main mass of chum salmon going to spawn, we must observe that the fish have remained close to shore, as shown by the nature of the catches during the time of the drift. Judging by the state of maturity of the sexual products (III-IV), all of the chums must lay their eggs during the current year. The size, weight and age of the chum salmon is given by the author in a table.

From the article by M. L. Alperovich (1935, 58) we can extract information on the relation of the migration of salmon in the sea to hydrological factors.

To study the biology of salmon in the open part of the Sea of Okhotsk an expedition was conducted in 1934 on the trawler "Lebed". Work at sea was performed at various distances from the coast (up to 100 miles) and comprised a series of observations concerning the fishery and biology, as well as hydrology. The conclusions concerning hydrology were as follows: the distribution of salinity made it clear that the coastal region of west Kamchatka was significantly influenced by fresh river waters (Bolshaîa and Ozernaîa Rivers); this influence was apparent mainly in the surface layer (and not farther than 20 miles from the coast) where the salinity was markedly lower than normal; at 15-20 miles from the coast the salinity again rose to 32.7°/₀₀. The same observations made it clear that the main mass of river water is directed to the right after entering the sea and moves northward at no great distance from [page 55] the coast; while the band of water in immediate contact with the coast has a somewhat higher salinity because of the more intensive mixing with lower-lying layers caused by the surf and tidal currents. Brackish water (below 32°/₀₀) extends to a depth of 20-25 m in the coastal zone, while in the sea it goes only to 5-10 m.

To characterize the fishery and to make biological observations three series of observations were made. The first series was between the mouths of the Bolshaîa and Koshegochek Rivers; the second traverse was on a line out from the Koshegochek River--vertical series being taken at distances of 5, 10 and 15 miles from the coast; the third vertical series was made off the mouth of the Bolshaîa River 100 miles from the coast in order to shed light on the question on how far out in the sea salmon are encountered. Experimental fishing at different depths showed that the fish remained in the upper layers of water. Fishing at night gave better results than by day. Usually the nets were set before sunset and were lifted after sunrise.

An analysis of the catches of useful fishes along the cross-section showed that near the Koshegochek River catches increase with proximity to the coast, while farther north the fish remain farther from the coast. The migration of sockeye is determined by fresh waters: the hydrological map of the region shows that a current of water discharged by the Ozernaîa River is directed northward parallel to the coast up to the Koshegochek River, where it turns northwestward. It may be supposed that the sockeye enter the brackish stream and move along the latter in a southerly direction. From observations on sockeye migration, consequently, it is clear that their approach to the coast is confined to the region between Koshegochek and Opala, where we should expect the schools going to the Bolshaîa River to separate from those going to the Ozernaîa. Age analysis of sockeye catches this year showed that the Bolshaîa River catches were mainly of 5th-year fish [4-letki] which had spent 1 year in the river, while 4th-year fish were lacking completely; while sockeye of the Ozernaîa River were mainly in their 4th year [3-letki] with 1 river annulus. We must observe that at the time of these investigations pink salmon were encountered 100 miles from the coast.

The Pacific Fisheries Institute in 1935 studied the hydrometeorological and hydrochemical conditions of the migration of salmon in the regions off the mouths of rivers and during their entry into the rivers; this work was done by scientists of the Kamchatka Division P. A. Dvinin and R. S. Semko (1936, 50) during July and August in the region northward from the mouth of the Bolshaia River on the west coast of Kamchatka. The migration of pink salmon (in July) occurred at temperatures from 8.6° to 12.4°C, average 9.7°. According to some data (1936, 84), the best run of salmon near the west coast of Kamchatka occurs at 10-13° water temperature. The expedition did not discover any regular advance of the fish along the coast and decided that the fish approach the river from the sea.

Southeast winds were most favourable to the approach of salmon to the shore; maximum catches at the time of the main run coincided with southeast winds in a majority of instances.

An extremely curious phenomenon was observed, which shows clearly that the oxygen content of the river water decreases markedly at times of massive runs into the river when the fish are concentrated into dense schools, as actually happened for pink salmon at the time of the main run. This phenomenon is most characteristically developed in the lower courses of rivers, where fish collect in tremendous numbers. Along with the decrease in oxygen [page 56] the carbon dioxide content increases in such circumstances, and the pH is shifted toward acidity.

In 1936 in the Morzhovaia Bay (in Kronotsk Gulf on the east coast of Kamchatka) experimental fishing for salmon was carried out in the open sea by the Kamchatka Division of TINRO. Pink salmon, sockeye, cohoes and chums were caught in the nets. Under commercial conditions salmon comprise 45% of the total catch of all fishes, but since no considerable rivers of any sort flow into Kronotsk Gulf the author considers that all this region does not offer great prospects for the development of a salmon fishery; although in the sea salmon fishing is successful even there (as shown by the Japanese salmon fishery at sea in the northern part of Kronotsk Gulf). Sockeye here run from the first days of June to the middle of August; cohoes from the middle of August to the middle of September and later; and keta from June through September.

These very scattered observations represent the sum total of all the results of our studies of salmon in the sea.

In dealing with questions of the conservation of fish stocks, TINRO must include among its other investigations such projects as a study of the effects of log-driving on rivers on the fish and the fishery, the effects of hydroelectric constructions, and so on. In the past 10 years the Institute has given some attention to one of these objectives. Thus, in 1932 a member of the staff of the Kamchatka Division of TINRO, Zheltenkova (1932, 59), studied the effect of log-driving in the Ust-Kamchatsk fishery region, where large scale utilization of the forests began in 1929. In her article the author makes some practical proposals for the regulation of log-driving in the interests of the fishing industry, but it must be said, without prejudice, that the question of the effect of log-driving remains almost wholly uninvestigated, although numerous observations by fish guardians indicate a harmful effect of log-driving on salmon stocks.

In concluding this section of this work I must remark that TINRO during the 13 years of its existence has added extensive materials to the story of the investigation of Pacific salmons; among these materials are many new facts which will be most useful in the further development of these investigations.

A large part of the activity of the Institute during this period was directed toward a preliminary census of salmon stocks and toward the accumulation of data concerning salmon biology. Without such a census and without these data it is impossible to come anywhere close to a solution of the most important question before us--what is the state of the salmon stock?

II. THE PRESENT STATE OF OUR KNOWLEDGE OF FAR-EASTERN SALMONS AND SOME CONSIDERATIONS CONCERNING THEIR STOCKS [page 57]

1. PINK SALMON (Oncorhynchus gorbuscha Walb.)

It is not yet 10 years that pink salmon have occupied first place among the species taken by the Soviet far-eastern fishing industry. During recent decades pink salmon have made up more than half the total catch of salmon of the Far East in even-numbered years; in odd-numbered years pinks occupy second place, chums being first. Later we will show that very recently pink salmon in some sectors of our industry have fallen off somewhat in the even-numbered years, and at the same time have increased in the odd-numbered years. Catches of pink salmon in certain individual years are very high: in 1932 the pinks landed in all sectors apparently exceeded 1.5 million centners, or more than 150 million pieces (186,358,000 pieces were landed in 1934; and we must not forget that 50 million additional salmon were caught in our waters [this evidently refers to Japanese landings--W.E.R.]). These are large figures; nevertheless, for a long time there has been deep-seated uneasiness in the industry about failure of the pink salmon in the odd-numbered years in the most important fishing regions--Nikolaevsk and West Kamchatka (in very recent years in the West Kamchatka region the largest catches have shifted to the odd-numbered years). Naturally these fluctuations in catches have made it difficult to plan operations in the fishery. The causes of this biological phenomenon have proved puzzling so far, though apparently studies on gorbusha have had more attention than those on other species of salmon; however, our knowledge of the pink salmon is gradually increasing and becoming more meaningful, the rate of progress being determined by the various kinds of circumstances which now accelerate, and now slow up, scientific work.

Racial studies of pink salmon. Some rather important results have been achieved in the study of pink salmon races. We now can say that pink salmon living in the waters of the west coast of Kamchatka differ from the pink salmon which are found in the Amur estuary and river. The Amur gorbusha are smaller than those of Kamchatka; the average length of Amur gorbusha is 44 cm, and of West Kamchatka ones is 49 cm (from material taken in even-numbered years). There are differences in other characteristics also; hence the Amur gorbusha have been separated off as a special race Oncorhynchus gorbuscha natio amurensis (Pravdin, 1932, 16).

The discovery of differences between the Amur and west

Kamchatka gorbusha became possible because previously (1929, from materials collected in 1926) a suitable description of the west Kamchatka (specifically, Bolshaía River) pink salmon had been made (Pravdin, 1929, 14), as the type of Oncorhynchus gorbuscha (W.). This description became the standard by which comparisons of pink salmon from other places were made: it should be observed that the Pacific Institute occupies a leading position in the study of pink salmon.

Racial study of pink salmon, as of other salmons, will in the long run provide an answer to the question of the localization of pink salmon stocks, something which is [page 58] extremely important from the commercial point of view. In the work of N. M. Milovidova-Dubrovskaía (1937, 60) on the Maritime Province pink salmon I also found valuable materials on this same racial problem, although the author herself is not inclined to separate the Maritime Province pink salmon as a distinct biological race. We may notice that in the Maritime Province, in contrast to the Amur, greater quantities of pink salmon appear in the odd-numbered years. This suggests that the Maritime Province gorbusha may possibly comprise part of the stock which is caught near the Island of Hokkaido, where larger catches of gorbusha are taken in odd-numbered years, as indicated by information obtained in Hakodate and published in 1932 (16). It is possible that two components of the run of gorbusha from the region of Hokkaido come to the Maritime Province; one part, the smaller one, directs itself toward the rivers of the southern Maritime Province, while the other, larger, one goes to the rivers of the northern Maritime Province. At least it seems correct to say that all of the pink salmon which enter the Amur estuary arrive from the southern parts of the Sea of Japan adjacent to Korea, because [in streams] along the eastern shores of Korea there are at present no pink salmon; any references to Korean pink salmon there require confirmation, for masu salmon do occur there, which are easy to confuse with pinks.

The racial study of pink salmon necessitated special studies of the methodology of this question (Pravdin, 1929, 14; 1936, 61). Determination of length in the manner used by Smitt (1886, 62) [from tip of snout to fork of tail], which up to now has been used by all ichthyologists working on salmon systematics, apparently can be replaced by a simpler length, one which on the whole will lead to more accurate results. The reason for my proposal is that the body length of salmon with which comparisons of the size of the other parts of the body is made, and which is accepted by all ichthyologists as fundamental, is a quantity that becomes greatly changed at the time of the spawning migration of the fish, so that if one and the same fish were to be measured first in the sea before the beginning of the spawning migration, then later during migration or on the spawning grounds, there is no question that many of the figures for its morphometric characters would be different; actually they are less in the latter case, since we are relating them to a measure of body length which we know increases because of the marked lengthening of the body that results from the growth of the premaxillaries and other bones of the skull. If, however, the standard length for comparison for morphometric characters be taken as length of the trunk [tulovishche] (length od), defined as the distance from the gill aperture to the end of the scale covering, then results are obtained which are more in accord with reality, and all biometric work takes far less time since many relationships based on the Smitt length will disappear.

In order to change over to the new method, it is necessary to initiate it by a broad discussion among ichthyologists and, in the event this method is accepted, for all to change over to it. The American authors Davidson and Shostrom in 1936 (63), citing our work, have already accepted length of the trunk of pink salmon as their standard length.

In racial studies of pink salmon and also of other representatives of the genus Oncorhynchus--and for that matter representatives of Salmo as well--it is in my opinion essential to use the length of the trunk as the standard length; and the same length can have a decisive importance in the study of the "condition" of Pacific salmon, which is usually done with the aid of the condition factor calculated from Fulton's formula which makes use of [page 59] the Smitt body length; this length should be replaced by the length of the trunk.

I cannot in any way agree with the views of those investigators who believe that they must restrict themselves mainly or even entirely to meristic characters only, in studying races of fish. Many such [meristic] characters, which are rather unvarying within the limits of so comparatively high a taxonomic category as a subspecies, cannot serve to outline [obespechit polnotu] the racial characteristics of fish. Species changes and species formation in fish most frequently involve morphometric characters which, being more changeable, for that reason more easily reflect environmental conditions and the influence of biological factors; consequently, the delineation of some particular group of fish as a small local form involves the study of morphometric characters primarily. This kind of work presents special difficulties (a large mass of material is required, there is need for extensive application of the statistics of variability [variatsionnaîâ sistematika], we must take into consideration changes in morphometric characters with sex and age, and so on), but the results can yield interesting conclusions which are very important not only for theoretical ichthyology, but also for the fishing industry. If we were to succeed in showing that pink salmon have local forms [formy] or simply local stocks [stada] (and this apparently is so) then we would have taken a long step forward in studying the condition of the pink salmon stocks [zapasy]. It is understood, of course, that the study of racial composition in pink salmon cannot be limited to biometric characters alone; along with the study of morphological differences there must go a study of biological characteristics, and we must take into consideration age, sex and maturity changes; without this, the errors of previous investigators can be repeated, as for example the description of a chinook-like pink salmon (Salmo tschawytschiformis) which Smitt made when he failed to take into consideration the changes in the fish accompanying maturity.

We have dwelt somewhat on questions of methodology in the study of pink salmon because many people are working on these problems, and because the racial question in pink salmon stocks is very much to the fore at present, when before our very eyes such phenomena occur as the alternation of good and poor catches, and when it is necessary to make rapid decisions in respect to measures for management and regulation of a fishery. The same racial questions are of first rate importance also in the study of all other far-eastern salmons of the same genus; chums, sockeye, cohoes, masu and even chinooks. Consequently the work of the Pacific Institute in the study of races of pink salmon has already yielded these results: the west Kamchatka pink salmon are distinct, the Amur pink salmon are distinct, and there is some reason to recognize the distinctness of the Maritime Province stock of pinks.

The racial question also occupies a conspicuous role in the work of Americans who study this problem by marking pink salmon in order to define local stocks associated with particular rivers (Pritchard, Davidson and others).

Length of life, rate of growth, and food of pink salmon. Among the problems of pink salmon biology, the question of their length of life and rate of growth must be considered fundamental, for the length of life of the pink salmon is regarded as a basic element of the method of managing its stocks.

The long-disputed question of the length of life of the pink salmon is now solved, it would seem, correctly and finally. Study of the age of Pacific pink salmon was begun by Gilbert (1912, 79) [page 60] and Marukawa (1917), who concluded that the life cycle of pinks was restricted to 1.5-2 years in all. Among Soviet ichthyologists the following have come to the same conclusion: M. M. Tikhy (1926, 15) for the west Kamchatka gorbusha, I. F. Pravdin (1932, 16) for the Amur and west Kamchatka gorbusha, N. V. Dubrovskaia͡ (1934, 64) for the Maritime Province gorbusha, and R. S. Semko (1937, 47) again for the west Kamchatka gorbusha. On the basis of a review of the truly colossal amount of material on the question of age of gorbusha, I accept as incontestable the conclusion that pink salmon spend a summer and a winter in the sea, and return to the river for spawning at the middle of their second summer. All the other material on age of pink salmon, collected by the Pacific Fishery Institute over 12 years (1925-1936) in different regions of the Soviet Far East, leads to exactly the same conclusion. We may now put behind us the great argument about the age of the pinks.

In this connection, there is still another piece of evidence, more acceptable to everyone, which also indicates a 2-year life cycle among pink salmon. A large run of pink salmon to the spawning grounds, good conditions for reproduction, favourable development of the eggs and downstream migration of the young, results in a new dense run of pinks in the same river in the second subsequent year. Fish management work carried out by I. I. Kuznetsov shows the same thing.

Some experiments done by the Americans are particularly conclusive. In 1913 and 1915 eggs of pink salmon (at the eyed stage) were taken from the Pacific coast and were transported to hatcheries in the New England states; in the following spring pink fry were hatched from the transported eggs, and were liberated along the coast and in the rivers. In the summers of 1915 and 1917, that is in the second year of life, a great quantity of mature pinks returned to spawn in those same rivers where they had been released as young (Davidson, 1934, 78). These experiments confirm the 2-year life cycle of the pink salmon and indicate a strongly developed instinct of return to the same place where they spent the first days of their life (at the fry stage), that is, to the native river.

