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Reprinted from the
Alaska Fishery Research Bulletin
Vol. 5 No. 2, Winter 1998

The Alaska Fishery Research Bulletin can found on the World Wide Web
at URL: http://www.state.ak.us/adfg/geninfo/pubs/afrb/afrbhome.htm .

Alaska Fishery Research Bulletin 5(2):143–148. 1998.

Age and Marine Survival of Ocean-Type Chinook Salmon *Oncorhynchus tshawytscha* from the Situk River, Alaska

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ABSTRACT: Chinook salmon *Oncorhynchus tshawytscha* smolts were sampled for scales, coded-wire-tagged, and released in the Situk River, Alaska. As returning adults, they were then sampled for scales to compare freshwater age composition at release and recovery and to estimate marine survival. Of 10,191 chinook salmon smolts tagged (July 1989), 98% were age 0. From 1991 through 1993, 23 of 35 tagged chinook salmon adults recovered in the commercial fishery and spawning-ground surveys had readable scales that identified 87% of the fish as age 0. (ocean-type). Estimated marine survival was 2.9%, excluding returning age-0.1 jacks. We concluded that ocean-type chinook salmon are the predominate life history type for the Situk River. Situk River chinook salmon are unique because they are the only known stock in Alaska that migrates to sea primarily at age 0.

INTRODUCTION

Chinook salmon *Oncorhynchus tshawytscha* stocks in Alaska are referred to as "stream-type" (age 1.) because they spend 1 year in fresh water before migrating to sea (Healey 1983). "Ocean-type" (age 0.) chinook salmon migrate to sea during their first year without spending a winter in fresh water; they were initially discovered by Kissner (1986) in the Situk River, Alaska, and in 1989 this stock was identified as predominately ocean type (Johnson et al. 1992). Unlike chinook salmon in other Alaskan rivers, those in the Situk River attain sufficient size in their first summer to migrate to sea as age-0. smolts.

Chinook salmon scales from Situk River adults are difficult to age because the life history of this stock is unique. Fry emerge early in February or March, and most migrate to sea in late summer of the same year (Johnson et al. 1992). Situk River juveniles are similar to those from British Columbia to California, which rear in estuaries for about a month and then migrate to sea (Healey 1991). Although the Situk River has little estuarine habitat, juveniles live up to a month in the tidally influenced lower Situk River, growing rapidly before completing their emigration to sea (Figure 1; Johnson et al. 1992). Ocean-type scales can exhibit 3 growth patterns that can confound the aging of juveniles: (1) early growth in the upstream and middle portions of the Situk River where fry emerge from the gravel, (2) growth in mid to late summer in the lower intertidal section of the river, and (3) fall growth in marine waters.

Most marine survival estimates of Alaskan chinook salmon are for fish from hatcheries; little survival information is available for wild stocks. Our objectives were to validate, by using juveniles that were coded-wire-tagged in 1989, the freshwater aging of adult Situk River chinook salmon and to estimate their marine survival. This information will help managers to determine freshwater ages from scales of Situk River chinook salmon,which are predominantly ocean-type stock and rare in Alaska.

STUDY AREA

The Situk River, located 18 km southeast of Yakutat, Alaska, is a clear groundwater system with 3 lakes and an average summer discharge of 6 m^3/s (Clark and Paustian 1989). The main stem is 35 km long and originates at the outlet of Situk Lake (315 ha). Mountain Creek, which is fed by Mountain Lake (87 ha),

Authors: JOHN F. THEDINGA, SCOTT W. JOHNSON, and K V. KOSKI are fishery biologists with the Auke Bay Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 11305 Glacier Highway, Juneau, AK 99801-8626.
Acknowledgments: Scott Feldhausen, Elizabeth Wilson, Blaine Ebberts, Ben Woodard — helped with coded-wire-tagging. Jerry Pella, Jon Heifetz, Joe Orsi, Frank Thrower, and Scott McPherson — reviewed the manuscript. Alaska Department of Fish and Game and U.S. Forest Service — provided logistical support.
Project Sponsorship: This project was funded by the U.S. Forest Service and the Habitat Investigation Program at the Auke Bay Laboratory.

