NPAFC
Doc. 1231
Rev.
Rev. Date:

Russian Pacific Salmon Research Program for 2010-2014 Period

by

V.P Shuntov

Pacific Research Fisheries Center (TINRO-center), 4, Shevchenko Alley, Vladivostok, 690950, Russia

Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

Russia

May 2010

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Shuntov V.P. 2010. Russian Pacific Salmon Research Program for 2010-2014 Period. NPAFC Doc. 1231. 15 pp. (Available at http://www.npafc.org).

In the preceding period, 2006-2010, Pacific salmon studies were conducted under the "Far Eastern Basin Program on Studies of Pacific Salmon for 2007-2012" (Doc. NPAFC 1122).

Results from these studies were published in the Bulletins of the realization of "The Far Eastern Basin Program on Pacific salmon Studies" (Bulletin… 2006, 2007, 2008, 2009).

In this Program (2010-2014), the continuity of approaches and research directions of the above-mentioned documents has been retained.

1. Reproductive range and state of spawning pool

Though stock abundance and stock dynamics of Pacific salmon can be influenced at different stages of the fish life (from freshwater to marine), it is initially formed in areas where reproduction takes place, i.e. on spawning grounds in rivers and lakes.

Reproductive range of Pacific salmon in Russia is extended, and includes thousands of rivers and lakes scattered over vast areas from Chukotka down to south Kuril Islands and Peter the Great Bay. Regular and reliable assessments of salmon spawning pool in the Russian Far Eastern area and of how effective are different spawning grounds (including the number of spawners coming upstream to the spawning ground) over greater part of the entire range could be obtained only using aerial surveys. The need to continue and even expand observations on the salmon spawning pool is nowadays quite evident, given that, beginning from 2009, salmon fishery is regulated on the real-time basis using information about the abundance of spawners on the spawning grounds.

Along with assessments of various spawning grounds and entire spawning pool for fishery management purposes, it is necessary to continue studies on ranking (major, important, minor) of different water bodies where salmon spawning takes place according to their reproduction input. This research field has much in common with studies on optimal filling of spawning grounds and ecological capacity of low-productive salmon rivers for farmed juvenile fish.

The above-mentioned themes and directions for Pacific salmon spawning pool research and monitoring imply that aerial observations covering vast areas should be coupled with studies in selected reference regions. The former studies will end up in classifications of spawning grounds and generate baseline for spawning pool using GIS-technologies with mapping of salmon distribution and spawning grounds, distant evaluation of river conditions and neighboring landscapes.

Intensive studies of anthropogenic, climate and other impacts on the spawning pool should be conducted within reference areas. Paired areas with initially similar natural backgrounds (one is control area with natural hydrographic features and the other is cultured area) should be selected. The following issues should be covered by these studies: evaluation of the amount and dynamics of annual discharge, assessment of water property, bottom sediments, flora and fauna; estimation of salmon populations and the effectiveness of their reproduction.

2. Assessment of natural reproduction efficiency

Data on natural reproduction efficiency of salmon are important for assessment of generation strength, and therefore, for forecasting trends in salmon abundance. Traditionally, these studies include assessments of spawners' abundance and intensity of spawning, conditions for and the course of embryogenesis, calculation of number of smolts, and, for species with long freshwater life, also estimation of forage conditions in freshwater habitats.

In all salmon areas, assessments of spawners and smolts abundance are conducted in basic rivers. However, the number of such rivers is more or less sufficient only in several areas. The number of controllable rivers should be increased in the greater part of salmon reproductive range (Kamchatka, northeast Asia, continental coast of the Okhotsk Sea, northeast Sakhalin, Primorye). Another aspect of this problem is also important. So far, there were no reliable data supporting appropriateness of expanding assessments of smolt abundance, obtained in basic rivers, into vast fishery areas, where salmon stocks are considered units of management and forecasting. However, long-term observations in a number of rivers along with regional fishery statistics make it possible to estimate the reliability of coefficients that are used to overcome this issue of data extension. There are also many problems associated with techniques for smolt counting, especially in big rivers.

Traditional observations over dynamics of hydrological conditions, forage base, food competitors and predators should be continued in respect of those species, which juveniles forage in freshwater habitat, especially, for more than a year. These studies are particularly important for water bodies where reproduction of sockeye takes place, and for the Amur River system.