However, we do not yet have the final materials which would answer the question whether all individuals without exception, which are hatched in a particular year and escape to the sea, invariably return to the river in the second year. May it not be possible that for one reason or another occasional individual pink salmon remain longer in the sea? This question remains because of the fact that in any large quantity of pink salmon scales there occur (although in quite negligible numbers) scales on which the exact age can be determined with great difficulty. Naturally this is of interest not so much from the practical point of view as theoretically, because even if occasional individuals were to reach their 3rd or 4th years, this would not in any way change the general conclusion about the 2-year life cycle of the gorbusha, which is thus the most rapidly maturing salmon of the genus.

The scales, which are the best means for determining age in pink salmon, show that the young pinks quickly go out into ocean waters without remaining in the river; in cases where the river in which the pink salmon hatched has an estuary, the young remain in the region off the mouth of the river, and their scales frequently have a special annulus put down in these estuarine waters (Pravdin, 1932, 16); in rivers whose mouths open directly to the sea, the young gorbusha do not [page 61] have such an estuarine annulus (Dubrovskaiā, 1934, 64; Semko, 1937, 40). Nevertheless we may say that in these cases also the young pinks, after migration down the river, remain for some time in the sea close to the river; Pritchard (1932, 80) has also mentioned this accessory annulus.

The scales also show that the west Kamchatka, Amur and Maritime Province pink salmon, after going to sea, grow quickly in their first summer and do not stop growing even in the winter--a time when, it would seem, we might have expected their growth to be much retarded, for two reasons: a) as the result of the lower water temperature in the winter, and b) as a result of the diversion of the energy of the organism to the elaboration of the sex products, that is, in preparation for spawning. Obviously a main factor in the rapid growth of pink salmon, besides the general nature of their organic constitution, is the food which they eat and rapidity with which they digest it.

About the food of pink salmon we know very little; however there is no doubt that pinks eat a great quantity of live food, among which are included the kind most similar to themselves, that is, fish. In the stomach contents of young pink salmon swimming out of the river, which are quite small in size (3-5 cm) it is easy to find abundant food in the form of insect larvae. According to American data (Chamberlain, 1907, 65) young pink salmon remain some time in the coastal zone, in brackish marine waters, and there eat insect larvae, crustaceans, and even young fish, although at that time they are themselves only about 4 to 12 cm long.

The indication that young pink salmon in fresh water feed only occasionally (65)--in itself of highest interest--nevertheless requires that this fact be confirmed by additional material. In the work of TINRO we have as yet no observations on the food of young pink salmon during the first days of their life. Some gorbusha (age 8-9 months, 22 cm) studied by Dubrovskaia͡ (1934, 64) had "stomachs full of amphipods with a small admixture of tiny fish".

At the time of their marine migration to the spawning grounds pink salmon apparently also feed heavily (Golovanov, 1931, 85; Pravdin, 1932, 16; Milovidova-Dubrovskaia͡, 1937, 60); therefore, rate of growth of the migrating pink salmon apparently either does not decrease at all, or decreases only slightly, up to the very moment of their entry into fresh water. Pritchard (1932, 80) had evidence that pink salmon feed little at migration time; but these observations apparently were made on migrators that were close to spawning.

We may consider that the rate of growth of the Maritime Province gorbusha goes as follows: in the first summer they reach 24 cm on the average, during winter the body increases by 3 cm, and in their last (spawning) year they increase 21 cm; that is, up to the beginning of spawning time they have reached an average length of 48 cm (Milovidova-Dubrovskaia͡, 1937, 60). At the close of the first summer they spend in the sea the Amur pink salmon (at an age of 8-9 months) have reached 23 cm; in the first winter spent in the sea they grow 10 cm, and up to June-July, that is, after a year and a half of life, they have reached 40-44 cm (Pravdin, 1932, 16). These two sets of figures are rather close, and differ only in the amount of winter growth; it is possible [page 62] that this is a difference in the method of identifying the winter ring; what is of interest here is that the pink salmon does grow in winter.

Size of pink salmon. Observations on the sizes of pink salmon of the strong and weak runs show that in years of large stocks the gorbusha of west Kamchatka and the Amur are smaller than in years of small stocks. In the even-numbered years (up to 1934) the west Kamchatka pink salmon had a body length of 46 cm on the average, while those of the odd-numbered years were 52 cm (Semko 1937, 47). In 1928 the average size of the pink salmon in the Amur estuary (near Cape Dzhaore) was 42 cm, and their average weight was 1 kg (Pravdin 1932, 16). In the TINRO data there are many examples of this same phenomenon, which we are as yet unable to explain.

If a decrease occurs in the stock of pink salmon in the dominant even-numbered years, the size of the fish increases. This is well analysed in the works of I. O. Baranovsky (1936, 30) and I. P. Kozyrev. They observed the pink salmon at Cape Dzhaore in an even year (1936) and compared their data with ours from the very same sector. A large difference appeared: in 1936 the pinks had an average length of 48 cm and an average weight of 1.5 kg; in 1928 the average length was 42 cm and the average weight 1 kg. These conclusions for 1928 and 1936 are based on a large mass of material, and they fully illustrate the statement made above. In 1926 the catch of pink salmon in the Amur estuary was especially heavy (more than 14 million pieces were caught); the spawning streams of the Dzhaore sector produced a large quantity of pink salmon fry, and in 1928 there was again a heavy run of pink salmon to their native rivers. The stock of pink salmon in 1936 was the progeny of spawners that laid their eggs in 1934, in which year comparatively few adults reached the spawning streams and the commercial catch was less than in 1932; the pink salmon of the even year 1936 were of large size and the quantity of them caught at Dzhaore was comparatively small; in 1932 the catch of pink salmon at Dzhaore was more than 1 million pieces, whereas in 1936 it was about 250,000 pieces. For the Maritime Province pink salmon there is information contradicting the situation just described: there, when there are big catches, which is in the odd-numbered years, the pink salmon are larger--the average weight of Maritime Province pinks in even years is about 1.4 kg, and in odd years it is 1.7 kg. Hence to solve the problem of the size changes of pink salmon in different years two conclusions suggest themselves: in the first place, only observations made over a period of years in one and the same region can supply the necessary results, and in the second place, it is urgently necessary to make concurrent studies of the spawning grounds and of the marine part of the life of the pink salmon.

In 1937 A. Pritchard (1937, 89) published some work in which it can be seen that the size of the pink salmon was different in different years.

Reproduction of pink salmon. Investigations of the spawning grounds, begun by I. I. Kuznetsov in 1923 and continued down to the present, have permitted us to assemble an important body of material on the biology of the pink salmon. We now know how long the process of spawning lasts in pink salmon, we know how the pink salmon lays its eggs in the redd, we know the number of eggs it lays (at our Institute there is an especially large body of material on the fecundity of the pink salmon), but we still do not know everything about the ecology of spawning or the physiology of the development of the eggs. The studies of Kuznetsov and other fish managers are very informative; they show that the density of seeding of the spawning grounds in different years varies, and that with a normal seeding (one female per 2 square metres of spawning grounds) the eggs in the redds die [only] in small numbers (for the Amur [page 63] gorbusha it is 6-7%); when there is over-population of the spawning grounds by spawners so that more than 10-15 females spawn per square metre, the mortality of eggs in the nests rises to 50-70% and more. And here the significant point is not the accuracy of these figures, but the evidence that natural reproduction has different degrees of effectiveness under different conditions. It is in the interests of man, who uses the pink salmon, to give it assistance in increasing its progeny. We have the data from a survey of the more important characteristics of the spawning grounds of pink salmon for the west coast of Kamchatka, the Amur basin, the region of Okhotsko-Aîansk, as was described earlier.

The publication by TINRO of the book by E. M. Krokhin and F. V. Krogius (1937, 55) on the salmon spawning grounds of the Bolshaîa River basin adds considerably to our knowledge of this question. According to the above authors' data, spawning of pink salmon occurs primarily in rivers with a current speed from 0.3 to 0.6 m [per second], where there is relatively high oxygen content, low CO_2 concentration, and a pH not lower than 7.0. In these authors' opinion pink salmon do not ascend into spring streams [kliûchi] for spawning "because of their water chemistry (high concentration of free carbon dioxide and acid reaction), and also because of their insignificant current speed".

The most important features of the spawning have been described by many observers, and in general these descriptions do not disagree. In the Maritime Province the pink salmon are running from the first days of June (or even earlier), and in the northern parts of the Maritime Province (for example the Tumnin River) pinks may be encountered up to the middle of August; the spawning of pink salmon in the Maritime Province takes place in August and ends at the middle of September. In the Amur estuary the run of pink salmon is from the beginning of June to the end of July, and spawning is from the end of July to the middle of September. The run of pink salmon in the Shantar Sea is in June, July and August; in the Sea of Okhotsk it is in June and July; in Taui Bay it is in July; in Gizhigin Bay, in July and August; in Penzhin Bay, in July and August. Along the west coast of Kamchatka pink salmon run from the first days of July to the middle of August or later, that is, appreciably later than in the Amur estuary; along the east coast of Kamchatka pink salmon are scarce, and their run lacks any time of large concentration of fish. In the region of Karagin Island the run of pink salmon is in June, July and August; in Oliutorka Bay it is from the end of June to the middle of August; and in Anadyr Bay it is in July and August.

To utilize these times for the study of migration of pink salmon we need more extended information (over a period of several years), which must be collected simultaneously in many sectors.

On the marine life of pink salmon. Little has as yet been done in respect to the conditions of life of pink salmon in the sea. I mentioned above the available materials; no important conclusions can be drawn from them. An experiment was made in fishing for salmon in the sea (in 1933 and 1934), but it too did not give much information. However such important aspects of the biology of the pink salmon as its food during the marine stage of its life, and its migrations, urgently require the initiation of serious investigations.

N. V. Milovidova-Dubrovskaia (1934, 64), taking advantage of the accidental capture in the Maritime Province region, in the Svetlaia Bay (November 1931), of several specimens of young pink salmon (in the fingerling stage), made a number of observations on them. The size of these pink salmon, which were furnished to our Institute [page 64] in the winter of 1932, varied from 20 to 22.5 cm, and averaged 21.2 cm; their vertebrae numbered 69-70; gill rakers on the first arch 30-31; and branchiostegal rays 11-12. The scales had from 13 to 16 sclerites, most often 14. The beginning of the deposition of the sclerites, in the author's opinion, coincided with the marine life of these fish. In addition Milovidova remarks that, in mature Maritime Province pink salmon, river sclerites are absent "with rare exceptions". In 1932 the Pacific Fishery Research Institute performed an interesting experiment (unfortunately on a very small scale) in marking young pink salmon (400 specimens) "by attaching to the right gill cover a thin, oval silver tag about a centimetre long". The size of the marked individuals (December 14, 1932) was from 24 to 29 cm, average 26.6 cm (from 25 specimens), and their weight was from 110 to 200 g, average 153 g (from 25 specimens). In 1932 young pink salmon were observed (during the first half of November) in Nelma Bay and also 60 miles southward of the Island of Furugelm (in the southern Maritime Province opposite Poseta Bay) in the sardine fishery, in floating gill nets fishing at a depth of 3-4 m below the surface of the water. In the stomach of one of these pink salmon Amphipoda were found, along with a small admixture of remains of a small fish.

In another work (1937, 60) N. V. Milovidova gives more concrete data on the biology of and fishery for the Maritime Province pink salmon. The figures for the Maritime Province pink salmon catches given in this work show that more pink salmon are caught there in the odd-numbered years, but it should be pointed out that Milovidova's figures differ a great deal from those shown in Table 3; however in our table too it is indicated that in the Maritime Province the small catches of pink salmon occur in the even-numbered years. The run of pinks in the Maritime Province begins toward the end of June or even earlier and lasts to the end of July and later; the most intensive run is in the first half of June. Among the Maritime Province rivers, the one of most importance for pink salmon catches is the Tumnin River, which flows into the Bay of Datta (Strait of Tartary). Spawning in the Tumnin River takes place in August and ends about the middle of September. The average sizes are from 46 cm (in even years) to 49 cm (in odd years); the average weight is from 1.4 kg in even years to 1.7 kg in odd. With an increase of 1 cm in the length of the fish, the weight increases by 97 g.

Whither do the pink salmon from our rivers travel, and whence do they return to our rivers? We do not yet know precisely. In 1928 a pink salmon was caught in the Amur estuary bearing a Japanese tag; according to Japanese information this pink was released off the coast of northeastern Korea. If this information is correct, then the pink salmon taken in the estuary came back to its native home from the southern part of the Sea of Japan. We know that in Japan for more than 10 years they have been busy with studies on the marine migrations of the salmons, including pink salmon. During this time only a few marked pinks have been taken in Soviet waters (in the Maritime Province, in the Strait of Tartary, and off Kamchatka). At one time A. N. Derzhavin (1933, 74) put forward the hypothesis that "the pink salmon of our Maritime Province in the main perform their spawning migration from far to the south, from Korean waters at least, and they traverse a much greater distance in the sea than in the ascent of their spawning rivers". If this is really true, then obviously no one can say that the question of the marine migrations of pink salmon has already been solved.

I mentioned above that we have data indicating a synchronization of the dominant and weak catches of pink salmon in our Maritime Province and in Hokkaido. Does this not indicate that the Maritime Province [page 65] pink salmon may be closer to the Hokkaido pinks than to the Amur pinks? If, however, an Amur pink salmon stock feeds off Korea, then it is impossible to believe that the mass migration of this pink salmon along our Maritime Province in even-numbered years would not be observed by our industry; actually the reverse is observed: in even-numbered years in the Maritime Province, as I have already said, pink salmon are scarcer than in odd-numbered years. And moreover it remains unclear whether, as a rule, there are any pink salmon in Korea.

In his list of fishes of Korea, T. Mori (1928, 77), with reference to pink salmon, gives the locality Joshin (this port is situated on the continent south of the Tumen-Ula River, not on the Korean peninsula). In a later work (1935, 94) the same author says that pink salmon are encountered along the northern coast of Konkyodo (Konkyodo also is situated on the continent) and in the Tumen-Ula River. We will be close to the truth if we assume that in Pacific waters there are a number of subdivisions in the grouping of the pink salmon stocks. But it is necessary to undertake a study of the migrations of pink salmon, and to undertake it immediately, inasmuch as the development of a marine salmon fishery is a most urgent objective.

In America work in marking salmon has been carried out for many years. Pritchard has published several articles on this matter (1932, 80); and in the work of Davidson (1934, 78) experiments in marking young pink salmon are described.

Experiments were performed in the State of Washington in 1930 and in Alaska in 1931. In the first experiment 36,000 fry were marked, taken from the troughs of a fish hatchery where the fry had been hatched artificially. The operation of marking consisted in the removal of the dorsal and adipose fins. In the other experiment 50,000 fry were captured as they were naturally migrating downstream, and they were marked by the same method, with only this difference, that here the marking was done at night rather than during the day, in order to give the fry a chance to continue their migration by night. It was found that the dorsal fin regenerates more often than the adipose. Davidson comes to the conclusion that the pink salmon return to the river in the second year of their life, and he does not agree with the view of Pritchard (1932, 80), that pink salmon on returning to fresh water can continue a long distance past their native river. In spite of individual exceptions I do not believe there is any evidence that pink salmon marked in our waters have been caught by our fishermen anywhere else in quantities sufficient to draw any well founded conclusions. In comparison with other representatives of the genus Oncorhynchus, pink salmon occupy a tremendous distribution range, which from south to north extends from Korea, or at least from the southern limits of the Soviet Maritime Province, right to the bleak icy waters of Bering Strait, and they even pass through it and along the north coast of Asia to the Lena River; while from east to west they extend from the Amur River to California. Only the chum salmon somewhat exceeds the pink in this respect. We may readily imagine that the pink salmon in the south are not exactly the same kind of fish as those in the north, and that the pink salmon in the east and in the west are not identical (here I have in mind local stocks of pink salmon). Such a conclusion cannot be used as a refutation of the observed fact of distant migrations which are known for some fish (the Atlantic salmon makes a journey of up to 3000 km on its way to spawn); occasional individuals of pink salmon may have a very long migration path but, on the whole, possibly gorbusha stocks do not move as far away from their native rivers as many of us suppose. In connexion with all this, it is impossible to exclude the influence [page 66] of hydrological factors on the distribution of pink salmon (and also of other fishes).

The size of the gorbusha stocks. Concerning the present condition of pink salmon stocks, we may say that these stocks are large, and that formerly they were even larger. Up to 1915 pink salmon were caught only in such numbers as the fishermen could capture, that is, exploitation was restricted not by the size of the stocks but by the limitations of the fishery. In the Nikolaevsk region 7.5 million pink salmon were caught in 1912 and on Kamchatka 18.5 million--which is only 1½ times more than on the Amur, although the Kamchatka gorbusha stocks at that time were, naturally, no less than they are today when, on the coasts of Kamchatka and in its rivers, the pink salmon landed by the Soviet industry alone averages about 60 million pieces a year; in individual even-numbered years more than a hundred million Kamchatka gorbusha have been caught.

