The evolving Dungeness River: juvenile salmon and their use of side channel habitat

A comparison of data collected
1997/1998 vs. 1999/2000.

By

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Table of Contents

List of Figures

List of Tables

List of Appendices

Introduction

The Dungeness River once supported mighty runs of Spring chinook and Summer and Fall Pink (Lichatowich 1993). A century of irrigation withdrawals, riparian forest harvest, filling in and building on floodplains, hatchery manipulation, and turn-of-the-century overharvest have left the runs a mere ghost of their former glory (Lichatowich 2000, Haring 1999). It is the goal of Jamestown S'Klallam Tribe for salmon to return to harvestable levels in the Dungeness River. This is the home watershed of the Jamestown S'Klallam's; healthy salmon runs are both culturally and economically very important to the tribe.

Some progress has been made to improve salmon spawning conditions and habitat quality. The amount of water withdrawn for irrigation has been reduced during the past 15 years by over 50% due to water conservation measures (Foster Wheeler 2002). Riparian forest harvest is not allowed, or is at least limited, under the Clallam County's Critical Areas Ordinance and the Department of Natural Resources Forest Practices Rules. Washington State Dungeness Hatchery has discontinued the often-criticized practice of planting salmon stocks from other watersheds, and now works to enhance chinook and pink stocks using the local stocks (although Elwha Fall chinook are still eyed up in the Hurd Creek hatchery). The Dungeness Chinook broodstock program has resulted in increasing annual spawner returns to the river, with approximately 630 returns in 2002. A targeted fishery for Dungeness chinook and pink has not occurred for decades. A modest number of large woody debris (LWD) structures have been added to help regain lost habitat, with much more LWD work needed. Offsetting this work is that residential areas, especially in the floodplain upriver of Hwy 101 and historical salt marshes at the mouth, occupy significant areas of habitat or potential habitat, thereby limiting the scope of recovery.

The habitat condition, hydrology, geomorphology, and fire history of the Dungeness watershed is well understood. The Orsborn and Ralph report (1994) was the first thorough study of salmon habitat and river hydrology. This was followed by the U.S. Forest Service watershed analysis (1995), which added the forest disturbance history of the upper watershed to our knowledge. The Limiting Factors Analysis provided a general overview of habitat conditions watershed-wide (Haring 1999), while Recommended Restoration Projects for the Dungeness (DRRWG 1997) provided a reach-level analyses for habitat restoration. The most valuable riparian habitat has been identified for acquisition or protection (Hals draft), and the Bureau of Reclamation report provided a comprehensive overview of geology, geomorphology and hydrology in the lower watershed (Bountry et al. 2002).

Despite the promising work and studies of habitat, our understanding of community composition and distribution patterns of salmon is still rudimentary. The most difficult variable in the recovery equation is when, where, and why fish thrive in the Dungeness. To be sure, there has been previous work. Hiss (1994) looked at movement of juvenile pink in Dungeness Bay, WDFW operated a screw trap for several years near Matriotti Creek in the lower river, U.S. Fish and Wildlife Service conducted snorkel surveys in the mainstem, and we have many years of chinook spawning survey data with the GPS location of each redd since 1992 (Randy Cooper, WDFW, Rot and Cooper, data unpub.). Finally, Hirschi and Reed (1998) looked at juvenile salmon patterns in side channels of the Dungeness.

This study is essentially a continuation to the Hirschi and Reed study. The primary objective for both studies was to document seasonal distributions and habitat use patterns of native juvenile salmonids. For this report, the specific objectives were to: 1) compare and contrast the results from the two studies, 2) discuss changes in side channel habitat through time, and 3) outline future study needs. Given the years between this report and the 1999/2000 fieldwork, new or updated information will be utilized where possible.

Methods

The methods follow Hirschi and Reed (1998) and will be briefly described here[1]. A decision was made early on to not significantly change methodology, so that the results could be compared. The two studies were conducted from October 1997-September 1998 and November 1999-October 2000.

The primary survey crew was composed of Byron Rot, Ray Johnson (WDFW retired biologist), and Lori DeLorm (JST technician). Ray was almost always present, accompanied by one or two others. Additional surveyors included Nikki Sather and Stephanie Adams (JST interns and technicians). This project was funded at 40% of the previous study (Hirschi and Reed 1998); therefore some data was not collected. Habitat surveys were not repeated. Necessarily, the number of field sample dates was reduced from several per week to at most one per week.

