Use of Otolith Marking for Evaluation of Hatchery Output Efficiency

Elena Akinicheva and **Alexander Rogatnykh**
MagadanNIRO
51, Nagaevskaya St., Magadan 685024, Russia

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This report presents information on the status of otolith marking at Russian fish hatcheries. We also use the results of otolith-mark identification of hatchery fish to evaluate the effectiveness of fish farming in the Magadan Region.

The method of marking salmon otoliths with subsequent identification of marked fish in mixed-stock catches is not new, and is successfully used in salmon hatcheries in Canada and the United States. Mass marking of salmon otoliths has been conducted in Magadan since 1994. In recent years, salmon hatcheries in Kamchatka and Sakhalin began to conduct large-scale marking based upon our recommendations.

The first years of method introduction were used to adapt otolith marking to the operational conditions of Russian salmon hatcheries and to search for methods to increase the number of possible marks and their information content. The dry method of marking otoliths, which was recently invented, allowed us to a great extent to avoid the problem of a short marking "window." As a result, we can use either thermal- or dry-marking methods or both to produce otolith marks. The increase in the number of possible types and content of marks allows us to arrange the marking processes for all hatcheries to avoid mark duplications. This provides an opportunity to recognize salmon from different reproduction areas (Kamchatka, Sakhalin, Magadan) and hatcheries among salmon stocks.

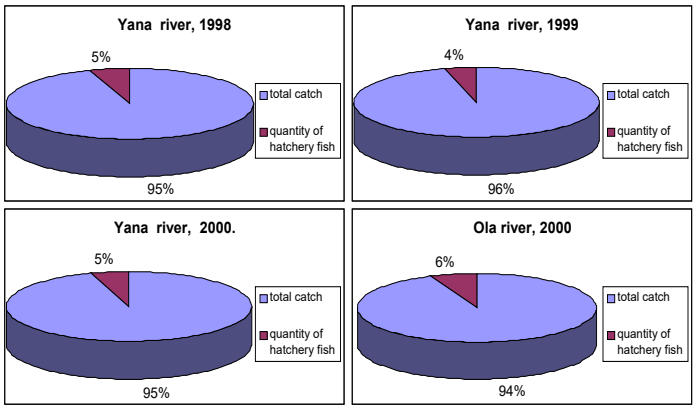
We are now ready to undertake total marking at all hatcheries producing Pacific salmon. However, it is important not only to conduct marking but also to identify marked fish in spawning runs. The problems related to marking can be generally regarded as solved, however, several methodological and organizational problems arose while arranging the monitoring of marked fish. Resolution of these issues is essential, even for the small rivers of Taui Bay. Correct organization of data collection is especially important for long rivers with numerous tributaries in Kamchatka and Sakhalin. For example, depending on the task assigned, it is necessary to correctly identify the places for collection of spawning individuals, the number of individuals to be taken in order to determine the proportion of the hatchery fish in the stock mixture, and the frequency of data collection.

Hatchery production of fish in the Magadan Region is young. The majority of hatcheries began operations quite recently. The oldest hatchery started up fifteen years ago. Marked fish, which can be recognized by otolith marks, have been identified among spawning salmon returning to hatchery rivers during the past three years (1998–2000). The main subject of our study is chum salmon. Evaluation of hatchery output efficiency, assessment of rearing techniques, and identification of features characterizing the hatchery fish in the mixed stock are the main tasks of our studies.

The spawning runs of the marked fish in 1998–2000 were analyzed, and the following observations were made:

- The identification of otolith-marked fish showed that the main portion of mixed spawning runs of chum salmon is represented by wild fish. The oldest hatchery, which releases up to 20 million juveniles per annum, is located on the Ola River. Inseminated eggs from donor rivers have been delivered to that hatchery since it was founded. Based on the identification of adult salmon that were otolith-marked as eggs, the calculated return coefficient of hatchery salmon was lower than that of the wild chum salmon populations. The portion of hatchery released chum salmon was about 6% of the total catch in 2000 (Fig. 1).

Fig. 1. The percentages of hatchery-released chum salmon in total catches in the Yana and Ola rivers, 1998–2000.



All correspondence should be addressed to E. Akinicheva
e-mail: tinro@online.magadan.su

Table 1. The Yana River salmon hatchery return coefficients (based on results of marking).