In the book by P. A. Pushkov (1912, 66) some interesting data are given concerning the catches of pink salmon by individual regions; these data differ a great deal from the quantities given in our tables.

Beginning in 1915, a very marked insufficiency of pink salmon in the Nikolaevsk region began to occur in the odd-numbered years, but in very recent years, particularly in 1936, this insufficiency has begun to weaken in comparison with the even-numbered years: catches in the even years in the Nikolaevsk region have fallen off, and the landings of pink salmon in the odd years are increasing (Baranovsky, 1936, 30). On Kamchatka, where the principal pink salmon industries are along the west coast, the decrease in the catches in the odd-numbered years began in 1923, that is, considerably later than on the Amur. In the Maritime Province for more than 10 years now it has been observed that catches in the odd-numbered years surpass the even years'. In the Karagin region, as in the Maritime Province, since 1931 the catches of pink salmon have increased strongly in the odd-numbered years. In the rest of our regions there are no marked differences in the fluctuations in the catch of pink salmon of the even-numbered and odd-numbered years; although it is true that there is some basis for speaking of a predominance of the even-numbered years during the present cycle of catches; only in the northern regions of the Bering Sea, as in the Karagin region, can we

Table 8. [page 66] Catches of pink salmon in 1912 (in thousands of pieces).

Nikolaevsk region (Amur River and estuary, and Sakhalin)	7,661
Maritime Province	429
Okhotsk region	110
West Kamchatka	17,979
East Kamchatka	572
Total	26,751

observe a superiority of the catches of the odd-numbered years over the even-numbered years. On the Island of Hokkaido the alternation of catches is similar to our Maritime Province, and in central Alaska it is like western Kamchatka, while in the State of Washington more pink salmon are taken in the odd-numbered years. In the works of American investigators (for example, Pritchard) there are numerical data indicating the yearly fluctuations in catches of pink salmon by separate regions and rivers of British Columbia: in some regions the fluctuation is extremely pronounced, in others it is weak, and in still others, the alternation of catches does not fall in the same years as in neighbouring regions. In general, however, it may be said [page 67] that in northern British Columbia the larger stock of pink salmon migrates in the even-numbered years, while in the southern parts it is in the odd-numbered years.

Thus there is no evidence that poor pink salmon years occur concurrently throughout all regions of the fishery, and equally there is no evidence of a strict, so-called zakonomernaīā, stability of the small landings. As the fishing industry develops the catches increase. From these figures we may conclude that more fish are caught where the stocks are larger. But possibly the reverse is also true: there are still some places completely unutilized by the fishery, but which have rich fish supplies.

Should we say that in the Nikolaevsk fishery region the stocks of pink salmon have been completely fished out? Obviously not. In the even-numbered years, the present-day catches greatly exceed the pre-war even-year catches, although these catches do exhibit a tendency to decrease. As for the poor catches of the odd-numbered years, we now have data which lead us to believe that the decrease in catches in the odd-numbered years is being checked: it is obvious that it declined not only because of the action of the fishery, but also from other causes, whose actual nature we do not know as yet.

Let us take a look at these two groups of causes which affect gorbusha stocks: the first group may be called bio-ecological causes, and the other group, causes which are the result of man's activity.

The principal biological peculiarities of the pink salmon consist of the facts that it lays its eggs only once in its life, the young gorbusha migrate to sea very rapidly, they attain sexual maturity as early as their second year of life and all return for spawning simultaneously, in the same stage. In a word, the pink salmon never finds itself in a dispersed condition: all the young fish leave the river in the very first days of their life, not leaving behind any reserve members of that generation; and the pinks also come in to spawn without leaving any reserve in the sea (with the possible exception of occasional individuals, concerning which we made some conjectures earlier). As the result of this, as it is easy to imagine, when there is any kind of catastrophe (for example mass mortality of the young in the river or in the sea, or a mortality of the mature fish) one generation of pink salmon is left without reserves; and this loss cannot be compensated by the fish of another age, for these do not exist. Hence it is clear that the size of the run, under such conditions, must vary abruptly. But in nature apparently it does not happen that any individual year-class of pink salmon has been completely exterminated, and therefore it is possible (and this is in fact observed) to re-establish the progeny of a reduced stock from the surviving individuals of the same generation.

From the catch statistics (and in these matters we must use statistics mainly) it is impossible to find an example where in a given year pink salmon absolutely did not return at all to their usual places. The fluctuation of the catches in the Nikolaevsk fishery region is very sharply developed; but in the odd-numbered years there is a certain catch of pink salmon even here; hundreds of thousands of pieces are caught, and a considerable quantity of pink salmon enter the river and spawn every odd-numbered year. A small number of pink salmon, after reaching the spawning rivers in a particular year--when there have been favourable spawning conditions and good growth of the fish in the sea--can increase to a marked degree. Everyone knows how rapidly stocks of domestic animals increase [page 68] if these animals have broad opportunities for reproduction and feeding. This rule has the same importance in the life of water animals too.

Where then do the pink salmon encounter conditions which are importantly unfavourable for them: in the sea or in the river? As yet we must confine ourselves to hypotheses. Mortality of the pink salmon in the sea is possible; but it is difficult to imagine that this mortality--for example resulting from a mass epidemic--could simultaneously affect so wide an area as the whole of the Sea of Okhotsk and the neighbouring portions of the ocean itself; in that event we should have to suppose that the stock of the area indicated must have some sort of common feeding centre. It is also hard to imagine that there are ever years when there is a complete absence of food [polnaia beskormitsa] for pink salmon in the sea--from what was said earlier it is apparent that pinks do not exhibit any strict selectivity in their feeding since they feed on insects, crustaceans and fish. But at the same time the possibility of an insufficiency of food for pink salmon is indicated by the observation that pinks of the big years are small in size, while those of off years are larger.

This matter requires a more searching investigation than has yet been made, either by us or by others, although we do have some information on the ecology of the spawning. We may now regard it as adequately demonstrated (I. I. Kuznetsov has worked in this field more than anyone) that neither a sparse nor an overabundant population on the spawning grounds makes for a large year-class of pinks. When there are few spawners on the grounds it is impossible to expect a really large stock of gorbusha to return there a year later; while when there is overpopulation of the spawning grounds, studies by many people and in many places have shown that there is a tremendous mortality of the eggs, and under these conditions too it is impossible to expect a large year-class of pink salmon. In the event of overpopulation of the spawning grounds, the eggs laid by one species of fish--in our case pink salmon--can perish in colossal quantities as a result of the utilization of these same places for spawning by other fishes, after which the exposed eggs of the pinks may to a large degree be eaten up by other fishes (these facts too are known); in addition to all this, eggs can perish from unfavourable physical conditions on the spawning grounds--decrease in the oxygen content in the water, overflow of the water, a changeover of the water from alkaline to acid, and so on.

The numerous factors just mentioned, which affect the fate of developing eggs, do not, of course, include all such factors: in addition, apparently a number of others are also involved. These as yet unstudied factors appear to be of a more general nature, and can exert their influence simultaneously over the spawning grounds of a broad region; for example, there are hydrometeorological factors: greater or less atmospheric precipitation, good or poor food supply in the gravel waters of the spawning grounds, a severe freezeup in the winter, and so on.

The effects of man's activity are more easily studied, understood, and modified. Too great a catch of the fish migrating toward, or already in, a spawning river, and removal of the fish on the spawning beds themselves--all this acts not to increase and save the stocks, but to devastate them. There is conclusive evidence of this in the management of our fisheries, and in American and Japanese experience.

Davidson (1934, 78) in studying this very same question of fluctuations in pink salmon landings [<u>page 69</u>] in Alaska, says that the fluctuations in the catches take place not only as a consequence of changes in natural conditions in the places which pink salmon inhabit (rivers and seas), but also, and to a much greater degree, as a consequence of fluctuations in the intensity of the commercial fishery, which occurs at the time of the migration of the fish from the ocean. Incidentally, we may recall that in 1924 a law was introduced in Alaska, according to which not less than 50% of the mature salmon had to be permitted to ascend to the spawning grounds. Another pink salmon investigator, Pritchard in British Columbia, locates the causes of fluctuations in catches exclusively in natural conditions, because the quantity of fishing gear in a majority of cases remains the same or even decreases [in a poor year].

Man, who uses fish stocks, can do much to assist them by means of artificial propagation, by cooperation with the natural reproduction of the fish, and by having a rational fishery--all this is well known: but unfortunately in applying this knowledge we have as yet made very little progress. It is not my purpose here to analyze this activity, but it must be said that when a marked depletion of pink salmon occurred in the odd-numbered years (on the Amur and in western Kamchatka), it appeared that the fishery was the least to blame; its causes were different, as is evident from what was said above. If anyone makes a special study of the fluctuations in gorbusha stocks, he will find many references indicating that these fluctuations also occurred during times long past, when the commercial fishery for gorbusha did not exist.

Thus, in general, it can be said that pink salmon stocks remain at a very high level. The annual average contemporary catch of pinks (over a ten-year period), which is about one million centners, should not be considered the upper limit. There is no reason to regard the future with pessimism, or imagine that some day we will find ourselves without pink salmon, the more so as the ways in which these stocks can be managed, to increase their size, have already been outlined in a fairly clear manner.

Concluding our consideration of the pink salmon, it is of some value to make an analogy between the fluctuations of its stocks and the fluctuations of other fishes whose biology has been more studied. It is well known that among fishes in which there is a rapid attainment of sexual maturity, that is, of capacity for reproduction, there frequently occur discontinuities (the so-called biotic cycles [volny zhizni]) in the quantitative condition of the stock. The lake smelt, which has the capacity of reproducing at one year of age, not infrequently completely "fails", as the fishermen put it--its catches drop sharply. The main cause of the decline of the smelt is unfavourable spawning conditions. The vendace [<u>Coregonus albula</u>] begins to mature in its third or even its second year; its stocks also are subject to strong fluctuations. The same may be said of herring and some other fishes. But in the final analysis it is precisely <u>these</u> fishes whose stocks exist in abundance and are the principal commercial species in many waters, greatly exceeding in numbers the other fishes which live in the same body of water. We may also observe that the three groups of fish just named do not have a long life history (the smelt lives, on the average, 2-3 years; the vendace up to 9 years; and many herring live no more than 6-8 years).

Among fishes with a long life history and late attainment of sexual maturity, for example among the sturgeons, these abrupt natural fluctuations in abundance are not observed; the unsuccessful spawning of one year can be compensated at a subsequent spawning of the same adult fish [<u>page 70</u>] in the following years. These same observations also indicate that among the late-maturing fish a colossal number die both from natural causes and from the fishery, before they reach the time of their first reproduction; while rapidly maturing fish, like the pink salmon, under normal conditions apparently suffer relatively little mortality up to the moment of the spawning migration; in this we recognize one of the favourable aspects of pink salmon biology, one which gives assurance that pink salmon stocks will be large and that, with intelligent utilization, they can be inexhaustible. The testimony of the catches being made indicates this; for in the Far East the following quantities of pink salmon have been taken: 1935, 1233.2 thousand centners; 1936, 994.5; 1937, 1474.2; 1938, 1273.8; 1939, 1546.1--that is, the catch of pink salmon is increasing.

Distribution of the pink salmon stocks by individual regions. The quantitative distribution of the pink salmon stocks in the various regions can be judged from Table 9, taken from the work of N. V. Milovidova-Dubrovskaia (1937, 60). This table shows that the main region of abundance of pink salmon continues to be west Kamchatka, and next is Nikolaevsk and Sakhalin together, then Karagin and Oliutorka, and after them the Maritime Province; catches of pink salmon are unusually sparse in east Kamchatka and the Anadyr, and are weak in the Okhotsk region, although in the latter the pink salmon catch has already more than once achieved significant proportions.

From this we may outline the hypothetical distribution of the basic stocks of pink salmon; the Japan Sea stock is distributed in the Maritime Province and along the coast of Hokkaido; the Amur stocks are found in the Amur estuary and along the coasts of Sakhalin; the west Kamchatka stocks are found along the whole coast of Kamchatka; the Karagin stock is in Karagin and Oliutorka Bays. For further information concerning the questions posed here about the distribution and size of the pink salmon stocks, we must make a determined effort to study the regions lying close to the Kuril Island chain and the regions which lie close to the Aleutian chain, which may possibly serve as natural limits for the principal pink salmon stocks.

2. CHUM SALMON (*Oncorhynchus keta* Walb.) [page 71]

In size of catch chum salmon occupy second place among the salmons of the Far East, and in years of reduced pink salmon catches the chums occupy first place. The average yearly catch of chums for the 9-year period 1925-34 was almost 800,000 centners (783,350 centners, I. I. Kuznetsov, 1937, 31) or more than 30 million pieces (1928-1936 according to the new data of Dalryba [Far-eastern Fisheries Administration]).

Chum salmon, like pinks, exhibit fluctuations in catches, although the scale of this fluctuation is different among the chums. For autumn keta, the fisheries statistics support the conclusion that catches for many years, approximately from

Table 9. [page 70] Number of pink salmon caught by regions and years (in thousands of centners).

Region	1926	1927	1928	1929	1930	1931	1932	1933	1934
Maritime Province	7.5	57.2	13.8	93.6	56.4	89.6	27.39	39.99	16.5
Nikolaevsk	171.5	-	116.5	-	73.2	0.3	75.49	0.39	53.4
Sakhalin	0.4	-	0.4	5.3	28.2	9.9	27.8	5.87	39.7
Okhotsk	9.2	0.4	19.7	1.0	26.8	3.5	48.6	14.4	76.1
Gizhiga	2.3	0.2	4.1	0.1	2.7	0.16	6.29	0.55	23.0
Icha	206.7	70.8	239.5	21.8	209.9	20.95	213.8	37.17	218.1
West Kamchatka	964.6	247.0	773.2	57.4	703.4	283.5	987.79	201.17	791.5
East Kamchatka	0.05	-	0.2	0.8	5.2	7.2	3.97	3.0	14.7
Karagin	11.0	5.7	63.6	49.7	64.95	154.0	29.36	175.5	40.8
Oli͡utorka-Navagin	9.5	3.8	9.3	30.1	71.5	66.8	3.2	132.0 (with Anadyr)	14.5 (with Anadyr)
Anadyr	-	-	-	-	0.25	0.68	0.2		
Total	1382.75	385.0	1240.3	-	1245.5	637.0	1429.7	610.04	1288.3

1911, have declined gradually (with ups and downs), although in individual years considerably increased catches are also observed; 1931 was a particularly rich year for the catch of autumn keta (more than 10 million pieces).

The catches of summer keta have varied more. In pre-war times more summer keta were caught than autumn keta in the Nikolaevsk region, but a rapid decline in the catch began in 1914, and in 1916 the summer keta landings in the Nikolaevsk region was only a twentieth of the catch of autumn keta. The depletion of summer keta continued even farther, and as a result, in 1925 a complete fishing closure on summer keta was instituted for 5 years. During the present period it is evident that the stocks of summer keta on the Amur are increasing, as may be seen from the figures in Table 10 (Kuznetsov, 1937, 35).

The recently published book by I. I. Kuznetsov (1937, 31)--"The chum salmon and its production"--contains very valuable information concerning the life, the fishery and culture of keta salmon. To a large extent this information was obtained by the author during the period of his scientific work at the Pacific Fisheries Research Institute; but Kuznetsov also utilized other materials available at this Institute, thus the book presents conclusions based on scientific data and at the same time provides a review of the work done on chum salmon at the Pacific Research Institute. Thus our objective here has been made easy by Kuznetsov's work, and I will dwell primarily on the questions which are of greatest importance to the study of keta stocks, using both the information presented by Kuznetsov and other materials at our Institute.