Timeliness of studies on natural reproduction efficiency increases nowadays due climate change, especially in the northernmost and southernmost parts of geographic ranges.

Numerous attempts were made to relate rises and drops in salmon abundance with different indices describing dynamics of natural processes (atmospheric circulation, climate-hydrological regime, solar activity, etc.). Recently, great attention has been given to global greenhouse warming and discrepancy between modern high salmon abundance and carrying capacity of marine and oceanic ecosystems.

However, correlations between salmon abundance and various factors are more or less evident only in restricted periods. The real pattern is much more complicated, and is governed by numerous factors. It is, therefore, necessary to refine the existing approaches of salmon abundance assessment, and to increase theoretical studies of waves in salmon numbers.

3. Estuarine and coastal life of salmon juveniles

Estuarine and coastal stage is critical for survival of salmon juveniles. During this period, the abundance of generation that will migrate offshore to forage in the open sea is formed.

Counting total number of salmon smolts migrating from the streams to the coastal zone is extremely difficult, because the coast of the Far Eastern seas is long, duration of downstream migrations is extended, and distribution of juveniles along the coast and ocean-ward is “conveyor belt”. That is why estuarine and coastal life studies of salmon juveniles should be concentrated in several selected reference areas, which are typical for major large regions. Suchlike studies have already been done successfully in the following regions: Amur liman with adjacent parts of Sakhalin Bay, Aniva and Terpeniya bays, Taui cove, coastal southwest Kamchatka, and Kamchatskyi and Karaginskyi bays.

Major objective for studies within standard areas are: assessment of impact of different factors limiting the number of salmon juveniles during the period of fish adaptation to marine environment. Such factors are: condition and dynamics of forage base, food competitors, predators, and dynamics of meteorological and hydrological conditions. Technogenic (anthropogenic) factors (in particular, those related to oil and gas exploration) will be more and more important along with natural factors in some regions.

In the coastal zone, methods of data collection (including gear type) are less developed with respect to both salmon and hydrobiological surroundings.

4. Salmon ecology during marine and oceanic life

This phase of salmon ontogenesis is the longest even in a short life-history pink salmon. The longevity of marine life and vast forage areas of salmon mean that extensive field studies should be performed in order to study salmon ecology during this life period. However, the experience of multi-purpose salmon trawl surveys aimed at forecasting salmon abundance indicate that quantitative assessments obtained during anadromous and catadromous migrations and during wintering provide reliable basis for prediction of approaches of spawners to Far Eastern coastal regions.

Data on juvenile and immature salmon abundance indicate generation strength at least one year ahead, and estimated numbers of adult fish migrating toward the shore allow making quick decisions before and during fishery.

Combination of nekton, plankton, trophologic and hydrologic surveys makes it possible to obtain information about forage and wintering conditions of salmon and their nektonic surrounding (predators, competitors, forage nekton). Having long-term observations at hand, such information proved to be quite useful for evaluation annual and long-term dynamics of carrying capacity of the pelagic zone in respect of salmon, and for assessing state of their stocks.

Methods, time and place of multi-purpose marine and oceanic surveys, as well as catch gear and techniques for sampling (salmon, other nekton and zooplankton) have been basically developed already. The use of express-methods of data treatment allows processing and organizing information at sea, so that basic quick assessments can be made during surveys.

Major reference areas for estimation of juvenile salmon abundance

1. Deep-water part of the Okhotsk Sea (Figure 1). In October – early November, pink and chum salmon yearlings from the Okhotsk Sea, Kuril and Japanese stocks regularly gather in this region in large quantities.

