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Stehekin River Kokanee Expanded Spawning Surveys, 2000 and 2010

Natural Resource Data Series NPS/NOCA/NRDS—2013/506

ON THE COVER
Pair of spawning kokanee in a side channel of the Stehekin River.
Photograph by: North Cascades National Park.

Stehekin River Kokanee Expanded Spawning Surveys, 2000 and 2010

Natural Resource Data Series NPS/NOCA/NRDS—2013/506

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Abstract

To effectively manage the kokanee population in Lake Chelan, data needs to be gathered regarding adult escapement and the extent of natural reproduction within Lake Chelan tributaries. The need for a comprehensive assessment of the kokanee spawning populations was documented in preliminary FERC relicensing study plans and again in the 2009 Lake Chelan Fishery Forum (LCFF) Work Plan. As a result of these planning efforts, funds were provided in 2000 and 2010 to conduct expanded kokanee escapement surveys in the Stehekin River drainage to complement data collected annually from the existing Chelan PUD kokanee index reach surveys within the Stehekin River. The objectives of these surveys were to determine the distribution and total escapement of kokanee in side channels and mainstem habitats of the Stehekin River.

A probabilistic sample of suitable kokanee spawning habitat was used to estimate total kokanee escapement for all side channel habitat in the Stehekin River during 2000, and for all mainstem and side channel habitat in 2010. Expanded Stehekin River kokanee spawning surveys occurred on three occasions between September 12 and October 9, 2000 and on four occasions between August 30 and October 15, 2010. In the 2000 survey, 13 fish sample segment groups representing 6.2 km of the 19.8 km of suitable fish habitat (31.3%) were sampled. In 2010, 16 fish sample segment groups representing 3.4 km of 9.6 km of suitable fish habitat (35.4%) were sampled. Kokanee surveys were also conducted on six of twelve 500 m sections of the mainstem Stehekin River depositional zone habitat in 2010. Two surveyors worked in tandem; one on each side of the channel counting live and dead kokanee from the stream bank as they walked upstream.

A total of 33,050 kokanee were counted in side channels during 2000 and 49,614 were counted in 2010. The majority of kokanee counted were located in the Blackberry and Company Creek side channel complexes and accounted for 84.8% (2000) and 91.4% (2010) of the total kokanee counts for all sampled side channel habitat. In 2010, a total of 27,872 kokanee were counted in mainstem sample segments with 53% of them observed in upstream sample reaches between river kilometers 9.5-15.0. Using Area-Under-the-Curve (AUC) methodology with a spawning fish residence time of 15 days, a total escapement of 120,447 was calculated for side channel habitat in 2000. Total escapement of kokanee during 2010 was estimated at 141,651 fish for side channel habitat and 53,812 for Stehekin River mainstem habitat. The total 2010 kokanee escapement for side channel and mainstem habitat combined was 195,463.

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Introduction

On November 6, 2007, Public Utility District No. 1 of Chelan County, Washington State (Chelan PUD) filed the Lake Chelan Fishery Plan (LCFP) pursuant to Article 404 of the Federal Energy Regulatory Commission Order on Offer of Settlement and Issuing New License dated November 6, 2006 for the Lake Chelan Hydroelectric Project No. 637. The Federal Energy Regulatory Commission (FERC) approved the LCFP on December 4, 2007. Implementation oversight of the LCFP was given to the Lake Chelan Fishery Forum (LCFF), established through the Settlement Agreement and including various representatives from Chelan PUD, federal, state, tribal, and public stakeholders. The LCFF is responsible for development and implementation of annual work plans that describe fish stocking, monitoring and evaluation measures that address the objectives of the LCFP. Implementation funding is provided by Chelan PUD, as directed by the Settlement Agreement, and agency cost share contributions.

The annual work plan includes measures to manage kokanee salmon (*Oncorhynchus nerka*) within the project area. Though not native to the Lake Chelan system, kokanee are the fish most sought after by recreational anglers and maintaining a popular sport fishery is a high priority (Brown 1984). Lake Chelan Fishery Plan management objectives for kokanee include: 1) to provide quality fishing opportunities for the public; and 2) to maintain an abundance of kokanee which will not substantially hinder managers attempts to restore native species in Lake Chelan and its tributaries.

To effectively manage the kokanee population in Lake Chelan, data needs to be gathered to facilitate the development of a Lake Chelan kokanee management plan. Since 1984 Chelan PUD has conducted annual surveys of spawning kokanee within index reaches located in Stehekin River side channels. These surveys have been conducted through the term of the past FERC licensing agreement and have established a long record as an index of kokanee escapement. With respect to the lower Stehekin drainage, the surveys have been limited to Company Creek and Blackberry Creek which only provides a partial estimate of kokanee escapement for the Stehekin drainage. Prior to the new FERC license, the LCFF acknowledged the need for periodic expanded kokanee spawning surveys. Consequently, an initial probabilistic survey of all suitable kokanee spawning habitat in side channels of the lower 17 km of the Stehekin River was conducted in 2000 by Chelan PUD contractors (Duke Engineering & Services Inc.) and NPS staff. In 2009, the LCFF Annual Work Plan provided funding for another expanded kokanee spawning survey within the Stehekin River that included the mainstem channel and side channels to be conducted by NPS staff in 2010.

Methods and results of the 2000 and 2010 expanded kokanee escapement surveys for the lower Stehekin River drainage are provided in the following sections. These results and future repeated surveys will be used to evaluate changes in the distribution and abundance of spawning kokanee throughout the lower river drainage and to calibrate total escapement in years not surveyed using existing annual index sites historically monitored by Chelan PUD.

Study Area

The Stehekin River watershed drains an area of 220,000 acres (344 square miles) of mostly public lands within Glacier Peak Wilderness Area, Lake Chelan National Recreation Area, and North Cascades National Park. The headwaters of the Stehekin begin at approximately 103 glaciers located along the Pacific Crest of the Cascade Range. The Stehekin is the largest tributary to Lake Chelan, and its major tributaries include Flat Creek, Bridge Creek, Agnes Creek, Company Creek, Rainbow Creek and Boulder Creek.

The upper Stehekin River and Agnes Creek emerge from deep box canyons into the broad lower Stehekin valley. This part of the valley was glaciated by both alpine glaciers and the massive continental glacier from Canada known as the Cordilleran Ice Sheet. During multiple ice ages these glaciers created the valley's characteristic U-shape, straight profile, and flat valley floor.

The gradient of the river at its confluence with Agnes Creek is about 80 feet/mile, decreases to 50 feet/mile above McGregor Meadows, and is 25 feet/mile just above Lake Chelan. However, gradient is somewhat steeper in lower valley reaches with straight, narrow channels where the river encounters large tributary alluvial fans of Company, Rainbow and Boulder creeks (km 2-3, 6-7 and 11-12). The relatively straight, steep reaches are net transport zones for sediment and large woody debris, and as a result are areas of relative channel stability. Wood and sediment storage zones between these transport reaches are characterized by the presence of massive log jams, multiple side channels, and channel instability (Riedel 2008). The location and extent of side channels and side channel complexes are largely determined by mainstem channel morphology. Side channels, located primarily in mainstem depositional reaches, are formed and maintained through aggradation of the stream bed and the deposition of large woody debris. Side channel bed materials are predominantly gravel and sand, with varying amounts of silt, cobble and boulder. Side channel gradients are generally 25 feet/mile and wetted channel widths range from 0.3 to 24.0 m. Side channel depths range from 0.02 to >3 m, and flow ranged from 0.1 to 2.0 m/sec. Side channels in the Stehekin River have a patchy distribution with large complexes of many channels in some mainstem reaches and other reaches with few or no side channels.

Our survey area for kokanee spawning consisted of mainstem Stehekin River reaches and side channel habitat located downstream of the Agnes Creek confluence to the head of Lake Chelan. These reaches include the majority of Stehekin River habitat where substrate and flows are suitable for kokanee spawning (Figure 1).

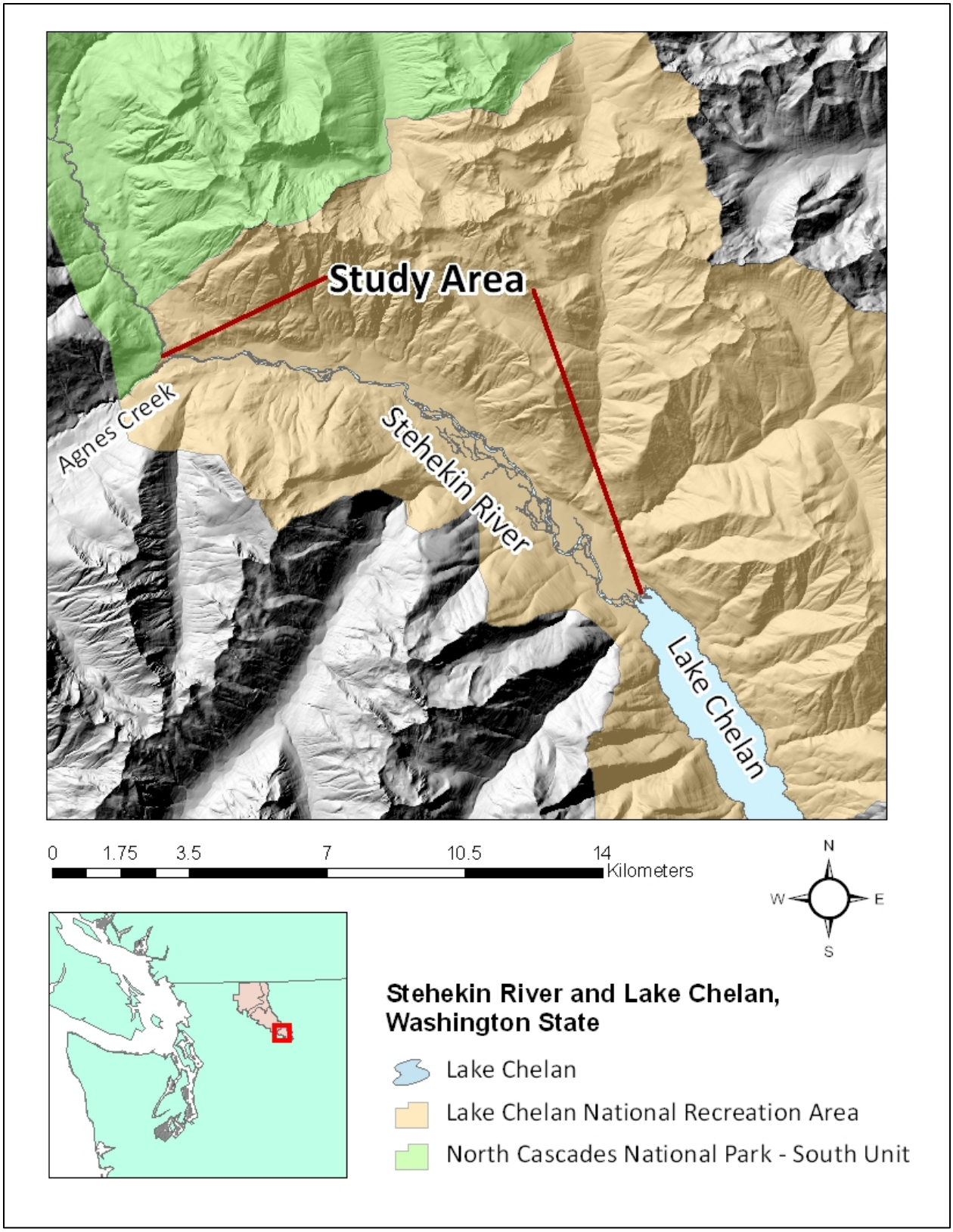

Figure 1. Map of the lower Stehekin River and Lake Chelan area where 2000 and 2010 kokanee spawning surveys were conducted.

Methods

Side channel habitat surveys, 2000 and 2010

Side channel kokanee habitat surveys were conducted by NPS biologists within the lower 17 km of the Stehekin River during the summer of 2000 and the lower 14 km in the summer of 2010. Habitat assessment followed a modified Hankin-Reeves Level II habitat survey (USFS 2007). Channel unit type was determined to be riffle, pool or dry habitat. Measurements taken at each unit include wetted width, length, dominant and subdominant substrates average depth and maximum depth. A subjective assessment of spawning habitat quality was determined for each channel segment based on observed flow velocity, water depth, accessibility to fish and the presence of suitable substrate. Side channel habitat units were grouped into consecutive segments (generally, 200 to 500m long) delineated by floodplain location and secondary channel connections. These segments were numbered sequentially and used as side channel survey units.

Mainstem Stehekin River habitat surveys, 2010

Mainstem habitat was included in the 2010 kokanee escapement survey but not in the 2000 survey. The mainstem Stehekin River was divided into 32 consecutive 500 m segments from the head of Lake Chelan upstream to river kilometer 16. Each 500 m segment was determined to be either a depositional or transport reach, based on depth, velocity and substrate size. Transport reaches were generally constrained by bedrock and boulder channel banks, with deep, swift water and cobble and boulder substrates. These straight, narrow reaches of the lower valley transports clasts with median diameters of 15-25 cm leaving cobbles and boulders as the river substrate (Riedel 2008). Depositional reaches were markedly wider, shallower and contained smaller substrates than transport reaches (Appendix A). Due to their physical characteristics, transport reaches had marginal spawning habitats and lacked low velocity pools used by kokanee for holding on their upstream migration. Survey segments located within transport reaches were eliminated from the mainstem Stehekin sample area due to their poor suitability as spawning or holding habitat.

Kokanee spawning surveys

Spawning survey channel segment selection

A probabilistic sample of suitable kokanee migration/spawning habitat was used to estimate total kokanee escapement for all side channel habitat in the Stehekin River during 2000 and for all suitable mainstem and side channel habitat in 2010.

Side channel segment selection

In 2000, 94 side channel segments, averaging 235 m in length, were surveyed for a total of 22.0 km. Nine of these segments were excluded from the sampling frame because of unsuitable water depth and/or substrate (i.e., sand or silt) conditions observed during habitat surveys. To facilitate collection of fish count data, the remaining 85 segments were spatially ordered by their location along the Stehekin River mainstem. These habitat survey segments were then grouped into 48 fish sample segments by combining smaller habitat survey segments into groups having roughly similar total lineal distance (avg.= 450m) and in close proximity to each other. From this sample frame, a

systematic sampling procedure with a random start point was used to select the sample of segment groups for the survey. Fifteen fish sample segment groups were selected representing approximately 1/3 of the suitable habitat. During the initial fish sampling period, seven of the habitat survey segments included in the overall sample had to be removed because of low flow. This resulted in the partial reduction of the length of channel surveyed in three of the selected fish sample segment groups and eliminated two other fish sample segment groups. The final sample included 13 fish sample segment groups representing 6.2 km of the 19.8 km of suitable fish habitat (31.3%).