Racial studies of chum salmon. For a long time it has been customary to separate two commercial groups of chum salmon: the summer keta and the autumn keta. These were discussed long ago by Krasheninnikov, Steller and others, and also by all the authors who have written about chum salmon in more recent times (Brazhnikov, Soldatov, Kuznetsov, Navozov-Lavrov, Berg and others). In 1932 L. S. Berg (7) [page 72] separated the summer keta as a discrete group, making it the basic type form of this species. This separation must be considered correct, although very little has yet been done to study summer keta. Morphological studies have yet to begin--it is known only that the summer keta is smaller than the autumn keta; but among biological differences the following have already been found: summer keta enter rivers earlier and spawn earlier than autumn keta, the fecundity of summer keta is less, and the summer keta do not ascend very far up the Amur River. Summer keta arrive on the Amur River spawning grounds in July and August, whereas autumn keta arrive in September and October; the average size of summer keta on the Amur is 59 cm, and their average weight is 2.7 kg; autumn keta have an average body length of 77 cm, and an average weight of 4.6 kg. The fecundity of the summer keta, on the average, is 2400 eggs, and of the autumn keta it

Table 10. [page 71] Catches of summer keta [in the Nikolaevsk region].

1926 -	696,380 pieces	1931 -	1,673,216 pieces
1927 -	416,000 "	1932 -	617,578 "
1928 -	88,262 "	1933 -	99,162 "
1929 -	60,479 "	1934 -	4,576,095 "
1930 -	1,875,650 "		

Table 11. [page 72] Rate of growth and yearly length increments of Amur chum salmon (from N.P. Navozov-Lavrov, 1927, 10).

Age	1	2	3	4	5	6
			Summer keta			
			Length of the body, in cm			
Males	27.9	43.5	56.1	62.9	70.6	78.0
Females	28.0	42.7	54.6	59.9	67.6	-
Both	27.95	43.10	55.35	61.40	69.10	78.0
			Yearly increase, in cm			
Males	27.9	15.6	12.6	6.8	4.7	-
Females	28.0	14.7	11.9	5.3	3.5	-
Both	27.95	15.15	12.25	6.05	4.10	-
			Autumn keta			
			Length of the body, in cm			
Males	31.40	50.73	66.03	78.23	84.80	92.33
Females	30.63	48.83	62.80	72.30	77.65	80.20
Both	31.01	49.78	64.21	75.26	81.22	86.26
			Average yearly increase, in cm			
Males	31.40	19.33	15.27	13.30	8.73	6.37
Females	30.63	18.20	13.63	9.50	8.20	6.30
Both	31.01	18.77	14.46	11.40	8.47	6.33

is 3500. This shows that among keta there are two biological groups or races, which possess hereditary characteristics that are maintained even under different external conditions. It has been observed that during the last 10 years the fecundity of keta of the odd-numbered years has been somewhat less than in the even-numbered years.

The summer keta were subjected to their most thorough investigation by N. P. Navozov-Lavrov (1927, 10) from materials collected in 1923. This author was the first to establish the difference between summer and autumn keta in respect to rate of growth (the summer fish in general grow more slowly than the autumn fish) and was the first to determine that summer and autumn keta in the Amur River migrate at the same age (3-6 summers [3-6 let = age 2+-5+--W.E.R.] and mainly in the 4th year of life).

[page 73] From Table 11 it is evident that summer keta grow more slowly than autumn keta (compare the rates of growth of summer and autumn keta of both sexes given by Navozov-Lavrov, as shown above). More recent studies have shown that the principal age-group of autumn keta in the Amur consists of individuals 4+ years old [in contrast to the 3+ in 1923--W.E.R.].

Information has been collected by the Pacific Research Institute concerning the keta of different sectors over a period of 13 years, but in no case have there been year-round observations. A summary of the data on keta up to 1934 has been made by Institute worker E. A. Lovetskaiä (1935, 67), and has been supplemented by I. O. Baranov and I. P. Kozyrev (1936, 28), and by I. F. Pravdin (1937). Materials have been collected principally in the Amur estuary and the Amur River. Particularly abundant material by Lovetskaia supports the conclusions of Navozov-Lavrov concerning the age and growth of chum salmon, and gives new reasons (supplementing the conclusions of L. S. Berg) for the separation of summer and autumn keta as two races: the autumn keta is later in becoming mature as compared with the summer keta, and the amplitude of fluctuations in length and weight of the body in the summer keta is less extreme. In passing, Lovetskaia comes to the conclusion that the Okhotsk keta occupy an intermediate position between the Amur summer keta and the Amur autumn keta. However on the basis of rather scanty data on the keta of the Okhotsk and Ayansk regions in articles by V. E. Rozov (1931, 86; 1931, 87; 1930, 88), V. Pavlov (1933, 38), F. F. Golovanov (1931, 85) and P. A. Moiseev (1933, 68) we may conclude that in these regions there are two forms of keta, the summer and the autumn. With the light fishery of the Okhotsk and Ayansk region, summer keta have been able to maintain their stocks better than on the Amur, where the Amur summer keta are greatly depressed; therefore the difference of the Okhotsk keta [from the Amur] observed by Lovetskaiä may possibly not be real, since she was using material without separating it into summer and autumn types. Lovetskaia had at her disposal material from the following regions:

Summer keta	Autumn keta
Khuzi River	Baĭdukov Island (Langr)
Naleo River	Cape Ozerpakh
Baĭdukov Island (Langr)	Cape Puir
Beshenaīā River	Nizhnīāīā Gavan (on the Amur River)
Ulcha River	

In determining the age of chum salmon, Lovetskaīā observed that there was a fingerling annulus on the scale, which apparently is formed after the time of the residence of the young fish in the brackish water of the Amur estuary. Lovetskaīā's conclusion must be considered as correct. From data on sex ratios Lovetskaīā showed that females somewhat exceed males in abundance among summer and autumn keta both. Similar conclusions, as is well known, were reached earlier by other investigators: V. K. Soldatov (1912, 8), I. I. Kuznetsov (1928, 9), V. E. Rozov (1926, 69). Lovetskaīā's statements [page 74] concerning a decrease in size of the summer and autumn races are interesting. For autumn keta she relates this phenomenon to the intensive removal of keta of large sizes. Furthermore Lovetskaīā indicates quite correctly that the Amur summer keta is very close to the west Kamchatka keta in size: we must remember that, for example, it is principally the summer form of keta that run in the Bolshaīa River (in Kamchatka): apparently the same summer form occurs in the Anadyr region and in other places.

In addition to the summer and autumn forms of chum salmon, in Kamchatka there is still another form known by the name of monako. F. V. Krogius, V. S. Bool and A. S. Baranenkova (1934, 44) of the Kamchatka branch of TINRO have described the important characteristics of the monako: it spawns early, has a larger number of pyloric caeca, and the body form is somewhat different; the length of monako along the eastern coast of Kamchatka is 40-60 cm, most frequently about 50 cm, and along the west coast it is 50 cm; that is, it is smaller than the [other] chum salmon.

For the various regions of the Far East the author quotes different values for the average weight of chum salmon.

The differences enumerated above indicate that keta are to be divided into several forms; in addition, within these forms there are still smaller local groupings of keta, which as yet largely remain unstudied. In Lovetskaīā's (1935, 67) article it is stated that D. A. Kanevets had observed "two forms of keta while inspecting the catch of keta in the [Amur] estuary (at the Puir fishery) during the 1929 fishing season: a northern or Okhotsk form, dark in colour and found in small quantities (up to 10%), and a northeastern or Sakhalin form, light in colour and silvery".

For racial studies of keta there is no question that it is necessary to make biometrical descriptions of the two basic forms, the summer keta and the autumn keta, using the characters which were mentioned in connection with the study of races of pink salmon.

Age, rate of growth and food. The age composition of keta has been most thoroughly studied for the Amur fish. We can regard it as established that both summer and the autumn keta enter the river preponderantly in their 4th year of life. "Individuals which have lived two full years and are in their third year (t r e k h l e t k i), and also individuals which have five complete years and are in their sixth (s h e s t i l e t k i) . . . enter the river to spawn usually in very insignificant numbers" (Navozov-Lavrov, 1927, 10). E. A. Lovetskaîa, who examined more than 4000 specimens of scales of Amur keta, comes to the same conclusion, saying: "the age composition of the Amur keta is characterized by a small number of age groups. Summer and autumn keta attain sexual maturity and enter the Amur for spawning in their third, fourth, fifth and sixth years of life, counting from the time of hatching of the fry from the eggs." (Lovetskaîa, 1935, 67). One specimen of keta Lovetskaîa regarded as being in its 7th year; on the basis of a study of the scales of this individual the author suggests the possibility of return of some of the fish to sea after spawning (this requires careful verification, since all investigators consider that chum salmon, like the other representatives of this genus, do not live in the sea after spawning and do not return for a second spawning, rather, they all die in the spawning rivers and kliuches).

[page 75] The data of Table 12 show that in some years--in this case the odd-numbered years--a great quantity of young summer keta (in their 3rd year of life) come back to spawn.

A. S. Babaskin (1926, 12) who engaged in studies on Amur keta, shows that the summer keta are mainly 3+-year-olds, but for the autumn keta (samples of 1925) he presents data which differ markedly from the conclusions of all other people who have considered this question. According to Babaskin, among the 1925 autumn keta of the Amur River, specimens in their 4th year of life amounted to 26.5%, in the 5th 35.8%, and in the 6th 37.7%. However, from Lovetskaîa's materials we must conclude that in odd-numbered years fish of the older age-groups are very few; there is also a great difference between the results of Lovetskaîa and Babaskin in their determination of the average size of the keta of each age group: the sizes indicated by Babaskin greatly exceed the sizes given by Lovetskaîa. Females of summer and autumn keta reach sexual maturity somewhat earlier than the males, therefore they make a greater contribution to the younger age-groups, but the males (of the autumn and especially of the summer keta) usually exceed in size females of the same age. I. I. Kuznetsov (1937, 31) thinks that the normal numerical relationship of the age-groups of Amur keta can be represented by the figures shown in Table 13.

Table 12. [page 75] Distribution of age groups, in percentage (after Lovetskaiā).

	Summer keta				Autumn keta			
Age	2+	3+	4+	5+	2+	3+	4+	5+
1927	3.6	79.2	15.8	1.4	3.2	79.2	15.3	2.3
1928	-	88.1	11.5	0.7	1.5	67.1	29.5	1.9
1929	60.2	26.6	13.2	-	12.2	73.7	14.1	-
1930	0.6	98.1	1.3	-	1.7	38.7	56.2	3.4
1933	-	-	-	-	1.7	84.6	12.4	1.0

Table 13. [page 75]

	Summer keta	Autumn keta
Third-year fish (2+)	1.6%	5.25%
Fourth-year fish (3+)	90.7%	76.03%
Fifth-year fish (4+)	7.2%	17.69%
Sixth-year fish (5+)	0.5%	0.97%
Seventh-year fish (6+)	-	0.06%

If such data [as are given in Table 13] are obtained year after year from the same place (for example from somewhere on an important fishing river), from the average results it will be possible to determine even the size of the run of fish expected in the river in question [each year]. For this, systematic investigations of chum salmon ages must be organized at the necessary level of effort.

The age composition of commercial groups of chum salmon in individual regions will differ from the age composition of chums of other regions, and in addition age composition will differ from year to year in the same place. In the article by Krogius, Bool and Baranenkova (1934, 44) [page 76] there is an indication that in the Ozernaīā and Bolshaīā Rivers (on Kamchatka) in 1929 chum salmon 4+ years old (in their 5th year) predominated, while in 1930 fish 3+ years old predominated; and in the Penzhina River chums 3+ years old predominated both in 1930 and 1931. Yokayama and Kawakami (1932, 70) show that in coastal waters of the northern part of the Kuril Islands 4th-year [chetyrekhletnie] fish predominated in 1932 (77%), while 3rd-year fish amounted to only 0.8%, 6th-year were 1.4% and 5th-year 20.8%. In the Yukon River (Alaska) chum salmon migrate at 2, 3, 4 and 5 years [idet keta na 2, 3, 4 i 5 let] (according to data of Gilbert, 1922, 71); age 3+ fish (in their 4th year)[1] comprise 3.3%, age 4+ fish 68.1%, and age 5+ 28.6%, that is, the age composition of the Yukon keta is close.

In the Puir fishery in 1935, material was collected for age determination of the autumn keta (N. N. Guseva and V. K. Chernīavskaīā); the age determinations, reported by Zborovskaīā and Pravdin (1937), showed that in this year the predominant age-group in the fishery were fish in their 5th year of life.

In size of body, as we have already seen, the summer keta differ from autumn keta, and in addition it has been observed that there is a difference between the sizes of chums from different regions; the largest autumn keta are the Amur ones (average weight 4.6 kg); after them come the keta from Datta (4.5 kg), the Sakhalin keta (3.9 kg), the Okhotsk keta (3.2 kg), the Kamchatka River keta (3.2 kg), the Anadyr keta (3.1 kg), the Bolshaīā keta (3.0 kg), the Icha keta (3.0 kg), keta from Tauīsk Gulf (2.9 kg) and the Amur summer keta (2.7 kg).

[page 77] The differences mentioned, although they are not accurately determined, nevertheless show that in some places chums are large and in other places small. A comparison of size of keta with the distance from their spawning grounds to the mouth of the river leads only to the conclusion that there is some relationship (the autumn keta, which are larger, go to the more distant Amur spawning grounds, while the summer keta, which are smaller, go to spawning grounds that lie close to the sea), but it is scarcely possible to see in this any

[1] [This expression [3-letki (po 4 godu)] shows that Pravdin has misinterpreted Gilbert's ages, which were 2, 3, 4 and 5 years in the American nomenclature (1+, 2+, 3+ and 4+). In addition, age 2 (1+) chums were not actually reported by Gilbert from the Yukon, but only from Nanaimo (quoting Fraser), where they were very scarce.--W.E.R.]

Table 14. [page 76] Age-groups among autumn keta in 1935 [in the Puir fishery].

	Males		Females		Both sexes	
Age	No.	%	No.	%	No.	%
2+	1	0.15	19	2.44	20	1.40
3+	139	21.44	308	39.54	447	31.30
4+	288	44.37	347	44.54	635	44.46
5+	170	26.19	90	11.55	260	18.20
6+	40	6.16	14	1.80	54	3.80
7+	6	0.92	-	-	6	0.42
8+	5	0.77	-	-	5	0.35
9+	-	-	1	0.13	1	0.07

Table 15. [page 76] Age composition of Amur autumn keta (Dzhaore, N. Pronge and Ozerpakh, in 1935--from V. K. Cherni͡avskai͡a).

	Males		Females		Both sexes	
Age	No.	%	No.	%	No.	%
3+	54	23.5	112	33.6	166	29.5
4+	158	68.7	215	64.6	373	66.3
5+	18	7.8	6	1.8	24	4.2

direct connection between the size of the fish and the length of its migration. Autumn keta migrate up the comparatively short rivers of Sakhalin and Hokkaido, and they are not small fish.

The existence of distinct races of fish among both autumn and summer keta is the result of many causes, not the least important being food. In spite of the scanty material on the food of keta that is available at the Institute, it is nevertheless possible to make the suggestion that at the time of their spawning migration keta feed as long as they remain in the sea. Keta taken in the sea near Baĭdukov Island on August 27, 1927, contained the remains of food, consisting of crustaceans. Rozov and Golovanov (1931, 75) have observed capelin and crab larvae in keta taken at the mouth of the Kukhtuĭ River in July and August. In an article by A. Danilova it is mentioned that chums taken in the Icha marine fisheries contained in their alimentary tracts "capelin, shrimps and mysids". From published work it is known that keta eat young cod, and also other fishes, being a true predator while in the sea.

V. K. Soldatov (1912, 8) who observed fingerling keta while they were migrating downstream in the lower Amur River and after they had gone out into the wide expanse of the Amur estuary, observed that the fingerlings ate a particularly large number of mayfly nymphs, and also larvae of mosquitoes and other insects.

I. I. Kuznetsov (1928, 9) cites his own and P. A. Popov and V. I. Orav's observations on young keta. In the Bystraia River (on Kamchatka) young keta had already lost their yolk sacs at the beginning of April. Young summer Amur keta at the Bolshoi Chkhil fish hatchery hatched from the eggs about 40-49 days after fertilization. At the end of March the young fish had an average body length of 36 mm. Among his observations on young autumn keta the following statement is interesting, that "the time of downstream migration of the young fish after leaving the nest depends, we must suppose, on the food supply in the body of water, the speed of its current and other conditions" (Kuznetsov, 9, page 89). It is too bad that there have been no investigations on the biology of the earliest period of the life of young chum salmon.

Migration and reproduction. Chum salmon return from their marine feeding grounds to rivers for reproduction. In the keta migration it is customary to differentiate 3 runs, called the first, second and third. Materials available in our Institute are not sufficient to clarify this phenomenon completely, but there is no question that the chum salmon spawning migration can be grouped into stocks characterized by different age compositions; hence we also observe differences in average fish size in the so-called first, second and third "runs".

