The Problem of Pacific Salmon Stock Identification during the Marine Period of Life (Results and Prospects)

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The problem of stock identification of Pacific salmon caught on the high seas was important from the very outset of fishing at sea. However, the priorities for the problem have varied considerably through time. Initially, during the period of large – scale high seas fishing, the stocks of salmon needed to be identified in order to establish the scientific basis for further diplomatic, legal, or enforcement efforts. In recent years, with the drastic reduction in high seas fisheries, the need to track the origin of the salmon taken from some specific regions of the ocean was dictated primarily by ecological considerations.

At present the task of studying the population structure is being accomplished by applying several sets of techniques: morphological, genetic, parasitological, and marking or tagging. A collation of the potentials of these methods, even in most general terms, shows that the identification of local fish populations is not simple enough to entrust to any of the above sets of methods alone if we are to obtain an unambiguous solution. This makes it extremely important to compare and give an unbiased interpretation to the results of studies made using various techniques.

The technique of tagging stands out from all methods used because it ensures unambiguous results which do not need interpretation. That is why the results of tagging can be reasonably used as a kind of reference point or null hypothesis in interpreting the results obtained by other methods. It is appropriate to remember that the problems of population structure have been successfully resolved in ornithology where ring tagging was applied for a long period time.

Let us consider the results of tagging made between 1956 and 2000 (Gritsenko 2002). Both the abundance of salmon and their sea habitat conditions have varied widely throughout that period. That is why the pattern of distribution of individual stocks obtained has a generalized format. For the most part it shows the range of adult Pacific salmon during their spring and summer feeding and the pre-spawning migrations. Given below are the essentials of the spatial interaction among the Asian and American stocks.

In spring and summer a great number of the Asian pink salmon is found west of 180°. However, a considerable portion of is still east of 180°. The major concentrations of the Asian pink salmon in May–July occur on the high seas; an important part of them is found in the U.S. zone, north and south of the Aleutians, and in the Central Bering Sea. The bulk of American pink salmon stay east of 160°W. For the most part, it is the pink salmon of the north-western coast of Alaska.

Consequently, the feeding ranges of the Asian and American stocks of pink salmon overlap in a small area limited by 170°W and 180° because of the wider distribution range of the Asian pink salmon.

The Asian coast chum salmon is more frequent in the North Pacific than the other salmon species. It feeds in the Pacific waters off the Aleutians within the U.S. zone, the high seas area of the Bering Sea, the U.S. EEZ north-east of the eastern boundary of the Central Bering Sea, and the high seas areas in the Pacific Ocean north of 40–41°N. Besides, large amounts of the Japanese chum salmon migrate between June and October north to south within the Russian EEZ. Most of the American chum salmon stay within the zones of the USA and Canada or the high seas area of the Gulf of Alaska. The feeding ranges of the Asian and American chum salmon overlap mostly inside the U.S. zone off the Aleutians; east of the donut hole in the Bering Sea; and insignificantly in the Gulf of Alaska.

The Asian and American sockeye salmon stay together in a vast territory between 168°E and 175°W. However, less than 1% of the total number of fish of the Asian and American stocks feed in this far-reaching region. It should be pointed out that their ranges coincide mostly on the high seas and in the U.S. zone.

One important feature of distribution of coho salmon at sea is its relative proximity to the continents which is probably related to the shortness of its marine period of life. The overlapping zone of the Asian and North American stocks of coho salmon is located between 167°E and 172°W where there is not more than 32% of the

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Asian and 1.54% of the North American stocks. The North American coho salmon remain far away from the Russian EEZ whereas small quantities of the Asian coho salmon occur in the U.S. zone south of the Aleutians, while most of it stick to the high seas areas of the Pacific.

Unlike the other species of salmon, the American stocks of chinook are distributed across a relatively small area of the ocean. The inshore stocks of chinook in the Gulf of Alaska, off British Columbia and the state of Washington cling to shores near Washington and Oregon, as well as the Alaskan Peninsula and the Aleutians. One exception is the chinook off the Bering Sea coast of Alaska which is widely distributed throughout the Bering Sea. We have heard of individual cases of it entering the EEZ of Russia (off Koryak hills) in July.

Of all the salmon near the American coast the steelhead has the longest westwardly range. Unlike the other species, the concentration density in the steelhead salmon does not decrease along with the increasing distance from the American continent. Its range is attached to the North Pacific drift and is located over its main branch.

According to S.A. Kovalenko et al. (2003), some individual steelhead marked by removal of fins occur in the Russian EEZ around the Kuril Islands.