The 2010 fish survey segment sample selection procedure was similar to that of 2000 except that separate sample frames were used to represent left (LB) and right bank (RB) locations (looking downstream) of side channels along the Stehekin mainstem. A total of 99 (42 LB, 57 RB) side channel segments (13.8 km) were surveyed to evaluate fish habitat. Thirty nine of these segments were excluded from the sample frames because of inadequate flow and/or unsuitable substrate (silt and sand). The 60 remaining segments represented a total of 9.6 km (2.3 km and 7.3 km, respectively for the LB and RB) of suitable side channel habitat. Grouping of habitat segments into fish sample segments and sample selection was done as previously described for the 2000 survey. Six of the 11 LB fish sample segments (total of 1 km) and 10 of the 30 RB fish sample segments were selected for kokanee surveys, representing 35.4% of the suitable habitat.

Side channel habitat survey data, habitat survey segments included in sample frame, fish sample segment grouping, and selected fish sample segment groups for 2000 and 2010 are shown in Tables B.1 to B.2 of Appendix B. Map locations of the fish sample segments are shown in Appendix C (2000 survey) and Appendix D (2010 survey).

Mainstem channel segment selection

To ensure sampling covered the geographical extent of survey area, the mainstem Stehekin was partitioned into four 4-km sections, each with eight 500 m survey segments. Survey segments were identified as transport or depositional reaches. Within the 16 km survey section there were twenty four 500 m depositional segments and twelve 500 m transport segments. The sampling frame included only depositional segments (Table 1). A Microsoft Excel sampling routine was used to obtain a random ordered list of sample locations. We worked down the list until three 500 m depositional reaches were selected from each 4-km section resulting in a 50% sample of the mainstem depositional habitat. Map locations of the of the 2010 mainstem fish sample segments are also shown in Appendix D.

Fish spawning survey methods

Stehekin River kokanee spawning surveys occurred every 13 to 15 days on three occasions between September 12 and October 10, 2000 and on four occasions between August 30 and October 15, 2010. Snorkel and bank observational methods were used by Chelan PUD contractors (CCPUD 2001) for counting fish during the 2000 side channel spawning surveys. The 2010 mainstem and side channel fish surveys were conducted by North Cascades National Park staff. Two surveyors worked in tandem, one on each side of the channel counting live and dead kokanee from the stream bank as they walked upstream. Surveyors wore polarized sunglasses to facilitate fish viewing. Numbers of fish were tallied and recorded in a field notebook. Large numbers of congregating kokanee were

estimated. Field personnel calibrated their estimations of large groups of fish by occasionally enumerating every individual fish in a group and comparing estimates with their survey partner.

Live fish count data was used to calculate kokanee escapement to the Stehekin River. Escapement is the total number of adult fish which successfully return to spawn in a given stream or waterbody. To determine escapement of kokanee in the Stehekin River, Area-Under-the-Curve (AUC) methodology was used (Irvine 1993). AUC is calculated by graphing the number of live fish counted (y-axis) against survey dates (x-axis). The area under this curve represents fish-days, and it is divided by the estimated residence time of an adult fish on its spawning grounds. For kokanee in the Stehekin River system, stream residence time is estimated at 15 days (Brown 1984). In order to estimate the number of fish in the left and right tails of the AUC curve, the spawning escapement period start and end dates were fixed at August 15th for the beginning of the spawning migration and November 5th for the end of the migration. These dates were developed based on information from historical Chelan PUD and NPS kokanee spawning survey data for Company and Blackberry Creeks in the Stehekin River drainage.

Table 1. Stehekin River mainstem reach locations and depositional reaches selected for kokanee spawning surveys in 2010.

Section	River km	Type of reach	Reaches selected for survey
1	0-0.5	Depositional	
1	0.5-1	Depositional	X
1	1-1.5	Depositional	
1	1.5-2	Depositional	X
1	2-2.5	Transport	
1	2.5-3	Transport	
1	3-3.5	Depositional	X
1	3.5-4	Depositional	
2	4-4.5	Depositional	X
2	4.5-5	Depositional	
2	5-5.5	Depositional	
2	5.5-6	Depositional	X
2	6-6.5	Transport	
2	6.5-7	Transport	
2	7-7.5	Depositional	
2	7.5-8	Depositional	X
3	8-8.5	Depositional	
3	8.5-9	Depositional	X
3	9-9.5	Depositional	
3	9.5-10	Depositional	X
3	10-10.5	Depositional	X
3	10.5-11	Depositional	
3	11-11.5	Transport	
3	11.5-12	Transport	
4	12-12.5	Transport	
4	12.5-13	Transport	
4	13-13.5	Depositional	X
4	13.5-14	Depositional	
4	14-14.5	Depositional	X
4	14.5-15	Depositional	X
4	15-15.5	Depositional	
4	15.5-16	Depositional	

Results

Side channel fish counts

2000 Survey

A total of 33,050 kokanee were counted during the three survey periods in 2000 (Table 2). The majority of the total kokanee counted (84.9%) were observed in the Blackberry (FS#16 and 19) and Company Creek (FS#25 and 28) side channel locations and a left bank side channel (FS#22) located adjacent to the inlet end of the Blackberry side channel complex. Significant numbers of kokanee were also observed in two lower Stehekin side channels (FS#1 and FS#4; 2502 fish) and the furthest upstream side channel sampled (FS#43, RKM13.5; 1076 fish). Peak kokanee counts occurred during the September 23-25 survey with exception of FS#22 that peaked during the October 8-10 sample period.

Table 2. Stehekin River side channel kokanee and Chinook salmon counts by fish sample segment number (FS No.), distance surveyed, and Stehekin mainstem river kilometer (RKM) and bank location, September and October, 2000.

		Kokanee Live Count				Chinook Live Count				
FS No.	Survey Dist. (m)	9/14	9/25	10/10	Tot.	9/12	9/24	10/10	Tot.	RKM/ Bank
1	591	206	870	543	1619	5	0	0	5	0-2 LB
4	533	327	370	186	883	1	0	1	2	2-4 RB
7	218	0	53	174	227	0	0	0	0	2-4 RB
10	397	98	81	55	234	3	17	18	38	4-6 LB
16[1]	456	2088	4103	3789	9980	3	5	3	11	4-6 RB
19[1]	456	940	2381	1632	4953	0	0	0	0	4-6 RB
22	533	869	950	1297	3116	0	0	0	0	4-6 LB
25[2]	480	1231	2968	1075	5274	1	0	1	2	6-8 RB
28[2]	510	777	1973	1981	4731	0	0	0	0	6-8 RB
31[2]	509	0	0	0	0	0	0	0	0	8-10 RB
34[2]	457	0	0	0	0	0	0	0	0	8-10 RB
37	342	0	0	366	366	0	0	0	0	8-10 LB
40	193	205	254	132	591	0	0	0	0	10-12 LB
43	517	87	902	87	1076	0	0	0	0	12-14 RB
Total	6171	6828	14905	11317	33050	13	22	23	58	

[1]Blackberry Creek fish sample segments.

[2]Company Creek fish sample segments.

A total of 58 Chinook salmon were also observed in the 2000 surveys. The majority of the Chinook salmon observed (38) were in FS#10 located near RKM5. Chinook salmon were not observed in sample segments located more than 8 RKM from the mouth of the Stehekin River.

2010 Survey

A total of 49,614 kokanee and 16 Chinook salmon were counted during the four survey periods in 2010 (Table 3). Kokanee returning to Company Creek (FS#RB18-30) accounted for 76.5% of the total fish observed and fish returning to Blackberry Creek (FS#RB6-15) accounted for 14.9% of the total. Significant numbers of spawning kokanee were also observed in a left bank side channel (FS#LB7; 3523 fish) located near Stehekin RKM9. Peak counts for most of the sample reaches occurred sometime between the middle and end of September with the exceptions of FS#RB27 and FS#LB7 where the highest counts occurred during the August 30 to September 1 fish survey.

Table 3. Stehekin River side channel kokanee and Chinook salmon counts by fish sample segment number (FS No.) and bank location, distance surveyed, and Stehekin mainstem river kilometer (RKM), September and October, 2010.

		Kokanee Live Count					Chinook Live Count					
FS No.	Survey Dist. (m)	9/1	9/14	9/30	10/14	Tot.	9/1	9/14	9/30	10/14	Tot.	RKM
RB 3	161	36	24	8	4	72	0	0	3	1	4	2-4
LB 1	255	5	4	43	2	54	0	0	0	0	0	4-6
LB 4	250	96	113	246	116	103	0	0	1	0	1	4-6
RB 6[1]	250	679	700	1413	989	3781	0	0	0	0	0	4-6
RB 9[1]	290	465	1100	574	378	2517	0	0	0	0	0	4-6
RB 12[1]	217	64	210	513	129	916	0	0	0	0	0	4-6
RB 15[1]	210	59	95	19	7	180	0	4	0	0	4	4-6
RB 18[2]	240	2548	4640	2282	966	10436	0	0	0	0	0	6-8
RB 21[2]	240	1570	5020	4450	1211	12251	0	0	4	0	4	6-8
RB 24[2]	240	632	1640	2370	859	5501	0	0	0	0	0	6-8
RB 27[2]	282	3900	2361	2407	580	9248	0	0	1	1	2	6-8
RB 30[2]	203	36	288	164	29	517	0	0	0	0	0	6-8
LB 7	235	1385	895	1078	165	3523	0	0	1	0	1	8-10
LB 9a	30	0	6	9	2	17	0	0	0	0	0	8-10
LB 9b	250	17	6	43	0	66	0	0	0	0	0	10-12
Total	3353	11456	17102	15619	5437	49614	0	4	10	2	16	

[1]Blackberry Creek fish sample segments.

[2]Company Creek fish sample segments.

Mainstem Stehekin River fish counts, 2010

A total of 27,872 kokanee and two Chinook salmon were counted at the twelve 500m survey sections of the Stehekin River mainstem during the late summer and fall of 2010 (Table 4). Very few kokanee were observed in the lower 3 kilometers of the Stehekin mainstem and total counts of kokanee were the highest in the 7.5-8 RKM survey reach (8187 fish). Over one half of the total fish counted (53%) were observed in upstream mainstem survey reaches located between RKM 9.5 and 15. Peak counts in two of these reaches (RKM 9.5-10 and 14-14.5) occurred during the first survey period. Peak counts for other reaches occurred mostly during the September 14-15 survey period.

Table 4. Stehekin River mainstem kokanee counts by river kilometer (RKM) sample reaches, August 31 – October 14, 2010.

	Kokanee Live Count				
Mainstem RKM	**8/31-9/2**	**9/14-9/15**	**9/27-9/30**	**10/12-10/14**	**Total**
0.5-1	1	11	9	5	26
1.5-2	0	10	1	5	16
3-3.5	22	273	71	60	426
4-4.5	458	920	22	9	1409
5.5-6	169	214	935	130	1448
7.5-8	1281	6150	713	43	8187
8.5-9	323	206	796	225	1550
9.5-10	1950	1247	120	33	3350
10-10.5	1715	1891	285	98	3989
13-13.5	326	333	59	24	742
14-14.5	1342	1098	363	187	2990
14.5-15	1100	1315	890	434	3739
Totals	8687	13668	4264	1253	27872

Distribution of kokanee spawning

Kokanee density (no/m) for mainstem and side channel sample segments by Stehekin River location in kilometers from the river mouth is shown in Figure 2. Kokanee density values were determined using the season totals divided by the total survey distance in each sample segment. The early sample for the 2010 side channel survey was not included in order to facilitate comparison with the 2000 side channel survey.

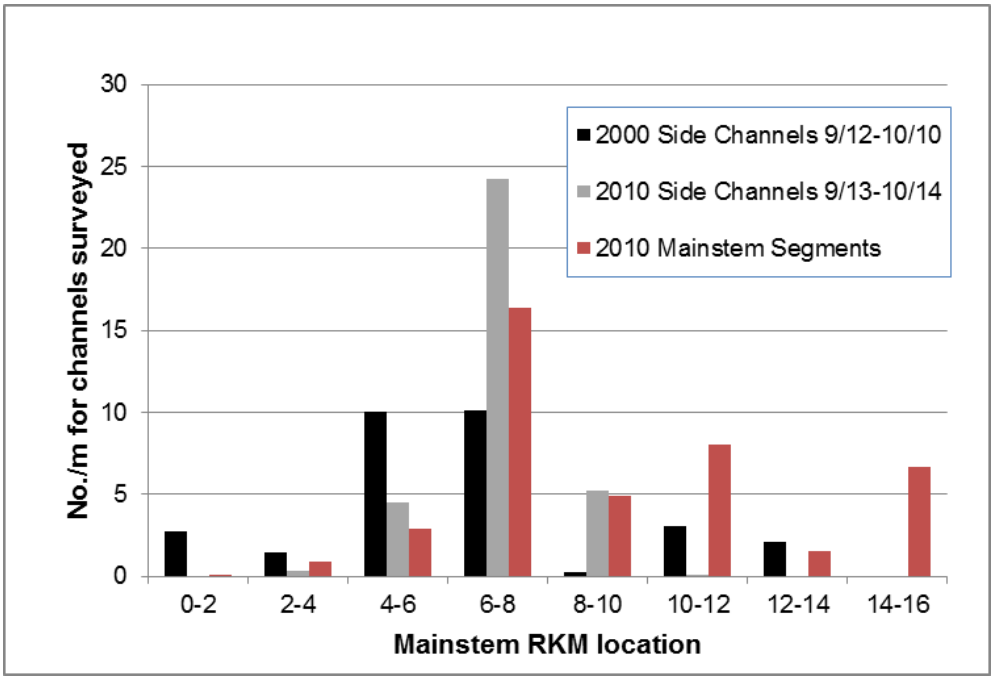

Figure 2. Kokanee density (no/m) by Stehekin River kilometer for mainstem reaches and side channels sampled in 2000 and 2010.