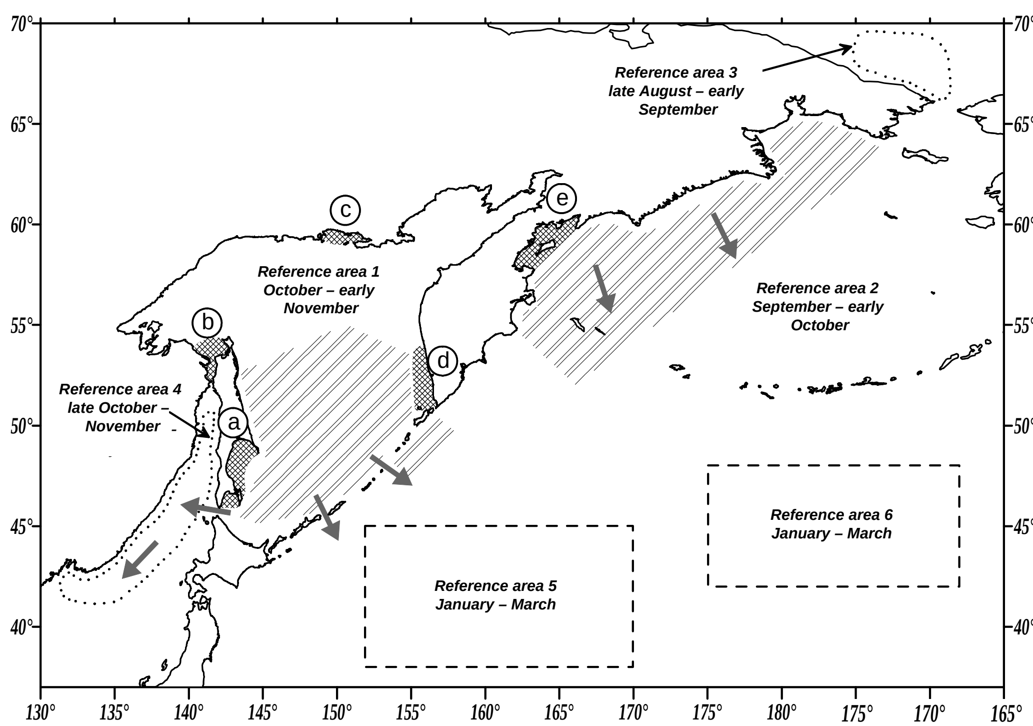

Figure 1. Reference regions for multi-purpose surveys during estuarine-coastal and marine periods of life of juvenile Pacific salmon: а-д – estuarine-coastal reference areas; 1-2 – major reference areas for assessment of juvenile salmon numbers in autumn; 3-4 – additional reference areas for assessment of juvenile salmon numbers in autumn; 5-6 – reference areas for studies of wintering conditions for salmon in the Pacific Ocean. Arrows show general salmon migrations to wintering areas.

2. Waters off southwest Kamchatka and around Kuril Islands (Figure 1). In September and October, the majority of post-catadromous juvenile sockeye, coho and chinook salmon migrate out of the sea into the ocean through this region.

3. Deep-water regions of the western Bering Sea (Commander and Aleutian basins). Of particular importance is the northern Bering Sea areas, in particular, Anadyr Gulf, where juvenile salmon appear after downstream migrations from Anadyr River and rivers of Chukotka Peninsula (Figure 1). In September – early October, assessments of the total number of post-catadromous juveniles from the rivers flowing into the western Bering Sea and from Kamchatka River can be made within this reference region. Annual early-autumn assessments of salmon are important, because great numbers of large juvenile chum and sockeye, which have already spent one and more years at sea, are also found within this reference region.

Northern deep-water part of the Japan/East Sea within the Russian EEZ (Figure 1). Post-catadromous pink, masu and chum salmon juveniles migrate through this region in November. Pink salmon is highly abundant here in some years. Migrations of chum yearlings to wintering places into the southern parts of the sea have never been traced here. The Japan Sea is of lesser importance for Russian salmon fishery; therefore, annual salmon assessment surveys are not obligatory within this reference region.

5. Winter total assessment of salmon juveniles across vast North Pacific areas can be made only during large-scale international expeditions from several research vessels. Occasional Russian expeditions can be conducted into the Subarctic frontal zone and adjacent waters to the north and south of the zone (reference regions 5 and 6, Figure 1) with the aim to control juvenile salmon survival during winter.

Reliable information on the number and biological condition of salmon during their anadromous migrations can be obtained from the following multi-purpose surveys (Figure 2).

1. In Kuril waters of the Northwestern Pacific Ocean, 300-350 miles away from Kuril passes in June – early July. It possible to estimate all pink salmon of the Okhotsk Sea stocks. Extending station grid further along the east Kamchatka coast will enable to assess the abundance of sockeye salmon from west Kamchatka spawning grounds.

