

**Strategic plan for Far Eastern basin-scale Pacific salmon research
program for 2006–2010 period**

by

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Strategic plan for Far Eastern basin-scale Pacific salmon research program for 2006–2010 period

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Abstract

This strategic plan substantiates content and priorities for fisheries research of Pacific salmon for 2006–2010 period. Overview of contemporary status of Pacific salmon stocks substantiates conclusion that their abundance is at historically high level. Current research status of Pacific salmon at different periods of their life cycle (freshwater, estuarine-coastal and marine) is provided. The achievements of recent years research are noted with a special emphasis upon insufficiently understood and controversial issues of Pacific salmon biology. The list of further comprehensive research activities is proposed to gain better forecasting of Pacific salmon abundance dynamics and returns, as well as to achieve better stock management.

1. INTRODUCTION AND CONCEPTUAL PRESUPPOSITIONS OF THE PROGRAM OF STUDIES OF PACIFIC SALMON IN 2006-2010

Pacific salmon is one of the most valuable commercial fish, which occupies an important place in the coastal fisheries of USA, Canada, Japan and Russia. The implementation of effective Pacific salmon fishery does not require the organization of large and expensive fishery vessels dispatches. Their fisheries are conducted mainly in the coastal zone and in the rivers, when they arrive for spawning.

During the last century, judging by the fisheries statistics and data on abundance monitoring, there were two periods with a high level of total salmon stocks in North Pacific: the mid-1920-ies — early 1940-ies and the mid-1980-ies — early 2000-ies. (The last period has not finished yet). They were separated by an approximately 40-year period with a low abundance of Pacific salmon (Fig. 1).

Characteristically, such abundance dynamics was observed in both Asian and North American stocks (Fig. 2), which testifies of the importance of the global climate changes for Pacific salmon dynamics, with which the long-term abundance fluctuations of these fish are connected in many ways.

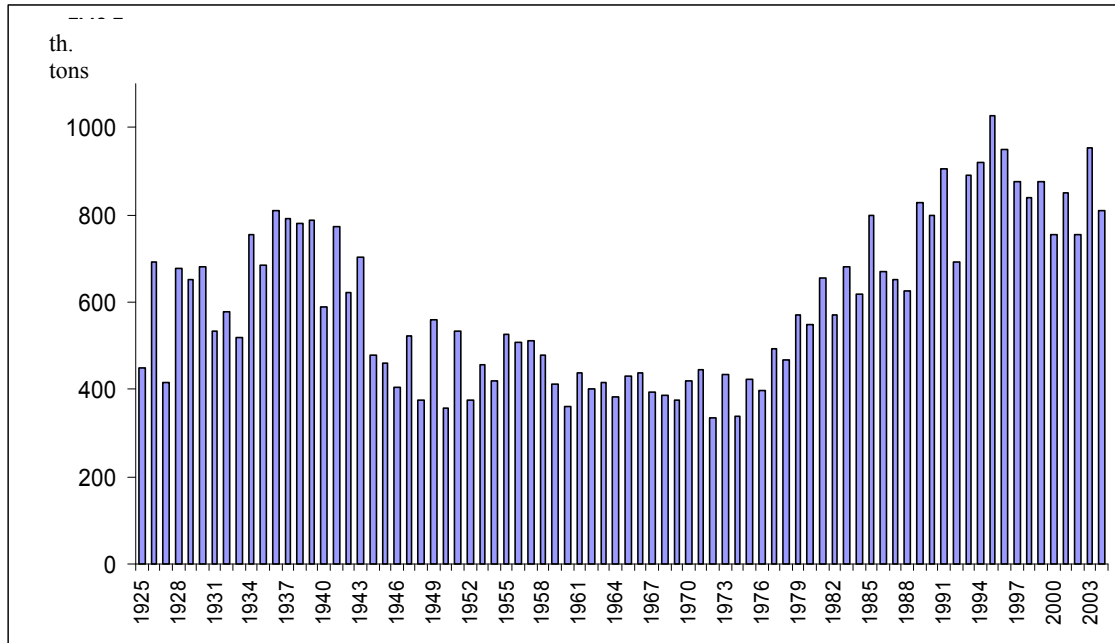


Fig. 1. Pacific salmon total abundance dynamics in North Pacific region during 1925–2004 period

The views of the specialists on the favorable reproduction and habitat conditions for Pacific salmon during the periods of their high abundance are basically generally accepted. On the other hand, a long period of low abundance (1940–1970) is associated with the deterioration of the reproduction conditions, as well the large-scaled Japanese fisheries (up to 200–250 th. tons per year) that developed during 1950-ies.

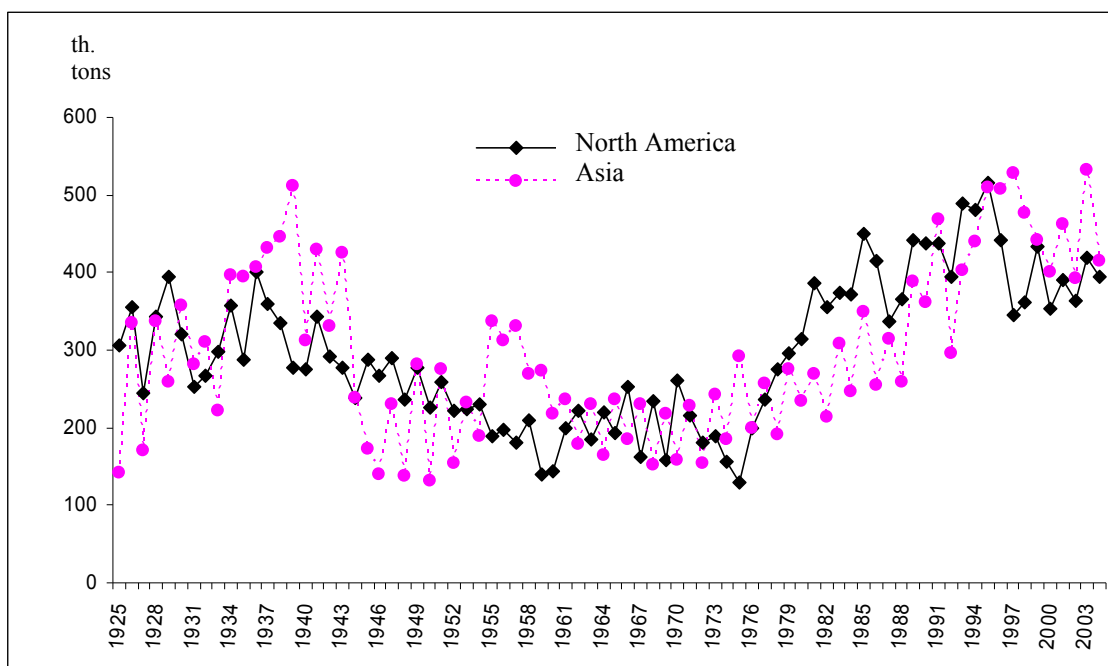


Fig. 2. Pacific salmon total catches in Asia and North America during 1925–2004 period

The maximal total catch of about 1000 th. tons from the Asian and North American stocks was recorded in 1995. During the previous wave of abundance, the maximal catches reached only 600–800 th. tons. The higher fisheries harvests during the last wave of abundance were caused by the intensification of the fisheries as well as the large-scaled artificial reproduction of Pacific salmon, first of all, chum salmon in Japan.

After 1995, the decreases in total catches of Pacific salmon in North Pacific by 150–200 th. tons were repeatedly observed. However, these declines were temporary, at least, taking into account only the Pacific salmon reproducing in the watersheds of Russia. However, taking into consideration the cyclicity of Pacific salmon abundance, as well as the long-term dynamics of their catches, which is shown in Fig. 1 and 2, it is possible to say that the next and long-term decrease of their abundance is an event of the close future.

The long-term abundance of the Pacific salmon stocks mentioned above is an integral indicator of the biomass of all Pacific salmon species and stocks. At the same time, it is known that the differences that are often significant are observed in the

dynamics of specific species and stocks, even those inhabiting the adjacent regions. This is explained by the prevailing influence of the local factors on the reproduction. In such a way, the phenomenon of regional specificity is manifested, which is hardly taken into consideration when the attention is focused on the global factors.

In the Russian fisheries, pink salmon is absolutely dominant. On the average, i.e. based on the long-term aspect (1971–2002), it comprises about 75 % of the total Pacific salmon catches. It is followed by chum salmon (16 %) and sockeye salmon (6 %). The presence of coho, chinook and, especially, masu salmon in the fisheries is non-significant. This ratio of the species in the catches reflects their ratio in the nature in general.

In different years, the species ratio slightly differs from the average picture, which is especially evident in the specific fisheries regions. Typically, the contribution of the fluctuating pink salmon into these differences is most significant, especially with the contrast differences between the odd and even generations.

As it is shown in Table 1, during the most recent abundance wave of Pacific salmon, their coastal catches in Russia varied between 79–260 th. tons (on the average 170 th. tons), i.e. the stocks were quite abundant. The driftnet catches in the Russian waters (Russian and Japanese) (not included into Table 1), which comprised 5–33 th. tons in the 1990-ies and 6–22 th. tons in the 2000-ies, should be also considered. If, in addition to that, we take into account the massive poaching in all the entities of the Russian Federation in the Far East, as well as the widely spread underestimation of the commercial fisheries catches, it can be assumed with great confidence that the real catches during all those years were significantly higher as compared with the official statistics and, quite likely, they could be 25 per cent higher. It seems that on the average they could be 210–230 th. tons.

In 2000–2005, the total Russian Pacific salmon catches were not much different from the catches in the first and second halves of the 1990-ies (Table 1, Fig. 3).

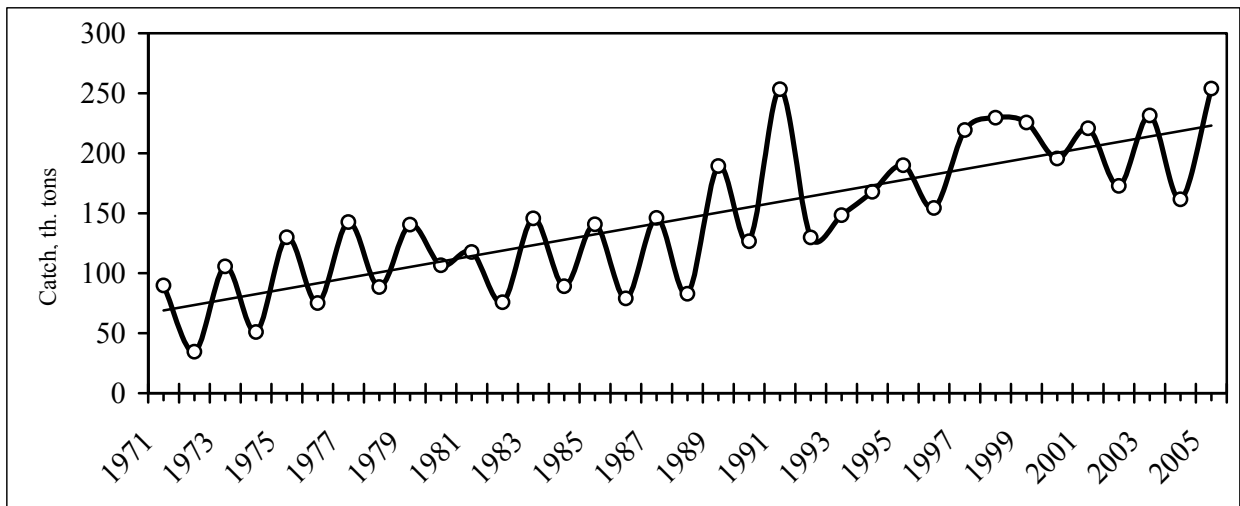


Fig. 3. Dynamics of Pacific salmon Russian coastal catches during 1971–2005 period
(th. tons)

Table 1

Pacific salmon Russian coastal catches during 1971–2005 period (th. tons)

Year	Pink salmon	Chum salmon	Sockeye salmon	Coho salmon	Chinook salmon	All salmon species
1971	66.9	14.1	2.4	4.4	2.0	89.8
1972	20.4	8.7	1.3	1.9	2.2	34.5
1973	91.0	8.4	2.0	2.2	2.2	105.8
1974	33.0	11.1	1.2	3.4	1.8	50.5
1975	110.4	12.5	1.4	3.3	2.2	129.8
1976	54.5	13.9	1.2	3.4	2.0	75.0
1977	115.2	18.3	2.0	4.0	3.1	142.6
1978	57.7	22.0	3.5	2.3	2.9	88.4
1979	103.8	27.2	3.0	4.0	2.4	140.4
1980	79.3	19.8	4.0	2.4	1.1	106.6
1981	87.9	20.7	4.0	3.7	1.4	117.7
1982	47.8	19.7	3.1	3.8	1.3	75.7
1983	107.7	28.2	4.5	3.4	1.8	145.6
1984	56.7	19.4	6.6	4.8	1.7	89.2
1985	96.4	28.2	9.3	5.3	1.5	140.7
1986	41.0	25.4	7.5	3.3	1.8	79.0
1987	98.8	30.0	11.8	4.0	1.4	146.0
1988	40.7	29.2	8.4	3.1	1.5	82.9
1989	149.6	25.6	9.8	3.1	1.2	189.3
1990	76.1	30.5	16.4	2.6	1.0	126.6
1991	211.9	22.5	14.4	3.4	1.0	253.2
1992	87.3	21.2	15.4	4.7	1.1	129.7
1993	108.1	22.2	14.2	2.7	1.3	148.5
1994	125.2	28.2	10.8	2.5	1.1	167.8
1995	145.3	28.2	14.0	1.5	0.9	189.9
1996	110.0	25.1	16.8	1.9	0.5	154.3
1997	188.4	19.4	9.0	1.9	0.6	219.3
1998	192.1	25.1	10.1	1.7	0.5	229.5
1999	187.7	23.9	12.0	1.2	0.7	225.5
2000	147.6	30.8	15.1	1.7	0.5	195.7
2001	170.8	29.6	18.1	1.7	0.5	220.7
2002	108.1	37.6	24.8	1.7	0.6	172.8
2003	180.1	32.1	17.7	1.4	0.2	231.5
2004	113.6	30.2	16.3	1.5	0.3	161.9
2005	205.7	33.0	19.7	0.9	0.6	259.9

Comment. Starting from masu salmon catches were added to total catches.