In 2000, kokanee were observed in side channels in every RKM segment except the unsampled RKM 14-16 location (Figure 2). Kokanee density was greatest in side channels originating in RKM 4-6 and 6-8 during the 2000 survey. During the 2010 survey kokanee were observed in RKM segments 2-4, 4-6, 6-8, and 8-10. In 2010, fish sample segments were not selected for RKM 0-2, 12-14, and 14-16 and no fish were observed in RKM 10-12. Kokanee density in 2010 was greatest in side channels originating in RKM 6-8 followed by upstream reaches at RKM 10-12, 14-16 and 12-14, respectively (Figure 2).

Overall the greatest densities of kokanee in side channels were observed in the 4-6 and 6-8 RKM sections. These two sections correspond with the Blackberry Creek and the lower and middle sections of the Company Creek side channel complex, respectively. Kokanee escapement in these two streams accounts for the majority of the total escapement in the Stehekin River. Density of kokanee in Blackberry Creek was higher in 2000 than in 2010. The reverse pattern was observed in Company Creek (RKM 6-8) where kokanee density was much higher during the 2010 survey (10.1 fish/m in 2000 and 24.3/m in 2010). The lower density of kokanee in Blackberry Creek during the 2010 survey is likely the result of the record flood that occurred on Oct. 20, 2003 (26,000 cfs) and another severe flood occurring on Nov. 3, 2006 (19,000 cfs). The effects of habitat alteration from these floods appear to have had a long-lasting impact on kokanee escapement in Blackberry Creek. Figure 3 shows a decline in the Blackberry Creek proportion of the combined kokanee escapement for both Blackberry and Company creeks following the 2003 flood.

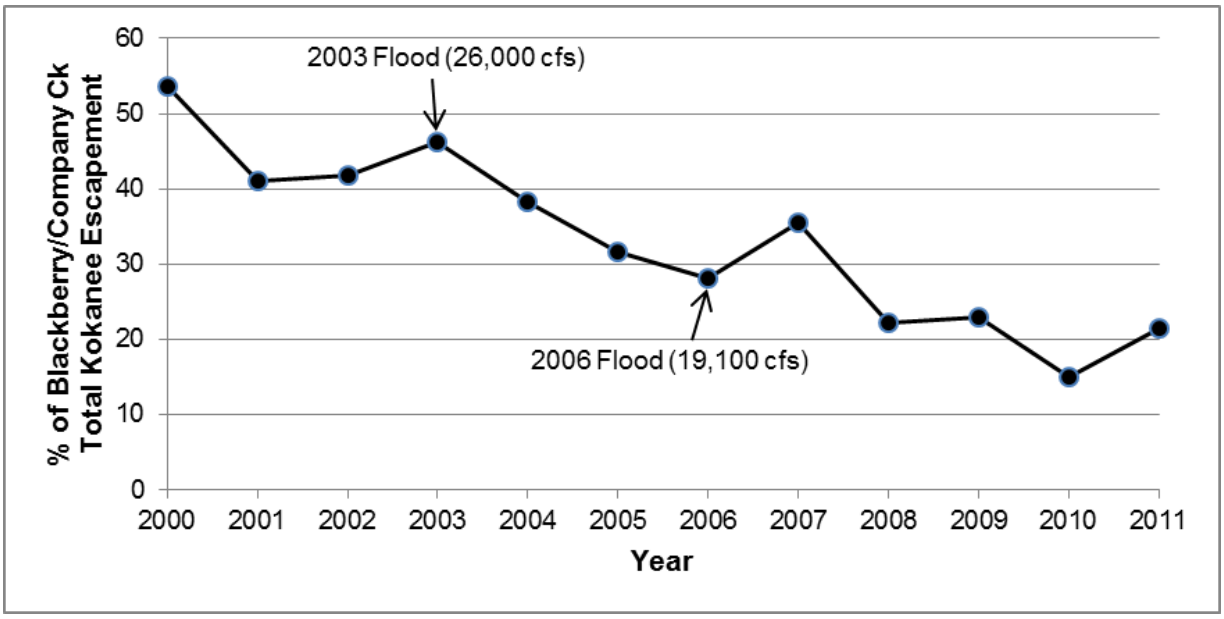

Figure 3. Blackberry Creek kokanee component percentage of the total escapement in Company and Blackberry creeks, 2000-2011 (escapement data from Keesee et al. 2009 and 2010, Keesee and Keller 2012).

Kokanee escapement estimates

2000 Survey

Kokanee escapement estimates for Stehekin River side channels sampled in 2000 and 2010 are shown in Figures 4 and 5. During the 2000 survey, 6.8 km of the 19.8 km of suitable side channel habitat in the lower 17 km of Stehekin River was sampled. The estimated number of fish in the sample using the AUC method was 37,716 and the extrapolated total side channel escapement was 120,447 fish (Figure 4).

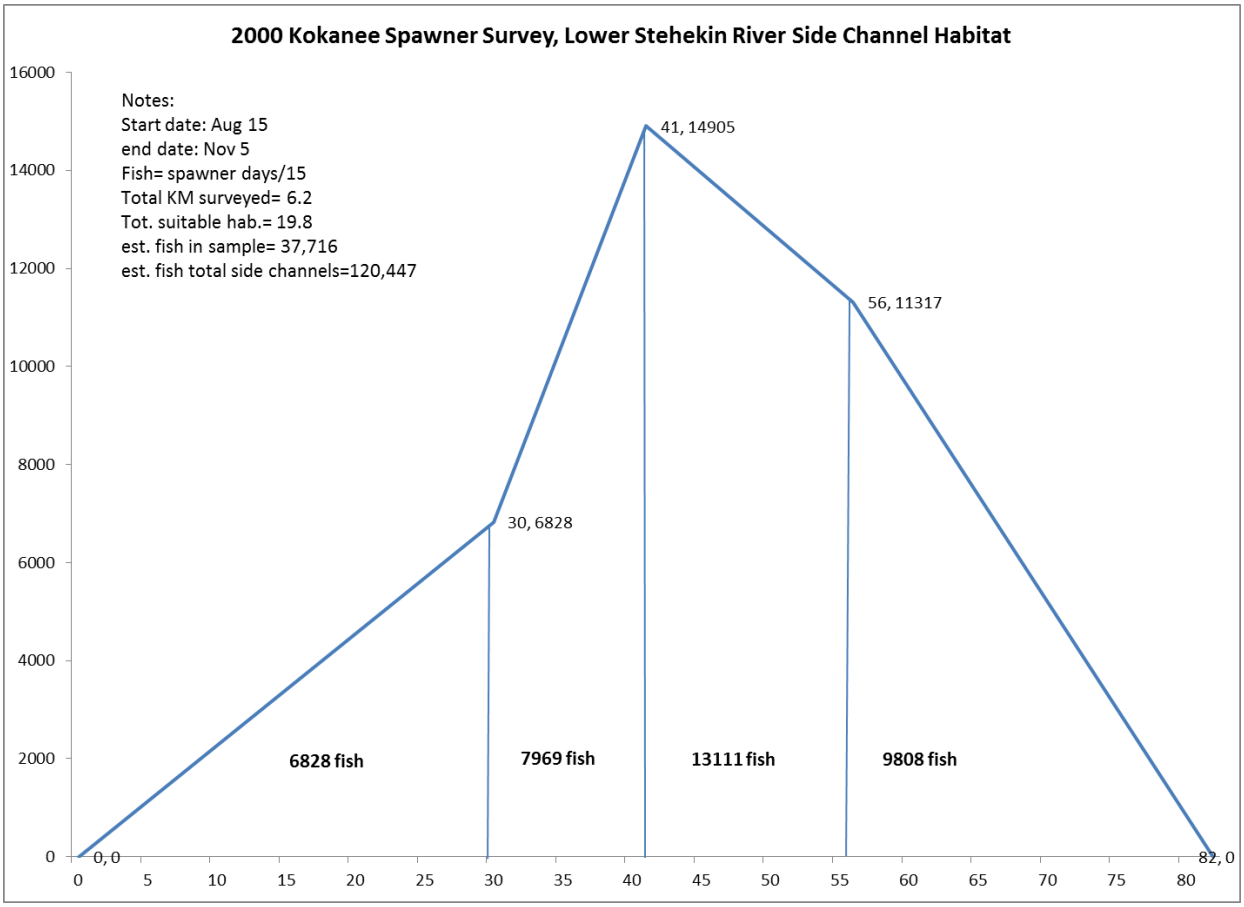

Figure 4. Kokanee AUC escapement estimate for Lower Stehekin River side channel habitat during 2000.

2010 Survey

During the 2010 survey, 3.4 km of the 9.6 km of suitable side channel habitat in the lower 14 km of Stehekin River was sampled. The estimated number of fish in the sample using the AUC method was 50,168 and the extrapolated total side channel escapement was 141,651 fish (Figure 5).

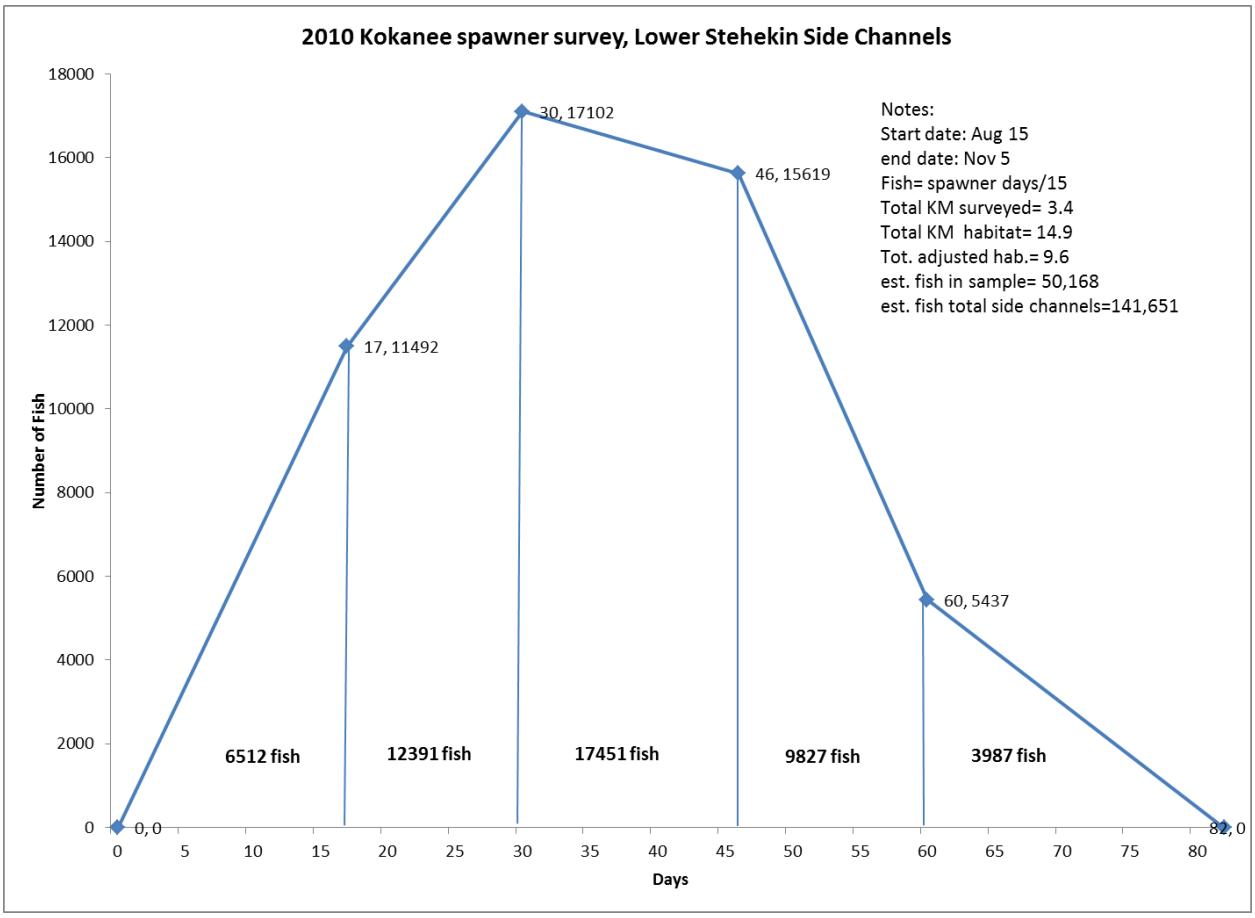

Figure 5. Kokanee AUC escapement estimate for Lower Stehekin River side channel habitat during 2010.

Six of the 12 km of suitable Stehekin River mainstem depositional zone habitat was sampled. The estimated number of fish in the sample using the AUC method was 26,906 and the extrapolated total mainstem escapement was 53,812 fish (Figure 6). The 2010 combined escapement for side channel and mainstem habitat was 195,463 fish.

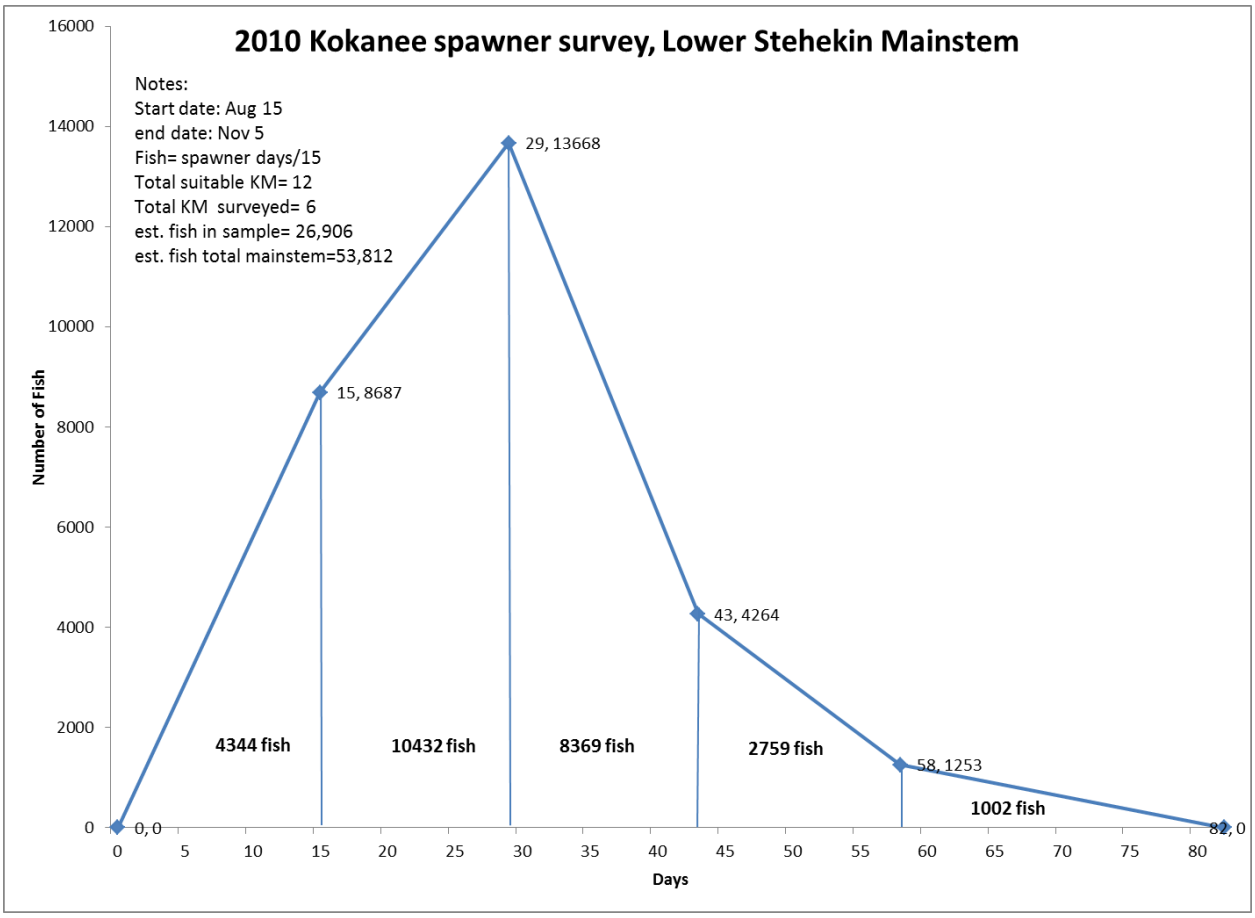

Figure 6. Kokanee AUC escapement estimate for Lower Stehekin River mainstem habitat during 2010.