2. In July – early August, it is possible to distinguish fish, which have entered the Okhotsk Sea, basing on the deep-sea survey in the area between Sakhalin, southwest Kamchatka and Kuril Islands.

3. West Bering Sea and east Kamchatka stocks are relatively well covered by the survey during the second half of June through July, along with the above mentioned autumn survey aimed at assessment of post-catadromous juveniles (in Russian waters of the Bering Sea and oceanic waters off Commander Islands). Summer survey provides reliable information about both anadromous fish, and large juvenile salmon, which have already spent one or more years at sea and are entering the Bering Sea in large quantities to forage. These young fish are from the Bering Sea and other stocks.

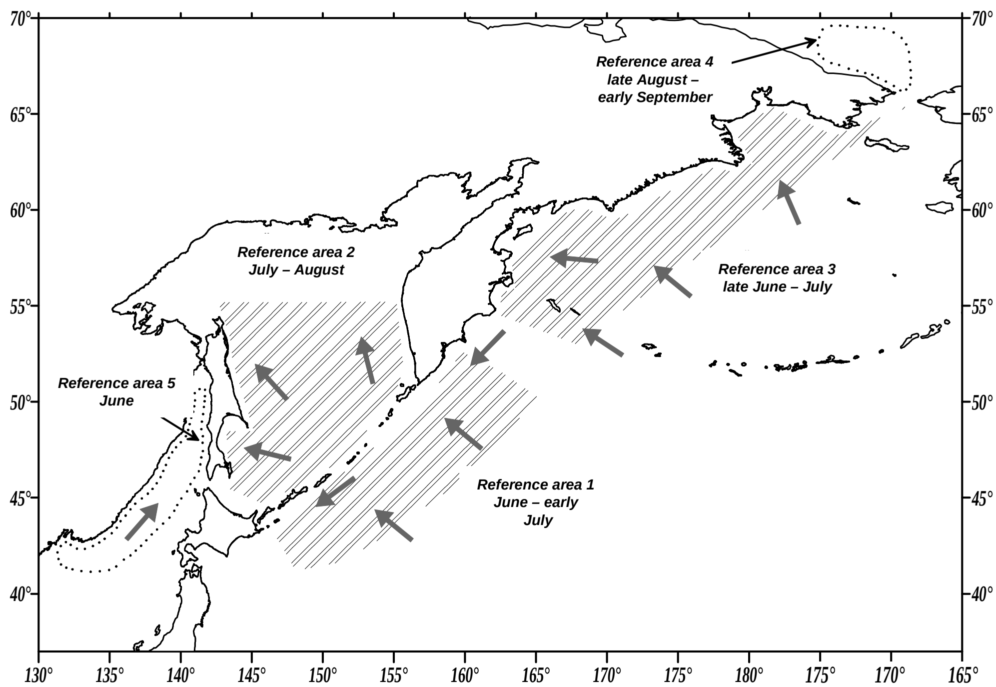

Figure 2. Reference regions for multi-purpose surveys of anadromous migrations of Pacific salmon: 1-3 – major reference areas for assessment of the number of spawners migrating towards spawning grounds; 4-5 – additional reference areas. Arrows show general salmon migrations to spawning areas.

4. The above mentioned three summer macro-surveys cover major routes of anadromous migrations of Russian salmon stocks towards major fishery areas. Annual basis for these surveys should be considered as an obligatory requirement for providing scientific background for salmon fishery management. Similar multi-purpose surveys can

be conducted on a less regular basis, i.e. not every year, in another two regions within the Russian EEZ: in the south (northern Japan Sea) and north (southern Chukchi Sea). It is important to make such surveys, because insufficient data exists on the composition and relative abundance of foraging salmon stocks in the Japan Sea, and due to recent enhancement of salmon reproduction in northern parts of their ranges.