As it can be seen from Table 2, the last three five-year periods were characterized by the largest numbers of the spawners arriving to the spawning grounds. From the data in this Table and in Fig. 4, it is also seen that the same tendency was observed both in the catches dynamics and the dynamics of the Pacific

salmon escapement to spawning grounds, i.e. an increase between the 1970-ies and 1990-ies. Although in the late 1990-ies, a noticeable decrease in the number of the reproducing spawners was observed, firstly, it did not influence the stocks status (moreover, in the 2000-ies, a significant increase in Pacific salmon abundance took place), and secondly, the total escapement to spawning grounds during the last three five-year periods did not show significant differences.

Table 2

Pacific salmon escapement to Russian spawning grounds during 1971–2005 (th. tons)

Year	Pink salmon	Chum salmon	Sockeye salmon	Coho salmon	Chinook salmon	All salmon species
1971	42.0	5.9	3.3	1.6	3.8	56.6
1972	85.7	8.2	2.9	2.2	4.1	103.1
1973	68.8	3.9	2.0	1.0	2.3	78.0
1974	27.6	8.7	2.0	1.4	1.8	41.5
1975	84.2	6.0	2.9	2.2	1.6	96.9
1976	46.3	5.6	3.0	1.6	2.3	58.8
1977	93.9	6.5	6.1	1.7	1.8	110.0
1978	33.3	10.2	7.3	1.2	1.6	53.6
1979	84.5	11.6	5.8	2.7	1.6	106.2
1980	36.9	8.2	6.7	1.1	1.2	54.1
1981	124.0	12.2	6.9	2.5	1.5	147.1
1982	41.0	9.5	4.9	1.5	1.4	58.3
1983	163.6	14.6	9.0	2.1	1.0	190.3
1984	85.1	15.8	13.5	3.2	1.7	119.3
1985	66.8	15.1	15.2	3.5	1.6	102.2
1986	45.8	13.0	9.5	3.5	1.5	73.3
1987	91.0	13.5	12.7	1.6	1.2	120.0
1988	43.2	12.9	8.6	1.5	1.5	67.7
1989	92.7	11.6	10.6	1.7	1.1	117.7
1990	72.3	19.4	23.7	1.8	1.5	118.7
1991	119.0	11.5	9.5	2.4	1.0	143.4
1992	62.0	7.8	5.7	1.8	0.8	78.1
1993	109.8	29.6	7.2	2.6	1.3	150.5
1994	159.8	38.1	11.0	2.5	1.3	212.7
1995	92.4	28.6	8.7	1.4	0.8	131.9
1996	126.2	50.8	11.7	2.4	0.8	191.9
1997	121.4	24.0	6.3	2.0	0.7	154.4
1998	85.5	24.7	4.7	3.5	1.2	119.6
1999	71.1	22.7	6.2	1.3	0.8	102.1
2000	57.0	27.6	6.2	1.1	0.7	92.6
2001	50.9	59.9	4.0	0.5	1.0	116.3
2002	101.4	44.9	10.1	0.6	0.8	157.8
2003	151.2	59.2	10.1	3.7	1.1	225.3
2004	128.2	32.0	7.4	1.7	1.2	170.5
2005	130.0	20.0	7.2	0.5	1.3	159.0

In Fig. 5, the total coastal catches, the number of the spawners in the spawning grounds and the driftnet catches of Japan and Russia in the Russian EEZ are summed up. The summed data characterize the dynamics of the Pacific salmon returns to the Russian coasts quite well. It is well seen that during the last 15 years the total catches of the Russian Pacific salmon were quite high. Therefore, as compared with other fluctuating fish species, for example, walleye pollack and Far-Eastern sardine (iwashi), the abundance dynamics of which “fits” the rhythms of the Aleutian Low and the Pacific Decadal Oscillation more distinctly, the abundance wave of the Russian Pacific salmon occurs with an obvious delay. Taking into consideration the long-term dynamics of the Pacific salmon abundance, for which the abundance waves are typical, two principal but not quite concise conclusion can be made at this stage: a) a massive decrease of the Pacific salmon abundance is not very likely during the few nearest years, b) it is hardly likely that the present Pacific salmon abundance wave will last for a long time and it is quite possible that a growing decrease in the Pacific salmon abundance will start during the period of this program. The last circumstance makes it especially necessary to continue the monitoring and also to take the necessary measures for the protection, artificial reproduction and rational use of the Pacific salmon resources.

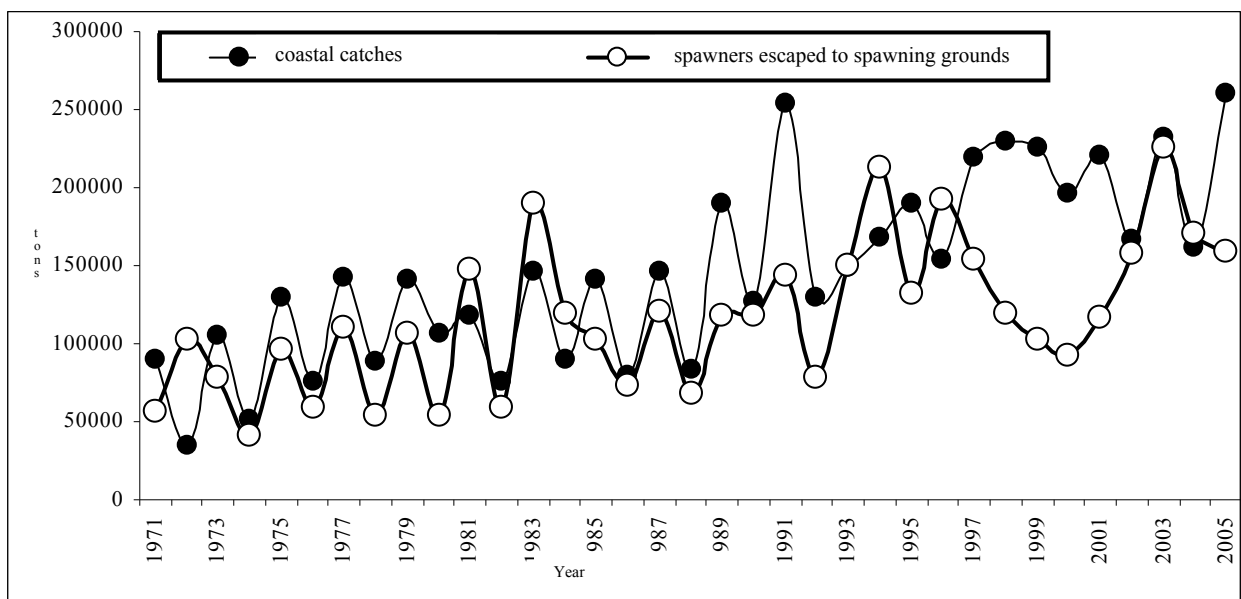


Fig. 4. Number of Pacific salmon spawners escaped to spawning grounds and coastal catches during 1971–2005 (tons)

The above data on the Pacific salmon catches and escapement to spawning grounds show only the general picture for all Pacific salmon species and all Russian regions. At the same time, the significant differences in the abundance dynamics and the catches of the specific species are observed. During the 35-year period of studies, first a tendency for growth and after that, the retaining of the higher abundance level in the 1990–2000-ies were observed as typical for pink, chum and sockeye salmon. In contrast to that, at the same time a decrease in the catches of chinook and coho salmon occurred (Fig. 6). However, considering the escapement to spawning grounds, which was close to that of the previous period, the decrease in their catches was due to the various organizational reasons, first of all, due to poaching. However, in all the circumstances, these two species and, moreover, masu salmon, have never determined and will not determine the fate of the Russian Pacific salmon fisheries.

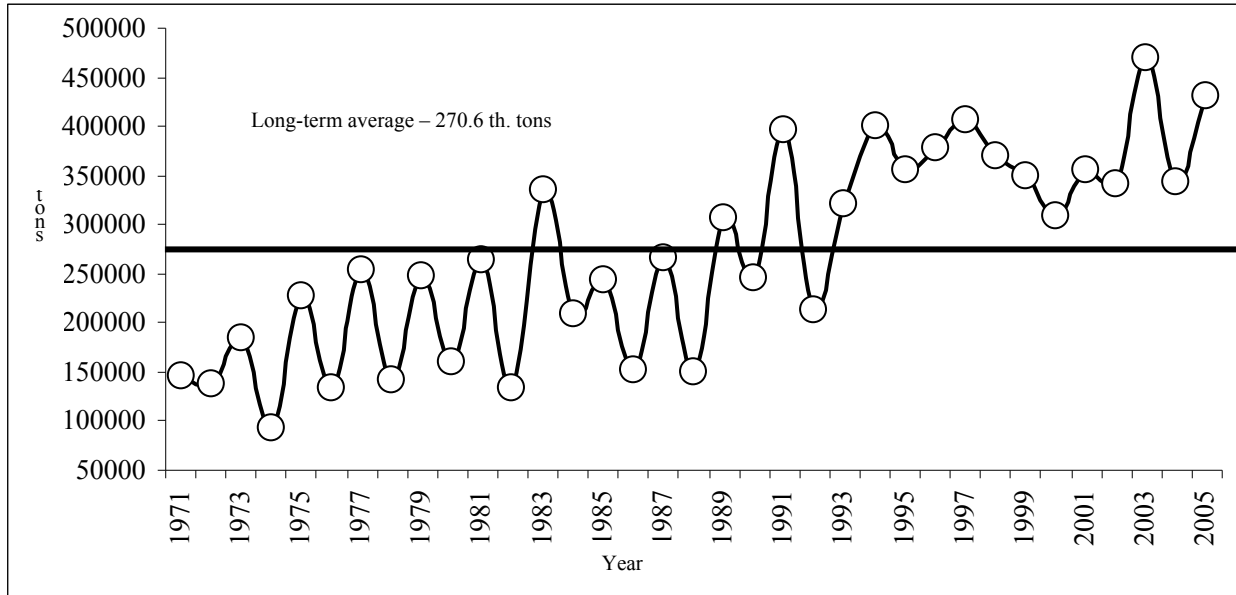
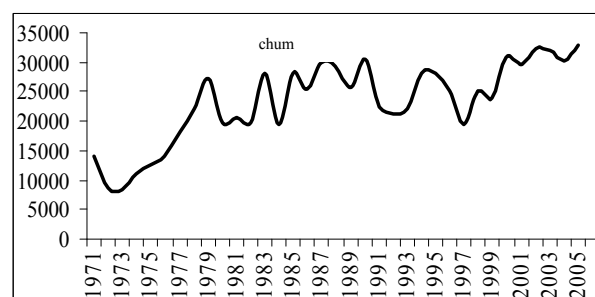
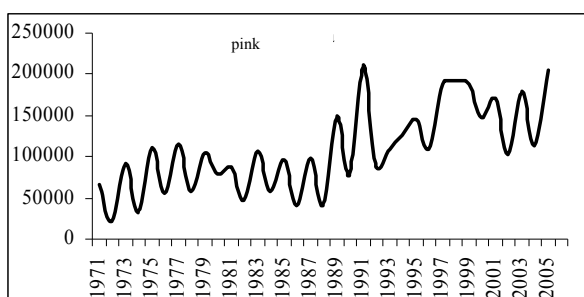


Fig. 5. Dynamics of Pacific salmon returns to Russian coast during 1971–2005 (tons).

Coastal and driftnet catches and number of Pacific salmon spawners escaped to spawning grounds within Russia are summed up

In every way, the regional differences that are well expressed in all these fish have a special significance for the understanding of the abundance dynamics of Pacific salmon, as well as the conditions and prospects of their fisheries. The action of the phenomenon of regional specificity is expressed in it. The run of the catches curves of the main Russian commercial Pacific salmon species (pink salmon, chum salmon and sockeye salmon) in Fig. 7–9 illustrates that every regional population (or a complex of populations) of every species has its own peculiarities (Karpenko, Rassadnikov, 2004 // Studies. KamchatNIRO. Issue 7) and often the tendencies in the catches dynamics do not coincide. First of all, it is connected with the natural abundance dynamics. However, sometimes the stocks state as well as the fisheries conditions (the objective ones, connected, for example, with synoptic conditions and the subjective ones connected with organizational activities) has a certain and even determining effect on the specific catches values.