The information concerning chum salmon that was reviewed in the first part of this article is interesting in that it provides a general picture of the times of migration of chum salmon in different rivers, "of the times of spawning"; in addition, we may observe that in some regions two forms of keta (summer and autumn) are represented, whereas in others there is only one. We may [page 78] regard it as established by numerous observations that in the Amur the summer keta migration starts in the first half of July, their heaviest run being from July 7 to August 11, and the end about August 10-30; autumn keta migrate from the beginning of September, the main run is September 28 to October 20, and the end is December 10-15 (Kuznetsov, 1937, 31). In the Okhota River both summer and autumn keta unquestionably occur, according to observations of V. E. Rozov and P. A. Moiseev. In the Tauisk Gulf the principal run of keta was observed (in 1930) between July 20 and August 16; so that we must apparently include these chums among the summer keta. In the Penzhin Gulf keta were migrating (in 1930) between July 4-6 and August 19; I postulate that these fish too belong among the summer keta. In the Icha River in 1929 chum salmon entered during July. In the Vorova River a heavy run of keta was observed on July 2 in 1930; in the Kikhchik the main run was from July 19 to August 5; for the Bolshaiā River it was July 22-24; for the Kamchatka River the main run was July 12 to October 1 (I believe that in the Bolshaiā and Kamchatka there are both summer and autumn keta). In Korf Bay chums migrate from the end of June to the end of July (apparently they are summer chums). The maximum arrival of keta in the Oliūtorka River was from July 15 to August 15 in 1930. In the Anadyr there are undoubtedly summer keta (Kaganovsky, 1928, 81).

For their reproduction chum salmon select kliuches, brooks and side channels where there is ground water and where the speed of the current is from 0.1 to 0.3 m/sec (Krokhin and Krogius, 1937, 55). Such suitable places for keta spawning occur in abundance throughout the Amur watershed (the Ussuri and its tributaries, the Bidzhan, Bira, Tunguzka, Aniūi, Belaiā, Yagodnaiā, Chernaiā, Khungari, Elbin, Khilka, Tundur, Gorin, Simasi, Tuchanikha, Ulchi, Khivanda, Beshenaiā, Pulsa, Bystraiā, Limuri and many others). Similar rivers are not scarce in other parts of the continent and of Kamchatka. Nevertheless in some rivers chums go upstream a long way--it is known that chums have been fished in the very headwaters of the Amur.

Few details are available concerning the time of spawning of chums, but it is known that the summer chums in the Amur spawn mainly in August and the autumn chums mainly in October; these same times are apparently characteristic for the similarly-named forms of keta in other regions.

Judging by the reports brought by Kuznetsov to the Pacific Institute for Fisheries and Oceanography, we know that the fishery management organizations (Dalrybvod and the Control Stations) have extensive materials from which it would be possible to put together a detailed account of the times of spawning of chum salmon in different rivers. In the future this obviously will have to be done, for such an account will provide much-needed information: from it it will be possible to get a better picture of the regional distribution of summer and autumn keta, something which is very important for the fishery.

Marine life of chum salmon. It is known that young chum salmon leave the river during their first summer after hatching from the egg. A. S. Baranenkova (1934, 42) has given some information on young keta obtained from small rivers of east and west Kamchatka, although a fuller and more circumstantial description of young keta (from the Amur) can be found in Soldatov's book (1912, 8). Baranenkova, who examined more than 2000 specimens of young keta from Kamchatka, comes to the conclusion that in Kamchatka Rivers also the young keta do not remain over into the following year, but rather migrate to marine waters during May and June; but these young fish may be encountered in the rivers later also. Baranenkova did not find a river annulus on the scales of chum salmon, although there were individuals with 1-3 river [page 79] sclerites. Navozov-Lavrov (1927, 10) counted 9 circuli on young Amur keta; the size of these young was 5.2 cm (fork length).

The size of the downstream-migrating young along the Paratunka River was from 29 to 48 mm, average 37.5 mm.

The marine life of chums has been little studied; a small amount of information can be found in the foreign literature, where data are given concerning the food of chums and concerning their migrations, about which we will say more later. The work of the Institute has been limited to only a few experiments on catching salmon in the sea, during which chums were caught, among others. A fishery for salmon using floating gill nets, conducted during 1933 off the west and east coasts of Kamchatka, produced only 7 specimens of keta (July 17-19), as far as I can tell from the account available (1934, 56). Experimental salmon fisheries conducted (also in 1933) near Sakhalin did not give any very significant results either; but keta were caught in small numbers. In the account of this fishing (1934, 57) it is stated that the chums remained close to shore. In 1934 (1935, 58) the expedition on the "Lebed" obtained some interesting hydrological data, but its ichthyological results were not very great. In 1935 the marine fishery off the west coast did not provide any chum salmon material.

Catches and the causes of their fluctuations. Let us consider in more detail the question of the pronounced decline in catches of Amur summer keta. Starting in 1909, the catch of summer keta considerably exceeded the catch of autumn keta, and in occasional years this excess was very great. From 1916 the catch of summer keta fell off so much that it was possible to speak of the complete collapse of the Amur summer keta stocks. The decline in the fishery for summer keta continued

Table 16. [page 79]

4-year periods	Average yearly catch, in pieces		
	Summer	Autumn	Total
1903-1906	7,547,187	6,277,409	13,824,596
1907-1910	11,330,924	6,792,139	18,123,063
1911-1914	10,263,880	5,846,684	16,110,564
1915-1918	1,686,864	2,602,292	4,289,156
1919-1922	481,250	2,568,875	3,050,125
1923-1926	614,033	4,058,718	4,672,751
1927-1930	745,341	5,026,600	6,771,941
1931-1934	1,741,750	7,910,981	9,652,349

even farther. Therefore measures were introduced to regulate the exploitation of summer keta, these being directed toward the restoration of the Amur summer keta stock. These measures gradually had a favourable effect in re-establishing the summer keta stocks, as may be seen in the article by Kuznetsov (1936, 72) which is on file in the Institute. Let us look at this article.

Kuznetsov presents commercial statistics of the average take of summer keta from 1903 through 1934, which characterize the condition of the fishery (Table 16).

Table 16 shows that the largest catches of summer and autumn keta were during the period from 1903 through 1914 (when they reached 18 million pieces), and the smallest catches were in the period from 1919 through 1922 (3 million pieces). The increase in average catch from 1927 through 1934 to 9.6 million pieces was, in [page 80] Kuznetsov's opinion, a result of the following measures: a) the establishment, beginning in 1924, of a norm[1] for salmon exploitation; b) abolition of salmon fishing on the spawning grounds; c) establishment of a closure on fishing for summer keta in the even years from 1925 through 1929; d) organization of special protection of the spawning grounds in some of the most important spawning tributaries of the Amur and Ussuri Rivers; e) the establishment, starting in 1925, of inspection points for the enumeration of salmon migrating to the spawning grounds and protection of their spawning; and f) artificial propagation of chum salmon.

Kuznetsov shows that the period of re-establishment of summer keta must be considerably more prolonged than for autumn keta, since in the period of the maximum decline of the fishery the stocks of summer keta became depleted 6 times more than the stocks of autumn keta. In order to speed up the rate of re-establishment of commercial stocks of summer keta Dalryba in 1934 established closed times for fishing, in order to permit a large number of spawners to reach the spawning grounds.

In 1934 the summer keta fishery was closed July 27, as a result of a check of the catches in the Ozerpakh fishery, where the catch had sunk from 100,000 pieces per day to 3000 pieces. In all other fisheries together the catch on the last two days before the closure averaged 123,469 pieces. The catch of fish by some fisheries shows that the run of summer keta continued without any interruption right through to the beginning of the autumn keta run.

On the basis of estimates of the number of adults that spawned in the neighbourhood of the Control Points in 1931, the

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[1] [Apparently this is not a catch limit, but rather an attempt to limit the fishery to a certain fraction of the run. I am not clear how this was accomplished.--W.E.R.]

run of summer keta in 1935 was expected to be considerably weaker than in 1934, which was fully confirmed by the event. Beginning on July 6, 1935, a 24-hour closure of fishing on general holidays was established, and at the end of the main run (July 27) summer keta fishing was completely closed.

Kuznetsov observed that the Control Points were of special importance in the rational utilization of salmon stocks. In order to make the results of their work available, he provides data on the catch and on the number of summer and autumn keta spawners which passed up to the spawning grounds [at the Control Points] from 1925 through 1935 (Table 17).

The work done at the Control Points includes the collection of biological material on natural reproduction of salmon, and the counting and protection of the spawning fish in brooks and kliuches. The work of the Control Points is organized to solve the following questions:

Is it possible, when there are Control Points on the spawning grounds, to regulate the fishery so that there is an escapement of a definite number of spawners to the spawning grounds, without sacrificing the maximum catch, and in correspondence with the actual size of the usable stock of each of the various salmons?

Is it possible, from the yearly statistical data of the catch, and from the percentage utilization of spawning grounds by spawners, to predict the size of future catches of salmon?

A comparison of the catch figures shown in Table 17 and those for percentage utilization of the spawning grounds, and the age composition of the spawners, shows: "that for autumn keta it is very difficult to discover any direct relationship between ages of the fish and their catches and the percentage utilization of the spawning grounds" (I. I. Kuznetsov). Out of 4 spawning runs of autumn keta (1925 through 1928), the strongest one in the catch and in intensity of spawning was the 1926 spawning stock. From this, and with a [page 82] 4-year life cycle of chum salmon, we should have expected in 1930 an even larger run of autumn chums. However in 1930 there was only a small increase in catch and very poor utilization of the spawning grounds in the Iman and Khor Rivers. The greatest catch of keta was in 1931. Kuznetsov makes the suggestion that: 1) the record high catch of autumn keta in 1931 either reflects the arrival of a large number of fish in their fifth year of age, or else favourable conditions for the development of eggs and fry in 1927-1928; 2) the weak seeding of the spawning grounds of the Khor and Iman Rivers might be an accidental result of the excessive keta fishery along the Ussuri River and in the mouths of its principal tributaries which took place in that year, whereas in the system of rivers below the city of Khabarovsk the fish might have reached their spawning grounds in considerable numbers.

Table 17. [page 81] Catches and percentage utilization of

Years	Number of Control Points	Catch on the Amur in pieces	Average number of females which spawned per Point	Percentage utilization
	Autumn keta			
1925	7	3,096,438	2,217	43.7
1926	7	7,996,914	5,086	100.0
1927	7	5,450,350	2,400	47.1
1928	6	4,781,304	1,149	22.6
1929	8	4,580,435	1,080	21.2
1930	10	8,533,230	875	17.2
1931	9	11,729,342	2,369	46.5
1932	9	7,340,648	4,171	82.0
1933	6	6,069,529	905	17.7
1934	6	6,996,239	3,690	72.5
1935	11	6,756,765	6,614	130.0
1936	10	7,369,626	13,120	258.0
1937	11	6,907,458	20,992	412.3

[1] The table includes catches from the Rybnovsk region (west coast of Sakhalin), the number of spawners utilized and counted at Lake Tëploe, on the Bidzhan River, and at other points which are not included in Kuznetsov's table because of

the spawning grounds by salmon on the Amur[1].

	Summer keta			Gorbusha		
Number of Control Points	Catch on the Amur in pieces	Average number of females which spawned per Point	Percentage utilization	Catch, in pieces	Average number of females which spawned per Point	Percentage utilization
	43,010	-	-	-	525	0.3
7	696,380	1,568	5.5	14,112,808	12,407	100.0
7	392,216	762	2.7	43,000	435	3.5
7	108,663	335	1.1	17,398,256	72,061	580.8
7	71,887	185	0.6	70	3,436	27.7
10	2,370,250	28,569	100.0	9,564,255	154,860	1248.1
8	2,004,878	2,651	9.3	48,317	3,216	26.7
7	612,942	10,353	36.2	10,028,017	194,567	1568.2
7	99,739	2,510	8.8	62,395	8,208	25.8
7	5,017,931	21,900	77.0	8,376,570	23,489	189.3
11	2,445,231	13,915	48.1	186,938	15,723	126.7
12	538,013	9,743	34.1	4,699,563	13,836	111.5
12	277,136	5,826	20.4	529,744	26,572	214.1

the small number of their spawning keta. In addition, for the period 1925 to 1927 corrections have been made in the number of spawners and in the average number of females per Control Point, because males had erroneously been entered [as females].

There is considerably more indication of a relationship between age of the fish, size of the catch and seeding of the spawning grounds in the summer keta fishery. Kuznetsov shows that as a result of the protective measures introduced by Dalryba there has been a steady growth in yearly catches and percentage utilization of the spawning grounds of these summer fish. Of the 4 spawning groups 1926 to 1929, the largest for summer keta was that of 1926, which returned to the Amur for spawning in 1930 and produced a record high utilization of the spawning grounds. The 1930 year-class returned to the Amur in 1934, and it had increased to more than 7 times its size in 1926 in terms of catch, and to 14.5 times in terms of intensity of spawning.

Table 17 indicates that on the basis of the count of fish at the Control Points the spawning potential of the 1934 adults was 23.1% less than those of 1930. In actuality, however, we must consider that in 1934 more summer keta went to the spawning grounds than in 1930, as is shown by an almost two-fold increase in the range of distribution of summer keta in the Amur, for in 1934 they were even caught along the Tunguzka River in the region of Khabarovsk, and up the Ussuri River as far as the village of Argunskiĭ.

As a result of the regulation of the fishery in 1931, the size of the spawning population of summer keta in 1935 was 5 times greater than in 1931. Kuznetsov believed that in 1937 it would be necessary to take measures for the restoration of the 1933 year-class, which was the weakest of the 4 lines during the period 1929 to 1933.

To examine the possibility of regulating the fishery on the basis of the work done at the Control Points, Kuznetsov gives general statistics of the catches of summer keta by 5-day periods for 1934 and 1935 and compares them with the data on the escapement of fish to the spawning grounds. His table shows that in 1934 the time of mass capture of summer keta by the fishery in no way corresponds to the times of massive entry into the spawning rivers. Up to the closure of the fishery only about 13% of the total adults had reached the spawning grounds, and the greater part of these (30.2%) migrated after the cessation of capture of fish by the fisheries. [This doesn't seem to make sense, but it is the best I can do. Possibly "fishery" refers to the estuarine industry, while "fisheries" refers to nets set along the course of the river itself.--W.E.R.]

In 1935 the maximum number of summer keta going up to spawn coincided with the most intensive migration and capture by the fisheries. After closure of fishing the arrival of keta continued more or less at the same level up to August 20. Kuznetsov suggests that the coincidence of time of fishing for summer keta in 1935 with their maximum entry into the spawning rivers occurred as a result of the 24-hour closures of commercial fishing for keta on holidays (July 6, 12, 18 and 24). At the close of his article Kuznetsov comes to the following conclusions:

[page 83] 1. As a result of the protective measures taken by Dalrybvod to restore the Amur salmon stocks, there has been a marked increase in landings of summer and autumn keta.

2. The catch of autumn keta has equalled or even exceeded the record high of the period 1907 to 1910.

3. The maximum catch of summer keta from the Amur was in 1934 when it reached 5,017,931 pieces, and at the same time gave very good seeding of the spawning grounds. The 1934 generation must be the source of a natural restoration of the remaining less-numerous year-classes of summer keta.

4. The heavy seeding of spawning grounds of summer keta in 1934 occurred partly as a result of the unpreparedness of the fishery organizations for fishing, but for the most part it is a result of the closure of commercial fishing starting July 27, at a time when the fisheries were still landing an average of 123,469 pieces per day.

5. The establishment in 1935 of 24-hour fishing closures for summer keta on holidays [po vykhodnym dniam], and the complete closure of fishing from July 27, has had a favourable effect on the escapement of fish to rivers for egg-laying.

6. In order to re-establish the summer keta of the 1932 and 1933 lines it is necessary to introduce similar fishing regulations.

7. Observations in 1935 have shown that when there are 24-hour closures of the commercial fishery it is easier to bring the fishery regulations into rapport with the intensity of the escapement to the spawning grounds.

8. Concurrently with these protective measures it is necessary to go ahead with artificial propagation of summer keta on the Ul River.