Sampling sites at each side channel were numbered, mapped, and flagged (Appendix 1)[2]. The watershed was divided into four areas: Dungeness mainstem (mouth to East Crossing campground), Dungeness side channels (mouth to East Crossing campground, Gray Wolf mainstem (confluence to Cliff Camp), and Gray Wolf side channel (confluence to 2 Mile Camp).

Photos were taken of each sample area. For each field visit, water temperature, depth, wetted width, bankfull width, water clarity, water velocity, substrate, Dungeness discharge, and presence of LWD were noted. Residual pool depth data was not collected.

Both a hand-held seine and minnow traps were used to capture juvenile fish. Fish were identified to species and were measured at total length (vs. fork length) to be consistent with the earlier study. Weight data was not collected. Seines were useful in water with low-levels of LWD, but proved ineffective and frustrating at many of our LWD rich sites. As the year progressed we migrated to use of minnow traps. The traps were set overnight and were baited with salmon eggs. Winter snorkel surveys were not used to maintain continuity with the original study.

Following the convention of Hirschi and Reed, we combined steelhead and trout into one number, trout. It is very difficult to differentiate the two species for juveniles smaller than roughly 60mm.

An opportunity arose the last month of the study to fully sample juvenile salmonid densities within a LWD restoration project area (Dawley side channel, October 2000). We erected two smolt fences approximately 300 m apart[3]. Fences were cleaned of leaves and debris daily to reduce backwatering. The area between the fences was trapped and seined nine days between October 7 and 17. All juveniles were moved downstream of the restoration project area. The data is presented and discussed separately in the report.

Data from each study was entered into Access and analyzed and graphed either in Excel or Statistica.

Results and Discussion

Background data: mainstem discharge, side channel water depth, width and temperature

Dungeness mean daily discharge is presented for the two study periods (Figure 1). While not analyzed, there appears to be no statistical difference in high water (fall rains or spring runoff)

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[1] The Hirschi and Reed study will also be referred to as '97-'98 study.
[2] All supplementary tables, or tables and figures that are too large, are presented in Appendices.
[3] This was an effort to remove all juveniles within a LWD restoration project area (Rot 2001). The LWD project was enclosed within the upstream and downstream fences.

between the two water years. One bankfull flood occurred November 11, 1999 (3490 cfs) while no bankfull or greater flood events occurred for the '97-98 water year (bankfull is 2990 cfs, Bountry et al. 2002). For the low flow period (September to October 1998), discharge was on average ¼ to 1/3 lower than in 2000. It is likely that side channels conveyed less water at summer low flow for the '97-98 study vs. '99-'00[4]. Additionally, summer flows during the summer 1999 were the highest on record with average daily flows exceeding 1000 cfs from May 24 through Aug 9. This may have had a negative influence on salmon fry survival as low velocity refuges disappeared. Conversely survival may have benefited through increased flow in side channels or overflow channels that would have been dry that time of year.