Consequently, the tagging data indicate that the American chum and pink salmon are actually not observed within the EEZ of Russia. It is the sockeye and chinook of the American stocks that feed in small numbers in the northeast of the western Bering Sea within the Russian EEZ during summer and autumn. On the whole, it is mostly the eastern part of the common range that the regions of distribution of the Asian and American stocks overlap. Hence, the fish belonging to most of the Asian salmon stocks inhabit in winter and spring the high seas area of the Pacific Ocean and the U.S. zone.

The data on the migratory routes and their length obtained from tagging appear to be most useful for making hypotheses regarding the potential presence of some or other representatives of local populations in catches. Such judgments make it possible to use a far smaller number of parameters employed in the statistical procedures of the maximum likelihood method and to avoid errors in conclusions on the composition of mixed concentrations obtained by analyzing the morphological or genetic data (Wood et al. 1987).

The choice of methods is dictated by the task set. In some cases simple express-methods are enough. For example, differentiation between the Russian and Japanese chum in the Kamchatkan waters of the Pacific and the Bering Sea could well be made using the technique of counting the sclerites on the fish scale in the summer growth zone of the first year of life at sea (Klovach and Zavarina 2001). The differences detected in the biological characteristics of individual stocks of pink salmon during the same spawning season are usually applied to subdividing the migrating groups both into large sets of stocks, e.g. northern and southern stocks in the Sea of Okhotsk (Temnykh 1996) and smaller stocks, e.g. West Kamchatka and East Sakhalin stocks of pink (Shubin and Kovalenko 2000). The length, weight, number, as well as the shape of spots on the tail, GSI, sex ratio, etc. were used as indicators. Analysis of the age structure of the migrating concentration is sufficient to differentiate between sockeye stocks on a specifically local level (West Kamchatka and North Kuril Islands sockeye) since among the West Kamchatka approach there are virtually no fish which had lived in fresh water for less than two years, while such individuals make up over 80% in the North Kuril Islands sockeye stock (Gritsenko 2000). Seeking and application of simple and cheap methods remains currently central since the situations as mentioned above can emerge in various areas of the ocean, and in various species.

Conversely, not only express methods, or complicated scale structure analysis techniques, but also the complex and expensive genetic method of isoterment analysis turned out to be of little use in dealing with the global challenge of distinguishing between the Asian and American sockeye.

In that respect we lay great hopes on the method of polymerase chain reaction using random primers or random amplified polymorphic DNA (RAPD), i.e. amplification of polymorphic DNA. It is exactly this technique that has often been used in recent years for DNA fingerprinting (Welsh and McClelland 1990; Williams et al. 1990).

The major objective in developing a molecular-genetic identification scheme is to establish a reference collection of DNA samples. In 2003 we began to set up such a collection for sockeye and Chinook since these species are the most debatable.

REFERENCES

Gritsenko, O.F. (Editor). 2000. Aquatic living resources of the North Kuril Islands. Moscow, VNIRO 163 pp.

Gritsenko, O.F. (Editor). 2002. Atlas of distribution of various Pacific salmon stocks at sea during spring - summer feeding and pre-spawning migrations. Moscow, VNIRO 190 pp.

Klovach, N.V., and L.O. Zavarina. 2001. Express method for differentating stocks of chum *Oncorhynchus keta* at sea. Vol. World Ocean. Moscow, VINITI. Issue 2. pp. 175–181.

Kovalenko, S.A., A.O. Shubin, L.D. Khorevin, V.A. Rudnev, E.V. Tarasyuk, V.M. Chupakhin, I.M. Ivanova, Yu. I. Ignatyev, and I.A. Nemchinova. 2003. Distribution and structure of *Parasalmo mykiss* grouping in the near-

Kuril waters of the Pacific Ocean and Okhotsk Sea. (NPAFC Doc. 667.) 19p. Sakhalin research Institute of Fisheries and Oceanography 196, Komsomolskaya St., Yuzhno-Sakhalinsk, 693023, Russia.

Shubin, A.O., and S.A. Kovalenko. 2000. Temporal structure of the Okhotsk Sea pink salmon *Oncorhynchus gorbuscha* at sea, and its pre-spawning migration routes. Vopr. Ikhtiologii 40, issue 5: 648–654.

Temnykh, O.S. 1996. Ecology and spatial differentiation of the Asian pink salmon during anadromous migrations. Izv. TINRO 119: 55–71. (In Russian)

Welsh, J., and M. McClelland. 1990. Fingerprinting genomes using PCR with arbitrary primers. Nucleic Acids Res. 18: 7213–7218.

Williams, J.G.K., A.R. Kubelik, K.J. Livak, J.A. Rafalski, S.V. Tingey. 1990. DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. Nucleic Acids Res. 18: 6531–6535.

Wood, C.C., S. McKinnell, T.J. Mulligan, and D.A. Fournier. 1987. Stock identification with the maximum-likelihood mixture model: sensitivity analysis and application to complex problems. Can. J. Fish. Aquat. Sci. 44: 866–881.