Generation	Fry released next year in thousand	Hatchery fish returnin thousand			Total return in thousand	Return coefficient (%)
		1998	1999	2000		
1994	800	3+ 2.233	4+ 0.398	5+ -	2.631	0.32
1995	7759	2+ -	3+ 0.214	4+ 1.187	1.401	0.02
1996	2432	-	2+ -	3+ 0.222		
1997	669	-	-	2+ -		
Total:		2.233	0.612	1.409		

Previous indirect assessments, however, led us to expect a much higher percentage of hatchery fish in the catch. An analysis of the Ola River Hatchery output efficiency showed that the use of inseminated eggs delivered from donor rivers is an ineffective practice. Despite large quantities of eggs incubated each year, the number of chum salmon in spawning runs in 1998–2000 did not increase. We are facing a situation in which the inefficiency of the donor-river eggs is evident, but at the same time home-river spawning individuals are too scarce to increase the quantities of salmon. At present, we do not have any high-yield hatchery fish stocks.

Monitoring of chum salmon on the Yana River, where hatchery activities have been conducted since 1994, showed that the wild chum salmon comprise the main portion of the spawning runs. The analysis of marked-fish spawning runs at the Yana Salmon Hatchery also confirms the low efficiency of the practice of delivering inseminated eggs from donor rivers. The return of 1994-generation chum salmon was higher for home-river spawning fish than for salmon produced from eggs brought from other rivers in 1995 and 1996. The 1994-generation return coefficient was 0.32% (Table 1). We consider this to be the most productive release group in the past few years. The return coefficient for the 1995 generation was considerably lower.

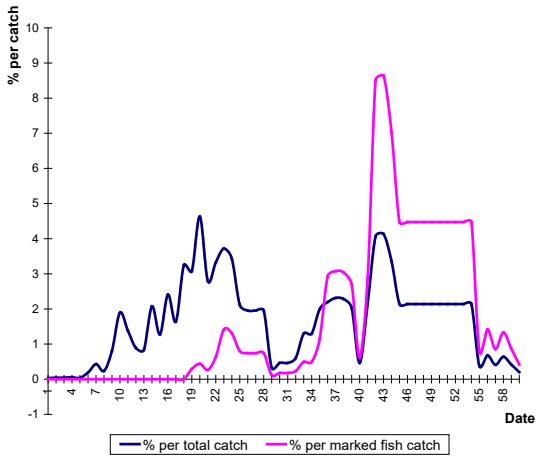
The low returns of hatchery salmon, evaluated by the recovery of otolith-marked fish, demonstrated the inefficiency of delivering eggs from donor rivers. This is why the Magadan fish hatcheries have gradually discontinued this practice.

- It is extremely important for the hatcheries to be able to evaluate salmon returns in order to select the most effective biotechnical techniques. The results obtained by identification of fish marked at the hatcheries confirm the increased returns of fry raised in marine net pens prior to release and released in the most productive coastal areas of Taui Bay. The return of the chum salmon raised by this method was estimated to be from 1.5 to 1.8% of the total number released. This result demonstrates the potential of marine rearing of chum salmon fry, which would make it feasible to create artificial industrial populations, one hundred percent of which could be used for commercial purposes.

- It was found that introduced salmon retain the ability to spawn during the period typical for their home rivers. The monitoring of the chum salmon spawning runs belonging to artificially produced commercial populations in the Kul'kuty River shows that the hatchery fish retain the features characterizing the parent stock. The population is represented and formed mostly by the late-run (fall) chum salmon. The returning hatchery salmon fully retain the ability to spawn during the period of the natural spawning migration, as well as the size and weight characteristics typical for the parent stock.

- The analysis of otolith-marked salmon spawning runs allows us to develop rational strategies for exploitation of salmon stocks. We found that hatchery salmon tend to migrate at the end of the spawning run (Fig. 2). Thus, the commercial fishery targets wild

Fig. 2. Chum salmon spawning runs dynamics, Yana River, 2000.



salmon, while the hatchery fish reach the spawning grounds. This fact results in directed selection, which may, over the course of time, have a negative impact on the population structure and its reproduction efficiency. In consideration of this situation, it seems that the intensity of commercial fishing should be increased at the end of the spawning migration and decreased at the beginning and the middle of the spawning season in order to preserve the most valuable natural subpopulations.

The impact of hatchery production on natural chum salmon populations in the rivers of the Magadan Region is generally insignificant except in the Ola River. In conclusion, we wish to emphasize that our results are based on a preliminary analysis of data that were collected during only three years. The subsequent use of otolith marking and further collection of data on identification of hatchery salmon will provide a means for solving all kinds of fish hatchery problems.