Discussion

Kokanee are managed in Lake Chelan through a number of methods including stocking hatchery raised kokanee fry, setting recreational creel limits, and trapping adult kokanee for egg collection and artificial spawning. Prudent management of this species requires that managers are able to establish population densities sufficient to provide a robust recreational fishery and escapement numbers sufficient to maintain target densities through natural reproduction.

Annual Chelan PUD surveys in Blackberry and Company creeks were initiated in 1984 and have established an index of kokanee escapement which may be used to infer a total escapement estimate for the Stehekin River. The 2000 and 2010 NPS expanded kokanee surveys represent an initial effort at providing data for developing calibration curves to extrapolate annual Chelan PUD index counts to obtain a total escapement estimate for the Stehekin River. However, several more expanded surveys may be required to develop a meaningful calibration curve. The initial two expanded surveys provide a representation of escapements during years with relatively large run sizes. Kokanee combined escapement for Blackberry and Company Creeks during 2000 and 2010 were the 4th and 5th largest runs over a twelve year period between 2000 and 2011 (Keesee et al. 2009, Keesee and Keller 2012). Development of calibration curves should include expanded survey data representing years with low or moderate returns. It is expected that a total of at least five years of expanded side channel and mainstem spawning surveys would be necessary to correlate index site escapement with total Stehekin kokanee escapement.

The total distance of suitable side channel habitat for kokanee spawning in 2000 was 19.8 km, while in 2010 only 9.6 km were deemed suitable. A significant part of this discrepancy can be accounted for by differences in survey areas included in the 2000 and 2010 sample frames. Most of the differences in the side channel survey areas occurred upstream of Stehekin River Kilometer 8 (RKM 8). Habitat surveys in 2000 included left bank (LB) side channels located between RKM 0 and 17 and right bank (RB) side channels between RKM 0 and 16. In 2010, LB surveys included side channel habitat located between RKM 0 and 14 and RB habitat between RKM 0 and 8. These differences accounted for a total of approximately 5.5 km of the discrepancy between the total amounts of suitable habitat for the two survey years.

The discrepancy between total suitable side channel habitat in 2000 and 2010 may also be attributed to impacts of severe flooding that occurred between the two sample periods, resulting in deposition of silt and sand and alteration of flow regimes. Flooding impacts are more likely to affect the lower river side channels and some evidence for this can be seen in changes in lower Blackberry Creek (RKM 4 to 5) and the lower Stehekin mainstem (John Riedel, personal communication, December 11, 2010). Potential flood related changes can also be examined by comparing the percentages of the total side channel habitat surveyed in RKM 0 to 4 that was considered unsuitable and excluded from 2000 and 2010 sample frames. Although similar amounts of side channel habitat in RKM 0 to 4 were surveyed in both years (3.5-3.8 km), only 13% of the habitat was considered suitable for kokanee in 2010 while 75% of the habitat was considered as suitable during the 2000 survey. Another factor that may contribute to the discrepancy between total suitable habitat surveyed in 2000 and 2010 could be

related to variation in the interpretation of what can be considered as ”suitable habitat” from one survey to the next. A specific definition for “suitable kokanee side channel habitat” should be developed. In addition, sampling error attributed to observer bias should be evaluated in future surveys.

Chinook salmon were first stocked in Lake Chelan by the WDFW from 1974 to 1978. No stocking occurred from 1979 to 1989, but the program was reinstated from 1990 to 2001 (Viola 2001). From 2002 until the present all Chinook salmon stocked in Lake Chelan are triploid and thus unable to reproduce. The sexually viable Chinook salmon planted in Lake Chelan from 1974 to 2002 have established a naturally reproducing population in the Stehekin River, and during the 2000 and 2010 kokanee surveys several observations of spawning Chinook salmon were made. While triploid Chinook salmon may exhibit spawning activities, the verification of a naturally reproducing Chinook salmon population in the Stehekin River has been evidenced by numerous observations of Chinook salmon fry during side channel snorkel surveys.

A peak count of spawning Chinook salmon in 2000 was made on October 10 and consisted of 23 fish, with a total count for the duration of the survey of 58 fish. In 2010 a peak count of spawning Chinook salmon was made on September 30 and consisted of 10 fish, while the total count for 2010 was 16 fish. The 2010 survey appeared to include the peak of the Chinook salmon run, while the peak count in 2000 was on the final survey date and may not represent the true peak of spawning fish. Kokanee expanded spawning surveys offer an opportunity to collect valuable information on Chinook salmon spawning for future fish management decisions. Additional information regarding stream residence time and run duration would be necessary to calculate Chinook salmon escapement.

In 2010, NPS personnel noted kokanee spawning upstream of the established survey boundary in the vicinity of High Bridge at the bottom of Tumwater Canyon. Future expanded surveys should include both mainstem and side channel habitat, and should proceed upstream as far as the bottom of Tumwater canyon (RKM 18). Interpretation of changes in fish distribution would be improved by using a spatially balanced fish survey segment sample selection procedure that would maximize representation of kokanee and Chinook salmon abundance in side channel and mainstem habitat throughout the extent of the survey area.

Three fish sample periods were completed in the 2000 survey and four sample periods were completed in 2010. Kokanee and Chinook salmon abundance and distribution information can be improved by completing at least four surveys spaced at approximately two week intervals from early September through mid-October. If a fifth survey were added in late October the peak of Chinook salmon spawning would likely be included (2010 peak on 9/30 and 2000 assumed peak on 10/10) allowing calculation of AUC escapement estimates.

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Appendix A. Longitudinal change in mean diameter of channel gravels along the lower Stehekin River.

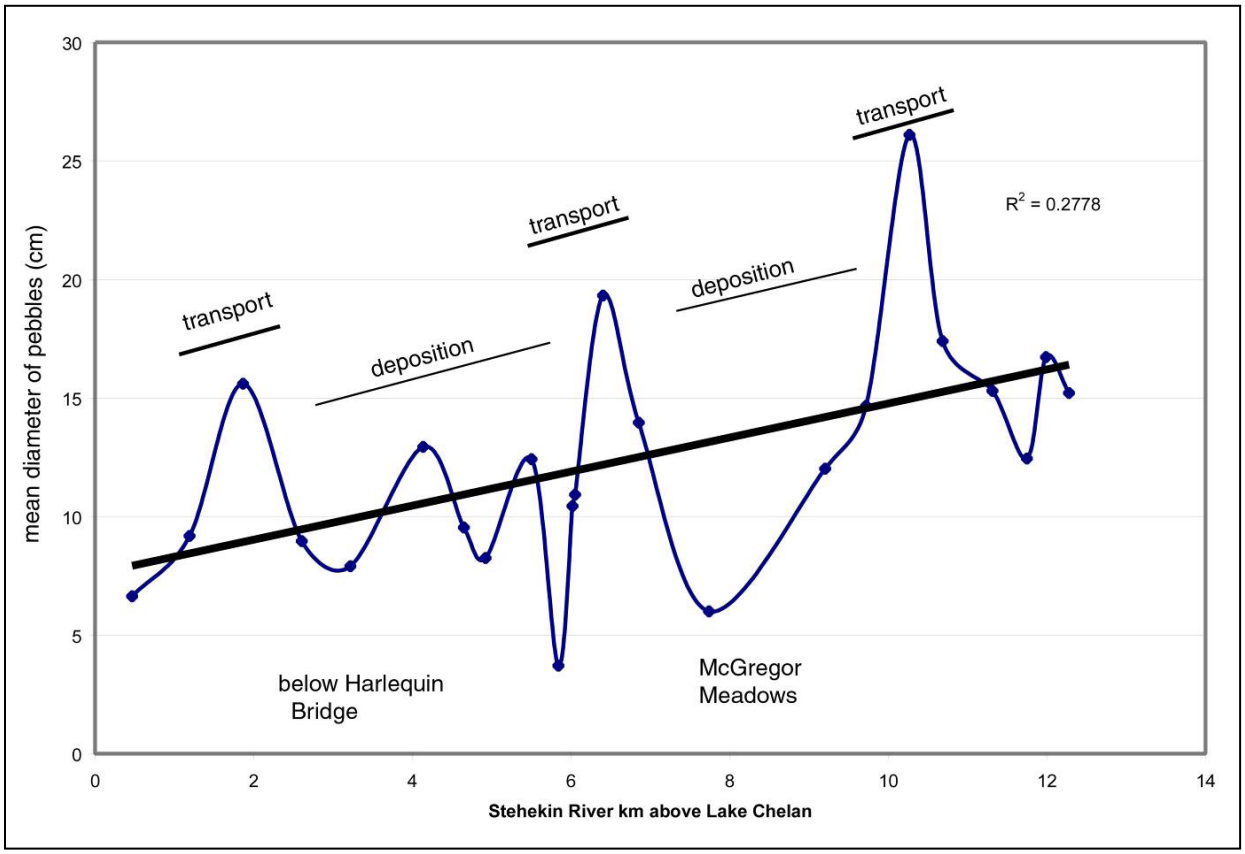

Figure A.1. Change in mean diameter of channel gravels along a longitudinal gradient in the Stehekin River, Washington. From Riedel (2008).

Appendix B. Stehekin River side channel habitat survey data, 2000 and 2010.

Table B.1. 2000 Stehekin River side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Lgth. (m)	Width (m)	Max Depth (m)	Pool %	Substrate
S1	ns	RB 0-2	250	1.2-12	1.2	70	sd/st
S2	ns	RB 0-2	Dry				sd/st
S3A	1	RB 0-2	135	2.1-6.7	0.8	77	co/gr/st
S3B	ns	RB 0-2	Dry				
S4	1	LB 0-2	456	3-10	0.9	38	gr/gr
S5	2	RB 0-2	305	1.5-6.8	1.4	73	gr/co/sd
S6	3	LB 0-2	300	3-10	1.1	51	gr/gr
S7(0-533)	4	RB 2-4	533	2.9-9.8	2	17	gr/co/sd
S7(0-1066)	5	RB 2-4	533	2.9-9.8	2	17	gr/co/sd
S8A	6	RB 2-4	505	6-17	1.3	47	gr/co/sd
S8D	7	RB 2-4	218	3-7	1.2	30	gr/gr
S8B	8	RB 2-4	99	8-12	1.2	75	sd/gr
S8C	8	RB 2-4	39	4-6	1.2	100	gr/sd
S10	9	LB 2-4	443	1.5-4	1.3	56	sd/st/gr
S11(0-376)	10	LB 4-6	376	11-25	1.8	43	sd/co/gr
S11(376-773)	11	LB 4-6	397	11-25	1.8	50	sd/co/gr
S13A	12	LB 4-6	355	2-8	0.9	44	gr/sd/co
S13B	12	LB 4-6	103	3-5	0.9	32	sd/gr
S15A-D	13[3]	LB 4-6	149	2-6	1	35	gr/sd
S14B(0-423)	14	RB 4-6	423	2.5-25.3	2	51	gr/sd/co
S14B(423-846)	15	RB 4-6	423	2.5-25.3	2	51	gr/sd/co
S14B2	15	RB 4-6	81	2.5	0.5	100	sd/gr
S14A(0-456)	16	RB 4-6	456	6.2-14.1	1.6	26	gr/co
S14B1	17	RB 4-6	582	2.5-8.5	1.1	72	gr/sd/co
S14A(456-912)	18	RB 4-6	456	6.2-14.1	1.6	26	gr/co
S14A(912-1368)	19	RB 4-6	456	6.2-14.1	1.6	26	gr/co
S14A1	ns	RB 4-6	107	.5-5.3	0.6	93	st/sd
S14A2	ns	RB 4-6	173	1.2-4.3	1.5	79	sd/st
S14A3	ns	RB 4-6	82	1.8-4.9	1.1	47	sd/st
S14A4	20	RB 4-6	26	6.5	0.6	0	gr/gr
S14A4a	20	RB 4-6	224	1.8-5.8	0.8	63	gr/co
S14A5	20	RB 4-6	38	3.6	0.8	0	gr/co
S14A6	20	RB 4-6	103	2.5-6	0.9	82	gr/co
S16	21	RB 4-6	349	8-18	1.5	37	co/gr
S18	21	RB 4-6	97	5-8.5	1.3	51	sd/co/gr
S17A	22	LB 4-6	533	4-14	1.6	43	gr/co
S17B	23	LB 4-6	178	1.5-4	0.7	49	gr/sd/co
S19A(0-465)	24	RB 6-8	465	1.1-20	1.6	52	gr/sd/co
S19A1	24	RB 6-8	59	8	0.8	100	gr/co
S19B	25	RB 6-8	480	5-11.5	1.4	36	gr/co/sd
S19B1	25[3]	RB 6-8	41	5	0.5	0	gr/sd
S19C	ns	RB 6-8	96	9	0.5	100	st/sd