The information adduced clearly indicates that the measures taken to re-establish stocks of summer keta (and autumn keta as well) have really given favourable results. Along with this it is necessary to make even further efforts in the production of keta stocks. When reviewing the data on pink salmon stocks we came to the conclusion that fluctuations of gorbusha stocks depend to a large degree on natural conditions, but for chum salmon we must reach the opposite conclusion: the summer keta stocks were depressed by excessive utilization in the pre-revolutionary years. Along with the measures taken to re-establish summer keta stocks, it is necessary to introduce also careful observations on the condition of the autumn keta stocks.

Distribution of chum salmon stocks. Thus the summer keta, according to data in our Institute, is distributed continuously along the whole coast of the Sea of Okhotsk and along the western shore of the northern part of the Pacific Ocean; but autumn keta are concentrated in the southern part of the Sea of Okhotsk. On the basis of these data, and also information on the number of keta in individual sectors, it seems likely that the basic stock of autumn keta belongs mostly to the region of the Kuril chain--and particularly to its southern half. As for the summer keta, it seems superfluous to try to indicate the possibilities. It is possible that the summer keta move through the Amur estuary and then around the western and eastern coasts of the same sea [the Sea of Okhotsk], but never go very far south. This is suggested by the catches (from Kuznetsov, 1937, 31): for the 9 years 1925-1933, the average catches of keta along the coast of the Sea of Okhotsk amount to 141,600 centners (18% of the total catch of keta in all regions), while along the west Kamchatka coast it was 124,300 centners (16.2% of the total catch), and in the Nikolaevsk region it was 230,000 centners (30.5% of the total catch).

Comparatively large catches in the Karagin region (82,200 centners [page 84] or 10.7%) can be associated with a separate stock of summer keta which inhabits the northern part of the Pacific Ocean.

The question of the distribution of chum salmon has occupied the attention of investigators for a long time. V. K. Brazhnikov (1906, 6) wrote that the keta arrive in the Amur from the north; the same thing is accepted by V. K. Soldatov (1912, 8), but he adds the suggestion that keta also come from the southern parts of the Sea of Okhotsk. Recently in Japan chum salmon have been tagged, and some kind of report on it has been published (Sato, 1938, 73). A. N. Derzhavin (1933, 74), on the basis of Japanese tags obtained from chum salmon, wrote that the chums of the eastern and northern coasts of the Sea of Okhotsk "fan out far to the south from their native rivers", and further: "we must suppose that the Amur keta also have feeding grounds in the Pacific Ocean near the eastern coast of Japan, and on their spawning migration they go through the southern Kuril gaps into the Sea of Okhotsk and then round the coasts of Sakhalin from the east and north". But in the same article Derzhavin mentions that in the summer of 1930 some sexually immature specimens of autumn keta ("we must regard them as being in their second or third summer of life") were captured in the Penzhin Gulf near the mouth of the Penzhin River, and on the basis of this fact suggests that "part of the keta can remain in northern waters or, it may be, in the course of their marine life they perform a cyclic migration, moving far to the north in summer and returning southward when the sea cools down".

In the work by Kawakami and Yokayama (1932, 70) it is stated, relative to chum salmon migrations, that keta from the coastal waters of the Island of Hokkaido travel to the rivers of the Maritime Province and the Amur for spawning; they also indicate that salmon entering rivers tributary to the Sea of Okhotsk (on Sakhalin, Hokkaido, in the Okhotsk region, the western coast of Kamchatka, and the Kuril Islands) all migrate from the Pacific Ocean.

A new work by Sato (1938, 73) which has just recently appeared gives more results of all the chum tagging experiments conducted by the Hokkaido Station of the Bureau of Fisheries of the Ministry of Agriculture and Forestry, and by commercial organizations. At different times more than 5000 fish have been tagged, of which recaptures amounted to more than 400 fish; but a majority of the fish were tagged close to the coast of Kamchatka (1-3 miles from shore), and only a few were tagged far out at sea. It was found that the migration paths of chum salmon have many branches and cover a tremendous area. The stock of chums which approaches Cape Kronotsk in June and July moves southward along the eastern coast of Kamchatka and goes around to the western shore, where it travels from south to north, reaching the central and northern parts of that coast. Keta which were off the southeastern coast of Hokkaido in May and June moved along the Kuril chain and, in part, went to Sakhalin. In September and October autumn keta from the southern Kuril Islands and Hokkaido move partly into the Sea of Okhotsk, partly through Laperouse Strait into the Sea of Japan, and partly along the coast of Hokkaido to the southwest. However, the marine migrations of chum salmon are far from being completely clarified.

For the quantitative distribution of keta stocks in the separate regions of the Soviet Far East up to now we have had to use the catch statistics presented in Kuznetsov's book (1937, 31).

[page 86] Table 19, prepared by D. A. Kanevets from Dalryba data, although it has the same weaknesses as Table 18 (taken from Kuznetsov), nevertheless reflects in its general features both the size of the keta catches since the last war and the contribution of the Amur keta to the landings of this valuable fish.

Tables 18 and 19 show that in the period 1925-1939 the various regions were as follows, in order of their importance in the keta landings: 1) Nikolaevsk, 2) Okhotsk, 3) West Kamchatka, 4) Karagin, 5) Icha, 6) East Kamchatka, 7) Oliutorka-Navarin, 8) Anadyr, 9) Gizhiga, 10) Sakhalin, 11) Maritime Province. If however we group the keta catches into larger commercial regions we obtain the following picture:

1)	Nikolaevsk (together with Sakhalin)	31%
2)	West Kamchatka (including Icha)	25%

Table 18. [page 85] Yearly keta catches in thousands of

Region	Landings 1925	1926	1927	1928
1. Maritime Province	0.2	0.8	0.5	1.0
2. Nikolaevsk and west coast of Sakhalin	59.7	318.6	220.7	148.9
3. Sakhalin (east coast)	-	2.2	3.5	4.4
4. Okhotsk	143.9	95.4	76.5	129.1
5. Gizhiga	5.1	8.4	7.1	14.2
6. Icha	24.2	39.9	35.0	81.3
7. West Kamchatka	64.9	45.1	96.5	210.6
8. East Kamchatka	20.6	32.3	53.1	25.0
9. Karagin	54.0	20.6	40.9	51.9
10. Oliutorka-Navarin	6.7	5.5	30.8	34.7
11. Anadyr	-	-	-	-
Total	379.3	568.8	564.6	701.1
Number of pieces	11,990.0	14,683.9	15,364.8	25,160.9

centners (from I. I. Kuznetsov, 1937).

Landings					9-year average	
1929	1930	1931	1932	1933	1000's of centners	%
0.6	1.4	3.0	3.8	17.4	3.2	0.4
135.3	305.2	434.2	262.7	215.2	230.0	30.5
2.5	5.2	8.4	4.5	6.2	4.1	0.5
158.3	212.6	108.2	180.5	170.0	141.6	18.5
20.3	24.3	22.3	33.2	41.6	19.5	2.5
186.6	111.0	62.8	68.4	27.9	70.8	9.2
273.0	156.0	137.0	178.8	57.2	124.3	16.2
27.2	40.0	75.5	35.4	28.2	37.4	4.9
89.9	142.6	142.6	88.9	108.7	82.2	10.7
36.4	32.0	40.8	37.9	38.5	29.2	3.8
-	22.6	23.2	18.3	-	21.3	2.8
930.1	1,053.2	1,058.0	812.4	710.9	753.3	-
28,267.0	36,648.8	32,521.7	27,051.3	22,064.9	23,750.3	

3) East Kamchatka (including Karagin, Navarin and Anadyr) 22.2%

4) Okhotsko-Ayansk (including Gizhiga) 21%

5) Maritime Province 0.4%

If the distribution of summer and autumn keta stocks shown above corresponds more or less to reality, we may say that the existing Soviet fishery for keta is based primarily on a fishery for summer keta, not autumn keta; the stocks of summer keta in the regions of our fisheries are more numerous than the stocks of autumn keta. And in spite of the fact that the stocks of Amur summer keta remain small, they now have a tendency to increase. Therefore the efforts made to maintain the stock of autumn keta must occupy a very special place, since in all our fishery regions other than Nikolaevsk the autumn keta do not exceed the summer keta in abundance.

3. SOCKEYE (Oncorhynchus nerka Walb.)

In the total salmon fishery of the Far East the sockeye occupies third place, producing an average of 254,000 centners a year (1925-1934), or 13% of the total salmon catch.

Study of the sockeye, like that of the coho and chinook salmon, has been conducted by the Kamchatka Branch of the Institute, inasmuch as these fish occupy an important commercial position in Kamchatka waters. The information given below is taken from reports which are available in our Institute and also from recent published data.

Racial composition of sockeye. The main mass of sockeye are an anadromous group, but there are also lake sockeye which never go out to sea. Discovery of these lake forms is described in the works of F. V. Krogius (1937, 41) for Lake Kuril, by V. E. Rozov (1937, 20) for lakes in the Okhotsk region and by R. S. Semko (1935, 54) for Lake Nachin. Further, it is well known in Kamchatka that two forms of sockeye enter the rivers--a spring and a summer form. The described races of sockeye are: azabach (L. S. Berg, 1932, 7), arabach (Cuvier and Valenciennes, 1848) and ovech (D. N. Taliev, 1932, 22). But scarcely any investigations concerning the racial composition of sockeye have been published as yet.

The description of the sockeye given by L. S. Berg (1932, 7) refers to spring and summer sockeye. The description of the azabach (Berg, 1932; Kuznetsov, 1928) is based on the difference in size of the azabach from the size of the ordinary sockeye and on the fact that the azabach lays its eggs later than an ordinary sockeye; thus the azabach is a form analogous to the autumn keta. About azabach sockeye it is known only that they differ from typical sockeye in smaller size,

Table 19. [page 86] Yearly landings of keta in thousands of centners (from D. A. Kanevets). [1 centner = 100 kg]

Regions	1934	1935	1936	1937	1938	1939
Total for the Far East	1065.5	827.8	1289.7	838.2	965.0	866.5
Maritime Province	2.3	1.5	2.8	0.8	1.4	1.5
Amur River and its estuary	280.3	186.4	218.2	195.7	270.1	267.1
Island of Sakhalin	90.4	67.9	58.4	71.9	67.3	74.9
Okhotsk and Tagil regions	186.5	135.5	157.0	174.6	233.2	116.2
Gizhiga region	49.5	39.7	51.0	54.9	38.4	25.8
Icha	74.4	54.5	135.5	77.3	100.8	16.1
Kikhchik	96.6	55.2	272.2	82.4	49.3	22.6
Bolsheretsk	46.2	28.8	115.1	23.3	23.3	24.0
East Kamchatka	34.2	101.3	65.7	31.2	35.5	81.2
Karagin	135.0	89.8	97.6	25.8	54.4	67.1
Oli͡utorka	70.1	67.2	77.1	89.3	79.2	46.4
Anadyr						69.1
Kichiga	-	-	39.1	11.0	12.1	29.5
Krutogorovo	-	-	-	-	-	25.0

smaller eggs, and a redder colour of the flesh during the spawning period.

A complete biometric investigation of the sockeye and its races should be made. This work was begun by R. S. Semko (1935, 54) for the sockeye of Lake Nachikin, which empties into the Bolshai͡a River basin on the west coast of Kamchatka. The spring sockeye in the Bolshai͡a River ascend during the last days of May, while the summer sockeye commonly run during the middle part of July. Spawning of the spring sockeye takes place throughout all July and the first days of August, while the summer sockeye arrive on the spawning grounds about 15-20 days after the end of spawning of the spring sockeye. The average fecundity of the spring sockeye is 2380 eggs, and of the summer sockeye it is 3600. The spring sockeye are smaller in size (average for males 59 cm, for females 54 cm) than the summer sockeye (males 61 cm, females 55 cm). R. S. Semko analyzed the morphological characteristics of the two forms and gave a description of them. The spring sockeye have a deeper body; their fins are low and short. F. V. Krogius (1937, 55) supposes that in the Ozernai͡a River basin there are two races of sockeye: one spawning in the kliuches and the smaller in size, and the other spawning in the lake. Investigations of the races of sockeye in the Paratunka River watershed were made by Krogius (1936, 92).

Age and rate of growth. In the first part of our review the work of M. P. Somov (1930, 53) was mentioned, who comes to the conclusion that the sockeye in the Kamchatka River return from the sea usually in their 5th year of life, but the fact is that [sometimes] the predominant age-group there consists of those in their 6th year, as occurred in 1929. Younger fish also take part in the migration, beginning with individuals in their 4th year. This age variation in the sockeye is closely related to the degree of utilization of the spawning grounds [in successive years]. For example, it was known (Kuznetsov, 1928, 9) that in 1924 the run of sockeye to the Kamchatka River was less than average--the whole catch amounted to 3,800,000 pieces. Few fish reached the spawning grounds, and in all the spawning regions seeding was poor. As a result of these unfavourable conditions, in 1929 not many fish in their 5th year of life could come back to the Kamchatka River, and the catch consisted principally of the next older age group, that is, fish which were 5 full years of age (in their [page 88] 6th year) and which were produced by the good seeding of 1923, when all spawning grounds were filled with spawners. Thus variations in the age of the commercial stock has an influence on the size of the catch of sockeye.

Semko (1935, 54) studied the age and rate of growth of sockeye in the Bolshai͡a River watershed using materials collected in 1932 and 1934, and obtained the figures shown in Table 20 for growth of spring and summer sockeye in Lake Nachikin.

Table 20. [page 88]

	Spring sockeye, cm		Summer sockeye, cm	
Age	Males	Females	Males	Females
1+	10.6	10.5	9.2	9.2
2+	31.0	30.1	28.9	28.0
3+	47.2	44.2	44.8	42.8
4+	59.8	55.4	57.8	53.9
5+	62.2	58.4	62.6	58.2

The Table gives an indication of the high rate of growth of spring and summer sockeye in the first year of life in the sea (the 3rd year of life after hatching from the eggs) but in general there is no pronounced difference between rates of growth of the two forms.

In addition to variation in the age composition of commercial sockeye of the sort just mentioned, there may possibly also be differences between localities. In the work of Krogius, Bool and Baranenkova (1934, 44) there are some interesting data. In the Anadyr material there were equal numbers of fish of age 4+ and 5+ (in 1928), in the Ozernaîà River age 5+ fish predominated (in 1932), in the Paratunka River the majority were age 3+ (in 1932). After reviewing sockeye growth rates, the above authors correctly indicate that: "rate of growth in the sea depends on the age at which the young fish go down to sea". Fingerlings which migrate downstream in their first summer, at a length of 6-8 cm, reach 20-25 cm after one year in the sea; while the fingerlings which remain in fresh water for a year grow to only 8-12 cm there. Fingerling sockeye which remain in fresh water for two years have grown to 7-10 cm at the end of the first year and at the end of the second year they are 12-15 cm. But at the time they become sexually mature, fish which continued to live in fresh waters for different lengths of time have become more or less equal in size. This phenomenon deserves careful study.

F. V. Krogius (1937, 55), after studying the age composition of sockeye in the Bolshaîa River watershed (from samples of 1932, 1930 and 1929), says that the age of the sockeye caught varies from 3+ to 5+ (and even to 6+) years. "In 1932 the fish that predominated were 5+ years old and had spent two years in fresh water, while in 1930 and 1929 it was fish 4+ years old with one river year."

Interesting material concerning the age composition of sockeye of Lakes Dalnee and Blizhnee of the Paratunka River system is given in a work by Gorogodsky and Orlova (1935, 46). In 1932, 1933 and 1934 sockeye entered both of these lakes primarily at the age of 3 years (in their 4th year) and having one river year; the first age-group predominated (i.e., 3+ with one river year). "In Lake Dalnee the age-groups 4+ (with two river years) and 5+ (with one river year) run [page 89] in rather small numbers, while in Lake Blizhnee they are encountered only as occasional individuals; the age-group 2+ (with one river year), which is found in Lake Blizhnee, is absent from Lake Dalnee." This age grouping of the sockeye is not fixed: according to Gorogodsky and Orlova's observations, in 1932 sockeye ran into Lake Dalnee primarily at age 3+ (with one river year), in 1933 fish of age 4+ (with one river year) were more numerous, while in 1934 age-group 3+ again predominated.

The rate of growth of sockeye of Lakes Dalnee and Blizhnee is apparently different for different age groups. A more rapid rate was observed among the sockeye of age 3+ (one river year), and a smaller rate of growth among those of age 4+ (two river years). "Sockeye which were of age 3+ (with one river year) and 4+ (one river year) achieved their greatest absolute growth in the second year of their life", that is, after the first year of their sojourn in the sea. Sockeye which had lived two years in the river system when young made their most rapid growth in their third year, also after the first year of sea life; apparently this rule is applicable also to all other groups of sockeye. The same authors indicate that rate of growth for sockeye of the same age does not remain constant over a period of years, but shifts each year in one direction or the other. In general, the rate of growth of sockeye from Lake Dalnee was greater than the rate of growth of sockeye from Lake Blizhnee, and as a result sockeye from the former lake are heavier than those of the latter.