The specificity of the regional Pacific salmon population dynamics dictates the necessity of a regular monitoring with a corresponding set of research tasks in each Pacific salmon region. It is especially important in the observations and studies of the freshwater and estuarine periods of the Pacific salmon life cycle. Clearly, such an approach requires more staff and material resources, but it is absolutely necessary. The regional approach is also necessary, but to a lesser degree, in the observations and studies of the marine and oceanic periods of the Pacific salmon life cycle. In this case, the marine studies on the stocks of each basin of the Russian Far Eastern seas – the Okhotsk and Bering Seas and the Sea of Japan present separate tasks.



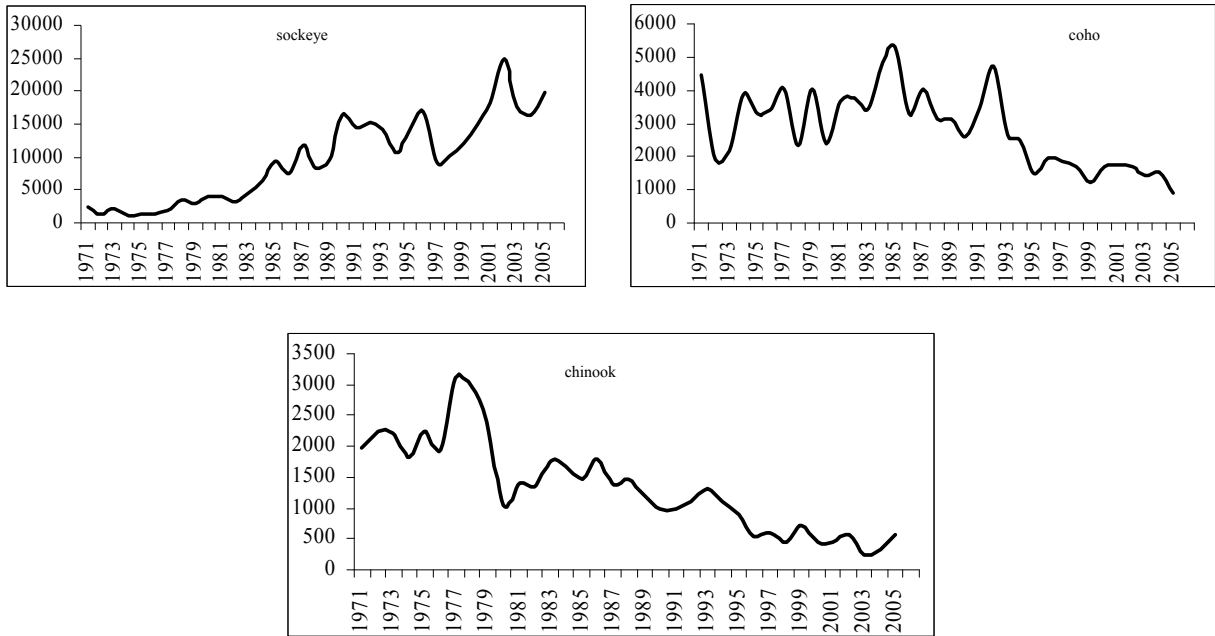
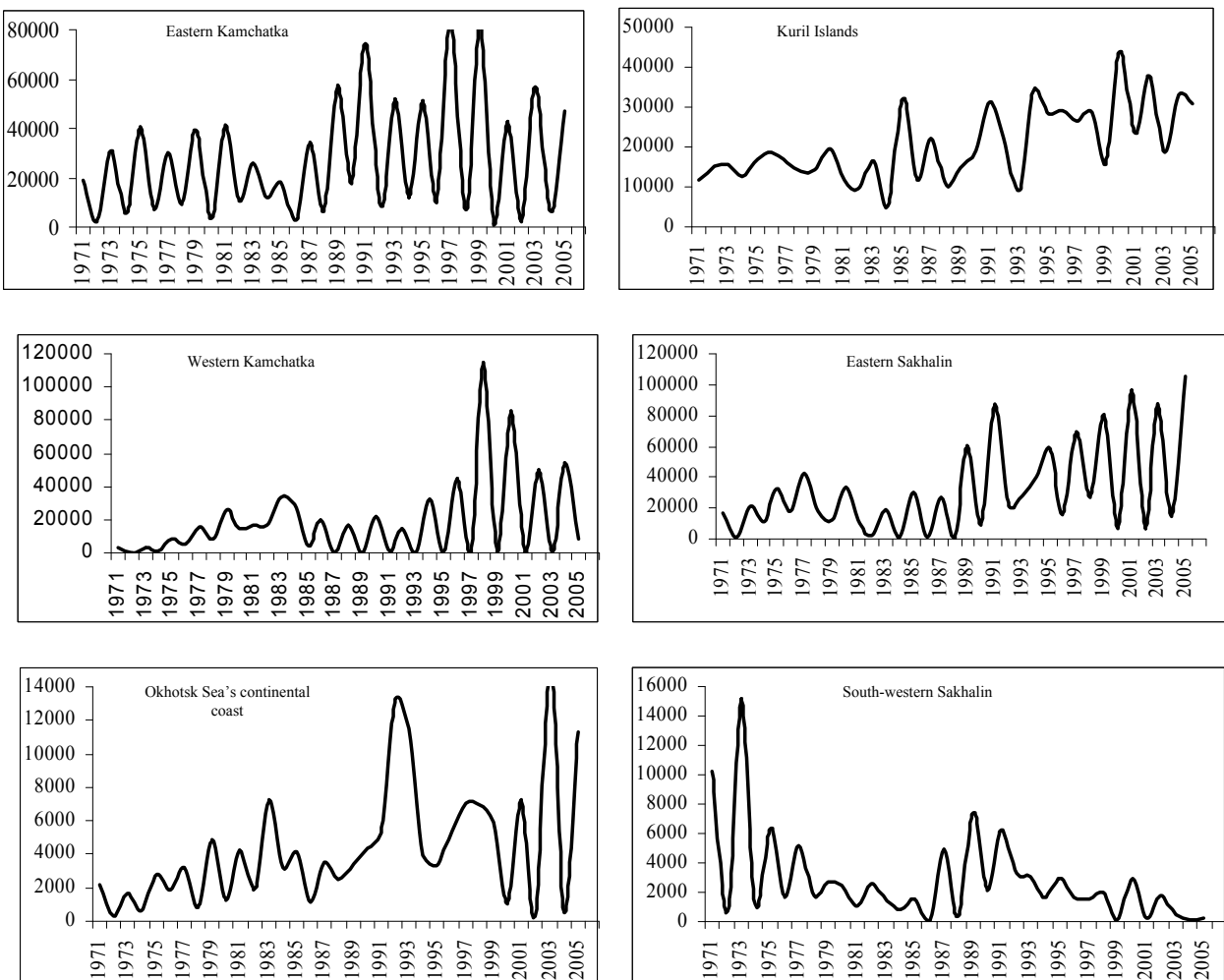


Fig. 6. Species-specific catch dynamics in the Russian Far East during 1971–2005 (tons)



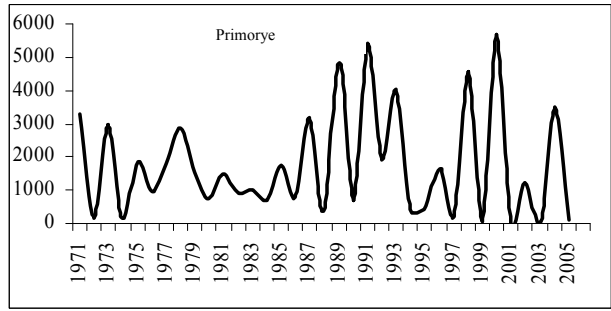
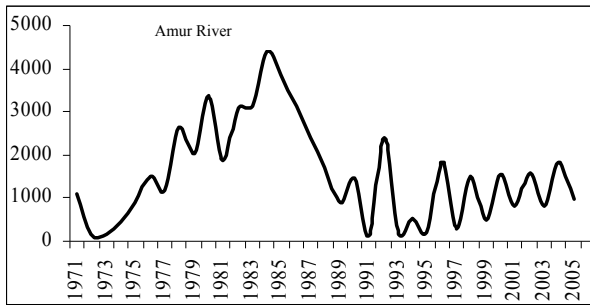


Fig. 7. Area-specific catch dynamics of Pink salmon in Russian Far East during 1971–2005 (tons)

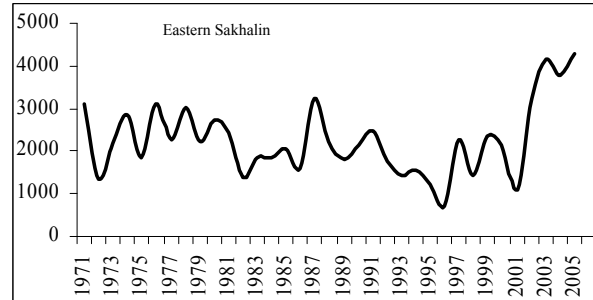
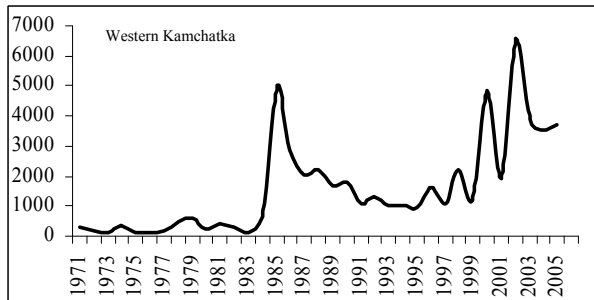
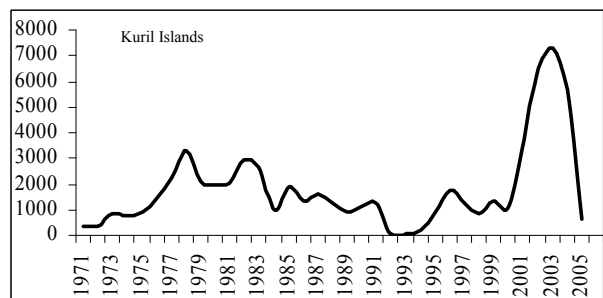
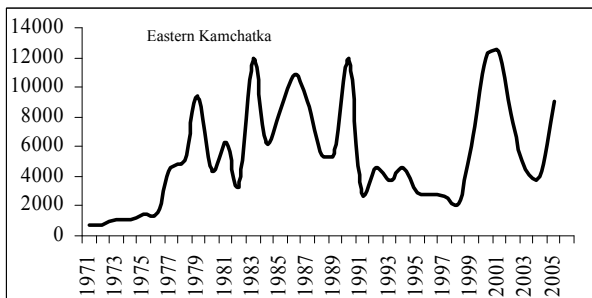




Fig. 8. Area-specific catch dynamics of chum salmon in Russian Far East during 1971–2005 (tons)

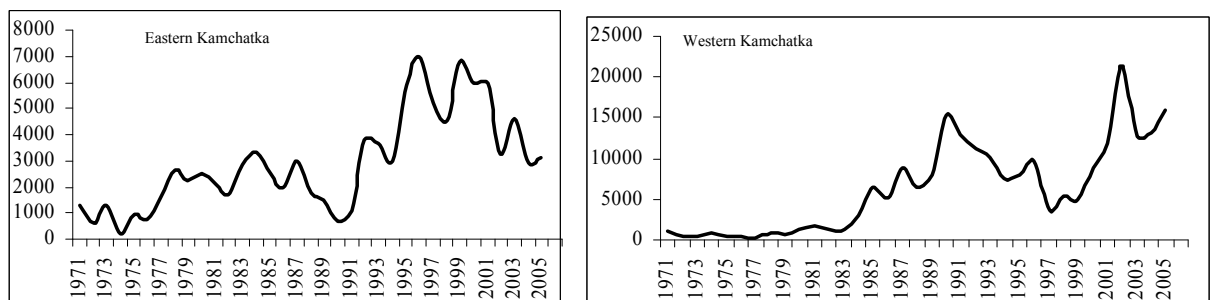


Fig. 9. Catch dynamics of sockeye salmon in western and eastern Kamchatka coast during 1971–2005 (tons)

2. STUDIES OF THE ASIAN PACIFIC SALMON AT DIFFERENT STAGES OF THEIR LIFE CYCLE

For many years, the big commercial significance of Pacific salmon attracted a special interest to them from several generations of researchers (both fisheries and academic scientists). In total, (together with the publications of foreign researchers) the publications on Pacific salmon are “counted by thousands”. Starting with the mid-1990-ies, the research institutes of Scientific Production Association “TINRO” (together with VNIRO) conducted the Pacific salmon research in accordance with two five-year programs, in which the focus was made on the marine period of life cycle. The general principles of these programs serve as a foundation for developing the thematic plans of the institutes. The studies of the freshwater and estuarine period of life cycle were continued by tradition. The structure of those studies was mainly introduced by the Complex Target Program “Salmon” that was adopted 20 years ago and included three blocks: “Nature”, “Reproduction“ and “Fertilization”. This large and well-elaborated program was not completed due to the lack of financing, but it determined the principal direction of further studies with retaining the continuity of the Pacific salmon studies in the earlier periods.

In 1992, the North Pacific Anadromous Fish Commission (NPAFC) started to function. Within the framework of NPAFC, since 2002, in the Bering Sea and the Commander-Aleutian oceanic waters, the studies of the oceanic life period of Pacific salmon have been conducted in accordance with the 5-year international program BASIS that will be renewed.