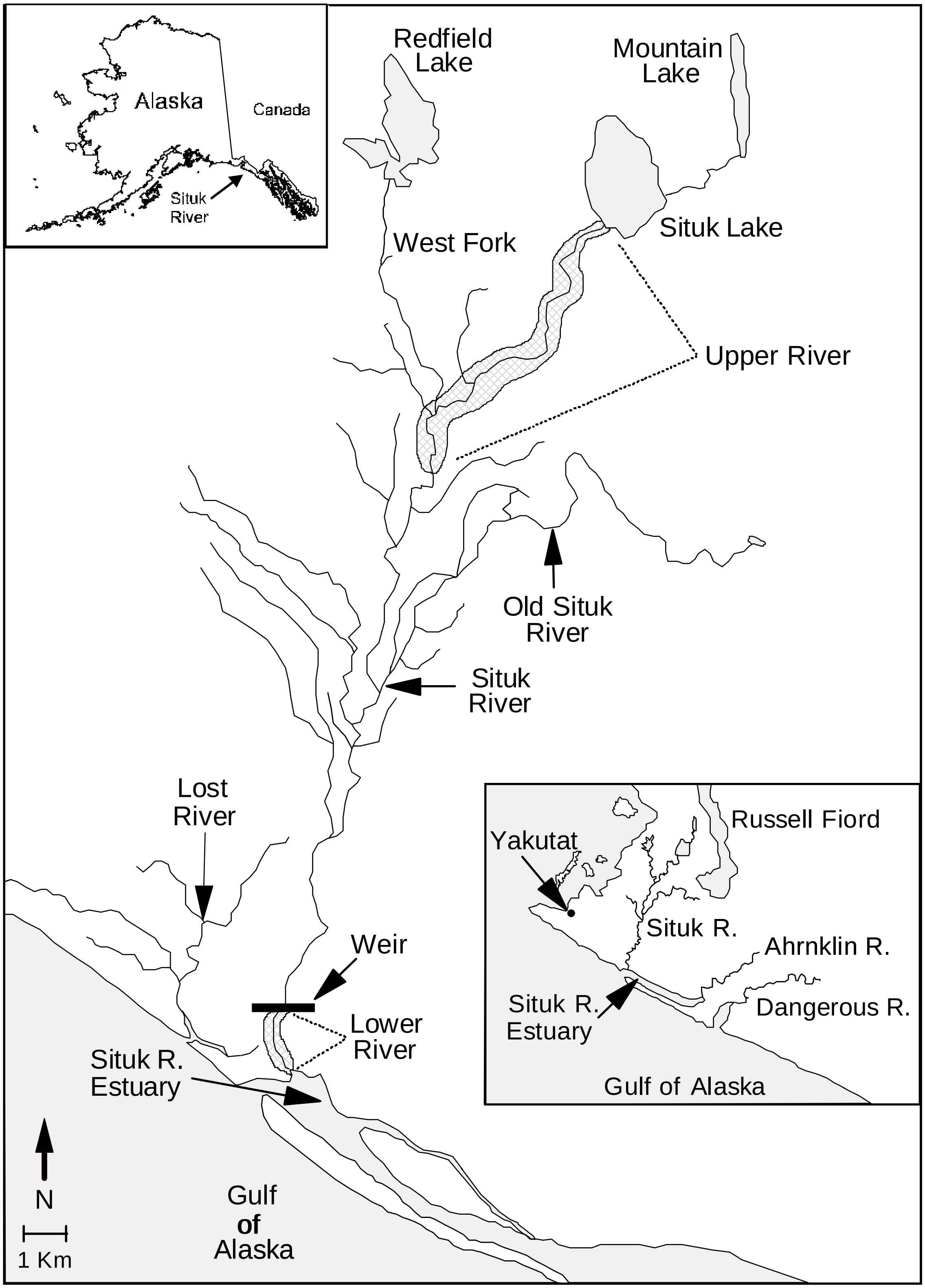

Figure 1. Location of the Situk River in Alaska. The upper and lower sections of the river are crosshatched and the weir is indicated by a solid bar.

drains into Situk Lake. The lower river (the last 3.5 km of the main stem before it enters salt water) is influenced by tides that increase salinity by up to 5.0 ‰ (Heifetz et al. 1989). The Situk River averages 25 m in width, drains an area about 200 km^2, and has 2 major tributaries. Old Situk River (20 km long) originates from a pond, and West Fork Situk River (10 km long) originates at Redfield Lake (200 ha).