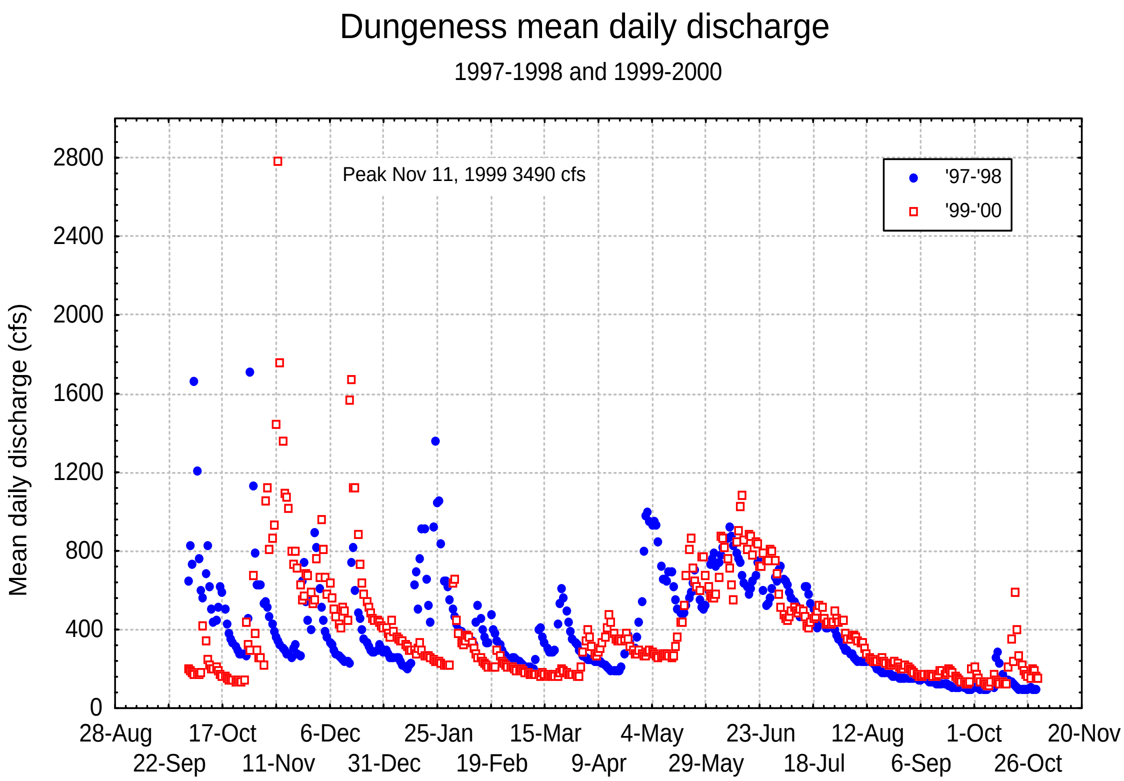


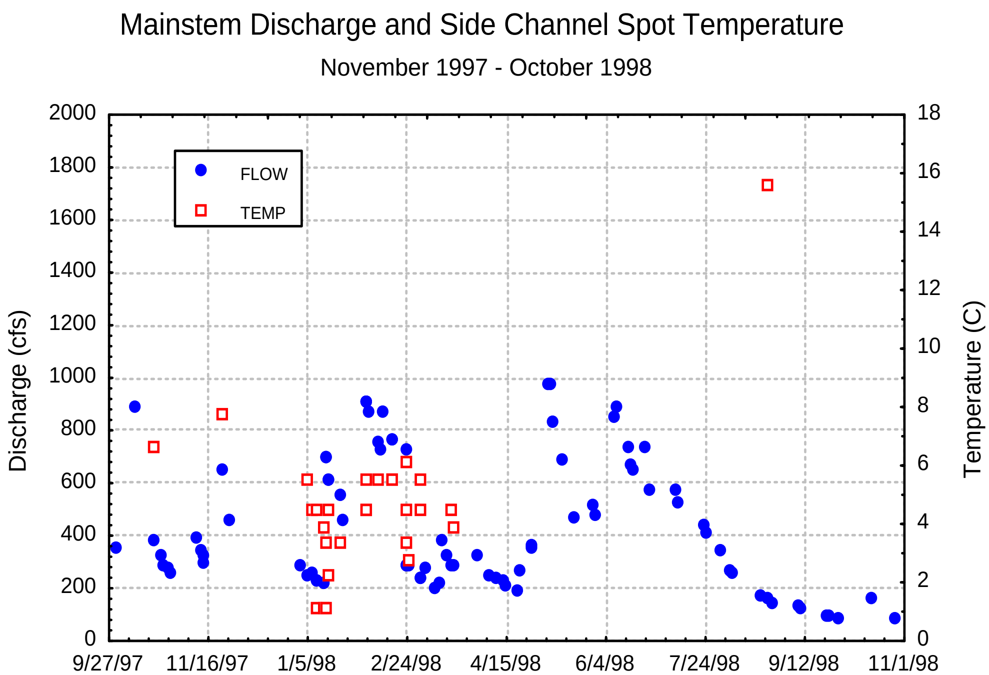
Figure 1. Dungeness mean daily discharge 1997-1998 and 1999-2000. USGS gauge, RM 11.8.