As a result of the long-term studies, the continuous series of observations and a huge database on many issues of the Pacific salmon ecology and fisheries have been accumulated. However, no significant progress in the forecasts accuracy of the Pacific salmon abundance dynamics and fisheries has been achieved. In principle, annually, the dynamics of the Pacific salmon returns in different regions of the Far East in general and for specific species significantly differ from those expected. It is due to several reasons, to be more precise — to the following complex of reasons.

A. The theory of fish abundance dynamics still remains underdeveloped. In this regard, the anadromous forms of Pacific salmon still present a special and even very special “hard case”. The factors that limit abundance, i.e. the factors determining the production of a certain brood year, affect three stages of the Pacific salmon life cycle: a) when reproducing in fresh waters, b) in the early marine period after the early juveniles downstream migration to the coastal zone, c) in the marine and oceanic period of life cycle, when immature and maturing individuals mainly occupy the areas beyond the shelf zone. This peculiarity of the abundance formation is illustrated in the generalized and schematic form in Fig. 10 and 11, while Fig. 12 shows how it is taken into consideration in the estimation of TOC (Rassadnikov, 2003 // Rybn. Khozyaistvo, No 2). The most important in it is that every stage mentioned can, to a certain degree, either level down the mortality (or survival) rate at other stages or increase it. Therefore, the random factor is inevitably present in the formation of the final abundance of brood year. For this reason, the corrections of TOC are so important in the process of specific fisheries seasons.

B. The effectiveness of the natural reproduction playing the main role in the reproduction of the Russian Pacific salmon is influenced (sometimes significantly) by a complex of anthropogenic factors. The results of this influence not always can be taken into consideration and predicted (for example, the overfishing of spawners, the contamination or destruction of spawning ground and habitat areas of early juveniles).

C. The vastness of the Pacific salmon reproduction areas, which makes it difficult to study in detail the multiple watersheds during the stocks monitoring and assessment.

D. In addition to the objective reasons, when explaining the failures in the predictions of the Pacific salmon abundance and catches, the “weak spots” of all used modern techniques should be mentioned, including the non-always sufficient professional level of their application, especially in collecting the survey data, as well as focusing the attention only on individual relationships (for example, parent generation – offspring generation, downstream migrants – returning spawners)

without the full recording of the parameters obtained during the studies at different stages of ontogenesis (for example, the information on the marine and oceanic observations is not always used in the work with the data obtained during the coastal period).

E. The wide use of the unproven and long-existing subjective postulates on the dependence of the dates of the arrival to the coastal zone and the feeding pattern during the spring-summer Pacific salmon migrations to the spawning grounds on a narrow set of factors characterizing the climatic and oceanological conditions, which has a negative effect on the accuracy of the real-time forecasts.

* * *

This strategic plan outlines program of the next phase of the Pacific salmon research in 2006–2010 with a prioritized attention to the issues connected with the improvement of the prediction of abundance and catches, as well as the rationalization of the ways of better stocks utilization. It takes into consideration the suggestions of many specialists of research institutes of Scientific Production Association “TINRO”, as well as the analysis of the history of the Pacific salmon fisheries studies in the Far East during several decades. It is worthwhile to preliminary discuss the state of the studies of different aspects of the freshwater and marine ecology of Pacific salmon.

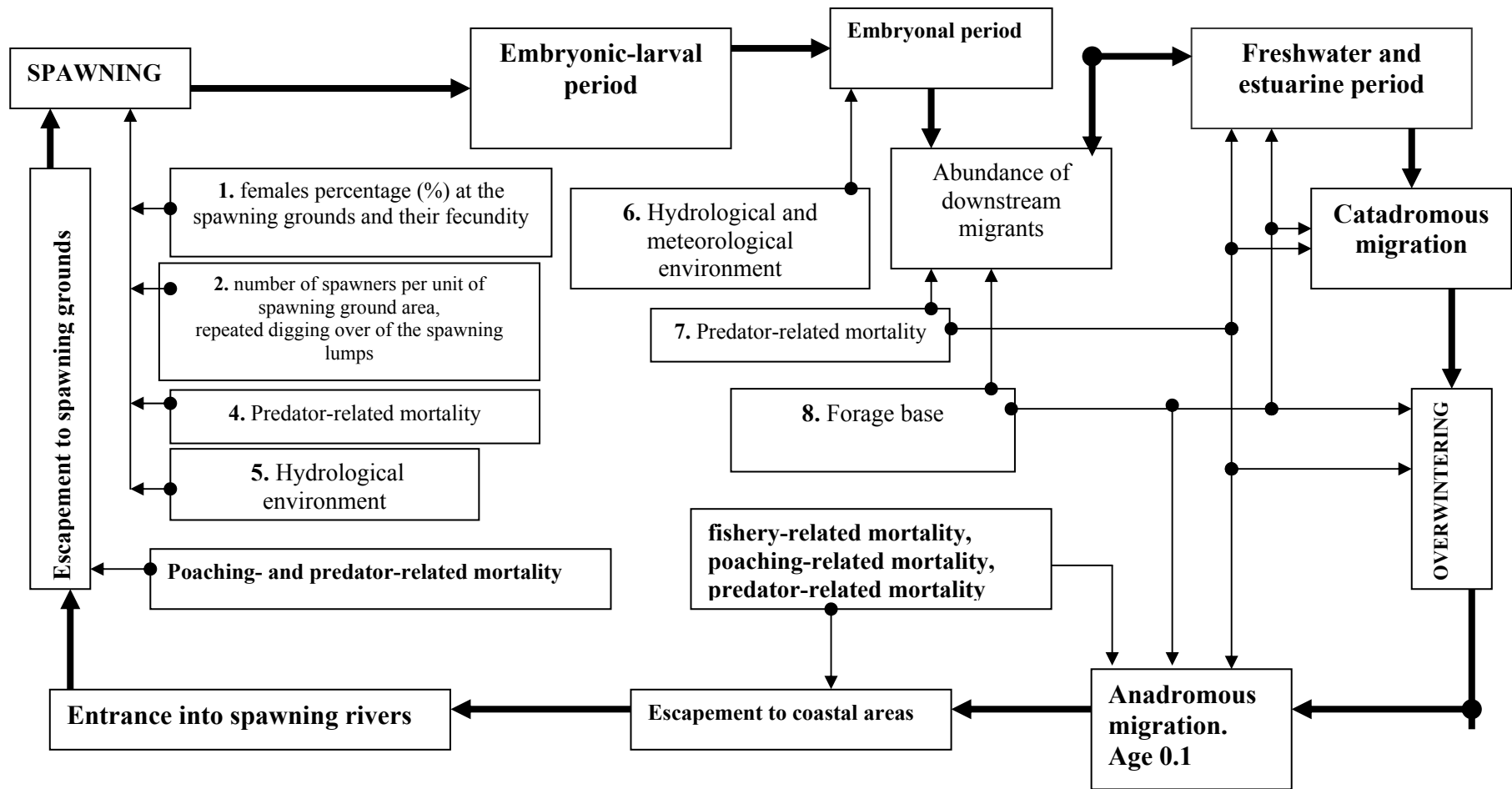


Fig. 10. Pacific salmon life cycle (as exemplified by Pink salmon) and factors influencing it

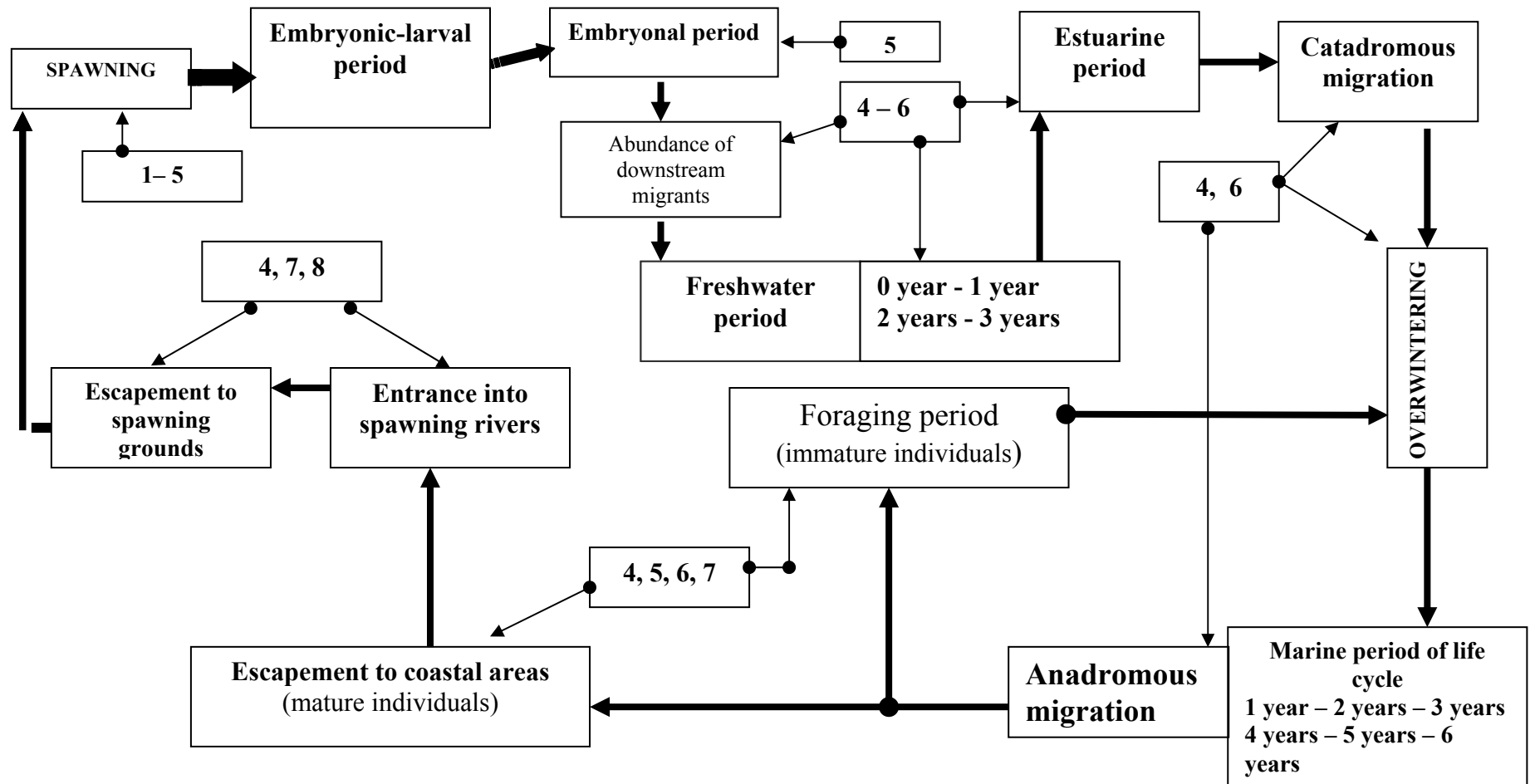


Fig. 11. Pacific salmon life cycle (as exemplified by sockeye salmon) and factors influencing it: 1 – 1. females percentage (%) at the spawning grounds and their fecundity, 2 – number of spawners per unit of spawning ground area, 3 – repeated digging over of the spawning lumps, 4 – predator-related mortality, 5 – hydrological and meteorological environment, 6 – forage base, 7 – fishery-related mortality, 8 – poaching-related mortality