Table B.1. 2000 Stehekin River side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey) (continued).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Lgth. (m)	Width (m)	Max Depth (m)	Pool %	Substrate
S19E	26	RB 6-8	355	1.9-5.5	0.8	57	gr/co
S19E2	26	RB 6-8	32	2	0.2	0	gr/co
S19E3	26	RB 6-8	14	1	0.4	0	gr/co
S19E4	26	RB 6-8	81	4	0.5	100	gr/sd
S19A(465-930)	27	RB 6-8	465	1.1-20	1.6	52	gr/sd/co
S19D	27	RB 6-8	130	3-7	0.6	22	gr/sd
S19A(930-1395)	28	RB 6-8	465	1.1-20	1.6	52	gr/sd/co
S19G	28	RB 6-8	45	2.1-4	0.5	36	gr/co
S19A(1395-1860)	29	RB 8-10	465	1.1-20	1.6	52	gr/sd/co
S19H	29	RB 8-10	121	2.8	0.2	0	gr/co
S19F(0-509)	30	RB 8-10	509	1-15	2	59	gr/co
S19F1	30	RB 8-10	10	1.4	0.2	0	gr/co
S19F2	30	RB 8-10	30	2.1-4.8	0.5	100	gr/sd/co
S19F(509-1018)	31	RB 8-10	509	1-15	2	59	gr/co
S19I(0-457)	32	RB 8-10	457	1-13	1.5	76	sd/gr/co
S19I(457-914)	33	RB 8-10	457	1-13	1.5	76	sd/gr/co
S19I(914-1371)	34	RB 8-10	457	1-13	1.5	76	sd/gr/co
S19J	ns	RB 8-10	53	2.5	0.8	100	sd/gr
S19K	ns	RB 8-10	54	2	0.3	100	sd
R2S1	35	LB 8-10	121	3.5-12	2.9	76	sd/co
R2S2	35	LB 8-10	298	2.7-11	1.1	30	gr/sd/co
S102N	36	LB 8-10	90	2.5-5.5	0.5	21	co/sd/gr
S106N	36	LB 8-10	154	4.5-14.6	1.3	42	co/sd/gr
S101N	37	LB 8-10	342	4-11.5	0.7	25	co/gr/sd
S103N	37[3]	LB 8-10	97	2-2.5	0.4	27	co/sd/gr
S104N	38	LB 8-10	515	1-8	1.2	49	gr/co/sd
S105N	38	LB 8-10	31	3-16.6	0.5	71	gr/sd/co
S107N(0-475)	39	LB 8-10	475	3.5-9	1.4	19	co/gr/bd
S107N(475-633)	40	LB 10-12	158	3.5-9	1.4	19	co/gr/bd
S108N	40[3]	LB 10-12	216	1-4	1.1	32	co/gr
S109N	40[3]	LB 10-12	30	2	0.5	0	co/gr
S110N	40	LB 10-12	35	1.5	0.2	0	gr/gr
S110S	41	RB 10-12	322	4.1-8.5	1.4	18	co/gr
S111S	42	RB 12-14	431	.7-9.2	1.5	49	gr/co
S112S	42	RB 12-14	142	.5-3.3	0.8	62	sd/gr
S113S	42	RB 12-14	31	4.7	0.4	0	co/gr
S114S	42	RB 12-14	23	.9	0.1	0	gr/sd
S115S	42	RB 12-14	46	.8	0.4	0	sd/gr
S118S	43	RB 12-14	394	6-15	2	59	co/gr/bd
S119S	43	RB 12-14	65	4.9	0.7	0	bd/co
S120S	43	RB 12-14	58	5.6	0.8	0	co/gr
S116S	44	RB 12-14	168	5.5-13	1.3	0	bd/co
S117S	44	RB 12-14	108	8.5	1.3	100	sd/gr
S121S(0-180)	45	RB 12-14	180	10-18	1.5	9	co/gr
S122S	45	RB 12-14	97	1.3-4.5	0.9	17	gr/co
S123S	45	RB 12-14	48	4.5	1.2	0	gr/co

Table B.1. 2000 Stehekin River side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey) (continued).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Lgth. (m)	Width (m)	Max Depth (m)	Pool %	Substrate
S121S(180-550)	46[3]	RB 12-14	370	10-18.4	1.5	9	co/gr
S126S AND S127S	46[3]	RB 14-16	86	1-4	0.9	28	co/sd/gr
S111N	47	LB 12-14	519	1.4-6	1.1	41	co/gr/sd
S112N	47	LB 12-14	86	1.5-7	0.9	58	sd/co
S113N	48	LB 14-16	154	3.5-7	1.5	27	co/gr
S114N	48	LB 16-18	229	17	na	0	bd/co

[1]Habitat survey side channel segment number (downstream to upstream distance in meters).

[2]Kokanee sample segment numbers. Segments deleted from sample frame during habitat surveys designated as 'ns' (dry to very shallow and/or poor substrate).

[3]Selected sample segments deleted during the initial kokanee survey (dry or very shallow).

[4]Location of side channel segments in relation to mainstem Stehekin River km (RKM) distances. Left and right banks (LB,RB) of mainstem designated by looking downstream.

Table B.2. 2010 Stehekin River left bank (LB) side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Length (m)	Width (m)	Max Depth (m)	Pool %	Substrate
1(0-333)	ns	0-2	333	na	0.0	na	na
2(0-433)	ns	0-2	433	1-9	0.7	38.6	st/co/sd
3(0-33)	ns	0-2	33	.5-2.2	0.6	45.8	sd/st
4(0-165)	ns	2-4	165	.3-7	0.8	75.9	sd/st
5(0-41)	ns	2-4	41	0.3	0.2	0	st/sd
6 (0-105)	ns	4-6	105	8-10	1.3	39.1	sd/st
6(105-360)	1	4-6	255	4.8-21.5	1.5	28.5	gr/co/sd
6(360-458)	ns	4-6	98	5-16.9	1.8	26.2	sd/st
6(458-498)	2	4-6	40	16.2	0.7	0	sd/st
6(498-600)	ns	4-6	102	10.3-18.4	1.8	100	sd/st/co
6(600-710)	2	4-6	110	8-12.4	1.2	18.9	co/gr
7(0-50)	2	4-6	50	3.8	0.5	0	gr/sd
7 (50-92)	ns	4-6	42	2.8-5.5	0.7	91.4	sd/st/gr
8(0-34)	ns	4-6	34	1.3-3.4	0.8	40.1	sd/st
9(0-30)	ns	4-6	30	2.2	0.1	0	st/sd
10(0-165)	3	4-6	165	2.6-7.2	0.5	19.2	sd/gr
11(0-150)	4	4-6	150	3.1-4.8	0.3	41	gr/sd
11(153-292)	ns	4-6	139	1.2-5.1	2.4	62.3	st/sd
12(0-45)	ns	4-6	45	1.2-3.5	0.8	86.9	st/co
13(0-115)	ns	4-6	115	12	2.3	0	st/sd
13(115-215)	4	4-6	100	11-13	0.8	28	co/gr
13(215-420)	5	4-6	205	3.3-6	0.9	12.9	co/gr
14(0-46)	ns	4-6	46	5.6	0.7	0	st/sd
15(0-85)	6	6-8	85	3.9	0.4	0	st/sd
15(85-100)	ns	6-8	15	2.7	0.3	100	st/sd
15(100-145)	6	6-8	45	2.2	0.1	0	st/co
15(145-163)	ns	6-8	18	1.2-2.4	0.4	24.4	st/sd
16(0-12)	ns	6-8	12	9	0.8	0	co/gr
17(0-100)	6	8-10	100	12-16.2	1.2	45	co/gr
17(100-335)	7	8-10	235	16	0.9	0	sd/gr
18(0-155)	ns	8-10	155	2.5-3.8	3.1	8.4	sd/gr
18(155-180)	7[3]	8-10	25	2.5	0.1	0	co/gr
19(0-20)	8	8-10	20	1.6	0.2	0	gr/sd
19(20-33)	ns	8-10	13	2.2	0.4	100	sd/gr
20(0-30)	9	8-10	30	4.4-6.4	4.8	42.6	co/gr
21(0-155)	ns	8-10	155	.3-3.7	0.4	45.8	st/sd/co
22(0-10)	ns	10-12	10	3.8	0.5	100	co/gr
22(10-260)	9	10-12	250	1.4-6.2	6.9	48.1	gr/co/sd

Table B.2. 2010 Stehekin River left bank (LB) side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey) (continued).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Length (m)	Width (m)	Max Depth (m)	Pool %	Substrate
22(260-298)	ns	10-12	38	3.1	0.7	100	st/co
23(0-36)	10	10-12	36	1.6-1.8	0.3	7.2	co/gr
24(0-214)	10	12-14	214	14	1.0	0	co/gr
24(214-408)	11	12-14	194	7.5-11	2.5	55.2	co/gr

[1]Habitat survey side channel segment number (downstream to upstream distance in meters).

[2]Kokanee sample segment numbers. Segments deleted from sample frame during habitat surveys designated as 'ns' (dry to very shallow and/or poor substrate).

[3]Selected sample segments deleted during the initial kokanee survey (dry or very shallow).

[4]Location of side channel segments in relation to mainstem Stehekin River km (RKM) distances.

Table B.3. 2010 Stehekin River right bank (RB) side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Length (m)	Width (m)	Max Depth (m)	Pool %	Substrate
25(0-376)	ns	0-2	376	10-21	2	90.7	co/gr
26(0-110)	ns	0-2	110	10.9	2	100	co/st
27(0-248)	ns	2-4	248	20	1	0	co/gr
28(0-120)	1	2-4	120	4-7	1.2	36.7	gr/co
28(120-240)	ns	2-4	120	4-8	1.3	76.7	co/gr
28(240-360)	1	2-4	120	3.6-5	0.8	44.2	gr/co/sd
28(360-602)	2	2-4	242	2.6-4.6	1.1	21.9	gr/sd/co
28(602-1027)	ns	2-4	425	5-7	1.8	76.9	st/co/sd
29(0-167)	ns	2-4	167	17.4	1	0	st/sd
29(167-406)	2	2-4	239	8.3-24	0.92	16.9	gr/st
29(406-500)	ns	2-4	94	6-9	1.6	48.9	co/gr/st
30(0-93)	ns	2-4	93	7.5-9.5	1.8	61.2	co/st
30(93-254)	3	2-4	161	6-10	1.2	12.4	co/sd
31(0-250)	4	4-6	250	7.2-14.8	2	34.8	gr/sd
31(250-500)	5	4-6	250	11.4-12.1	1.2	10.4	sd/gr
31(500-750)	6	4-6	250	9.2-12.3	1.2	21.8	sd/gr/co
31(750-1000)	7	4-6	250	9.8-16.2	1.3	13.7	gr/co/sd
31(1000-1250)	8	4-6	250	9.8-16.2	1.2	17.6	gr/sd/co
31(1250-1540)	9	4-6	290	14-15.2	1.2	17.3	gr/sd
32(0-70)	10	4-6	70	7.5	0.8	100	gr/co
33(0-90)	10	4-6	90	5.7-6.1	0.9	16.7	sd/gr
33(90-131)	ns	4-6	41	5.7	0.8		sd/gr
34(0-102)	ns	4-6	140	3.3-5.5	0.8	17.1	sd/gr/st
34(140-343)	11	4-6	203	3.6-10	0.8	28.1	gr/sd
34(343-560)	12	4-6	217	2.1-8	0.7	29.4	gr/sd
35(0-210)	13	4-6	210	12-22	3	20.5	gr/sd
35(210-420)	14	4-6	210	12-17	2	26.7	gr/co/sd
35/36(420-630)	15	4-6	210	6.3-14	3	42.3	co/gr/sd
37(0-65)	ns	4-6	65	3-4.5	0.8	50.8	sd/gr/st
37/38(65-235)	16	4-6	170	3.2-8.6	2.5	58.2	sd/gr/co
39(235-395)	ns	4-6	60	4.8-5.5	1.1	76.7	sd/st
40(0-240)	17	6-8	240	10-20	2	11.3	gr/co
40(240-480)	18	6-8	240	7-20	1.6	24.2	gr/co
40(480-720)	19	6-8	240	12-15	1.5	15	gr/co
40(720-960)	20	6-8	240	10-12	1.1	6.3	gr/co
40(960-1200)	21	6-8	240	8-10	1.1	20.4	gr/co/sd
40(1200-1440)	22	6-8	240	13	1.3	0	gr/sd
40(1440-1680)	23	6-8	240	13	1.3	0	gr/sd
40(1680-1920)	24	6-8	240	13	1.3	0	gr/sd
40(1920-2170)	25	6-8	250	13	1.3	0	gr/sd
41(0-47)	26	6-8	47	10.1	0.9	0	gr/co
42(0-235)	26	6-8	235	13	1.5	0	co/gr

Table B.3. 2010 Stehekin River right bank (RB) side channel habitat segment survey (dark shaded rows indicate segments selected for fish survey) (continued).

Side Channel Segment No.[1]	Fish Sample Segment No.[2]	Location Stehekin RKM[4]	Segment Length (m)	Width (m)	Max Depth (m)	Pool %	Substrate
42(235-470)	27	6-8	235	14.4-15.5	1.8	28.9	gr/sd/co
43(0-47)	27	6-8	47	10.7	1	0	sd/gr
44(0-46)	28	6-8	46	6-6.3	0.9	23.9	gr/sd
45(0-103)	28	6-8	103	5.7	0.3	0	gr/co
46(0-147)	28	6-8	147	3.7-4.8	0.4	32.7	gr/co/sd
47(0-113)	29	6-8	113	9.6	1.1	0	co/gr
48(0-27)	29	6-8	27	3.5	0.5	0	co/gr
49(0-36)	29	6-8	36	4.7	0.7	0	gr/co
50(0-80)	29	6-8	80	6-8	0.8	15	co/gr
51(0-12)	30[3]	6-8	12	3	0.5	0	co/gr
52(0-10)	30[3]	6-8	10	4.5	0.5	0	co/gr
53(0-39)	30	6-8	39	6.1	0.9	0	gr/sd
54(0-129)	30	6-8	129	6	0.8	0	co/gr
55(0-35)	30	6-8	35	4.3	1.1	0	st/co
56(0-66)	ns	8-10	66	1.6-5	0.8	81.8	st/gr/co

[1]Habitat survey side channel segment number (downstream to upstream distance in meters).

