Northwest Science Notes

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Origin of Stray Sockeye Salmon Spawning in Western Washington

Introduction

Sockeye salmon (*Oncorhynchus nerka*) are generally found in watersheds containing lakes where the juveniles spend at least one year prior to emigration to the ocean (Foerster 1968). However, in western Washington sockeye salmon are often observed spawning in and smolting from systems lacking the normal lacustrine environment. All major Puget Sound rivers support small spawning populations of sockeye salmon (Williams et al. 1975, Phinney and Bucknell 1975), but these populations were described as insignificant, probably in reference to supporting a commercial fishery.

Recent molecular genetics studies identified that sockeye salmon spawning in the Nooksack and Skagit rivers are genetically part of an eastern Pacific coastwide riverine rearing sockeye group (Gustafson and Winans 1999). Prior to these genetic studies salmon managers in western Washington presumed that adult sockeye salmon observed spawning in areas without access to lakes represented strays from lacustrine populations, or they were kokanee.

Although molecular genetics are accurate methods used to identify individual fish stocks, the two drawbacks are that they are costly and time consuming. An alternative approach for sockeye salmon stock identification is the analysis of scale circuli patterns. Each sockeye salmon stock rears in a unique environment; differences in growth rate and developmental timing are recorded as circuli patterns its scales. Because of this, circuli patterns are used to identify and separate sockeye salmon stocks (Henry 1961, Roos 1991).

Sockeye salmon are considered to be the most accurately homing salmon because stocks utilize many different spawning areas in relation to where the juveniles rear. Some stocks spawn downstream of the rearing lake with emergent fry migrating upstream. For others, spawning takes place in inlets with emergent fry moving downstream. Finally, some populations spawn within the lake itself and do not migrate at all. The fry migration pattern has a genetic basis (Brannon 1973, Roos 1991). Consequently, if fish from an inlet spawning stock were to spawn in an outlet, the emergent fry would swim in the wrong direction and not end up in the proper lake for rearing.

Sockeye salmon are regularly captured at hatchery racks and observed utilizing unusual spawning areas in western Washington. Scales were collected and examined to determine if these fish were strays from known lacustrine populations. If they were not strays from known populations, could anything be inferred about their origin based on scale circuli pattern? Particularly, what sort of scale pattern did fish show from the recently recognized sockeye salmon that were part of riverine rearing metapopulation?

Methods

Between 1988 and 1993, scales were collected from sockeye salmon captured at Washington

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Department of Fish and Wildlife (WDFW) hatcheries or found dead during spawner surveys in areas remote from lakes offering access to anadromous salmonids (Figure 1). Collected scales were sent to the Pacific Salmon Commission (PSC) in Vancouver BC for analysis. At the PSC, the scales were mounted on gummed cards and then acetate impressions of the scales were made. The image of the acetate impression was projected on a screen of a microfiche reader. The number of circuli from the focus of the scale to the first annulus and to the end of freshwater growth at smolting was recorded for each fish. To provide comparison with known lacustrine sockeye salmon stocks in western Washington, freshwater circuli counts from 62 Baker Lake (Skagit River watershed) and 175 Lake