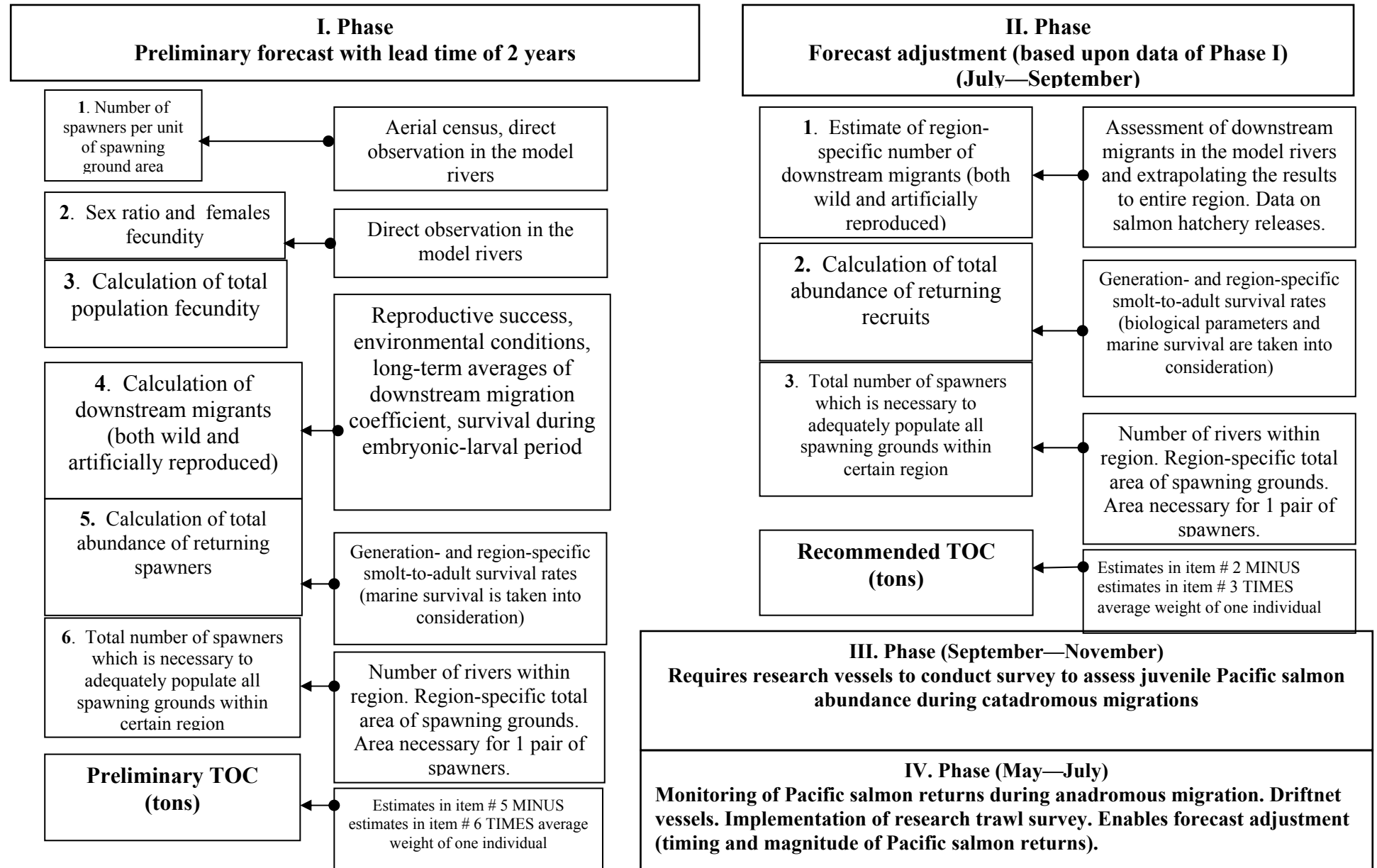


Fig. 12. Flow chart of major steps to produce forecast of Pacific salmon TOC

1. The reproductive areas of natural habitat and the state of the spawning fund

The reproductive areas of natural habitat, spawning biotopes and types of spawning grounds have been studied to a satisfactory degree for all Pacific salmon. For the main reproductive areas of Pacific salmon, the evaluation of the spawning water bodies and the main spawning grounds has been conducted. In the last decade of the 20th century, in particular, an increase in the reproduction and an expansion of the habitat areas of Pacific salmon in the northern latitudes with a simultaneous decrease of the reproduction in the southern regions were observed. The influence of the climatic factors can be traced in that dynamics (warming with further consequences in the watershed regime), and the influence of the anthropogenic factor (poaching, pollution, etc.) is also observed at the mainland coast of the Japan Sea and, partly, in some other regions. In the situation of the continuous influence of the natural and anthropogenic factors, the data on the evaluated state of the spawning watersheds and specific spawning grounds have become outdated and need a refinement, i.e. a regular monitoring of their state is necessary. In such assessments, it is important to clearly rank the significance of the watersheds and spawning grounds for the Pacific salmon reproduction at least by three categories (main, important, secondary). Without it, it is impossible to get a clearer picture of the parameters of the spawning grounds and, first of all, the optimal quantity of the spawners escaping to the spawning grounds (including the minimal and maximal values). The understanding of the issue of the significance of the excessive escapement of the spawners to the spawning grounds is partly connected with it. The opinions of different researchers on this issue are still alternative, as well as the issue of the values range of the optimal quantity of the spawners escaping to the spawning grounds.

2. The evaluation of the efficiency of natural reproduction

At present, all main factors limiting the survival of the Pacific salmon generations in the freshwater life period, i.e. during the embryonic development at the

larval and smolt stages, are known. The reproduction efficiency at this stage of ontogenesis is evaluated by the number of the smolt migrating into the sea. However, there are, at least, three reasons making it difficult to accurately assess the reproduction results of the Pacific salmon aggregations representing the units of stocks and predictions: a) the imperfectness of the methods of assessment of smolt migrants, especially in large rivers; b) the lack of the reliable data confirming the relevance of extrapolating the results of the assessment of smolt migrants from the individual model rivers to the vast fisheries regions; c) the lack of the data allowing to assess the differences in the mortality rates of the artificially reproduced and wild Pacific salmon juveniles, which makes it necessary to use the averaged values. At present, when the continuous series of observations and the fisheries statistics for specific biostatistical areas have been accumulated, the retrospective analysis of data in this direction should give a definite answer.

3. The ecology of juvenile Pacific salmon in the estuarine life period

The common features of the ecology of juvenile Pacific salmon at this stage of ontogenesis have been studied satisfactorily. However, for the prediction purposes, the information accumulated during those studies is only partly useful, and more precisely — to a small degree. It is explained by the following reasons: a) it is impossible to organize the total assessment in the coastal zone due to the long duration of the smolt migration and the “ladder-like” migration of the juvenile individuals to the offshore pelagic waters; b) it is problematic to obtain the reliable information on the feeding conditions for the juvenile individuals that started to feed due to the low reliability of the data obtained by use of the modern but non-perfect equipment for the abundance assessments of plankton and other food organisms in the sea coastal zone; c) methodically, it is difficult to get the accurate rates of the mortality of juvenile individuals from the coastal zone predators, the abundance of which is also difficult to assess. The views of the different authors on the role of predators in the natural mortality of early juveniles are still often alternative. Moreover, it is difficult to take into account the random but often very significant

changes in the climatic and oceanological factors: during high water, washing out and transfer of the weakly developed fry to the sea, the downstream migration under the fast ice, etc. In total, they strengthen the effect of other factors, in particular, the trophic or predation factors.

4. The ecology of Pacific salmon in the oceanic life period

During the last 15–20 years, the studies of the Pacific salmon ecology during the sea (outside the shelf zone) and oceanic periods of life cycle have improved significantly in several directions. It is connected to a great extent with the implementation of the ecosystem approaches to organizing and conducting the expedition research works, which were developed by TINRO-centre.

The dislocation of the main populations of all species from both continents in the vast areas of North Pacific has been generally studied. For the Asian Pacific salmon, the position and role of those fish in the epipelagic ecosystems have been determined, which became possible as a result of getting a detailed picture of their quantitative distribution (as well as zooplankton and the accompanying species of nekton and zooplankton) and the accumulation of the huge databases on the feeding behavior and feeding relationships of Pacific salmon (as well as the accompanying nekton species). It has been shown that the regularities obtained from the autecological studies of shoaling fish cannot be applied to the Pacific salmon inhabiting the high seas and the ocean in the scattered state. For this reason, the strict limitation of Pacific salmon by SST and their attraction to the local productive zones and their fronts, which is traditionally accepted by most researchers, as well as the downstream migrations, required serious corrections. It has been shown that the dislocation, quantitative distribution, timing and general trends in seasonal migrations depend on the prominence of the landscape zones and the development of the phenological phenomena in the ocean and seas in general. Using the large amount of data, it has been shown that in most cases in sea and oceanic biotopes, the Pacific salmon food supply can be either good or satisfactory. The species that are characterized by foraging plasticity usually have an opportunity for selective feeding

and always (or almost always) in their hydrobiological environment there are large amounts of reserve forage species (copepods, chaetognaths, gelatinous species and small-sized nekton species).

The knowledge of the Pacific salmon mortality in the ocean, including that from mesopelagic predators, has been significantly broadened.

At the same time, the explanation of many issues of the marine ecology of Pacific salmon as well as the methodological aspects of their studies remain controversial, unclear and disputable. Among them, we should distinguish:

a) the insufficient accuracy of the Pacific salmon abundance estimates during marine surveys (in case of trawl surveys these are the problems related to the catching coefficients and the dynamics of the technical characteristics of the trawl at different trawling regimes;

b) the insufficient data on specific mortality rates in the sea, as well as the reasons causing it, for example, such as the navigational problems and unknown diseases, including viral diseases. The lack of information on the sea and ocean mortality rates, especially that of their interannual dynamics, has a negative effect on the forecasting of the anadromous fish returns, first of all, pink salmon because of its short life cycle;

c) the issues related to the evaluation of the carrying capacity of the oceanic pelagic layer for Pacific salmon and its dynamics between the years and at different ecosystem status still remain problematic. To a great extent, it is related to the imperfectness of the methods and techniques for the evaluation of the Pacific salmon forage base (zooplankton and small nekton, the biomasses of which are usually significantly underestimated, while the nutritive value and its dynamics remain understudied) and the insufficient knowledge of the regularities of the quantitative redistribution of macroplankton and small nekton across the trophic chains. The assessment of the carrying capacity on the basis of the indirect indicators (for example, the growth rate changes) for such purposes is not reliable. The more so, the interpretations, in which the ambitious but mechanical conclusions are made based on the simple similarities in food composition seem not very convincing for such

purposes: for example, the suppression of pink salmon by chum salmon or the dependence of the sockeye salmon abundance on walleye pollack;

d) the scientific information resources still lack the indicators and orienting points determining the time and characteristics of the anadromous migrations, including their wave-like character. The interpretations based on just one factor prevail in their explanation due to the development of the synoptical and hydrological situations, as well as unsubstantiated interpretations on the dominant dependence of the waves on the presence of the temporal groups.

5. Pacific salmon population structure and managed stocks

There are a lot of literature sources describing Pacific salmon population composition and structure. These references focus primarily upon genetic-phenotypic, morphological (including scale pattern analysis), ecological and parasitological parameters, as well as upon tagging data. Until mid-1990-ies, genetic research was most extensive and focused amongst other research approaches.

Comparison of results achieved through different methods has usually resulted in controversial perspective. Present day researchers are still struggling to achieve unified synthesis of different approaches. This is also due to the fact that particular emphasis was put upon single method (primarily, genetic method).

The positive results of population research are evident (particularly, within the area of species and stocks differentiation). However, it should be noted that major managed stocks are considered to be composed of sets of stocks from large geographical units and regions (western Kamchatka, Karagin-Olyutorsky region, continental coast of Okhotsk Sea, etc.). These major managed stocks were set as early as 1920-ies by first fisheries scientists in Far Eastern region. This testifies for the fact that many researchers of Pacific salmon stocks differentiation were unable to fully implement wide scope of methods and approaches to elucidate Pacific salmon population structure (composition, geographic extent, and hierarchy) in order to provide recommendations for better fisheries management. The difficulty of this objective is strengthened by hierarchical complexity of many stocks (populations

residing within seasonal races, seasonal races residing within populations, ecotypes residing within populations, populations residing within ecotypes, etc.). Due to dissociation of efforts no baseline genetic and morphological databases were established and validated for major stocks. The imperfection of contemporary conceptions of Pacific salmon population structure is further illustrated by differences in pink salmon population structure interpretations (ranging between panmictic superpopulations to local stocks) and different perception of so-called fluctuating stocks hypothesis. This is of particular importance for Russian salmon fisheries, which is dominated by pink salmon.

6. Abundance dynamics and forecasting magnitude and timing of Pacific salmon returns at different time scales (short-term to interannual)

Pacific salmon abundance dynamics is cyclic in its nature. This cyclicity ranges from two years to several decades. Long-term cyclicity, which is influenced by global factors (cosmophysical, geophysical and climate-oceanological) is better studied. Cyclicity at scale of several years, which is influenced by local (region-specific) factors, is not that well understood. The major problem is absence of sufficient understanding of mechanisms that contribute to production of certain cohort. This is particularly relevant to pink salmon 2-year cyclicity and changes in dominance of even- and odd-year generations. There are many references with controversial and ambiguous interpretations of this issue.

Datasets and interpretations on stock-specific dynamics lay down foundation for catches forecasts with different lead time. Lack of perception of mechanisms that drive abundance dynamics will impair quality of these forecasts. In practice, they are often insufficient in accuracy. Total catches for Russian Far East (summed up for entire Far Eastern region) are, usually, somewhat closer to forecasts. This is due to the fact of low catches for certain region/species being compensated by high catches for other region/species combination. In practice it happened all the time, particularly, in recent years. This may cause an illusion of higher accuracy of forecasts, as compared to reality. For instance, in 2005 coastal catches forecast was

238 th. tons and real catches amounted to 260 th. tons (only 9% difference). Low catches in northern regions - Primorye and Amur River region (26 th. tons below forecast) were compensated by high catches in Sakhalin region (51 th. tons above forecast). Again, it should be emphasized, that similar collisions in Pacific salmon fishery happen almost every year. Regarding the year of 2005, it should be noted that in-season changes in forecast resulted in additional quota totaling 82 th. tons (pink, chum, sockeye and coho salmon). Respectively, correct initial forecast for 2005 should have been 320 th. tons, instead of 238 th. tons (81 % of real catch in 2005).

Further progress in forecasts of Pacific salmon abundance dynamics and region-specific returns to Russian coast can be achieved through:

a) improvement of overall perception of Pacific salmon ecology during all ontogenetic stages. Wide array of poorly understood issues is described in sections above. These include abiotic and biotic factors that limit Pacific salmon abundance;

b) improvement of methods for estimating Pacific salmon abundance during freshwater and marine periods of life; utilization of all information available on Pacific salmon abundance during different periods of life cycle (including data from international surveys);

c) integrated utilization of entire array of methods and approaches available nowadays. Presently, similar to past, forecasts are based on escapement and juveniles downstream migration estimates, as well as on archival catch statistics. Results of high-seas observations and surveys are used, primarily, for in-season forecasts and, sometimes, to estimate TOC of pink salmon with its short lifecycle.