Spawning of sockeye. I. I. Kuznetsov and other fish managers have collected information on the spawning grounds and spawning of sockeye. Kuznetsov (1928, 9) has given an excellent and detailed description of their spawning (the arrival of spawners on the spawning grounds, the act of spawning, covering of the eggs by gravel, death of the spawners, and so on). A description was also made of the spawning grounds of sockeye in the Bolshaia River watershed. A survey of the spawning grounds of sockeye in that same Bolsheretsk region was conducted by E. M. Krokhin and F. V. Krogius (1937, 55). The lake spawning grounds of summer sockeye in Lake Nachikin (according to Baranenkova's information) amount to 87,000 square metres. In 1932 about 50,000 female sockeye laid their eggs on these spawning grounds. Sockeye lay their eggs in kliuches, in rivers and in lakes; for the Bolshaia River spawning grounds (they amounted to 362,700 m^2 in 1933 and 1934) the speed of the current was determined as about 0.1 m/sec. Some investigators have studied the spawning grounds of sockeye in the Lake Kuril watershed (1937, 41) where typical spawning areas are found. From the data obtained from the lake spawning grounds it appears that the average mortality in the lake is lower than in the kliuches (35% in lake spawning grounds, 39-40% in kliuches). The principal cause of egg mortality is digging-over of nests by later-spawning females. The fry hatch from the eggs in May.

The conclusions concerning hydrochemical conditions on the spawning grounds are of great interest. Oxygen on the spawning grounds is less abundant than in places where spawning does not occur; the smallest O_2 content was observed on spawning grounds in the kliuches. On the spawning grounds pH was also low (not more than 7.8, and in the kliuches pH was 6.7), but the CO_2 content on the spawning grounds is higher than in the kliuches. Towards spring the amount of oxygen increased on the spawning grounds: "this is to be explained by the luxuriant development of green filamentous vegetation on the spawning grounds in spring" (Krokhin and Krogius, 1937, 55). [page 90] But the pH decreased and the acidity rose, which the authors associated with the decomposition of sockeye that died on the spawning grounds.

In an article by F. F. Golovanov (1931, 85) there are some interesting observations made by Gromov on the sockeye spawning grounds in the Kukhtui River watershed (at Lake Olen) on March 30, 1930. A mass of dead sockeye eggs was observed near shore at the surface of the gravel, and covered by a water layer 1-3 cm thick; at the same place there were live sockeye fry with yolk sacs under the stones. Live eggs were also found. The percentage of dead eggs and fry in the area examined was 40.5%. The migration of sockeye (Golovanov, 1931, 85) in the Okhota and Kukhtui Rivers begins at the end of June, and the principal run is in the middle of July; toward the end of August the run ends. They enter lakes for spawning (Nek, Olen, Aglykyt and others). The average fork length of the sockeye is 60.9 cm, and the average weight is 2.3 kg. Fecundity is 2142-5184, the average being about 3000 eggs (from 100 specimens).

Young sockeye. It was mentioned earlier that young sockeye, unlike young pinks and chums, remain in fresh waters for a rather long time--from 1 to 3 years, most often 1 year. The downstream migration of the young occurs at the time the spring flood is subsiding, at a temperature of about 12° C, and lasts up to September. Foerster (1937, 90) indicates a lower temperature for downstream migration of the young.

Young sockeye 3.5-3.8 cm long do not have scales, but at a size of 10.2-14.8 cm (one year of age) they have scales with 15-25 sclerites, most often 19. After going down to sea the young sockeye apparently at first remain near shore, but later go away from it. The further life of sockeye in the sea is almost unknown.

The Kamchatka Division of our Institute in 1933 and 1934 marked some young sockeye. In 1934, 20,000 young sockeye leaving Lake Dalnee were marked by removing part of the right pelvic fin and all of the adipose fin (Gorogodsky and Orlova, 1936, 46).

An article by Rokudzi Sato (1937, 76) gives information concerning the sockeye tagging experiments performed by Japanese scientists. For example, in July and August of 1936 more than a thousand fish were tagged near Kamchatka, but more than half of this number were tagged in coastal waters 2-3 miles from shore; inshore marking however does not have any particular interest for us, since the recapture of those marked cannot give any information concerning the purely marine and distant migrations that are of special interest for us in this connexion.

The conclusions from the sockeye tagging experiments were these. Sockeye caught in the open sea off Cape Kronotsk mainly

Table 21. [page 91] Catches of sockeye (in thousands of centners).

1925	155.8
1926	220.7
1927	234.3
1928	385.8
1929	326.5
1930	328.6
1931	255.4
1932	234.1
1933	151.9
1934	245.0
1935	108.1
1936	183.4
1937	208.9
1938	251.8
1939	194.5

go to the Gulf of Kamchatka and into the Kamchtka River, but a certain number of sockeye move northward into Karagin Bay and Oli͡utorka Bay, besides which one individual that was recaptured [and again released?] went from Oli͡utorka Bay to Karagin Bay.

Some limited experimental work conducted in 1934 on the vessel "Lebed" (M. L. Alperovich, 1935, 58) showed that sockeye movements from south to north agree with the direction of the flow of fresh water coming from the Ozernaı͡a River. This flow is at first directed northward along the coast, as far as the Koshegochek River, then the brackish layer [page 91] veers to the northwest. In catches of the Bolshaı͡a River region the sockeye were primarily 4+ years of age [osobi 4 let] and had spent one year in fresh water; catches in the Ozernaı͡a River showed a preponderance of fish 3+ years of age and they too had spent one year in fresh water. Along the west coast of Kamchatka sockeye were observed more than 56 miles from shore (15-20 days before the beginning of the sockeye run in the river). In 1936 in Malygova Bay (in Kronotsk Gulf) the Kamchatka Division of the Institute carried out some fishing for salmon in the sea. The investigators showed that here sockeye are moving from the first days of June up to the middle of August (see the earlier portion of the book for more accurate information concerning the migration times).

<u>Catches and stocks of sockeye</u>. In the total catch of salmon in the Soviet Far East sockeye amount to 15% on the average, or 254,000 centners (for 1925-1934). Information on the catches of sockeye since that period given by Kuznetsov (1937, 31) shows that catches of sockeye fluctuated between 152,000 centners in 1933 and 386,000 centners in 1928. Some periodicity can be observed in these catches--somewhat larger landings are made in the even years.

In addition, Table 21 shows that in spite of a widespread utilization of sockeye by the canning industry, the size of the sockeye catches is not growing, but on the contrary there is a trend toward decrease in these catches; and this falling off would be more noticeable if catches per unit of fishing effort were used. From this we must conclude that the stocks of sockeye in Kamchatka waters inspire misgivings concerning their future prospects, and especially for the sockeye which run into the Kamchatka River. There cannot be any kind of doubt that the decline in the sockeye stocks is closely related to the intensification of the Japanese ocean fishing for sockeye on their spawning migrations; this type of fishing, for example using marine "stenka", almost prevents the fish from entering their native river (the Kamchatka River).

The sockeye stocks entering Soviet waters are centered mainly near the eastern coast of Kamchatka, although sockeye are found in many other places, and are an object of commercial fishing in the Okhota-Ayansk [region], where sockeye sometimes amount to 40% of the total salmon catch (V. E. Rozov), in the region of Tauisk Gulf, the Anadyr, and other places. Evidently the principal feeding grounds of sockeye are along the Aleutian Islands; it is possible that the Ozernaîa River race of sockeye produces stocks that move not only from the eastern coast of Kamchatka but also from the region of the Kuril Islands. Thus for its marine stage of life the sockeye chooses waters of the southern part of the Bering Sea, for the most part.

4. COHO (Oncorhynchus kisutch Walb.)

The commercial importance of the coho is not very great--on the average about 40,000 centners were landed per year during the period 1925-1934, which is 2% [page 92] of the total salmon landings of the Far East. The systematics of the coho have not been studied, but it is likely that it too would yield interesting results (for example, in respect to the question of a lake form of coho). F. F. Golovanov (1931, 85), who described the fish in the Okhota and Kukhtuĭ Rivers, says that in lakes of the middle course of the Okhota River "there are mature fish, which in colour and form agree with cohoes, but are small--30-35 cm. It is possible that this is a lake form of coho."

Cohoes occur mainly along the American coast of the northern half of the Pacific Ocean (from Alaska to San Francisco). In our waters cohoes are found in greater or less abundance along both the east and west coasts of Kamchatka; they are also found along the coast of the Okhotsk Sea. For spawning the cohoes enter the Kamchatka, Bolshaîa and other rivers in July, August and September, commonly at the age of 2+ (that is, in their third year), but older ages are encountered, up to 5 years.

Spawning and spawning grounds. For spawning cohoes enter rivers and lakes. According to the investigations of F. V. Krogius and E. M. Krokhin (1937, 55), in the basin of the Bolshaîa River cohoes spawn in rivers and kliuches with a strong current, although there is information from V. V. Azbelev (I. I. Kuznetsov, 1928, 9) that coho can also spawn in parts of rivers quieter than those used for spawning by chum salmon. Egg deposition by the coho lasts a long time--up to February on the Bolshaia River, and on the Kamchatka River coho spawning ends at the middle of March (I. I. Kuznetsov, 1928, 9). I. I. Kuznetsov gives figures indicating a large loss of coho eggs at spawning time. A number of coho nests examined showed that, whereas the average fecundity of cohoes is 5000 eggs, only from 1527 to 3600 eggs were found in the nests; the loss of eggs among coho is considerably greater than among chums and sockeye. Mortality of eggs in the nests among coho is not great (6.5%) but cases were observed where all the eggs in a nest had died.

Young coho. Young coho hatch from the eggs after approximately 100 days, but there are too few observations on this point. The young ordinarily remain in fresh water for one year, rarely for two years; downstream migration of young coho is also observed at the fingerling stage, at a size of 3-4 cm. Young coho moving downstream out of the river at the age of 1 year are 10-16 cm in length, average 13 cm (Baranenkova's data, 1934, 42). Yearling coho which have migrated downstream in the Paratunka and Avacha Rivers spend much of the summer and autumn months in Avacha Bay; there is a particularly large number of them in the Petropavlovsk ship basin; the size of these young fish is 11-12 cm.

Baranenkova also describes the occurrence [vyklevyvanie] of young coho in Lake Kultuk near the city of Petropavlovsk throughout the summer and autumn months. Lake Kultuk, a tributary of the Petropavlovsk ship basin, is polluted. The bottom of Lake Kultuk is badly silted, and the depth of the lake is not more than 2 metres. Here young cohoes were caught by gill nets and by angling in November and December (the size of the young fish was 24-38 cm, and their age was 2 complete years and starting a third).

The food of young cohoes in the Paratunka River included larvae of chironomids and stoneflies and (rarely) crustaceans; the size of these young fish was 2-3 cm. In the stomachs of coho one year of age (length 9-13 cm), taken at the mouth of the Ozernaia River, insect larvae were found and a few crustaceans. In a few coho stomachs young of other [page 93] species of salmon also occurred. In the stomachs of young coho moving downstream in the Dalniaia River (age 1 year, length 10-16 cm) various insect larvae were found, eggs of sockeye, and small pieces of fish (which had fallen into the river from the floats where fish were being cleaned). In the stomachs of coho from Lake Kultuk (age 2+ years, length 24-28 cm) Gammarus and stickleback remains were found. Thus the principal foods of fingerling and yearling cohoes are insect larvae and mature insects (with a preponderance of chironomid larvae); 2-year-olds in the sea eat young fish principally.

An article by A. S. Baranenkova (1934, 42) gives information concerning the growth of coho. Young fish taken from the Paratunka River on May 25--during the spring flood--were 28 to 41 mm long, average 34 mm; the size of the young fish taken in the Nikolaevsk kliuches on June 18 was 25 to 37 mm, average 30 mm; the average weight of these fish was 0.43 g. Young fish taken from the Dalniaia River July 8-12 (age 1 and 1+ years) were 93 to 150 mm, average 129 mm, and their average weight was 22 g. Young taken August 21 in the Dalniaia River had an average length of 89 mm (35 to 135 mm). The number of sclerites on young coho [scales] from the Avacha region was 9-16 for the first river year and 12-18 for the second river year.

Coho stocks. Coho stocks in Soviet waters are not great (in comparison for example with chum salmon), and the landings also are not very large (Table 22).

Table 22. [page 93] [Coho catches, in centners.]

Years		Years	
1925	43,800	1933	19,600
1926	34,700	1934	27,700
1927	44,500	1935	30,500
1928	41,800	1936	101,500
1929	37,400	1937	65,600
1930	83,900	1938	54,300
1931	34,500	1939	37,100
1932	27,900		

Table 23. [page 93] Coho landings (from A. N. Derzhavin) [in thousands of centners].

	Regions			
Years	Okhotsk	West Kamchatka	East Kamchatka	Total
1925	0.3 (0.1%)	4.8 (10.4%)	41.1 (49.5%)	46.2
1926	0.5 (1.2%)	13.2 (33.1%)	26.2 (65.7%)	39.9

The contribution of individual regions to coho landings is indicated in Table 23, which shows catches in thousands of centners and percentages.

After 1926 the catch of cohoes considerably exceeded these figures: in 1930, 83,900 centners of cohoes were landed. But the general status of the coho catch was still small, partly because of the nature of the fishery--the coho migration is late, at a time when commercial fishing activity in Kamchatka has already slacked off. It might seem that there should be great opportunities for further increase [page 94] of coho catches however this is not so. In general coho stocks, in American waters as well as in Soviet waters, are not very great. Obviously there must be reasons which prevent great multiplication of the coho. Nevertheless the catch of coho can be increased, especially on the Kamchatka and Bolshaia Rivers. The principal accumulations of cohoes apparently occur along the eastern coast of south Kamchatka.

5. CHINOOK SALMON (Oncorhynchus tschawytscha Walb.)

The chinook salmon occupies a very minor position among Soviet fisheries: average annual landing of chinooks (1925-1934) was 8400 centners, although there is evidence that chinook landings amount to 150,000 pieces, which at an average weight of 8.3 kg amounts to almost 12,500 centners.

Remarks on the biology of chinook salmon. The life history of chinook salmon has been very little studied. In our waters it occurs primarily in the rivers of Kamchatka, principally the Kamchatka River and the Bolshaia River; it enters earlier than the other species of salmon (in May). The heaviest run of chinooks at the mouth of the Kamchatka River occurs in the first half of June; and the run ends in the last 10 days of July. In the Bolshaia River chinook salmon migrate from the first half of May up to the end of July. Spawning of chinooks in the headwaters of the Kamchatka River lasts from the end of June to August, while in the Bolshaia River basin it is from the middle of July to the middle of August. The spawning times indicated, if confirmed by further evidence, will show that the chinook salmon of the Bolshaia and Kamchatka Rivers differ in this respect; it may be that here too we have two forms of chinooks--a spring form and a summer form, comparable to the spring run and autumn run of chinook salmon which are distinguished in America. We may recall the extremely interesting work of Rich and Holmes (1928, 82) describing large-scale marking of chinooks in the Columbia River. This marking showed that there are two races of chinook salmon (similar to our sockeye salmon)--a spring and a summer race, and that spring-maturing fish grow from fry of the spring race, while fry of the summer race produce adults of the summer race. It was found that young summer chinooks have not yet reached the age of one year when they go down to sea, whereas the young of the spring race remain in the river a whole year.

The chinook salmon is the most long-lived and largest of the genus Oncorhynchus, reaching 45 kg; sexual maturity among chinooks is reached in the 4th to 7th year, the males maturing earlier. Males "sometimes become mature during their first year, while in the river, at a length of 75-175 mm" (Berg, 1932, after Gilbert, 1912, 79). The fecundity of chinook salmon is large, more than 8000 eggs on the average (from 4600 to 14,300). Chinook salmon choose a rapid current for their spawning. According to the information of Krogius and Krokhin (1937, 55) chinook salmon in the Bolshaia River basin lay their eggs in rather shallow bars (not deeper than 1 m), where the current of the water "apparently is greater than 0.5 m per second". I. I. Kuznetsov (9) mentions approximately the same depth.