Survey day mainstem discharge and side channel spot temperatures are presented in Figure 2. Most of the summer temperatures for the '97-'98 study were not collected. Temperatures for the October 2000 Dawley juvenile fish removal were also not collected. However, more recent work in the Dungeness has found daily maximum temperatures in side channels rarely exceed 16 degrees C (Rot and DeLorm data unpub.).

At each site, water depth and wetted width data was collected (Table 1). What stands out is the quality of side channel pool habitat. Maximum pool depths exceed 100cm at many sites. Why do deep scour pools occur in low velocity/low energy side channels? Likely some of these pools are remnants from when the mainstem (or major braid) flowed through the "side channel." Pool depths are maintained through the lack of bedload transport into the channel. Large woody debris accumulations at the head trap sediment and release fairly clear water in the channel, which allows modest flows to maintain existing scour pools. For some side channels hyporheic flow maintains pool depth (see **"**side channel change through time").

[4] Both studies encompassed each respective water year, which is defined as October through September.

More recently, we have collected data on flows in selected side channels (Figure 3). This data was collected in the summer of 2002. While the configuration of side channel entrances and therefore flow characteristics have changed from the water years in this study (see "side channel change through time"), this information can be used to understand the variety of flow conditions in side channels of the lower Dungeness.



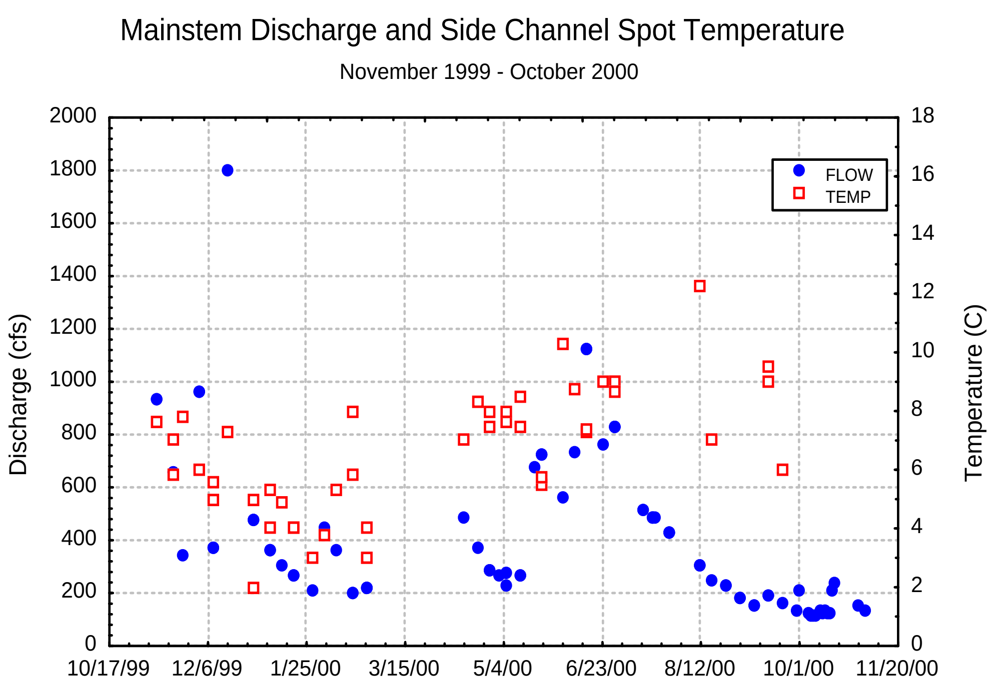
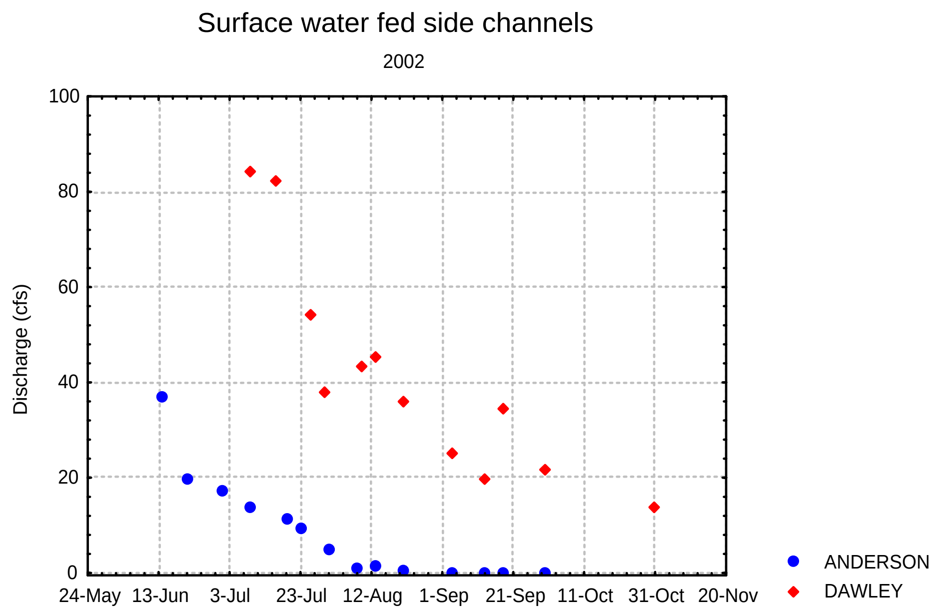