Usefulness and even necessity to conduct large-scale monitoring during marine and oceanic life of salmon is associated not only with applied objectives of these studies with respect to salmon. Except salmon, these observations also enable to gather valuable information about distribution and abundance of the entire upper epipelagic nekton (pelagic fish and squid, early ontogenetic stages of bottom fish) and plankton. These studies keep track of annual dynamics and structural rearrangements in pelagic communities, where salmon are only one of numerous components. When these studies are conducted together with large-scale trophologic investigations, reliable information is collected about feeding relationships of salmon in fish communities and on how predators influence salmon abundance. By counting the number of bitten fish it is also possible to decide upon the strength of predatory pressure. Numerous data have been collected and registry schemes for injuries caused by marine mammals, fish and cyclostomes, and ectoparasites. Suchlike studies are conducted during fishery in coastal areas and rivers. It is therefore possible to compare damage rates from predators in off-shore and coastal areas.

Regular studies on plankton communities and pelagic fish forage base should be accompanied by analyses of isotopes, calorie content and biochemical composition of major groups of prey organisms. In the long run, such an approach will provide a complex control over changes in regional, seasonal and age parameters of forage base.

5. Population structure and stock units of salmonid fish

Reliable knowledge about spatial and biological structure of salmon stocks provides better stock management, and is also necessary for increasing effectiveness of fish aquaculture.

Recently developed techniques have increased our ability to gain better results in this field. Experience to date and long sequence of observations make it possible to use traditional morphologic and ecologic approaches along with otolith markers more effectively and widely. However, new opportunities appeared with the development of advanced methodologies in population genetic studies, in particular, those dealing with various sources of variation in DNA: microsatellites, single nucleotide polymorphism (SNP) and mitochondrial DNA haplotypes. In order to achieve genetic stock identification objectives it is necessary to collect systematically genetic material from numerous spawning grounds, update previous extensive genetic database and compile the database for DNA variation, primarily, for microsatellites and SNP.

It is, therefore, very important to organize international annual cooperative exchange of samples for genetic and hard structure (otoliths, scales) analyses, which should be used in population studies of salmon within their species ranges.

Long-term monitoring of genetic processes in salmon populations will also favor our efforts to maintain the existing level of natural biological variability. Population structure analysis (using genetic and otolith markers) of cultured and wild salmon stocks in major water-bodies where salmon hatcheries are deployed will ultimately lead to the development of optimal proportions between farmed and wild-born salmon juveniles.

6. Dynamics in abundance and short- and long-term forecasts of salmon number and time of approach

This group of regular and traditional salmon studies includes at least three major issues: a) fundamental development of the problem of fluctuations in salmon abundance and underpinning factors; b) long-term forecasting of salmon approach to spawning grounds and catch; c) quick corrections in approach forecasts just before the onset of fishery operations and during fishery.

Traditional studies, which relate generation abundance with single biotic and abiotic factors during reproduction period, should be corroborated by ecosystem approach operating with combined influence of numerous environmental factors. Long-term forecasts of salmon approach (number of spawners, number of smolts, assessment of mortality in estuaries) should be accompanied by data on the observed numbers of post-catadromous juveniles migrating into the sea and large young fish, which have already spent one or more years at sea (Figure 1).

Likewise, short-term forecasting should utilize both assessments of salmon runs and corresponding structure of commercial catches, and also abundance of anadromous fish migrating towards fishery regions (Figure 2). Methods of total assessments of young salmon and spawners are well-developed and based on multi-purpose trawl surveys.

7. Artificial reproduction of salmon

Today, there are 53 salmon hatcheries (SH) in the Russian Far East. These fish farms produce up to 0.75 billion juvenile salmon, primarily pink and chum, which are released for further foraging in the wild. Views on significance and prospective of salmon farming both worldwide and in Russia are controversial and even alternative. Among the arguments against increasing the number of SH are genetic and ecological considerations. The former include gene pool weakening (decrease in genetic variability) and related negative impact on wild populations. The latter are associated with high abundance of farmed salmon, which are presumably too numerous for the existing carrying capacity of Subarctic pelagic zone. It increases food competition with corresponding negative consequences (decrease in quality of spawners, increased mortality, disturbance of population and pelagic community functioning).

Genetic aspects are certainly important, and this field of research should be further developed (see below). However, issues associated with low food availability for foraging salmon are not supported by facts. Long-term TINRO-Centre studies on marine and oceanic pelagic communities (in particular, total assessments of forage base for nekton, and the amount of zooplankton and small nekton taken as food by nektonic species) suggest that food abundance does not limit seriously salmon number during marine foraging, even in recent years, when salmon abundance is very high. It implies that future development of SH network in Russia should not be associated with carrying capacity of pelagic zone in Far Eastern seas and North Pacific. More important are other considerations, such as spawning pool state, climate-oceanographic and socio-economic factors, and the necessity of improving fish farming process.