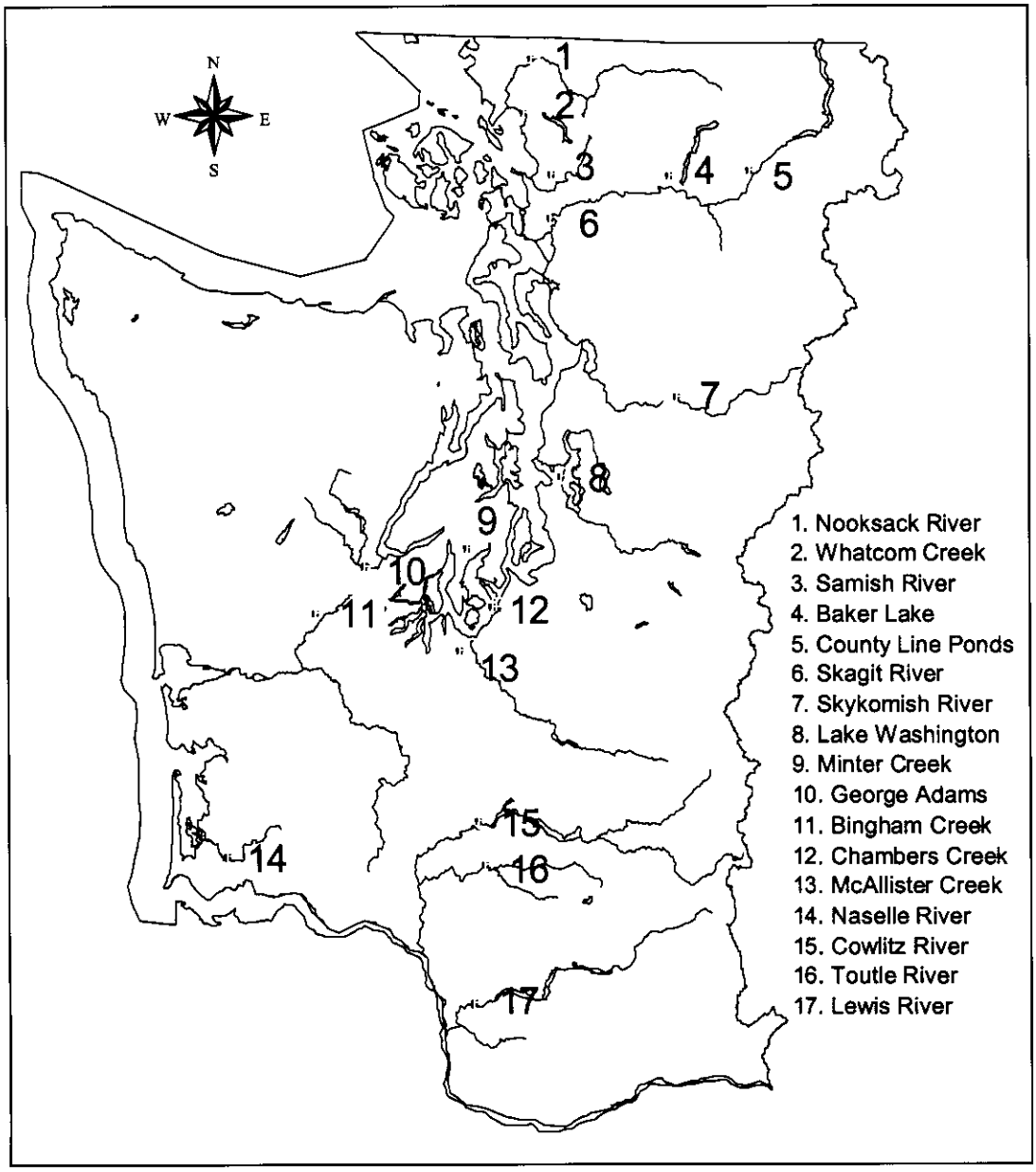

Figure 1. Locations where sockeye salmon were collected in western Washington.

Washington sockeye salmon were included. For locations where more than one fish was collected, the mean and coefficient of variation (cv) were calculated. Z-tests (P= 0.05) were used to evaluate statistical differences.

Results

A total of 91 fish were collected from 15 sites in 14 watersheds in western Washington (Table 1, Figure 1). These fish were placed into 15 groups based on location of capture. Group mean (or individual count in the case of single fish) circuli counts for the period of freshwater rearing ranged from 9.0 to 30.0 (Table 1). These counts represent the total number of circuli from the focus to presumed salt-water entrance. The majority of mean circuli counts were < 20. The two known western Washington lacustrine rearing populations (Baker Lake and Lake Washington) had mean counts > 20. None of the groups had freshwater circuli patterns considered to be from either Lake Washington or Baker Lake with the result that these two systems were removed from consideration as source of the strays (Carol Lidstone, Pacific Salmon Commission scale analyst, personal communication). All of the scales analyzed showed growth patterns indicative of fresh water and marine residence (sockeye salmon) rather than purely freshwater residence (kokanee or residual sockeye salmon). The CV for the nine groups where n > 1 ranged from 2.3% to 38%. Most CVs were < 20%, which was similar to the CVs for Lake Washington and Baker Lake, suggesting that a CV < 20% indicates the variation to be found in a single sockeye salmon population in western Washington lakes.