The Situk River contains species of 5 Pacific salmon, as well as steelhead *O. mykiss*, cutthroat trout *O. clarki*, and Dolly Varden *Salvelinus malma*. Mean annual escapement of chinook salmon into the Situk River from 1978 through 1997 was about 3,000 fish, including jacks (S. McPherson, Alaska Department of Fish and Game [ADF&G], Douglas, personal communication).

METHODS

A total of 10,191 juvenile chinook salmon were coded-wire-tagged in the Situk River from 16 to 20 July 1989. Juveniles were captured in the lower river with a pole seine, tagged, adipose fin-clipped, and released. Subsamples of tagged fish were retained in a holding box in the lower river to determine tag retention and mortality; each day, 80 tagged fish were held for 24 h and 80 were held for 96 h. Subsamples of about 100 fish were also measured daily for fork length and weight, and from those, we collected scales from 70 fish for aging.

Adults were counted at an ADF&G weir in the lower Situk River from 1990 through 1993; counts of age-.1 jacks were incomplete because some were able to pass through the weir. About 80 spawned-out adults were sampled in the upper river in late summers (1991–1993) to obtain lengths (mid-eye to tail fork) and scales for aging by ADF&G. Heads from adults with missing adipose fins were removed for tag retrieval and decoding later at the ADF&G Tag Laboratory in Juneau. Chi-square tests were used to determine whether the proportion of age-0. chinook salmon differed between commercially caught and spawned-out fish from the Situk River and between tagged and nontagged fish.

We estimated marine survival based on adults sampled from the commercial set gillnet, subsistence, and personal-use fisheries and the escapement into the Situk River. Adults caught commercially in gillnets near the mouth of the Situk River were sampled by ADF&G. About one-quarter of the commercial catch was randomly sampled, and heads of fish with missing adipose fins were saved for tag removal. All sampled fish were measured for length, and scales were removed for aging. The number of tagged fish sampled was expanded to estimate the total number of tagged fish caught in the commercial fishery. Because of problems sampling the 1992 commercial fishery, the proportion of tagged age-.3 adults from the 1992 spawning ground survey was used to estimate the total number of tagged adults in the 1992 commercial catch. In 1991 and 1993 the proportion of tagged fish in the commercial catch was used to estimate number of tagged fish in the subsistence and personal-use fisheries; but in 1992 the proportion of tagged fish on the spawning grounds was used for this estimation. At the ADF&G weir, fish were passed upstream without handling, so estimated age was based on visually estimated lengths and length-at-age data: age-.1 fish <40 cm, age-.2 fish were 40–70 cm, and age-.3 and -.4 fish were >71 cm. Age-.3 and -.4 fish could not be differentiated at the weir; therefore, their proportions were estimated from fish sampled on the spawning grounds. The proportion of tagged fish in the Situk River was also determined from fish sampled on the spawning grounds. Marine survival of all chinook salmon was based on the estimated total number of smolts to have emigrated in 1989 and the corresponding total number of adults that returned to the Situk River or were caught in local fisheries in 1991–1993. A small proportion of the commercial catch (<10%) is from the Ahrnklin River, which shares the same estuary as the Situk River (A. Burkholder, ADF&G, Yakutat, personal communication), but for estimating marine survival, we assumed all the commercial catch to be of Situk River origin.

Total number of smolts (N) that emigrated from the Situk River in 1989 was estimated with a modified Petersen estimator (Ricker 1975, p 78):

$$N = \frac{(M+1)(C+1)}{R+1} - 1,$$

where M = estimated number of tagged smolts that emigrated from the Situk River, C = number of adults physically examined over the age-.2 to age-.4 return (commercial harvest and escapement), and R = number of tagged adults.

Variance (V) for N was calculated by

$$V(N) = \frac{(M+1)^2(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} .$$

An approximate 95% confidence interval for N was calculated from $N \pm 1.96\sqrt{V(N)}$.

Table 1. Freshwater age percentages of coded-wire-tagged and nontagged adult chinook salmon sampled in the Situk River, Alaska, escapement and from the commercial fishery in the Situk River estuary, 1991–1993. Sampled fish spent 1 (age 0.) or 2 (age 1.) winters in fresh water and 2, 3, or 4 years in salt water.