[2]Kokanee sample segment numbers. Segments deleted from sample frame during habitat surveys designated as 'ns' (dry to very shallow and/or poor substrate).

[3]Selected sample segments deleted during the initial kokanee survey (dry or very shallow).

[4]Location of side channel segments in relation to mainstem Stehekin River km (RKM) distances.

Appendix C. Stehekin River side channel reaches surveyed for kokanee in 2000.

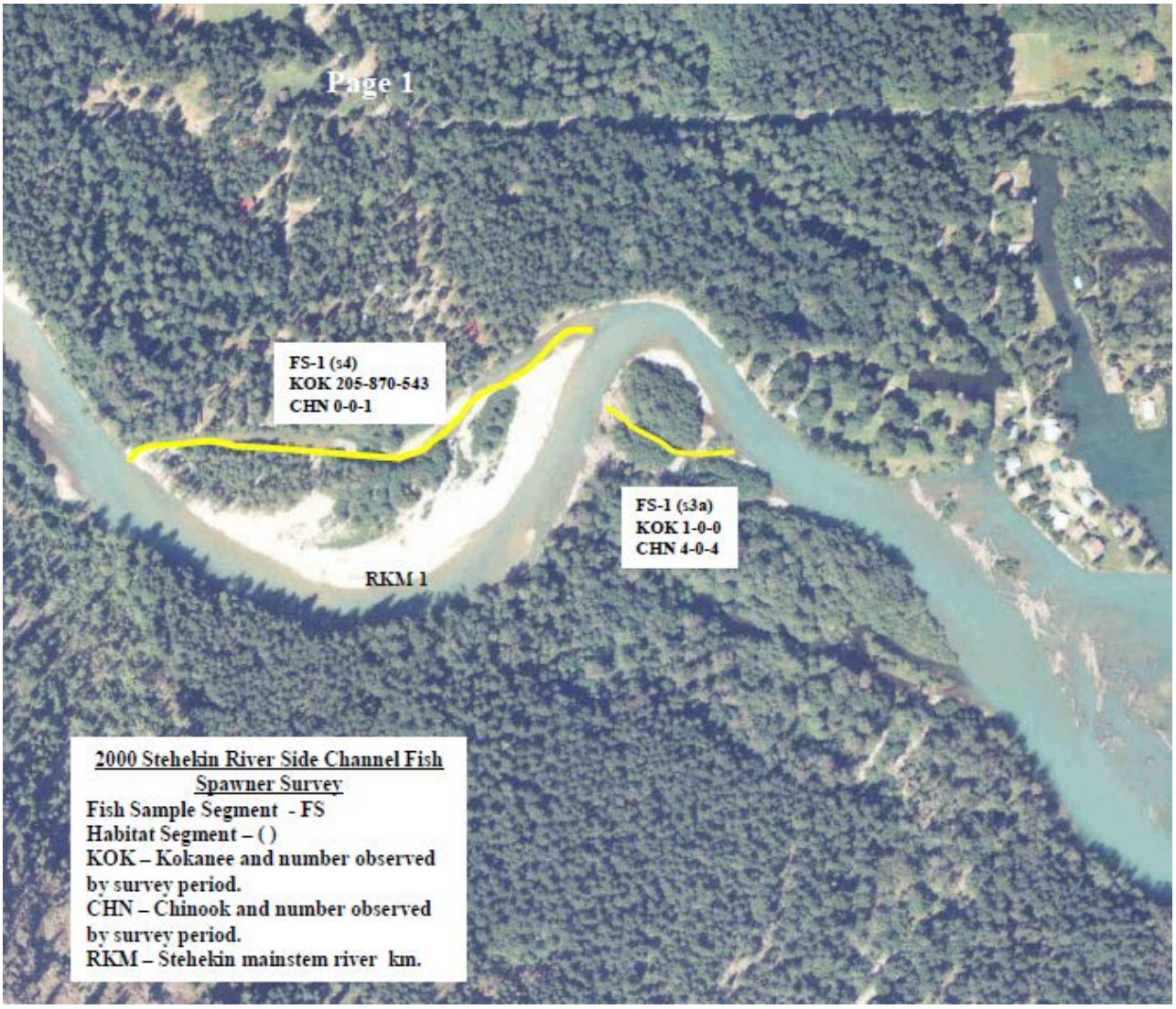

Figure C.1. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 1 of 9.

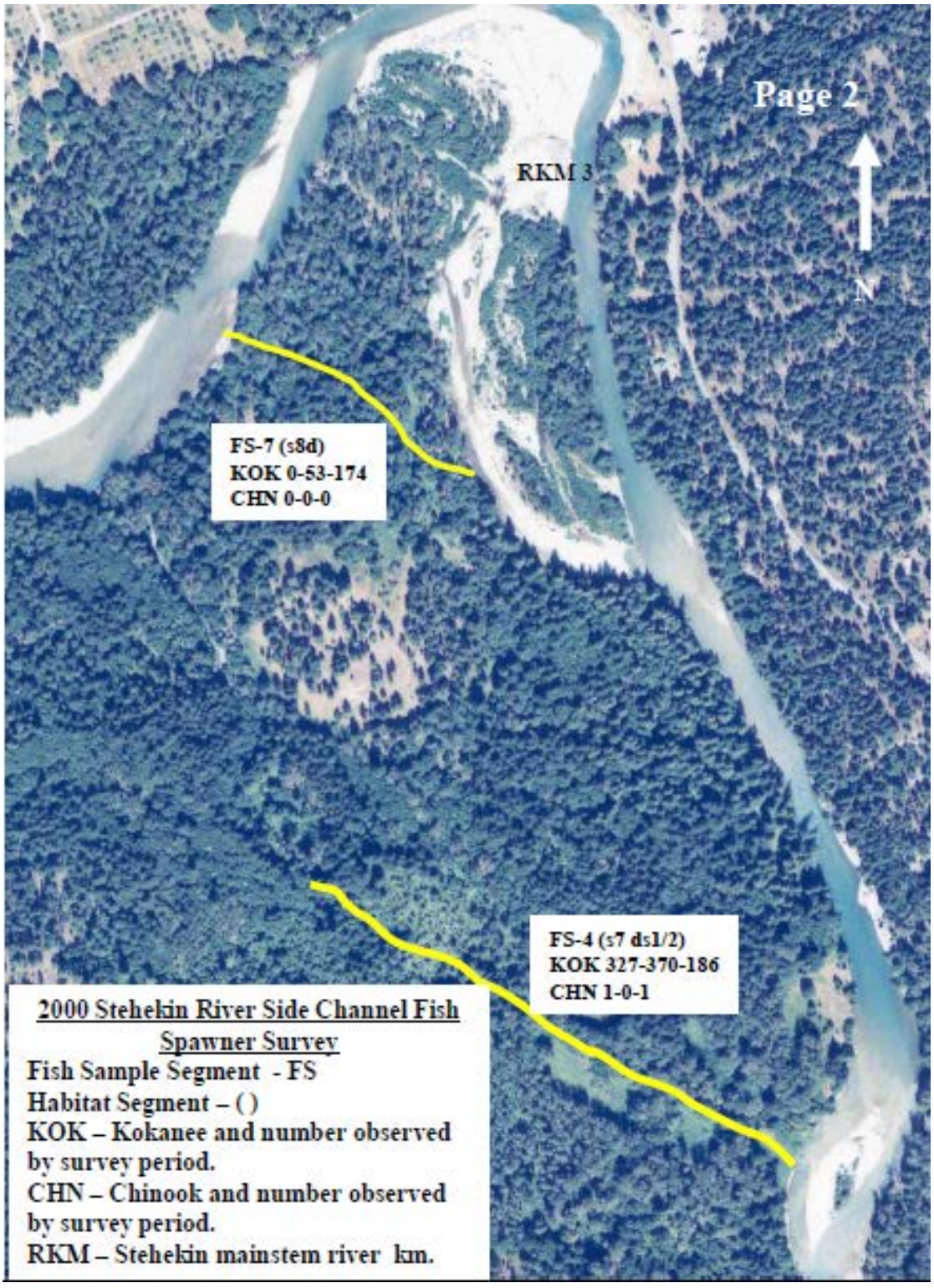

Figure C.2. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 2 of 9.

Figure C.3. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 3 of 9.

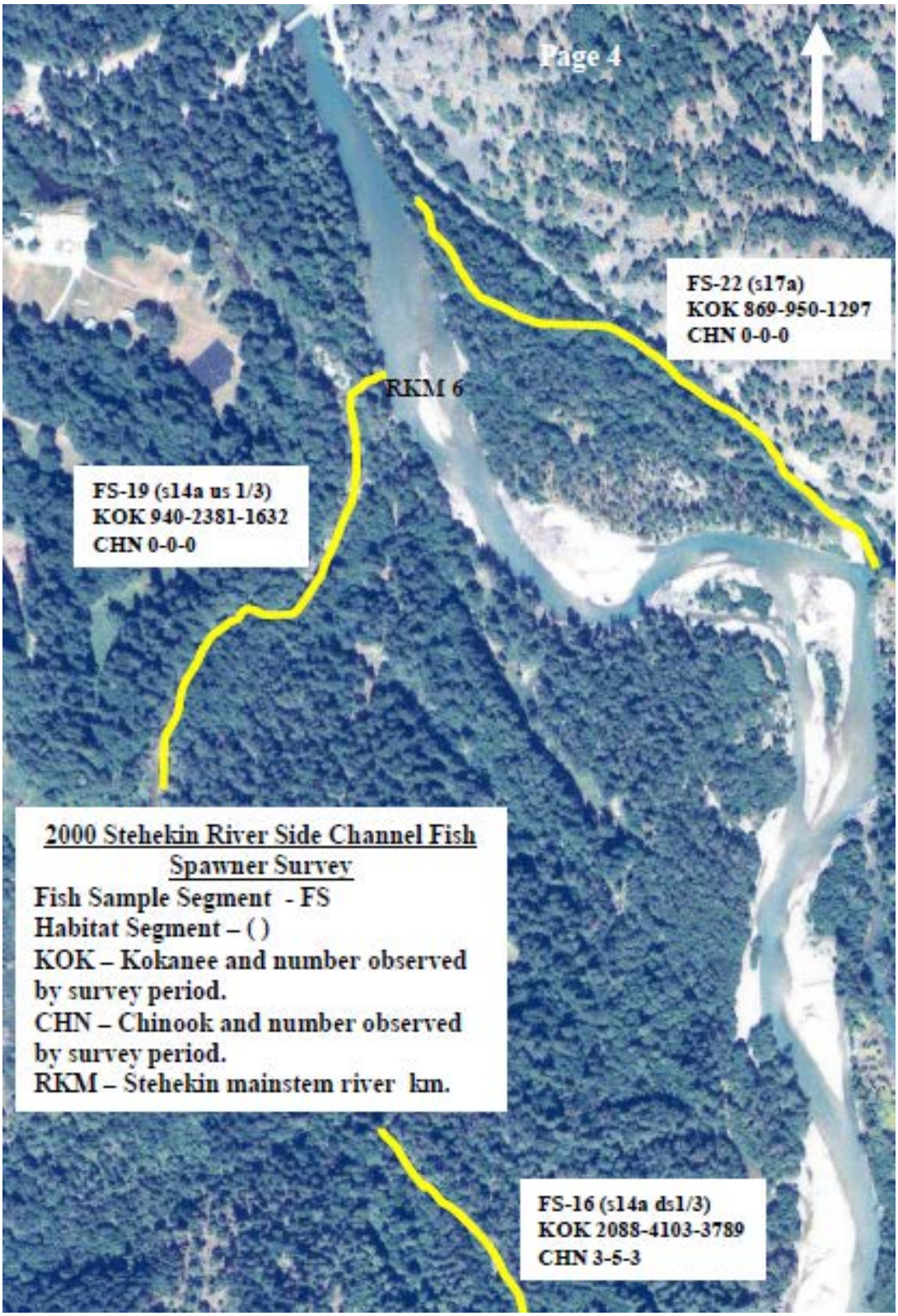

Figure C.4. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 4 of 9.

Figure C.5. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 5 of 9.

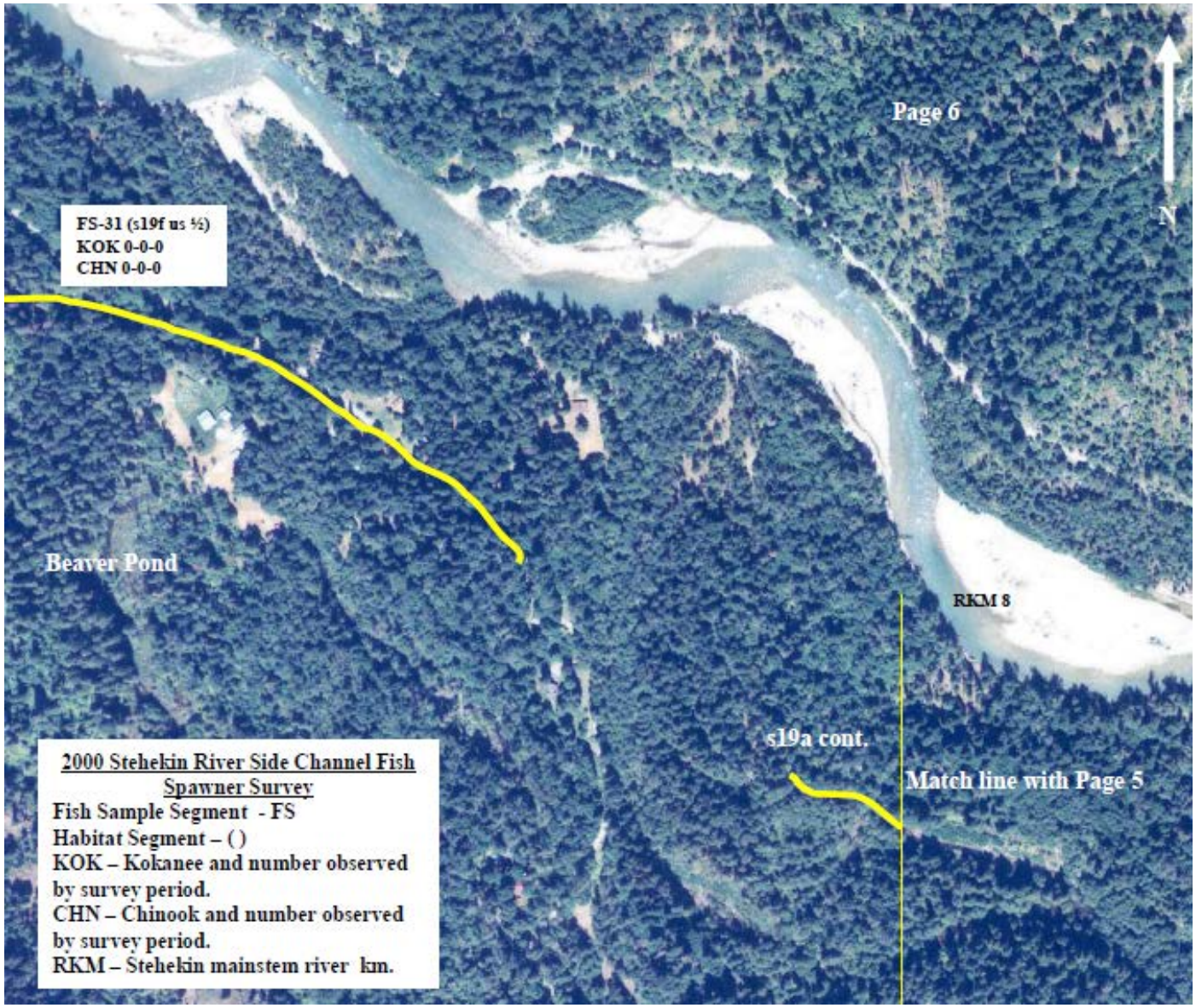

Figure C.6. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 6 of 9.