7. The artificial reproduction of Pacific salmon

As a result of the long-term studies and the practical implementation of the obtained results in the countries of the Asian-Pacific region, the Pacific salmon artificial reproduction has become large-scaled. The annual release of the juvenile Pacific salmon from the hatcheries is around 5 billion ind. In the Far East of Russia, there are 41 salmon hatcheries, out of which 0.6 billion ind. Of Pacific salmon are released (85 % in Sakhalin region). In accordance with some expert assessments, the

artificial reproduction of Pacific salmon in salmon hatcheries provides the catches of 25–30 th. tons. Therefore, the existing system of the artificial reproduction in the Far East of Russia, although it is done at small scale, shows positive results. The exceptions are Primorye and Khabarovsk regions, where the long-term activities of the Pacific salmon hatcheries have not yet brought any significant results.

The main problems of Pacific salmon artificial reproduction in the Far East of Russia are connected with the violation of the fisheries regulations (the spawners deficit), the non-perfect biological techniques for the reproduction, growing (including the enhancement of the size and age structure of the cultivated fish and the choice of the spawners) and the release of the viable juveniles (in this case, the fact of the region vastness is also important, including many of its places with harsh conditions), the insufficient development of many aspects related to the genetic divergence of the fish obtained as a result of the reproduction in the natural and artificial conditions, as well as the adaptive structure of the wild and cultivated stocks.

For the development of a prospective strategy of the Pacific salmon artificial reproduction, the issue of the relationship between the natural and artificial reproduction is very important. At present, only preliminary suggestions have been made about it, to be more precise, about the optimal possible contribution of the artificial reproduction. In accordance with one of them, they can be presented as follows: Sakhalin region – 60–80 %, Kamchatka – 5–8 %, Magadan region – 20–30 %, Primorye and Khabarovsk regions – 50–60 %. These ratios are not undisputable and require a confirmation with a due consideration of the long-term dynamics of the climate and the growing anthropogenic influence on the watersheds of the spawning rivers. The salmon hatchery in the river basin must become a guarantor of the escapement to the natural spawning grounds and their conservation. The ratio of the hatchery and wild Pacific salmon must be estimated annually based on the tagging data.

8. The studies of the sanitary and epidemiological status of the Pacific salmon stocks

The studies of the epizootic situation in the watersheds of the Far East allowed determining the most dangerous and especially dangerous species of bacteria, viruses and parasites that spoil the market condition of the fish and cause the mortality of both juvenile and adult fish. The survey of the world experience shows that in the case of epizootic diseases the fish mortality may comprise 10–50 % for the natural reproduction, and 40–100 % for the artificial reproduction. It is not improbable that such mortality rate is in principle possible for Pacific salmon. Therefore, it is quite realistic that the repeatedly observed cases of the so-called non-traditional mortality of Pacific salmon even in the high seas and oceanic waters can be related to the epizootic diseases

The monitoring of the Pacific salmon stocks status for infectious, parasitic and alimentary diseases is especially important for their artificial reproduction. The world experience of the artificial reproduction shows that the longer Pacific salmon hatchery operates, the more health problems of the cultivated fish are observed. Although at present in the Far East, the experience on monitoring of the health status of Pacific salmon has been accumulated, it is insufficient in case of the planned construction of large Pacific salmon hatcheries. It is necessary to broaden the viral, haematological, bacteriological, parasitological, histological and histochemical studies. It is important to develop the methods of instant analysis, which would allow to provide the conclusion on the fish health at short notice, as well as to enlarge the number of the studied watersheds and finally to build up their inventory (a growing database).

9. The studies of the Pacific salmon fisheries techniques

The main equipment and the fisheries techniques of Pacific salmon are well-known. For the research and application purposes, it is necessary to improve them. The main thing is to determine the proportions in the use of various equipment for each region (including its optimal number) and fisheries techniques. The most

effective ratio of the river, coastal and oceanic fisheries has not been completely proved. Further observations, experiments and analysis are needed. The biological feasibility and economic efficiency must serve as a criterion for the choice of different strategies.

10. The studies of the effect of marine mammals' predation upon Pacific salmon in the pre-estuary and estuary areas

The previous researches allowed obtaining the approximate data on the Pacific salmon consumption by seals and white whales during the anadromous migration to the coastal areas. Taking into consideration all the main Pacific salmon areas, the Pacific salmon loss can be counted by dozens of thousands tons, as a minimum. However, such calculations were mainly made using the limited field observations data and the local observations were extrapolated into the vast water territories.

It is possible to increase the Pacific salmon catches by limiting the abundance of the predators. However, this issue requires the specific calculations and justification of the ecosystem-based optimal ratio of predators and preys. It is also necessary to obtain differentiated data for various areas.

11. The international collaboration

In terms of the studies of Pacific salmon ecology and their habitat areas, NPAFC and PICES are the most significant among the international organizations. The bilateral collaboration between Russia and Japan has a more local significance. The collaboration within the framework of the international organizations significantly increases the potential of the scientific community, which has a positive effect on the intensity of the information exchange, as well as the exploration degree of many issues of the Pacific salmon biology, especially during the marine period of life cycle.

The differences in the methods, techniques and approaches in both field and laboratory conditions create a hindrance to amore effective work and collaboration of the participating countries (Russia, USA, Canada, Japan and Korea). The four-year

experience of the works of the BASIS program demonstrated it with all obviousness. The improvement of the collaboration is possible only in case of the adjustment and corrections of the research programs of the participating countries.

* * *

As it is seen from the above, the exploration degree of the biology of Pacific salmon in Russia is satisfactory as a result of the long-term studies. Partly because of the implementation of the recommendations of the fisheries scientists on the rational use of the Pacific salmon resources, their stocks in the Russian region are generally quite significant. At the same time it is obvious that the exploration degree of Pacific salmon remains insufficient for the effective management of their resources, the significant improvement of the escapement and the catch rates forecasting and, all the more, for the creation of a large Pacific salmon hatchery in the Far East. Noteworthy, some aspects and features of the Pacific salmon ecology are still based on the unproved postulates made in the 1920–1950-ies, i.e. at the initial stages of their research.

The progress in the above-mentioned fundamental problems is quite realistic on the condition of:

- the preservation of the positive experience and the continuation of the accumulation of the observations time series at all stages of the Pacific salmon life cycle – freshwater, estuarine and marine–oceanic;
- the use of the available long-term datasets on the Pacific salmon biology for the retrospective assessment of the long-term dynamics of stocks abundance and structure as well as the critical analysis and the search of the regularities in the biological processes and phenomena in accordance with the modern scientific ideas of population biology, biocenology and biological productivity;
- the undeveloped or insignificantly studied issues and problems, which are listed in the previous section of this document, will be taken into consideration during the research projects planning and implementation.

3. MATERIALS AND METHODS

Because this is a general strategic plan of the research program, it does not contain any detailed descriptions of the methods. All the necessary details will be included in the technical assignments of the annual thematic plans, voyage and expedition plans, and the subprograms on the specific problems of the general program (on population genetics, thermal tagging, sanitary and epidemiological observations). Moreover, the methods and substantiation of the expensive marine research of Pacific salmon are presented in a special manual approved by Federal Fisheries Agency of the Russian Federation (FFA) “Methodical recommendations on the implementation of fisheries resources marine surveys of Pacific salmon” (2004) and a recently published book “Planning, organization and maintenance of the studies of the fisheries resources in the Far Eastern seas of Russia and the northwestern part of the Pacific Ocean” (2005). Therefore, only some general issues of the methodological approaches in further studies are emphasized here:

a) the positive experience of the previous periods of the studies must not be neglected;

b) the long-term studies (not only in Russia but in other countries as well) show that the locally collected materials, especially those collected in small amounts, usually give a distorted picture. The similarly unrealistic results are obtained with the extrapolation of the local results (for example, for one river or one small marine range) to the vast regions and water territories;

c) as it was before, the methods of observations and data collection differ very much. It refers to the different research institutes in Russia (including the research institutes of Scientific Production Association TINRO) and other countries. For example, for the collection of plankton samples, the plankton nets with different catchability are used, the time of data collection during the day, the sampled water strata and the techniques of biomass assessment differ. As a result, the assessments of the food resources of Pacific salmon can multifoldly differ;

d) the insufficient integrity of the methodical approaches in the studies and forecasting of Pacific salmon requires “correction”. For example, in the studies of the population structure and organization of Pacific salmon, the absolute priority is given to the genetic data, while in the forecasting of the returns and catches – to the biological data obtained during the freshwater period of life cycle. The one-sidedness of the approaches manifests itself also in the accepted priority of the unifactor relationships in the ecology of Pacific salmon, for example, in the absolutization of the surface water temperature, the competitive pair-wise relations, e.g. chum salmon—pink salmon, etc.;

e) the assessment works in the freshwater require a serious improvement and correction in order to obtain the optimal variants. This refers also to the aerial assessment of the spawners (the visual observations must be combined with the assessments by use of digital and video equipment), the instrumental assessments of the spawners entering the rivers (by use of multibeam sonars) and the juveniles migrating downstream, for example, by use of screw traps and other kinds of floating traps;

f) due to the necessity to use the new approaches in the genetic monitoring, in particular, microsatellite loci, the additional equipment for the population and genetic studies will be necessary (for example, the instruments for DNA-analysis – amplifiers, scanners for gel-documentation with software, chambers for DNA-electrophoresis and other equipment and materials);

g) due to the vastness of the marine habitat areas of Pacific salmon, it is quite unrealistic to carry out the observations of the whole area of their distribution at any season of the year because of the expensiveness of the expeditions. Therefore, it is important to carry out the stocks monitoring and assessment on large study territories. It is necessary that data on Pacific salmon and their oceanological and hydrobiological environment were demonstrative, i.e. that it would give the maximally possible and reliable information for proper conclusions. At present, there is certain clarity about the number and borders of the study territories for the

integrated ecosystem assessments of Pacific salmon in the upper epipelagic layer and for the studies with the use of drift nets:

- in the Okhotsk Sea, the reliable data on the total abundance of the juvenile Pacific salmon from the northern stocks (including those from Kamchatka) are obtained as a result of the trawl surveys that are carried out by KamchatNIRO in the Kamchatka study territory (westward from Kamchatka to 1450 east longitude) in September-October. The juvenile individuals of the whole complex of the Pacific salmon stocks from the Okhotsk Sea, as well as the cultivated juvenile chum salmon from Japan, are included in the observations in the study territory of TINRO-Center, which covers all southern deep-water basin of the Okhotsk Sea southward from 530 north latitude;

- in the Bering Sea, the relatively total assessment of the juvenile Pacific salmon is carried out during the assessment surveys in September-October on the study territory covering the deep-water Commander Basin and the oceanic waters near the Commander Islands. During the years of the implementation of BASIS program, the expeditions of TINRO-Center extended that study territory northward to the deepwater part of the Olyutorsky-Navarin region (the northern part of the Aleutian Basin);

- as it was shown by the winter-spring expeditions of TINRO-Center in 1986–1991, the assessment results of the trawl surveys reached the level of the Asian stocks of pink salmon in their winter habitat areas – in the zone of the Subarctic Front (between 40 and 480 north latitude, eastward to 1760 west longitude). Due to the more northern winter habitat area of sockeye salmon, the winter study territory must be extended northward to the pre-Aleutian waters. The winter expeditions do not have a priority in terms of their significance. Their implementation requires the use of the powerful vessels, and the area of the study territory comprises several million square kilometers. At present, it is hardly possible that such expeditions can be carried out regularly. However, if the relevant NPAFC program for 2006–2010 is accepted, the large-scale monitoring of Pacific salmon during the wintering period from a few vessels of an international expedition is a realistic task;

- during the anadromous migrations of Pacific salmon, the complete information on the abundance and structure of the Pacific salmon stocks from the Okhotsk Sea is obtained during the trawl large-scale surveys in June-July in the 300-mile zone of the oceanic waters near the Kuril Islands. The similar information for the Pacific salmon stocks from Western Kamchatka and the western part of the Bering Sea is obtained during the same months in the Commander Basin with the adjacent oceanic waters near the Commander Islands and the waters of the deepwater basin of the Olyutorsky-Navarin region;

- in the Japan Sea, it has never been possible to conduct the regular integrated trawl surveys of Pacific salmon due to their generally low abundance. However, such surveys could become an integrated part of the monitoring in the Far East, if they are carried out simultaneously with other surveys of the subtropical fish (Pacific saury, Japanese anchovy, Pacific mackerel, Far-Eastern sardine) and squids: summer – in June—July, autumn – in the second half of September – the first half of November;

- the surveys carried out in May-September from the drift vessels give valuable information for the real time predictions of the anadromous returns of Pacific salmon to the specific areas of the Russian coast. The main thing is that in case the sufficient observations time series are available, it is possible to make conclusions on the dynamics of the pre-anadromous migrations and the returns rate of the spawners to the coasts every year, based on the catches rates by using the analogous year.

A big experience and the relatively continuous observations time series have been accumulated since the early 1990-ies from the drift vessels in the open waters near the Kuril Islands and western Kamchatka. The quantitative relation of the net catches rates to the returns rate of Pacific salmon has been confirmed. The best results are obtained for the forecasting of the rates and timing of the returns of Pacific salmon to Kamchatka and Sakhalin region. For other regions, the database of the observations from the drift vessels is insufficient. In addition to the above-mentioned main “drift net” study territories (the waters near the Kuril Islands and Kamchatka), it

is helpful to organize observations on the local study territories in the northern part of the Japan Sea, the northwestern part of the Okhotsk Sea (in the zone of the returns of Pink and chum salmon to the rivers of Khabarovsk region and the northeastern coast of the Sakhalin Island) and the northeastern part of the Okhotsk Sea (in the zone of the returns of Pink and chum salmon to the rivers of Magadan region). In addition to this, it would be practical to use the long-term observations data of the scientific research fleet of Japan, which carries out the standard cross-sections in the Bering Sea and the Pacific Ocean;

- during the previous periods in the observations from the drift vessels, the nets with a net mesh of the commercial fisheries size were usually used, to which the research nets with various mesh size were added. In case of the extension of such studies in the coastal areas, it is better to use the short line of nets.