Figure 2. Spot temperature collected with thermometer and averaged by site day. Temperature generally did not vary or varied by one degree between side channels. River discharge is the USGS gauge and reflects the midday flow.

Table 1. Maximum and minimum water depth and width collected for each sampling location for Dungeness side channels (The Gray Wolf data is presented in Appendix 2).

Side channel	Location	Maximum water depth (cm)	Minimum water depth (cm)	Average water depth (cm)	Maximum water width (m)	Minimum water width (m)	Average water width (m)
Anderson	1	145	65	103	11	6	8
Anderson	2	135	55	91	9	4	6
Anderson	3	130	78	106	9	5	7
Dawley	1	95	53	76	8	5	6
Dawley	2	105	15	70	11	2	6
Dawley	3	72	38	55	6	2	3
Dawley	4	75	55	62	6	2	4
Dawley	5	79	32	56	6	3	5
Dawley	6	85	0	43	5	0	2
East Crossing	1	110	100	105	20	18	19
East Crossing	2	110	47	79	9	3	6
East Crossing	3	68	68	68	5	5	5
East Crossing	4	81	81	81	11	11	11
East Crossing	5	44	44	44	3	3	3
East Crossing	6	90	74	82	8	5	6
East RR bridge	1	148	50	101	5	2	4
East RR bridge	2	106	50	76	9	5	6
East RR bridge	3	100	94	97	8	3	5
Gagnon	1	100	56	79	11	3	7
Gagnon	2	95	50	69	6	2	5
Gagnon	3	95	35	57	5	3	3
Gagnon	4	100	30	75	5	1	3
Leaf channel	1	85	62	70	5	2	4
Leaf channel	2	90	90	90	6	6	6
Leaf channel	3	66	20	42	4	2	3
Sequim Prairie	1	110	45	70	8	4	5
Sequim Prairie	2	95	42	72	5	3	4
Spring Creek	1	80	40	60	6	2	4
Spring Creek	2	97	72	82	5	3	4
Spring Creek	3	83	57	72	11	6	8
Spring Creek	4	87	85	86	9	5	7
Spring Creek	5	135	116	126	9	6	8
Spring Creek	6	126	67	104	30	20	24
Spring Creek	7	82	65	76	25	15	20
Spring Creek	8	85	45	66	12	5	9
Spring Creek	9	50	40	45	60	15	37
Towne Rd E	2	183	89	111	20	15	16
Towne Rd E	3	100	85	93	25	15	20
U-channel		175	85	138	30	15	24
West RR bridge	1	180	55	118	50	8	17
West RR bridge	2	107	45	70	15	7	11
West RR bridge	3	78	61	69	18	7	12
West RR bridge	4	74	46	60	10	6	8
West RR bridge	5	91	75	81	15	3	9
West RR bridge	6	76	76	76	15	15	15