TABLE 1. Freshwater circuli counts (mean) for sockeye salmon collected in western Washington.

Location	N	Freshwater circuli	CV (%)
Western Washington-known			
Baker Lake	62	27.34	12.1
Lake Washington	175	22.99	16.2
Western Washington-strays			
Nooksack River	15	16.00	15.7
Whatcom Creek	3	12.33	13.8
Samish River	10	14.20	9.9
Skagit River watershed			
Skagit River	5	15.40	38.0
County Line Ponds	2	21.50	2.3
Skykomish River	1	14.00	-
Chambers Creek	34	21.15	13.0
McAllister Creek	1	15.00	-
Minter Creek	3	15.67	15.0
George Adams	4	14.50	21.0
Bingham Creek	1	13.00	-
Naselle River	1	9.00	-
Cowlitz River	9	16.33	11.2
Toutle River	1	18.00	-
Lewis River	1	30.00	-

Broadly speaking, there were two groups of mean freshwater circuli counts. The Chambers Creek, County Line Ponds, and Lewis River means were all > 21 while the remainder were all < 18. These two groupings came from significantly different populations.

The sockeye salmon collected at Chambers Creek had mean circuli counts of 21.15 and a CV of 13% and those collected at County Line Ponds, a system of small ponds in the Skagit River system, had mean circuli counts of 21.50 and a CV of 2.3%. The single sockeye salmon collected at the Lewis River had a circuli count of 30. The mean (or individual) freshwater circuli counts for the remaining 13 groups were all < 20 with CVs ranging from 9.9% (Samish River) to 38 % for the Skagit River. The only other CV > 20% was for fish collected at George Adams.

The mean freshwater circuli counts for the sockeye salmon collected in the Nooksack and Skagit rivers were 16 and 15.4, with CVs of 15.65% and 38 %. These fish were collected in the same general location as the fish identified by Gustafson and Winans (1999) as being part of the coastwide riverine metapopulation.

Discussion

Interpretation of scale circuli patterns from sockeye salmon collected in western Washington concluded that they were not strays from either Lake Washington or Baker Lake, as had been previously believed. If these fish were not strays from the major western Washington sockeye salmon populations, could some salmon stocks use only fluvial habitat in the freshwater portion of their life cycle? Several pieces of circumstantial evidence point to this conclusion. Stray sockeye salmon 1) are not strays from Lake Washington or Baker Lake; 2) the strays are observed consistently (both temporally and spatially) in the areas where they were collected; 3) the Skagit and Nooksack rivers

have sockeye salmon that are genetically part of the Pacific coastal riverine rearing sockeye metapopulation; 4) sockeye salmon have been observed to spawn, incubate, and smolt successfully from non-lacustrine rearing situations; 5) stray sockeye salmon returning to systems where they had access to lakes (Chambers Creek, County Line Ponds, Lewis River) had freshwater circuli counts > 21; 6) stray sockeye salmon returning to the Nooksack and Skagit rivers had mean freshwater circuli counts < 16; 7) stray sockeye salmon from streams with no access to lakes had mean freshwater circuli counts < 18; and 8) there was a significant difference in the freshwater circuli counts between stray sockeye salmon that had the opportunity to rear in lakes and those that did not appear to have that opportunity.

There still remains one major unknown. In western Washington no documentation exists that shows that sockeye salmon use only fluvial habitat in the freshwater portion of their life cycle. That is, sockeye salmon successfully spawn, incubate, and rear in a stream; smolt, then successfully returns to that natal stream. While spawning, incubation, and smolting have been observed, no marked smolts have returned as adults to the spawning stream.

The difference in freshwater circuli counts can serve an initial filter to classify fish. Molecular genetics can be used as a second filter to determine genetic affinities. But, until the life history circle is closed, we will only be able to speculate on actual biology of the fish.

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