Taking into account the above-mentioned considerations, it is necessary to develop management plans, which will include such items as reasonable number, deployments and power of SH and particular salmon species for farming in every administrative and physical geographic region.

Major difficulties of salmon farming are associated with obtaining viable progeny. These are issues of updating biotechnology of fish rearing and growing, which should take into consideration physical geographic regional environmental conditions and species-specific adaptations, and how they work during ontogenesis, which, in the long run, should provide high survival of progeny. International and Russian experience has been gained on the above-mentioned issues. Therefore, in future, the following studies should be continued and expanded:

- development of recommendations on optimization of technology for increasing juvenile survival, and approaches towards intensive technologies for growing young salmon;
- assessment and comparative analysis of quantitative (biological and physiological) features of juveniles released from SH and juveniles from wild populations of major rivers for development of recommendations for increasing farmed juvenile quality;
- development of regional standards for biological quality of juveniles with respect to control SH;
- adjustments of regional temporary biotechnological reproductive standards of one- and two-year growing for different species of salmon and for particular SH;
- development of scientific basis for express organization and running of farmed salmon stocks, including application of identification techniques using genetic approach and thermal marking at each SH;
- development of effective compound food stuff, food additives and means of feeding;
- genetic monitoring of farmed populations; these studies are important, because during long-term management of fish population on a SH changes in genotypes occur,

which lead to a decrease in immune resistance of farmed fish and during their marine life they become more susceptible to diseases than wild fish, and may transfer pathogenic infection to spawning areas during anadromous migrations;

- development of methods for maintenance and control over transfer of super-hazardous pathogens from wild fish to SH juveniles.

8. Studies on sanitary and epidemiologic conditions in salmon populations

Sanitary and epidemiologic studies should be conducted during both marine and freshwater life of salmon, and include fish from wild and farmed populations. Modern high abundance of Pacific salmon in major salmon regions favors negative sanitary and epidemiologic conditions in wild and farmed populations of these fish. It is therefore necessary to expand studies of viruses, bacteria and parasites, as well as hematological, histological and histochemical techniques. Of particular importance are methods of rapid diagnosis, which are able to make quick conclusion about fish health, increase the number of surveyed water bodies and, in the long run, produce databases on parasites, viruses, bacteria and hematology.

9. Studies on salmon predation by marine mammals in river mouths and adjacent areas

Today, it is a well-known fact that predators influence salmon abundance in coastal and off-shore areas. Offshore, salmon losses are primarily due to predatory fish and cyclostomes. Though predatory pressure of marine mammals on salmon is strong, there are no reliable regional estimates of such losses, not to speak about annual changes in these assessments. Therefore, estimations of losses due to predators should be made in all major salmon regions. These activities are important for applied purposes and ecosystem studies.

Predators are a factor of natural selection, because they consume first of all less viable individuals. Quantitative calculations of predatory pressure are also necessary for our understanding of optimal proportions between prey and predator under various circumstances. That is why control over marine mammals' numbers should be considered as one of the elements of biological resource management.

11. Development of scientific basis for recreational fishery in Pacific salmon habitats

Nowadays, recreational fishery management in the Russian Far East is rather weakly developed, which is associated with weak development and vastness of the regional territory.

Submission of scientifically based proposals for developing and expanding of recreational fishery in the region is impossible without knowledge about abundance of recreational resources, their cadastre (certification), ecological potential (recreational capacity) and assessment of impact of such an activity on aquatic resources and their habitats. Eventually, certain recommendations on optimal exploitation regime of recreational resources in each region should be prepared.

Expected outcomes

1. New information on the state and abundance of salmon stocks in the entire Russian Far Eastern region and its sub-regions added to the existing database would constitute major scientific and practical outcome from traditional large-scale monitoring of salmon during their freshwater, estuarine and marine life; short- and long-term forecasting for fishery harvest and conditions will be based on that information.
2. State of knowledge on Pacific salmon spawning pool in the entire Russian Far Eastern region and its sub-regions, along with modern and historical patterns of salmon distribution across their reproductive range will be updated. Data on abundance and biological structure of salmon stocks obtained during traditional monitoring of anadromous migrations, analysis of fishery catches, data on abundance of spawners on the spawning grounds, information about environmental conditions for embryogenesis and smoltification will be also obtained.