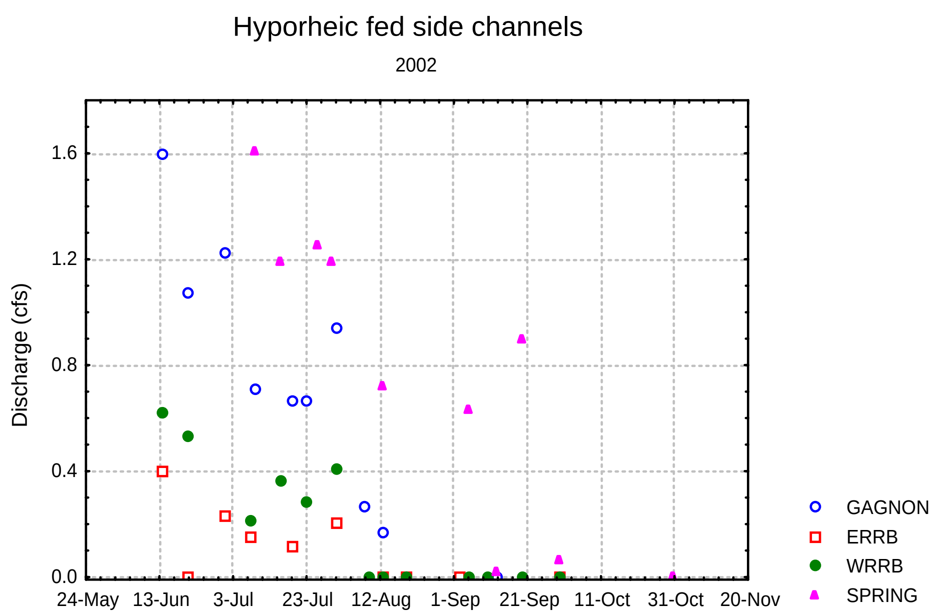


Figure 3. Discharge in Surface water and Hyporheic fed side channels for the summer of 2002. Discharge was collected at one cross section for each side channel. Note the scale change for the Y-axis for each graph (Daraio and Bountry 2003).

Side channel change through time

The health of the low gradient, unconstrained portions of riverine systems is dependent upon their ability to meander or change course within natural geologic controls. The Dungeness River is a very steep river system, falling about 6400 ft in 32 miles or 200 ft/mile (average 3.8%). Below the Dungeness Hatchery at river mile (RM) 10.5, the river valley widens and gradient falls to below 2% (Orsborn and Ralph 1994, Bountry et al. 2002). Analyses of historical records (1915 Clallam county survey maps) and old aerial photos (1942/3 to present) show that the river changed course frequently (Bountry et al. 2002). As the main channel changes course it leaves behind side channels carrying a portion of the flow and armored at the head with large woody debris (e.g. Figure 4). These side channels are incredibly important to salmonids at many life stages (e.g. Peterson 1982, Brown 1987).

It is difficult to present the subtle changes observed in these side channels over the past 3+ years. Side channels were divided into two main groups, which are really endpoints on a continuum (Table 2 and 3). These groupings follow Daraio and Bountry (2003). One endpoint is side channels that have a surface water connection to the main channel at their upstream end, even at summer low flow (e.g. Anderson '99-'00, Table 1); compared to others that are always disconnected from the main channel at their upstream end (e.g. Gagnon '97-98, Table 1). These latter channels are fed through the hyporheic zone. It should be noted that all of these side channels in this report are connected to the river at their downstream end and that overflow channels fed most of these side channels during floods. Bountry et al. (2002) found that in general side channels on the Dungeness were lower in elevation than the main channel (Figure 4, Appendix 1).