In terms of priority, the most important are the trawl surveys of the autumn juvenile Pacific salmon on the study territories of the Okhotsk and Bering seas, the anadromous Pacific salmon in the first half of summer in the northwestern part of the Pacific Ocean and the western part of the Bering Sea, and the drift vessel surveys – in summer in the northwestern part of the Pacific Ocean and the western part of the Bering Sea and also locally in the Okhotsk Sea and the Japan Sea. Without annual fulfillment of such surveys, it is difficult or even impossible to expect the progress in the forecasting of the Pacific salmon return rates and the TOC assessment.

4. MAIN TRENDS AND TASKS IN THE STUDIES OF PACIFIC SALMON DURING THE NEXT FIVE-YEAR PERIOD

Like in the previous periods, the scientific approaches and content of the studies of the freshwater, estuarine and marine (oceanic) periods of the life cycle of Pacific salmon during the next five-year period will differ in many ways. On the one hand, at each of these stages, the continuity of the methodological approaches as related to the previous long-term period should be preserved, on the other hand, the corrections of these methods should be made, which would be up to date with the modern knowledge of the biology of Pacific salmon and the variety of the new methods.

A. The escapement of Pacific salmon to the spawning grounds and the freshwater period of their life cycle

Like it was done before, for each region of the Far East, it is necessary to continue the surveys of the spawners arriving to the spawning grounds, the accumulation of the database on their size and population sex structure and other biological indicators, the escapement to the spawning grounds, the assessment of the conditions of embryogenesis and winter mortality, and in the spring-summer period — the assessment of the juveniles' catadromous migrations to the coastal zone. The juvenile Pacific salmon that live in the freshwater for over one year should become a research object at the standard monitoring sites that, for example, successfully function in Kamchatka for a long time. The data on the escapement to the spawning grounds and reproduction should be used for the forecasting and assessment of the status of the regional stocks, as it was done before.

In order to improve the understanding of the biology of Pacific salmon during the freshwater period of life cycle, it is also necessary to make the following additions and corrections to the studies:

- it is necessary to develop the schemes of the reproductive areas of the habitat territories with the ranking of the watersheds by their significance in the formation of the abundance of Pacific salmon. For this purpose, the new information

and the retrospective analysis of data of the commercial fisheries potential of the specific rivers as well as their contribution to the reproduction of the regional stocks in each region can be used. Based on the results of this analysis, it is useful to determine the list of the model rivers, in which the changes in the abundance of Pacific salmon correspond to the main trends in the species abundance dynamics in the specific commercial fisheries areas;

- the assessment of the modern status of the spawning grounds and the spawning stocks of Pacific salmon in general in each region should accompany this research;

- based on the ranking and assessment of the spawning rivers for each region, the schemes for the real time operation of the commercial fisheries should be developed in accordance with the principles of the multispecies fisheries, i.e. it is necessary to distinguish and rationalize the main fishery species, their TOC should be used as a basis for the regulation of the commercial fisheries during the anadromous migrations of Pacific salmon.

- In the next five-year period, it is necessary to create the detailed genetic and morphological databases that would cover all main reproduction areas of Pacific salmon. The complex structure of many Pacific salmon stocks should be taken into consideration. This requirement is important because the individual samples in the river estuary or sites represent either a random set of various intraspecific groups or, on the opposite, only a small part of the system with a complex structure. The difficulty of this task is especially evident in case of the species with the most extended reproductive areas, i.e. pink and chum salmons.

Many issues regarding the stability of the typical differentiating features in the specific reproductive areas of Pacific salmon still remain unclear, especially from the long-term or intraannual perspective. These issues should be explored by means of the regular collection of the proper and comparable data on the regional study areas.

When planning and organizing the sample collection for DNA analysis, it is necessary at this stage to take into consideration that microsatellite loci provide most of the information for the population and genetic analyses.

The clearly defined proposals on the optimization of the commercial fisheries, including the considerations of the preservation of the genetic diversity, should become a necessary and practical result of the studies on the population structure of Pacific salmon;

- The continuation and development of the research on the enhancement of the success of the artificial reproduction of Pacific salmon falls on the freshwater (and partly others as well) stage of ontogenesis. In addition to the specific tasks related to the technology of the aquaculture of Pacific salmon, the research on the mass otolith marking of the juvenile Pacific salmon, as well as the detailed development of the issues related to the determination of the optimal ratio of the wild and cultivated stocks in all the regions require a special attention.

B. The estuarine period of life cycle of Pacific salmon

At this stage, it is recommended to conduct the studies on the model regional study territories because of the huge geographic extent of the coastline in the Far East and the continuous downstream migration of the juvenile Pacific salmon as well as the continuous ladder-like dispersal of the juveniles into the offshore areas. Such study territories should be distinguished not only in the areas of the mass reproduction of wild Pacific salmon, but also in the regions of the large-scale artificial reproduction. The studies at the standard survey locations can help to clarify, at least, three important issues:

- on the hard limitations of the abundance of the juveniles migrating downstream by the forage base. In principle, all the existing assessments of the biomass and abundance in the coastal zone cannot be considered acceptable because of the imperfectness of the sampling methods. Therefore, the issue of the carrying capacity of the coastal waters for the juvenile Pacific salmon remains unclear without a proper field observations database. For the areas of the massive release of the artificially reproduced juvenile Pacific salmon, it is necessary to get a clear understanding of the phenology of the spring processes in the plankton communities, especially as regards the interannual dynamics;

- on the consumption rate of the juveniles of Pacific salmon migrating downstream by various predators. It is known that sometimes such consumption can be significant. However, it is not clear to what degree it affects the formation of the abundance of different generations. In addition to the direct decrease in the abundance, the consumption can also play some positive role through the selection of the juveniles of the best quality. The proper data on the abundance of the predators are necessary in order to deal with these issues. All the existing methods for its assessment cannot be considered reliable;

- in the areas of the large-scale natural and artificial reproduction of Pacific salmon, the survival and formation of different adaptation mechanisms in the juvenile Pacific salmon of different origin deserve the additional observations and comparative analysis during the adaptation to the marine environment.

C. The marine and oceanic periods of life cycle of Pacific salmon

The active studies of the marine period of life cycle of Pacific salmon during the last two decades contributed to the decrease of the number of the postulates that were used for decades for the explanation of many features (sometimes of mystic character) of the marine ecology of Pacific salmon. The large-scale non-selective trawl surveys of the abundance (often total abundance) of Pacific salmon from young-of-the-year to adult individuals, which were conducted by TINRO-Center, contributed to the progress in this area. They were accompanied by the integrated oceanological observations (not only those of the surface temperature), the assessments of the density and abundance of macroplankton, as well as the mass trophological sample collections. (In such case, a large amount of data on feeding of Pacific salmon and the surrounding nekton was used). The studies of the distribution of the main stocks of Pacific salmon as well as the structure of the migrating groups of Pacific salmon in North Pacific and the Far Eastern seas also showed the significant positive results.

A number of techniques of real-time, in-season and medium-term forecasts (of the dynamics and timing of the escapement of Pacific salmon to the coastal zone) has been developed by means of trawl and drift vessel surveys.

During the further marine research on Pacific salmon during the next five-year period (it is important that it overlaps in time with the NPAFC international research program, as a result of which it will be possible to get the comparable real-time data from the more eastern water areas) it is necessary and realistic to get the positive results in the following areas of research:

- the improvement of the quality of the reliability of the real-time forecasts during the fishing seasons of Pacific salmon and the medium-term TOC forecasts. The progress in forecasting is possible as a result of the accumulation of new data on the ecology of Pacific salmon, the improvement of the methods of the total abundance assessment of Pacific salmon and their nekton environment and the use of the whole complex of data (including the background data – hydrological and hydrobiological) on the freshwater and marine periods of the life cycle of Pacific salmon for the forecasts. In such case, for the TOC substantiation, the data series (drift and trawl surveys) not only on young-of-the-year (as it is done for pink salmon) but on the juveniles at the age of .1 year and over (other species of Pacific salmon) should be used;

- the assessment of the carrying capacity of the epipelagic layer of North Pacific for Pacific salmon and its temporal dynamics. At present, although the new vast information on the high production potential of the Subarctic waters, the generally sufficient forage base of Pacific salmon, the high intensity of their feeding during the foraging period of life cycle and the noticeable discrepancy in the trophic relations of different species, the perception of the exhausted carrying capacity in relation to the higher natural reproduction and the large-scale artificial reproduction of Pacific salmon is still dominant. The accumulation of the additional quantitative information on the structure, productivity and dynamics of the plankton and nekton communities, the improvement of the survey-based methods of the total estimates of the aquatic species abundance and biomass, the extension of the trophological studies to the entire foraging part of the habitat areas of Pacific salmon (the international expeditions connected with NPAFC will contribute to it), the extension of the studies

on the biochemical composition of the forage species will contribute to the progress in the research on this problem.

The trend mentioned here has one more large-scale aspect, i.e. the place and role of Pacific salmon in the pelagic ecosystems of the Far Eastern seas and North Pacific. This trend is successfully developing and the progress is quite realistic during the next five-year period;

- the continuous accumulation of the information and the validation of the effect of the limiting factors on the quantitative distribution of Pacific salmon during the foraging period of life cycle and the patterns of the anadromous and catadromous migrations. Despite the fact that the studies of this issue have a long history, the unifactor interpretations are still in practice, for example, those based on the influence of the SST, the plankton biomass (often not the macroplankton that is the food of Pacific salmon but the small- and medium-sized plankton is considered,), etc. For such studies, the complexity should be an essential part, which would provide the assessment of the total influence of different environmental factors on Pacific salmon, and the survey of the status of such ecological and ecogeographical categories as biotope and landscape;

- the continuous accumulation of the information and the quantitative validation of the marine mortality rates (as opposed to survival) of Pacific salmon. The significant abundance decrease of Pacific salmon in the open waters is an indisputable fact. However, the contribution of the different factors to the total mortality has not been fully and sufficiently validated. Moreover, the mortality rate and the contribution of the different factors change in different years and periods. As regards the proved and approximately assessed factors, for example, various predator species, it is necessary to extend the field observations database for different regions, seasons and ecological situations. At the same time, there is a need for the search for the new ways of the assessment of the mortality of Pacific salmon from the diseases and various parasites. It is necessary to organize the centralized data collections, the systematization of the data on the different types of injuries, disease symptoms and parasitic infections on the bodies of Pacific salmon, and the transfer of this

information to the regional database. This information could be used for different purposes, including the international exchange and the total picture across the whole northern part of the Pacific Ocean.

Although no reliable evidence is available, but because of the existing remarks on the hunger death or dystrophy of Pacific salmon, it is necessary to continue the studies of the influence of the food availability on it (including the food quality). It is important to decide, at which initial ratio of the abundance of Pacific salmon (and their needs) and their hydrobiological environment (the forage base and the abundance of predators) the density factor starts to work and when it starts to harshly limit their important biological characteristics, the vital activity and mortality (for example, a strong decrease of the growth rate and other indicators).

The so-called non-traditional causes of mortality still remain unclear, among them the loss of the navigational abilities by Pacific salmon. In this connection, the systematization of the cases of mass mortality from unknown reasons (even with the diagnosis “the fish drowned” and the accumulation of new data are necessary;

- during the development of the coastal database on the differentiating characteristics of the important and most important stocks of Pacific salmon and their forms, as well as the extension of the scale of the tagging (including the otolith marking), it is possible to enhance the research on the differentiation of the regional and temporal groups in the foraging areas and along the pathways of the long-distance anadromous and catadromous migrations in the Far Eastern seas and North Pacific. In such studies during the different seasons of the year, the emphasis should be made on the marine dislocation of the stocks and its changeability in different years and in different environmental situations, as well as on the identification of the structure of the anadromous and catadromous pathways. The latter seems to be very important in connection with the widely spread ideas of the wave-like patterns of the regional and temporal groups' migrations. The stocks differentiation based on the otolith analysis has one more important, i.e. international, aspect. In the salmon hatcheries in Japan, the thermal marking is used at a large scale, and in Russia – at a limited scale. Therefore, the proportion of chum salmon in the collected samples can

be underestimated, for which reason an impression of a higher, as compared with the real one, proportion of chum salmon from Japan in the Russian waters can be formed;

- the elucidation for the vertical distribution patterns, diurnal and seasonal vertical migrations of Pacific salmon. Pacific salmon mainly inhabit the upper 30-50-m water layer. At the same time, the fact of their regular dives to a depth of up to 100-200 m, and chinook salmon – to 450 m has been reliably proved. It is important to determine the scale of such migrations, their regional and seasonal variability, as well as their role in the feeding of Pacific salmon and to what degree their forage base is extended as well as their forage resources in this connection;

- the changes in the physiological condition are observed in the seasonal cycle of all Pacific salmon species, which is expressed in the dominant influence of the exogenous and endogenous processes. In particular, in autumn-winter period, a significant increase of the growth rate of Pacific salmon, especially among juveniles, occurred while the feeding intensity remained relatively high. At present, the interpretations of these processes differ very much: a) due to the lack of winter plankton (enforced fasting, which is hardly probable), b) in connection with the physiological changes in the organism.