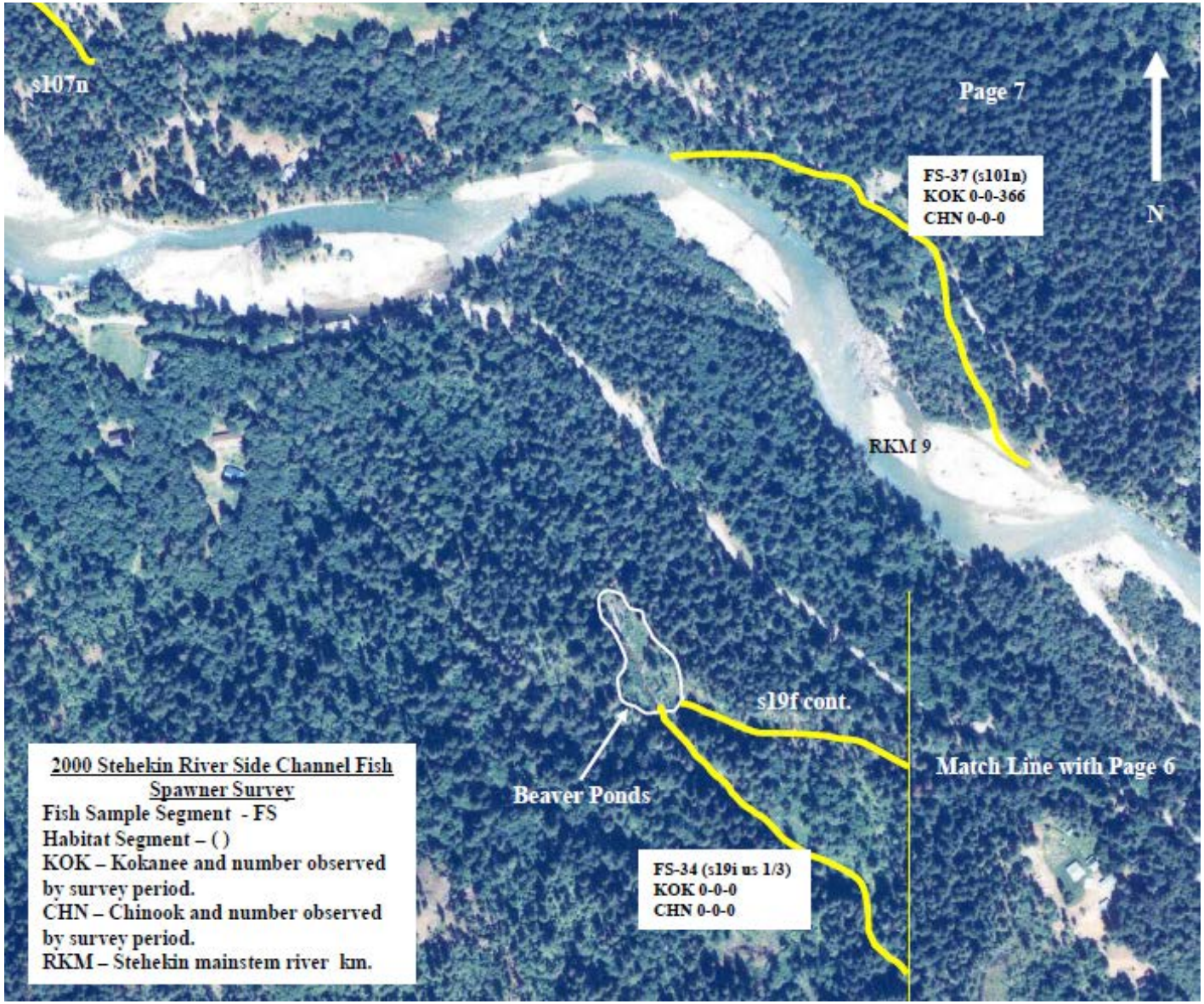

Figure C.7. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 7 of 9.

Figure C.8. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 8 of 9.

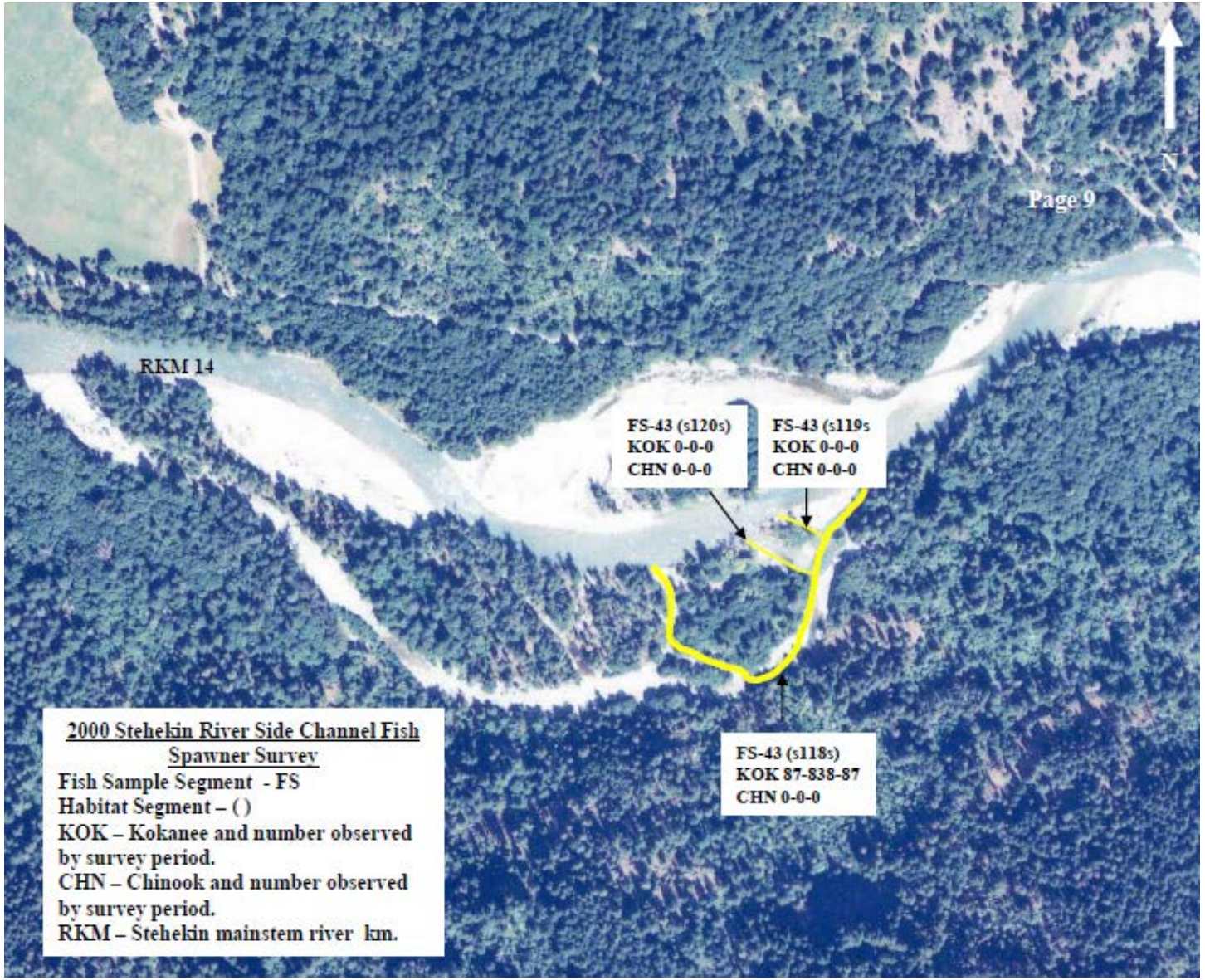

Figure C.9. Stehekin River side channels surveyed for spawning kokanee salmon in 2000, figure 9 of 9.

Appendix D. Stehekin River side channel and mainstem reaches surveyed for kokanee in 2010.

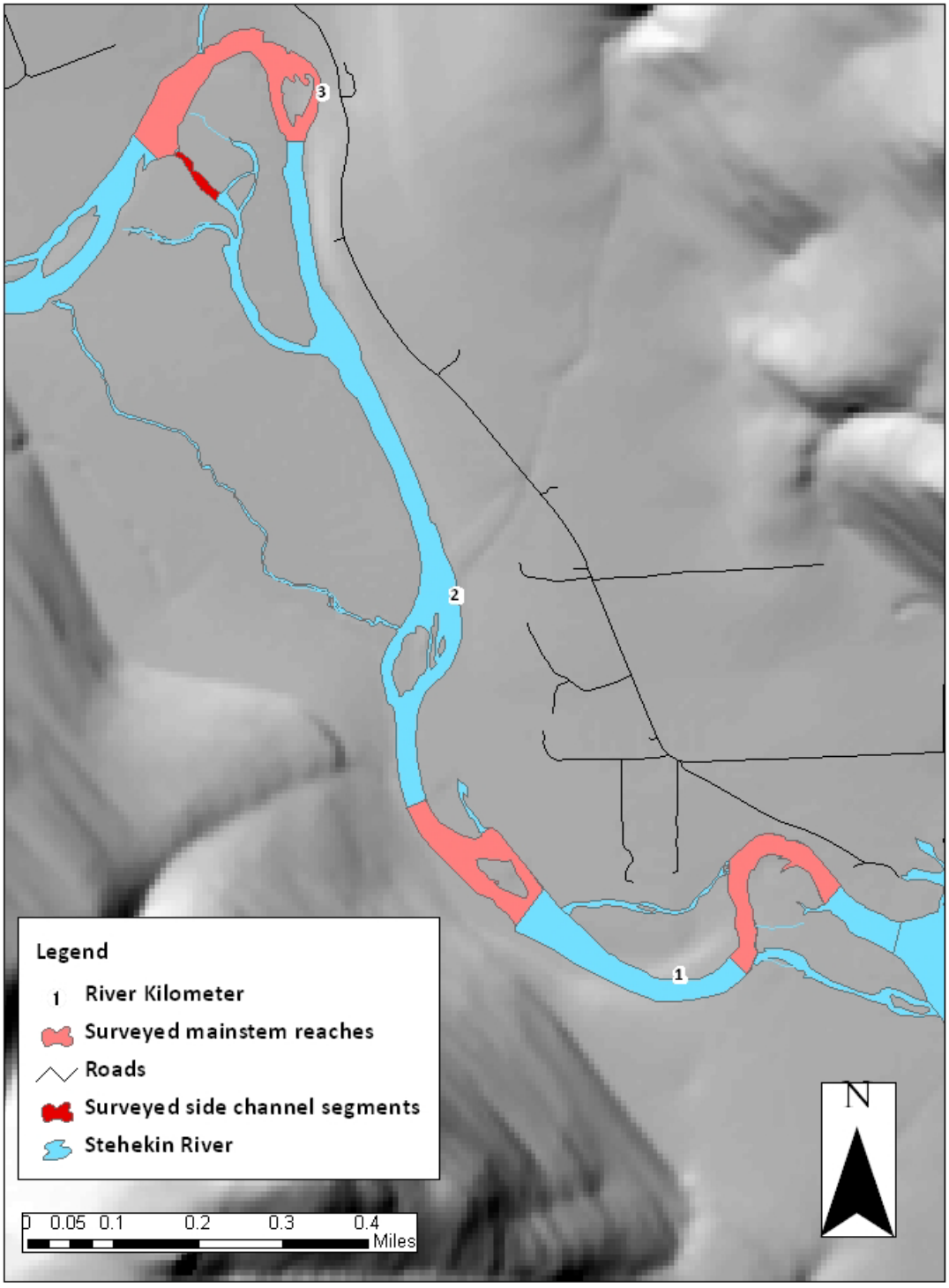

Figure D.1. Stehekin River side channels surveyed for spawning kokanee salmon in 2010, figure 1 of 5.