3. Results from studies of juvenile salmon adaptations to marine environment in coastal and estuarine reference areas. Quantitative assessments of salmon mortality and different factors, which limit juvenile salmon mortality.
4. Results of traditional annual total estimates of salmon abundance in open waters of the Russian Far Eastern seas and northwestern Pacific Ocean using data from standard trawl surveys of post-catadromous juveniles, young fish which have spent one or more years at sea, and adult fish as the basis for our conclusions about abundance of salmon generations and salmon numbers approaching spawning grounds in major Russian coastal fishery regions.
5. Expansion of database on marine salmon ecology, including quantitative information on structure and dynamics of "salmon population" in different regions, similar information about surrounding nekton and plankton communities, trophic relationships, amount of food consumed by salmon and other nekton – these are major parameters to address for estimation of carrying capacity of Subarctic pelagic zone for salmon, in particular for their foraging in the wild.
6. Development and submission of Far Eastern regional and sub-regional plans for Pacific salmon farming with suggestion of new SH number and schemes of their deployment, the number of released juveniles and species composition for each SH, reasonable proportions between wild and hatchery fish in each particular region. New proposals will be made on modification of technology for salmon breeding, in particular, for chum and pink, which have already been widely used in hatchery farming. Biological techniques and standards will be developed for hatchery farming of masu, coho, sockeye and Chinook salmon.
7. The following existing databases will be significantly updated, in particular, those constructed using genetic, scale and morphologic characters for major salmon groupings, which will improve our knowledge on population structure and allow designation of stock units for management. These databases will also provide necessary information for identification of fish from mixed stocks and for long-term monitoring of dynamics in genetic and phonetic features from wild and hatchery salmon stocks.

8. Regular assessment and presentation of results on estimation of sanitary and epidemiologic state of salmon stocks and their environment, first of all, in regions with increased industrial influence on ecosystems of salmon water bodies. Accumulation of data and experience on salmon health during their marine life.
9. Definition of regions with high concentration of piscivorous marine mammals in areas adjacent to mouths of salmon rivers. Quantitative information about influence of predatory mammals on salmon numbers and about frequency of salmon injuries from mammals. Proposals on regulation of number of predators in local areas, in particular, close to places where catch gears are deployed.
10. First results on preparation of cadastre (certification) of regional water bodies, suitable for recreational fishery for salmon. Preliminary data on recreational capacity of water bodies and recommendations how to use them in an optimal regime.
11. Preparation of proposals to optimize inter-relationships between fishery science and fishery and controlling organizations in order to increase effectiveness of collecting scientific-fishery information about freshwater and marine life of salmon, and improvement mechanisms of regulation of fishery pressure on various stocks and other intra-specific groupings.

References

Shuntov V.P.. 2008. Strategic plan for Far Eastern basin-scale Pacific salmon research program for 2006–2010 period. NPAFC Doc. 1122. 51 pp. Pacific Scientific Research Fisheries Center (TINRO-center). (Available at http://www.npafc.org).

Bulletin №1 of realization of "The Far Eastern Basin Program on Pacific salmon Studies" /Edited by V.P. Shuntov. TINRO-CENTER Publ., Vladivostok., 2006. 318 p. (In Russian).

Bulletin №2 of realization of the "The Far Eastern Basin Program on Pacific salmon Studies" /Edited by V.P. Shuntov. TINRO-CENTER Publ., Vladivostok., 2007. 297 p. (In Russian).

Bulletin №3 of realization of the "The Far Eastern Basin Program on Pacific salmon Studies" /Edited by V.P. Shuntov. TINRO-CENTER Publ., Vladivostok., 2008. 256 p. (In Russian).

Bulletin №4 of realization of "The Far Eastern Basin Program on Pacific salmon Studies" /Edited by V.P. Shuntov. TINRO-CENTER Publ., Vladivostok., 2009. 278 p. (In Russian).