5. ANTICIPATED RESULTS

Currently, significant number of fisheries researchers is studying Pacific salmon (primarily within framework of Scientific Production Association “TINRO”). Some Pacific salmon research (beyond fisheries forecasting) is also being done by academics and Universities. Large-scale international cooperation in Asian-Pacific Region along the NPAFC, PICES and bilateral agreements is directed towards better understanding of biology and improved stocks management of Pacific salmon.

Undoubtedly, the overall understanding of Pacific salmon biology and how they should be managed will improve as the research projects for 2006-2010, outlined in sections above, become implemented. Basically, Pacific salmon research on problems outlined above will be achieved through:

- sufficient financial and logistical support of research activities during all life stages of Pacific salmon (freshwater, including aquaculture, estuarine and marine). High-seas research is the most costly due expensive surveys needed to cover broad areas of sea. However, as the final production and returns magnitude are determined by high-seas period of life, this costly research is needed;
- growth in fisheries specialists' personal qualification and commitment;
- critical and unprejudiced analysis of preceding fishery season (both for successful and unsuccessful forecasts);
- clarification and even revision (based upon new research data) of obsolete postulates and conceptions from autecological or outdated research. For example, could be: predominance of unifactor relationships (SST, gradient zones and counterflow influence), homing overstatement, pairwise interspecific competition (pink—chum, pink—sockeye, sockeye—walleye pollack, direct influence of abundance upon body size and migration timing, rigid spatio-temporal migration patterns for particular stocks and seasonal races, impairment of spawning grounds by excessive numbers of spawners, etc.

* * *

During the 5 year process of strategic plan implementation and afterwards the following publications and improvements are expected be achieved:

- the established practice providing of TOC forecasts with different lead time (real-time, quarterly, in-season, annual and long-term forecasts) will be continued. The results of integrated research on issues outlined in this strategic plan (particularly, regarding methodological improvements and establishment of new research directions) will enable to improve quality and reliability of different types of forecasts;
- approaches to improve in-season forecasts precision will be prepared for every major commercial fishery area. This is of particular importance due to fast-paced nature of Pacific salmon fisheries and due to present difficulties to change TOC through the centralized federal system. Fisheries losses during recent years should be utilized while developing these approaches;

- catalogues on region-specific spawning grounds should be prepared for publication. These catalogues should reflect contemporary status of spawning grounds, and retrospective analysis should be provided as well in case if information is available. These catalogues should rank water bodies and spawning grounds based upon importance for Pacific salmon reproduction. As the poaching shows rapid growth nowadays, the areas of critical or vanishing habitat (regarding both natural and artificial reproduction) should be outlined;

- following parameters of spawning grounds should be given region-specific retrospective quantitative analysis and contemporary estimates:

- a) the confirmation of the validity of the model rivers data, which in the modern practice are interpolated to the vast regions. In the same context, using the available observations time series and catch statistics, the ranking of the main spawning watersheds will be done in each region;

- b) the parameters of the optimal and critical levels of the escapement to the spawning grounds should be clarified for each region using the available survey data and catch statistics. At present, as it was before, the volitive interpretations of it prevail. The results of these conclusions should be presented in the publications;

- the updating of the optimal ratio of the natural and artificial reproduction of Pacific salmon for each region should be validated using the additional data. Such validation should include the proposals on the dislocation of the new salmon hatcheries. It is necessary that the new studies on these issues were presented in the open publications. The studies on the improvement of the techniques of Pacific salmon artificial reproduction with consideration of the regional physical and geographical conditions should be also conducted;

- a database of genetic, scale and morphological data on all the main spawning watersheds of Pacific salmon in the Russian Far East should be created. For the vast river and lake systems, the database should reflect a complex organization of the intraspecific species. The development of the database should be accompanied by the studies on the identification of the degree of the temporal stability of differentiating parameters and the development of the proposals on the methodical

optimization of sampling with consideration of their conformity to the groups reproducing in a local area. The existing practice of collecting the individual, often random, samples from the vast regions and, moreover, the identification of the mixed marine samples based on it should be rejected. One of the results of the activities on the creation of the coastal database and the studies with the database itself should be the clarification of the borders of the commercial fisheries regions or the dislocation of the managed stocks. In the modern practice, despite the long-term studies, forecasting is mainly conducted based on the physical and geographical regions that were outlined in the first decades of the 20-th century;

- the preparation and publication of the major conclusion on the results of the activities of the international program BASIS (2002-2006) on Pacific salmon of the Bering Sea and adjacent Pacific waters of Aleutian Islands. In this publication, not only the new data on the marine ecology of Pacific salmon, the stocks differentiation and status should be presented, but also the experience and approaches used for the studies of Pacific salmon by the specialists from different countries and research institutions. The positive experience of the research integration during the period of the program BASIS should be extended to the international expeditions within the framework of NPAFC in 2006-2010, which will be extended beyond “the BASIS zone” to the entire North Pacific. The next stage of the international studies of Pacific salmon in the ocean should also find a reflection in the general summary of the studies presented in a major monograph by a collective of authors;

the continuation of the integrated studies on the marine and oceanic ecology of Pacific salmon during the period of the implementation of this program would allow to significantly extend the existing database on Pacific salmon, which even now is quite large. It includes various data on both Pacific salmon and their oceanological and hydrobiological (plankton and nekton, including competitors and predators) environment. Based on the existing and new information, the fundamental publications “Differentiation and dislocation of Pacific salmon stocks in the Far Eastern seas and North Pacific”, “Pacific salmon in the ecosystems of the Far Eastern seas and North Pacific”, “Feeding and trophic relationships of Pacific salmon in the

Far Eastern seas and North Pacific” will be prepared for publication and published. In the last two publications, the place and role of Pacific salmon in the ecosystems will be shown and discussed, the quantitative substantiation of the limiting abiotic and biotic factors and the mortality rate (as opposed to survival) with consideration of the interannual and long-term dynamics will be given, the quantitative parameters of the carrying capacity of the pelagic biotopes and ecosystems for Pacific salmon will be substantiated with consideration of the regional and long-term peculiarities. The quantitative information on all these and other issues can be used for building of various ecological and management (as applied to biocenoses and biological resources) mathematical models.

6. THE PARTICIPATING PARTIES

Traditionally, the studies of the freshwater and estuarine periods of the life cycle of Pacific salmon within the borders of the administrative regions will be conducted by the subdivisions of the research institutes of Scientific Production Association “TINRO”: TINRO-Center – Primorye region, its Khabarovsk division – Khabarovsk region, Chukotka division – Chukotka autonomous district, MagadanNIRO – the mainland coastal zone of Magadan region, KamchatNIRO – Kamchatka region and Koryak autonomous district, SakhNIRO – Sakhalin region. Traditionally, VNIRO conducts the research work on the northern and middle Kuril Islands areas. In all the mentioned subdivisions there are significant research staff sources for the successful studies on this program. To a certain extent, this potential should be extended by attracting the University students for internship activities (first of all, Dalrybvtuz and the Far Eastern State University). The collaboration with the Rybvod subdivisions gives more reserves for the enhancement of the efficiency of the Pacific salmon research in the areas of natural reproduction.

The marine and oceanic periods of the life cycle of Pacific salmon are most intensively and successfully studied by TINRO-Center and KamchatNIRO. At a smaller scale such studies are conducted by SakhNIRO and VNIRO and to a lesser

degree — by MagadanNIRO and Chukotka division of TINRO-Center. In the north-western part of the Okhotsk Sea and in Tatar Strait, Khabarovsk division of TINRO-Center can start such studies at a local scale. The implementation of the research programs within the framework of NPAFC and the bilateral international fisheries agreements can have a certain potential for the enhancement of the efficiency of the marine and oceanic studies.

The existing research staff potential of the fisheries science is sufficient for the majority of the sections of this program. There is a lack of the skilled professionals for the instrumental methods for both aerial and terrestrial surveys. A similar situation is observed as regards the specialists for the thermal marking of juvenile Pacific salmon. In all these cases, it is necessary to create special research teams.

The population and genetic studies do not have enough specialists. It is useful to invite the specialists of RAS (Russian Academy of Sciences) for such purposes, in particular, the Institute of Genetics and the Institute of Marine Biology (FEB RAS).

7. REPORTING OF THE RESULTS

Taking into consideration that the goals and tasks of the strategic plan will be reflected in the theme plans of the institutes and divisions of the research institutes of Scientific Production Association “TINRO” and VNIRO, the provision is made for the commonly accepted annual presentation of the quarterly and annual information reports.

Based on the results of the complex expeditions and the research fisheries surveys, a detailed study report should be presented within a month time period, in which the results of the studies in all the areas of research are presented in detail.

At the annual reporting sessions of both the individual institutes and all the research institutes of Scientific Production Association “TINRO”, the scientific reports on different issues and problems of the ecology of Pacific salmon and the status of their stocks are presented.

The progress of the research plans should be presented annually at the Regional Council on Pacific salmon, during which the corrections are made and the research plan for the next year is discussed and accepted.

As far as some sections of this strategic plan and the program NPAFC Science Plan for 2006-2010 are very much alike, the results and plans of the research are discussed at the annual meetings and workshops of this international organization.

After the duration of the above-mentioned project is over, a consolidated report is prepared, in which the results of the research work for the whole five-year period are presented in detail and the new proposals on the improvement of the management system of the commercial fisheries and resources of Pacific salmon are formulated.

All data and results that are worthy of attention are presented in the open publications.

8. LOGISTIC SUPPORT AND RESOURCES PROVISION OF THE STUDIES

The modern studies of Pacific salmon are traditionally very extensive and expensive. The scale of surveys, the themes and logistic support in the process of the realization of this strategic plan should grow even more, if, dictated by the present demands, the goal is to achieve the planned scientific and applied results. However, Pacific salmon is worthy of it due to its value and significance as an object of mass practical use. Besides, much more than any other aquatic animals, they can become the attractive objects of a large-scale salmon hatcheries in the Far East of Russia. This attractiveness, in addition to other well-known arguments, is explained by their wide geographical distribution – from Chukotka to the south Kuril Islands and Peter the Great Bay. However, at the same time, this peculiarity of the habitat area of Pacific salmon, i.e. its geographic vastness, is the reason of the high costs of their integrated research. One should think of the large distances, the vast territories and, even more, the vast water territories (the European standards are of little value in this case), as well as the need of the regular monitoring and the systematic study of Pacific salmon

at all the stages of their life cycle – from freshwater to oceanic, with the obligatory use of airplanes, marine and oceanic vessels, including the medium- and large-tonnage ones.

Since the early 1990-ies, due to the objective reasons, the federal center did not have the necessary financial resources to conduct the annual studies of Pacific salmon. It was compensated by the research quotas on Pacific salmon that were given in order to ensure both the inshore and high seas research. This approach helped to extend the long-term observations time series and to accumulate a certain experience of collaboration with the fisheries organizations on the use of those fisheries quotas simultaneously with scientific research plans and tasks.

Based on the experience of the recent years and the new research tasks determined in this strategic plan, the regional research subdivisions of the research institutes of Scientific Production Association “TINRO” and VNIRO presented the approximate catch volumes of Pacific salmon in the process of the research activities in 2006. Summing up those volumes, we come to the conclusion that in order to ensure the research activities, the following fisheries quotas allocations are needed: KamchatNIRO - 15504.5 tons, SakhNIRO – 5067.4 tons, VNIRO – 2768.0 tons, Khabarovsk division of TINRO-Center – 2297.5 tons, TINRO-Center – 1584.6 tons, Chukotka division of TINRO-Center – 1448.0 tons and MagadanNIRO – 1151.0 tons of Pacific salmon. Out of these quota volumes, for the inland and coastal studies following quota volumes are required: KamchatNIRO – 13006.5 tons, SakhNIRO – 3062.4 tons, VNIRO – 1033.0 tons, Khabarovsk division of TINRO-Center – 1947.5 tons, TINRO-Center – 112.0 tons, Chukotka division of TINRO-Center – 1048.0 tons, MagadanNIRO – 701.0 tons, and for the marine and oceanic studies: KamchatNIRO – 2498.0 tons, SakhNIRO – 2005.0 tons, VNIRO – 1735.0 tons, Khabarovsk division of TINRO-Center – 350.0 tons, TINRO-Center – 1382.6 tons, Chukotka division of TINRO-Center – 400.0 tons and MagadanNIRO – 450.0 tons of Pacific salmon.

In future, if it will not be possible to ensure funding for Pacific salmon research in a regular way, their catch volumes should be adjusted depending on the research

plan for a specific year. However, it should be emphasized in advance that the fisheries research of Pacific salmon in any organizational form is impossible principally without the significant catch volumes, not speaking about total expenses. It is especially true in case of the data collection for forecasting, total assessment of abundance at different stages of life cycle, high seas research of stock-specific distributions and seasonal migrations, high seas tagging and research on trophology and carrying capacity. However, the annual commercial fisheries catch of 220-270 thousand tons of this valuable fish species that are a national treasure of Russia, as well as the development of the recommendations on the enhancement of a large-scale Pacific salmon fishery in the Russian Far East, are worthy of it.