		Age 0.		Age 1.	
Sampled From	Adults	Sample Size	Percent	Sample Size	Percent
Commercial Fishery	Tagged	10	83	2	17
	Nontagged	144	66	74	34
Situk River Escapement	Tagged	10	91	1	9
	Nontagged	67	82	15	18
Total	Tagged	20	87	3	13
	Nontagged	211	70	89	30

RESULTS

In 1989 most tagged juvenile chinook salmon were age 0.; based on 62 juveniles with readable scales, about 98% were age 0. and 2% were age 1. Mean juvenile fork length was 80 mm and mean weight was 6.2 g. After they were tagged, the estimated total number of live smolts released was 9,681, based on survival (97%) and tag retention (95%) of fish held 24 h. The estimated total number of smolts that emigrated from the Situk River in 1989 was 87,000 ±26,500.

The proportion of adult Situk River chinook salmon with freshwater ocean-type characteristics was lower than that observed for smolts. Of all adults sampled, 70% were age 0., whereas for tagged adults, 87% were age 0. The proportion of adults with age-0. scale characteristics differed significantly between samples from the commercial fishery and the Situk River ($P < 0.01$) but not between tagged and nontagged fish ($P = 0.09$; Table 1). For all adults, spawned-out fish from the upper Situk River were 86% age 0., whereas samples from the commercial fishery in the Situk River estuary were 66% age 0.

Estimated ocean survival of tagged chinook salmon was 2.9% and for all fish was 2.3%. A total of 32 tagged adults were recovered, and 281 tagged adults were estimated to have returned to the Situk River or to have been caught in local fisheries (Table 2). Proportions of returning fish estimated to have been tagged varied from 6.9% in the commercial fishery in 1991 to 23.1% on the spawning grounds in 1993.

DISCUSSION

Scales from Situk River adult chinook salmon are difficult to age. The variety of habitats used by juveniles, most of which migrate to sea in the first year, produce confusing growth patterns on the scales. In addition, scale characteristics of Situk River chinook salmon differ from most other Alaskan stocks, which rear an entire year in fresh water before migrating seaward. After recognizing that Situk River juveniles emigrated to sea as age-0. smolts (Kissner 1986; Johnson et al. 1992; Thedinga et al. 1993), ADF&G revised their aging techniques for adult scales; before that, about 4% of Situk River chinook salmon were aged 0., whereas after that modification about 76% were aged 0.

We know some non-Situk River fish are caught by the commercial fishery in the Situk River estuary because the proportion of age-0. Situk smolts was about 33% higher than identified from adult scales from the commercial fishery and about 12% higher than from scales taken from escapement surveys. Because chinook salmon from the Situk River are predominately age 0., fish from other Alaska rivers caught in the estuary would presumably be age 1., therefore altering the age composition. Three non-Situk River chinook salmon have been captured in the commercial setnet fishery in the estuary since 1976. In addition, fish returning to the Ahrnklin River must also pass this fishery at the mouth of the Situk River. The Ahrnklin River chinook salmon run is considered to be small, but the actual number of fish, their contribution to the commercial fishery, and their freshwater age composition are unknown. Lower survival of age-0. than age-1. smolts could also contribute to the difference in age composition of juveniles and adults.

The estimate of 87,000 smolts that emigrated from the Situk River in 1989 is close to the number of juveniles (about 80,000) estimated to have emigrated from the Situk River in spring and summer 1990 (Thedinga et al. 1994). Although the assumption of a closed population of Situk River smolts does not hold, the Petersen estimate remains valid if the marine survival of tagged and nontagged fish was equal (Seber 1982: 71). Undoubtedly, some tag loss occurred between the time smolts entered salt water and their recapture as adults. Although all 11 adipose-clipped adults recovered from the Situk River spawning grounds retained their tags,

Table 2. Number of adult chinook salmon harvested in the commercial and subsistence fisheries in the Situk River estuary; number counted at the Situk River weir, 1991–1993; actual numbers of coded-wire-tagged adults recovered; and expanded number of tagged adults. An estimated 9,681 tagged chinook salmon smolts emigrated from the Situk River in 1989.

		Sample Size						
Source	Year	All Ages	By Age	Age of Tagged Fish	Percent by Age	% Tagged by Age	Nr Tagged Recoveries	Expanded Nr of Tagged Fish[g]
Commercial Fishery	1991	786	331	.2	26.3	6.9	6	14
	1992	1,504	102	.3	23.6	[a]	0	48
	1993	790	318	.4	34.3	11.9	13	32
Subsistence Fishery	1991	110	0	.2	26.3	[b]	0	2
	1992	325	0	.3	23.6	[b]	0	10
	1993	310[c]	0	.4	34.3	[b]	0	13
Situk River Weir	1991	1,613	78[d]	.2	8.2	10.5[e]	3[f]	14
	1992	1,985	78[d]	.3	24.2	13.6[e]	4[f]	66
	1993	4,101	64[d]	.4	8.6	23.1[e]	6	82
Total	1991–93	11,524	971	.2, .3, .4			32	281