Spawned-out chinooks can move downstream to the lower reaches of the river; for instance, near the mouth of the Bolshaia River chinooks are caught in August on their way down from the spawning grounds; but in addition many dead fish are observed on shallows in the river. Doubts concerning whether chinooks die after spawning apparently must be set aside by the work of Rutter (1902, 93), who showed that chinook die after spawning. The young of chinook salmon remain in the river (1-3 years).

[page 95] The catch of chinooks in the whole Soviet Far East amounts to 150,000 pieces; 95% of this number are caught in the region of the Kamchatka River, and 90,000 of these are taken in marine fishing sites. The catch of chinooks is increasing, as shown by the following figures (in pieces).

Years		Years	
1924	29,900	1927	101,896
1925	46,600	1928	281,243
1926	98,000	1929	103,624

The average weight of chinook salmon is 8.3 kg: some individuals reach 20 kg and even 25 kg or more. I consider it possible to increase the chinook salmon fisheries in the region of Cape Kronotsk and Avacha Bay. Chinooks are distributed more widely along the American coast of the Pacific Ocean; they are especially abundant in the Columbia and Sacramento Rivers; but in the latter river the catches have declined markedly. In California much attention is now being given to the artificial propagation of chinook salmon, ever since the stocks declined so drastically (Clark, 1929, 83). In Soviet waters, as we have seen, chinooks are most numerous in the regions of the Kamchatka and Bolshaia Rivers; but the fish also occurs in many other sectors (Anadyr, Oliutorka, and occasional individuals are observed in the Okhotsk region); the Kamchatka River's share is about 96% of the total catch (in 1926). We must observe that in spite of the small fishery the chinook stock is very limited; in addition there is information that in individual rivers chinooks have become scarcer than they were formerly. In the

Vorovskaîa River in 1910, 1857 chinooks were captured, while in 1924 no chinook catch was recorded from this river; a similar situation is also known for several other rivers (Kolpakova, Brîumkina, Kola, Kikhchik, Utka, and Opala).

6. MASU SALMON (Oncorhynchus masu Brev.)

The masu, like the chinook salmon, is not the object of a large fishery; its average catch (1924-1934) is 8300 centners per year (0.4% of the total fish catch in the Nikolaevsk region). One line of information suggests that masu were caught in the Amur in earlier times as well, but that they were mixed with pink salmon; another source of information indicates that the masu have begun to penetrate farther north (from the Sea of Japan). The latter seems more likely, since V. K. Soldatov, who was extremely well acquainted with the far-eastern salmon, encountered the masu in the Amur River during the 1900's only as occasional individuals.

Remarks on the biology of masu. In the Amur River masu run first among the anadromous salmons (from the beginning to the middle of May) and apparently go far up the river. The run of masu in the lower reaches ends at the beginning of August, and spawning of masu in the Amur is from the end of July. In the Gulf of Peter the Great a run of masu occurs in May and June. We may distinguish anadromous masu, which go to the Amur and the Maritime Province region, from the river masu, which live in rivers of the Maritime Province, Sakhalin, and west Kamchatka. The fecundity of masu salmon averages 3200 eggs (from 1386 to 3261). Sexual maturity is reached in the third year of life, or rarely the fourth year. The growth of masu (according to N. P. Navozov-Lavrov) is as follows (in cm).

Age in years	1	2	3	4
Males	13	32	65	-
Females	16	37	56	59

[page 96] Young masu remain in the rivers about a year, and reach a size of 12-20 cm, and it has been observed that males of 18 cm may be sexually mature; sexually mature females are not observed in the rivers.

Stocks. The place that masu live is in the Sea of Japan: their presence has been observed as far as the most southern portion of the Korean peninsula (Mori, 1935, 94). Formerly it was believed that 3000 centners of masu could be caught, on the average: however masu catches in individual years have exceeded 10,000 centners, and the average is now 8300 centners, as mentioned above.

CONCLUSIONS [page 97]

Pacific salmon (genus Oncorhynchus) are of great importance in the far-eastern fishing industry. The annual catch of salmon by the Soviet fishing industry is more than 2,300,000 centners; in addition, many salmon are taken by foreigners who catch the fish in the sea on their spawning migrations back toward the river systems of the Soviet coasts.

Studies of Pacific salmon by Russian scientists, which had an excellent beginning during the 1900's, were not immediately continued, and only when the Far East came under Soviet control were such studies seriously developed, particularly from the time of the establishment in 1925 of the Pacific Research Station (now the Pacific Research Institute for Fisheries and Oceanography--TINRO).

During 1925-27 studies of salmon and the salmon fisheries were conducted in two principal fishing regions--Nikolaevsk and west Kamchatka, where previous to that time the landings of pink salmon had fluctuated and there had been a catastrophic decline in the catch of Amur summer keta.

From 1928 to 1931 the attention of the Institute was directed toward the collection of basic material concerning salmon biology in almost all sectors of the Soviet seas where salmon occur. During the same period work was prosecuted on the problem of replenishment of salmon stocks. Information was obtained concerning the salmon of the Maritime Province, the Gulf of Tartary, the Amur estuary and its rivers, the Amur River and its watershed, the Okhota-Ayansk, Gizhiga and Penzhin regions, and portions of west Kamchatka (the Icha, Vorovskaia͡, Kikhchik, Bolshaia͡ and Ozernaia͡ Rivers), and also concerning east Kamchatka and the west coast of the Bering Sea (Kamchatka River, Karagin Gulf, Korf Bay, the Oli͡utorka Gulf and Anadyr Gulf).

From 1931 to 1937 seasonal studies were intensified and year-round investigations were begun for the Amur and especially (starting in 1932) for the Kamchatka salmons. Over a period of years materials have been assembled concerning the salmon at Cape Dzhaore and Cape Puir. Starting in 1932, the work in Kamchatka branched out into a study of the ecology of spawning grounds of salmon, and since 1937 similar work has been done at a point in the Amur estuary and at another point on the Amur River.

Studies of salmon in the sea, which are very necessary, have been conducted by the Institute on a very limited scale only.

The degree to which the different species of Pacific salmons have been studied, in relation to the question of the status of their stocks, is outlined in the following summary (based mainly on data obtained by the Institute from 1925 to 1937).

[page 98] Pink salmon. Pink salmon occupy first place in the total salmon catch; the yearly landings amount to about 1,000,000 centners on the average. Work begun by the Pacific Fisheries Institute on the racial study of pink salmon leads to the conclusion that there are separate stocks of pink salmon characteristic of particular regions.

An ecological study of the spawning of Kamchatka gorbusha has shown that they lay their eggs in comparatively fast water with high oxygen content, while they avoid the kliuches. Young pink salmon do not remain in the river long, but go quickly down to sea.

Mature pink salmon consume mainly crustaceans, insects and fish.

The length of life of pink salmon is 1½-2 years. The two-year life cycle of pink salmon, together with its single spawning, results in extremely sharp fluctuations in pink salmon catches and in the size of the stocks; on the other hand, the early sexual maturation of pink salmon is a favourable factor whose effect is to maintain pink salmon stocks at a high level. The fundamental cause of these fluctuations has not been explained; but it lies principally in the biology of the fish itself, and in the natural conditions for spawning and feeding. Man can either decrease or increase these stocks, depending on the nature of his exploitation of pink salmon.

At the present time, stocks of pink salmon during the summer months are densest in west Kamchatka and in the Nikolaevsk region; following these are the Karagin-Oliutorka region, the Maritime Province and Okhota-Ayansk; there is reason to believe that these stocks do not completely intermingle, but may comprise several independent stocks, each with its own centre of habitation.

Chum salmon. Chums occupy second place among salmon landings. Chum salmon are divisible into distinct racial groups--the summer keta, the autumn keta and the monako, which exhibit biological differences and have different geographical distributions.

Chum salmon spawn mainly in kliuches, in side channels and in rivers, where there is an upwelling of ground water and the current is comparatively slow.

The young fish move out of the river during their first summer after hatching.

In the sea chum salmon eat fish and crustaceans principally.

Chum salmon live to 7+ or even to 8+ years of age [do 7 i dazhe do 8 let]. The commercial stock of summer and autumn keta consists mainly of age 4+ fish (in their fifth year) [iz 4-letnykh (po pi͡atomu godu) ryb] or, in occasional years, of age 5+ fish. [Probably Pravdin has inadvertently made these ages 1 year too great; compare Tables 12-15 and the second paragraph of (our) page 96.--W.E.R.]

The unparallelled decline of summer keta, which has taken place in the Nikolaevsk region, was the result of an excessive fishery in the pre-Soviet period.

The principal stocks of chum salmon in summer and autumn are found in the Sea of Okhotsk, particularly in the Nikolaevsk and Okhota-Ayansk regions, where the principal form is the autumn keta; in the west Kamchatka fishing region the summer form of chum salmon predominates.

The stock of chum salmon in the northwestern part of the Bering Sea also consists mainly of summer keta.

Sockeye. Sockeye are third among the salmon fisheries. Several forms of sockeye are known (spring sockeye, summer sockeye, azabach and ovech); in addition there are lake forms of sockeye.

[page 99] Sockeye spawn in lakes. Mortality of eggs in kliuches is higher than in a lake.

Young of anadromous sockeye go to sea usually after 1 year from their hatching from the egg, rarely during their first summer or after 2 years, and extremely rarely after 3 years.

The food of sockeye has scarcely been studied.

Commercial stocks of sockeye usually consist of age 4+ and age 5+ individuals. The maximum length of life of the sockeye is 6 years [i.e. 6+].

The present Japanese fishery for sockeye in the sea has had a marked effect in reducing the catches of sockeye in the Kamchatka River.

The principal place of concentration of sockeye during the spring and summer, and the one closest to the Soviet coast, is the region of the sea adjacent to the southwestern coast of Kamchatka.

Coho. The commercial importance of coho is not very great. Cohoes lay their eggs in small rivers and kliuches, where there is an emergence of ground water and an alkaline reaction of the water.

Young cohoes remain in fresh water for 1 year or rarely 2, where they feed on the bottom fauna and on fish eggs.

Commercial catches of cohoes consist principally of 2-year fish (age 2+). Coho stocks are not very large, but their exploitation could be increased if the fishing season in Kamchatka were made longer.

Places of dense accumulations of cohoes in Soviet waters are almost unknown, but a majority of coho are caught in waters of the southern half of the Kamchatka coast.

Chinook salmon. In the fishery this species of Pacific salmon has little importance. Chinooks have been very little studied biologically, but it is known that they are the most long-lived species of Pacific salmon. Mature chinooks are 4 to 7 years old. Chinooks spawn in rivers with swift currents. The young remain in the river from 1 to 3 years.

Stocks of chinook salmon are limited and they are most numerous near the American shore of the Pacific Ocean, to judge by the landings. In Soviet waters the chinook salmon fishery may be increased by conducting fishing during early spring in the neighbourhood of the Bolshaia River, Avacha Gulf and Cape Kronotsk.

Masu salmon. The commercial importance of masu is not great. Its biology in Soviet waters has not been studied. It occurs in greatest numbers in the northern Maritime Province.

Thus the Soviet Pacific salmon industry, which in recent years has exceeded the catches of pre-war times, has some basis for further development. This development must be directed in three channels: first, greater exploitation of new or little-used regions (for example the Okhota-Ayansk region); second, increase in catches in years of great abundance of pink salmon; and third, the introduction of a marine fishery for salmon.

The Pacific Fisheries Research Institute has done a great deal of work in surveying the salmon stocks of the numerous sectors in the wide expanse of the Japan, Okhotsk and Bering Seas, and also in the part of the Pacific Ocean immediately adjacent to the southeastern coast of the Kamchatka peninsula.

The directions which future investigations on Pacific salmon resources [page 100] should take can be pictured in the following manner[1]. Pacific salmon investigations must have the following objectives: to learn the quantitative status of salmon stocks, to learn the character, causes and methods of correcting fluctuations in stocks, and to develop measures for increasing the productivity of salmon stocks.

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[1] I am listing the more important points in an address which I gave to the First Conference on Investigations of the Pacific Salmons.

The principal work leading to the goals mentioned during the next 5-year plan must be as follows:

1. Studies on the racial composition of each species of salmon (pink, chum, sockeye, coho, chinook and masu), and the distribution of each race in the various fishing regions. It is necessary to draw up a standard description of each of the species of the genus Oncorhynchus and their subdivisions, something which no one has yet done for chums, sockeye, cohoes, chinooks and masu, and also to continue the identification and description of the forms of pink salmon.

2. Determination of the age composition of each species of salmon in each fishery region, something which is especially important for the quantitative evaluation of commercial salmon stocks by individual year-classes, and for making catch predictions. Age composition and its changes must be followed through for each species for at least one life cycle; for chums this is 6 years, for sockeye not less than 5 years, for cohoes 5 years, for chinooks 10 years and for masu not less than 4 years.

3. Investigation of the migrations of mature salmon, young salmon and salmon fingerlings in the ocean and in rivers, for which purpose large-scale markings of salmon should be organized.

4. Ecological and biological studies of spawning and the spawning grounds, to provide a basis for measures that will increase the stocks. The work must illuminate fully the biology of salmon in fresh waters, starting from the moment of development of the eggs and ending with the death of the salmon after spawning. In addition to the usual studies made at the Control Stations, this will also require experiments (on the physiology of egg development, on the early period of life of the fry, and so on) which must be organized at the Control Stations by the Fishery Research Institute or by Dalrybvod. In addition, more intensive experimental work must be conducted at an appropriately equipped fish hatchery (or hatcheries). This branch of the work includes, in particular, studies directed to the determination of the percentage eggs in females that get deposited in the redds, the percentage of downstream-migrating young produced, and their percentage return as spawners [reading vozvrat instead of vozrast].

5. A description should be made, from the fishery and biological point of view, of all regions where there exists or can exist, in any degree whatever, a fishery for salmon either in fresh waters or in the sea; it is especially necessary to establish and develop a fishery in unexploited or little exploited regions. For this purpose methods must be worked out for obtaining accurate catch statistics in each fishery sector and for each species of salmon.

6. Research work at all the Dalrybvod Control Stations,

and classification of the salmon spawning grounds, must be carried out by the Institute in cooperation with Dalrybvod.

7. The publication activity of the Institute and Dalryba, which will be required by the work described above, must keep in mind: a) compilation and publication of monographs concerning each species of salmon; b) preparation and publication of articles on the classification of spawning conditions; c) compilation and publication of reports on other significant environmental factors; [page 101] d) compilation and publication of other special works concerning individual problems in systematics, biology, salmon fishing and salmon behaviour.

To implement these proposed studies the following will be necessary:

Seasonal observations on salmon must occupy first place among the activities of the Control Points and must be carried on year round, where it will be possible to follow the principal phenomena associated with the salmon stocks (density of seeding of the spawning grounds, degree of development of the eggs, quantitative estimation of the downstream migration of young, and of the spawners returning, etc.).

Starting in 1939, the establishment by the Institute of year-round observation stations on spawning areas for each of the important species of salmon (pinks, chums and sockeye).

Ichthyological, hydrological and hydrobiological studies at these observation stations, made with a view to explaining the condition of the stocks of each individual species.

In cooperation with Dalrybvod, experimental work must be done at the C o n t r o l Points on various aspects of the reproduction of salmon stocks (learning more about the ecological factors which affect the development and hatching of the young and so on).

For a better evaluation of the effectiveness of natural and artificial reproduction of salmon, the Institute must, in cooperation with Dalrybvod, carry out scientific work at fish hatcheries belonging to Dalrybvod where it will be possible to set up work on the physiology of development of eggs and young.

In assessing the density of seeding of spawning grounds by spawners and eggs, and also in assessing the downstream migration of young and studies of the food and growth of the young, those hydrological and meteorological factors must be studied which have an effect on the biology and size of the stock of these fish. It is also necessary to do mass marking experiments on young salmon.

In choosing places for continued observations the possibility must be kept in mind of extending the results from each point to other similar regions, where such work is not carried on.

In the years just ahead it is necessary to undertake mass marking of salmon (mature and immature) in the sea; in the first instance this should be undertaken in Primoriâ and Kamchatka.

Along with the work at the primary observation points, it is necessary to continue the collection of materials on the fishery biology of salmon in other sectors.

It is very important to go ahead with the organization of a Control Point on Bering Island, which has been proposed by Dalrybvod, where it will be possible to obtain more accurate results in determining age of the salmon.

Thus our investigations of Pacific salmon are now, in 1938, entering the second period of their development, a period of deeper probing into the foundations of the salmon industry.

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