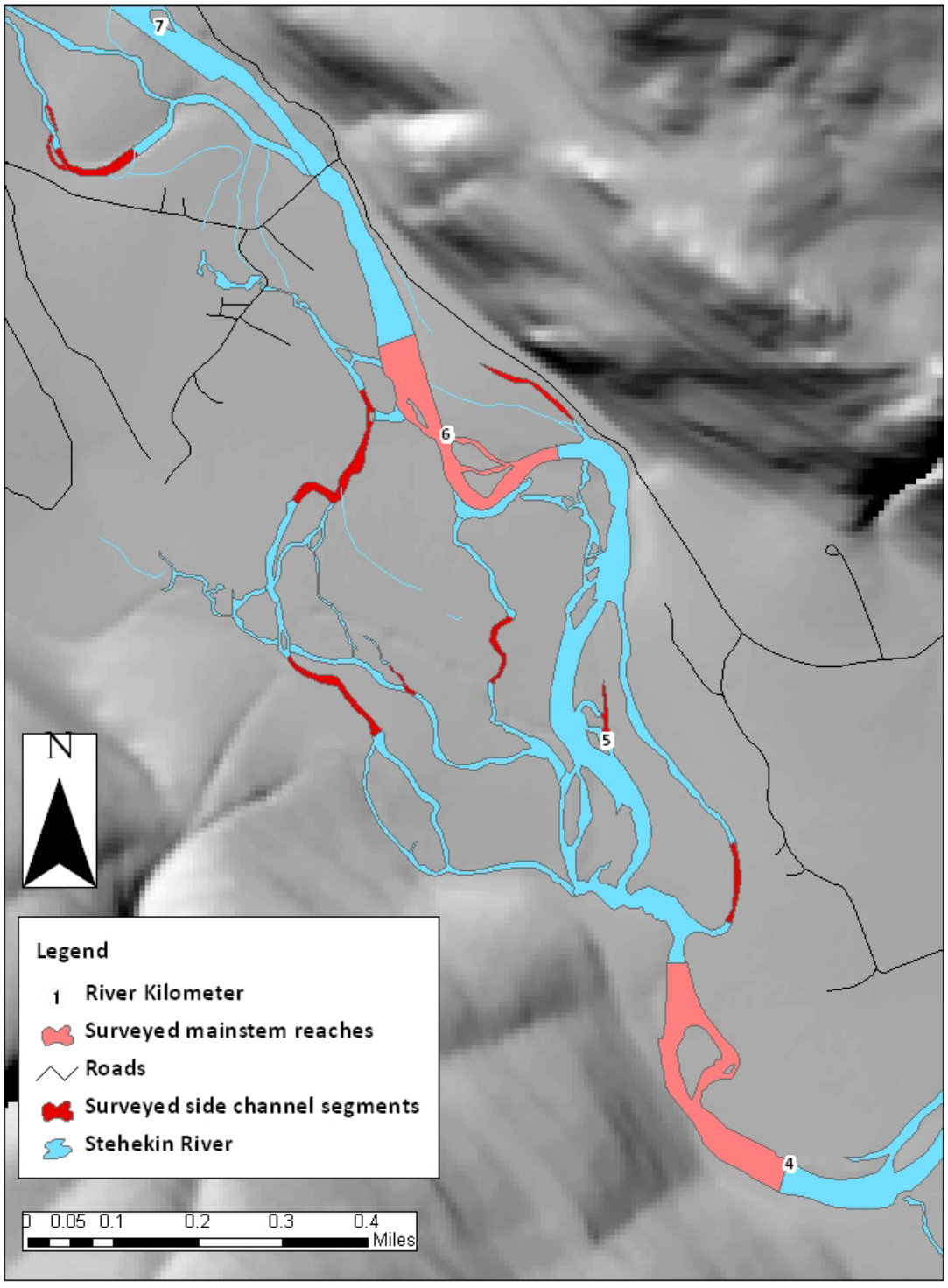

Figure D.2. Stehekin River side channels surveyed for spawning kokanee salmon in 2010, figure 2 of 5.

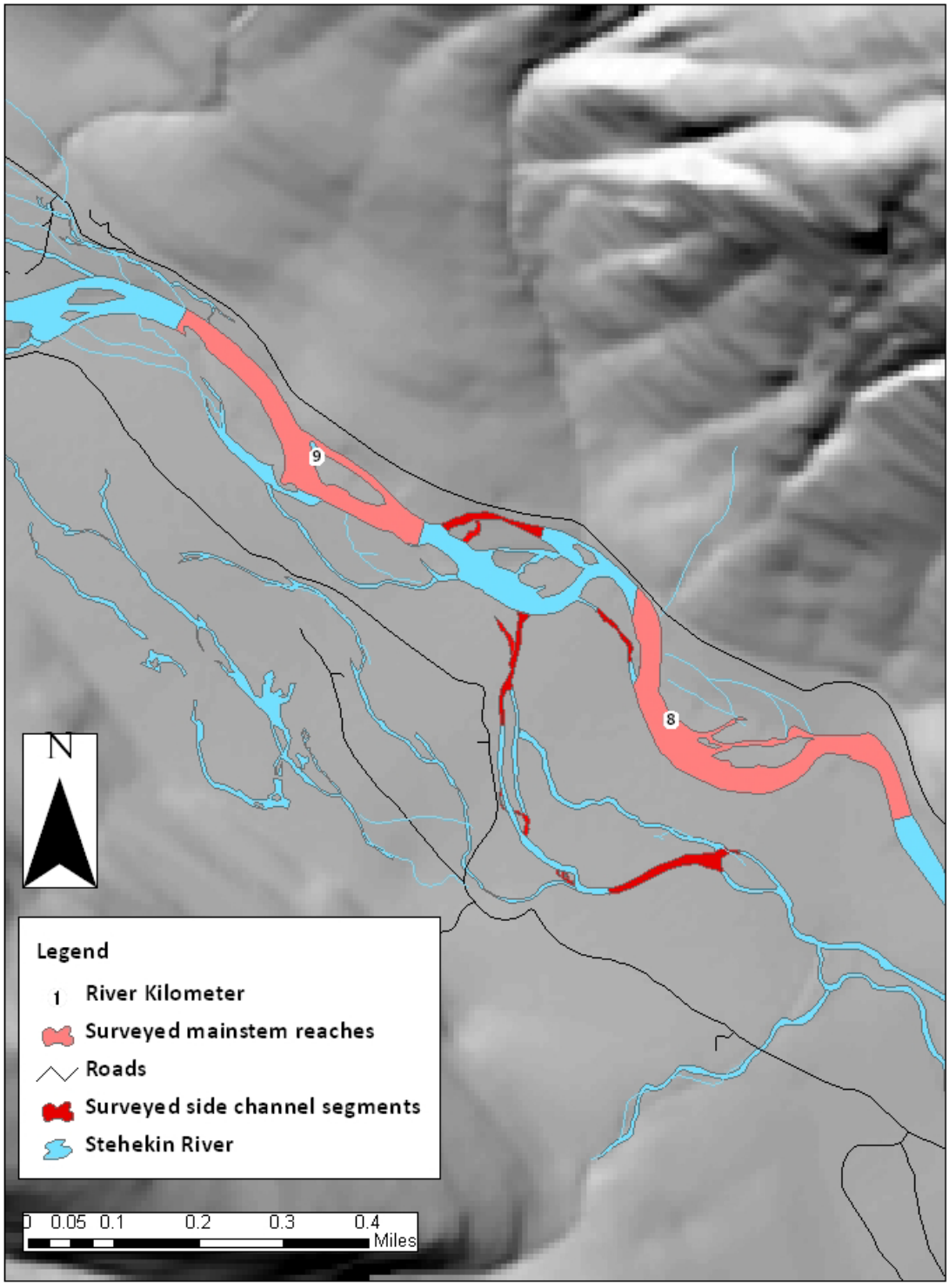

Figure D.3. Stehekin River side channels surveyed for spawning kokanee salmon in 2010, figure 3 of 5.

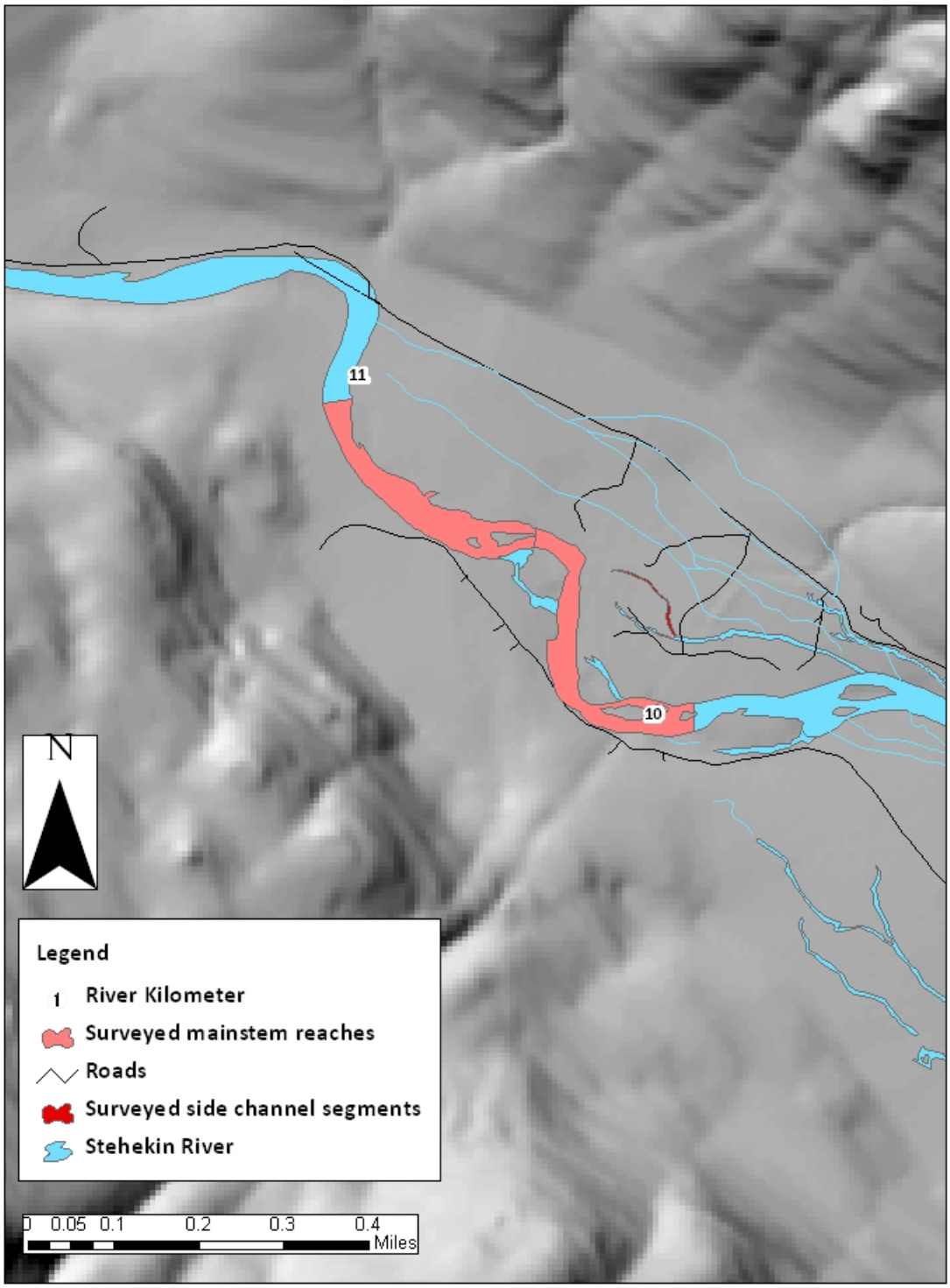

Figure D.4. Stehekin River side channels surveyed for spawning kokanee salmon in 2010, figure 4 of 5.

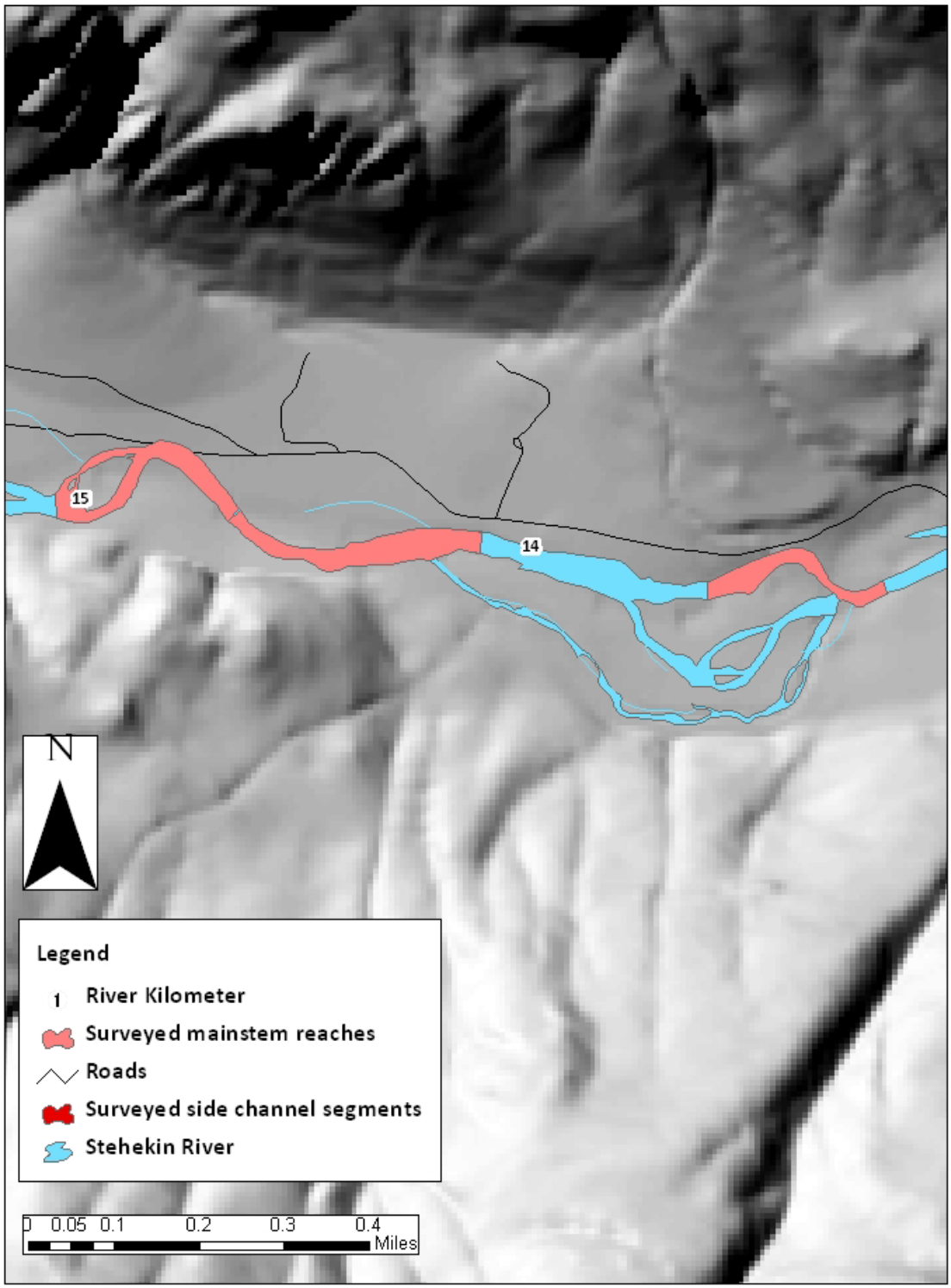

Figure D.5. Stehekin River side channels surveyed for spawning kokanee salmon in 2010, figure 5 of 5.