[a] Percent of chinook salmon on the spawning grounds that were tagged in 1992 was used to estimate marine survival because of problems sampling the commercial fishery.
[b] Values for the commercial fishery were used in 1991 and 1993 and for the spawning grounds in 1992 to estimate marine survival.
[c] Includes 78 chinook salmon from the Situk River personal-use fishery.
[d] Fish sampled on spawning grounds on the Situk River.
[e] Determined from samples on spawning grounds.
[f] Includes one tagged chinook salmon from the Situk River sport fishery.
[g] Equals products of entries in columns All Ages, Percent by Age, and Percent Tagged by Age.

some clipped adults sampled in the commercial fishery did not have tags and were probably from the Situk River. Unquantified tag loss would cause the size of the smolt population to be overestimated.

Apparently, most Situk River adults migrate to near the Situk River by the time the commercial troll fishery in southeastern Alaska begins. All commercially caught tagged adults from releases in the Situk River during 1989 were caught in the Situk River estuary, as were 95% of the 1986–1988 tagged commercially caught fish (S. Bertoni, ADF&G, Juneau, personal communication). The low exploitation rate of Situk River fish in distant fisheries simplifies management of this stock and provides maximum benefit to local fisheries.

Apparently, fish emigrated to sea soon after being tagged in 1989 and did not migrate upstream and winter in the Situk River. None of the 1989 tagged juveniles were captured in spring or summer 1990 by 2 rotary-screw traps in the Situk River (Thedinga et al. 1994), whereas of more than 32,000 juveniles captured, nearly all (99.9%) were age 0. (Thedinga et al. 1994). The fact that 13% of the recovered tagged adults were classified as age 1. demonstrates some misinterpretation of scale age.

Situk River chinook salmon are the only Alaskan stock that has been validated to be primarily age 0. Age-0. emigrants from Deep Creek, Alaska, were tagged beginning in 1994 and made up about one-fourth of the total number of chinook salmon smolts tagged (Bendock 1995). However, only one tagged adult returned in 1996 and 1997 (B. King, ADF&G, Soldotna, personal communication), indicating low survival of the age-0. component.

Most marine survival estimates for chinook salmon are from hatchery rather than wild stocks; most hatchery estimates are similar to both marine survival estimates for Situk River fish. Survival comparisons for the same year of ocean entry avoid large annual variations attributable to the first year of marine life when varied ocean conditions can effect wide survival differences (Parker 1962). Marine survivals of age-1. smolts for the same year of entry were measured for the Little Port Walter (LPW) research station (2.8%; F. Thrower, National Marine Fisheries Service, Juneau, Alaska, personal communication), Neets Bay Hatchery 1.9%, Whitman Lake Hatchery 2.0%, and Crystal Lake Hatchery 2.7% (S. McPherson, personal communication). Marine survival of age-1. chinook salmon smolts of Unuk River, Alaska, origin released in 1980 at LPW ranged from 0.7% to 3.0% (Martin and Wertheimer 1989), and survival of Situk River age-1. smolts released the same year at LPW was 0.1% (F. Thrower, personal communication). The only estimates of marine survival for wild chinook salmon in Alaska are from the Unuk and Chickamin Rivers in southern southeastern Alaska; mean marine survival was 3.3% (range 1.2–4.9%) for the Unuk River (1982–1986) and 4.0% (range: 3.7–4.4%) for the Chickamin River (1982–1984; McPherson and Carlile 1997). Marine survival could not be calculated from Kissner (1988) because the number of tagged fish that returned to the Situk River was not estimated. Possible negative bias in the marine survival estimates for Situk River chinook salmon could be caused by tag loss or by inclusion of chinook salmon from other rivers (e.g., the Ahrnklin River) in commercial catch samples.

Aging of tagged adult chinook salmon from the Situk River confirms that most were the ocean type. Although such stocks are rare in Alaska, their marine survival is similar to chinook salmon from other areas of Alaska. More is now known about this stock than about the neighboring Ahrnklin River stock that shares the same estuary and is caught in the same commercial fishery. A better understanding of that stock's characteristics and interaction with the Situk River stock is essential for their successful management.

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