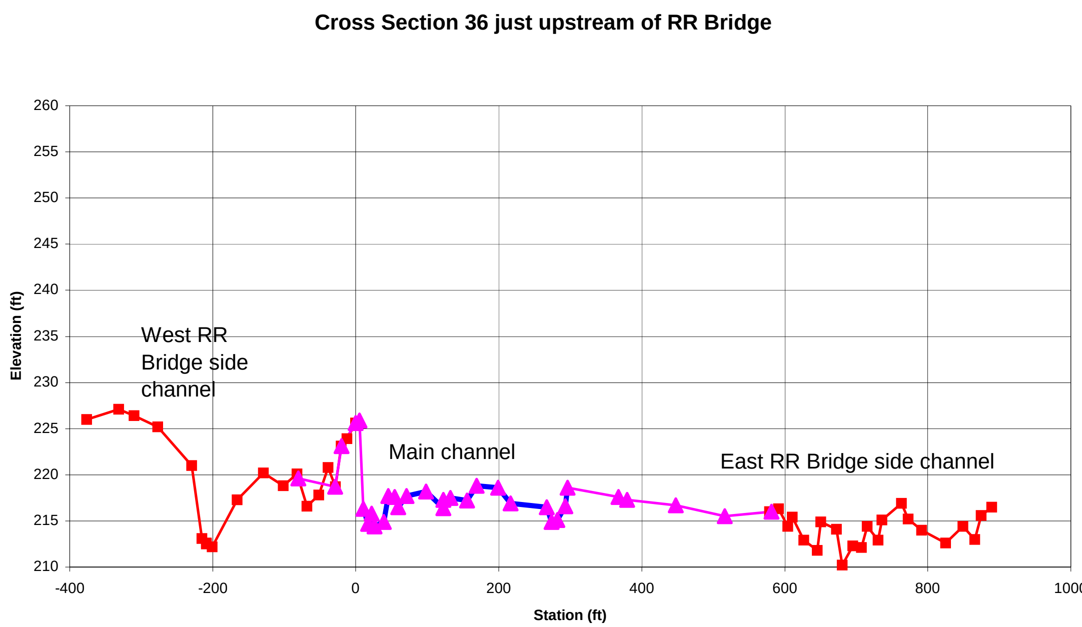


Figure 4. Sample cross section just upstream of RR Bridge. Note the elevation of the two side channels relative to the main channel (from Bountry et al 2002).

In between these two endpoints are those channels that are connected only at bankfull floods (East RR Bridge, '97-'98), those that are connected at flows above say 700 cfs, etc. Some side channels may have one surface water connection and several hyporheic connections (Gagnon, E RR Bridge, W RR bridge, Dawley). Hyporheic connections could be overflow channels that are evolving into surface water connections, or sediment accumulation has blocked a surface water connection and converted it to hyporheic. These channels are dynamic through space and time. One flood event can change the orientation of main channel and thus alter the connection of the side channel to the main channel. As discussed in Hirschi and Reed, the type of side channel will influence the salmonid species that are found there.

Table 2. Dungeness side channel connection to the main channel over the two study years. Surface water means the upstream end of the side channel is connected to the river. Hyporheic means that it was not connected, but water was fed into the channel through groundwater or the hyporheic zone. See Appendix 1 for side channel locations.

Side channel	Study year	Approx. river mile	Surface water	Hyporheic
Anderson	'97-'98	3.4-3.6	Not sampled	
Anderson	'99-'00	3.4-3.6	All observed flows	
Gagnon	'97-'98	3.6-4.0		Blocked by Burlingame Bridge
Gagnon	'99-'00	3.6-4.0	Above approx 700 cfs	Below 700 cfs
Gagnon-leaf channel	'97-'98	3.7		All observed flows
Gagnon-leaf channel	'99-'00	3.7		All observed flows
East RR Bridge	'97-'98	5.7-6.2	At higher flows	
East RR Bridge	'99-'00	5.7-6.2		All observed flows
West RR Bridge	'97-'98	5.3-6.1		All observed flows
West RR Bridge	'99-'00	5.3-6.1	At higher flows	
Dawley	'97-'98	6.4-6.9	All observed flows	
Dawley	'99-'00	6.4-6.9	All observed flows	
Sequim Prairie	'97-'98	6.8	All observed flows	
Sequim Prairie	'99-'00	6.8	All observed flows	
Spring Creek	'97-'98	6.8-7.7		All observed flows
Spring Creek	'99-'00	6.8-7.7		All observed flows
East Crossing Left braid	'97-'98	~17.3	Not reported	
East Crossing Left braid	'99-'00	~17.3	All observed flows	
East Crossing U-channel	'97-'98	~17.0	Not reported	
East Crossing U-channel	'99-'00	~17.0	All observed flows	

Anderson side channel has evolved from a channel that carries flows at all discharge levels ('99-'00) to one that is currently disconnected at low flows (see Figure 3, September 2002 flow measurements). While low flows are decreasing, due to meander patterns upstream, the channel is receiving increased flood flows with the potential of a mainstem avulsion into the channel.

In November 1999, the new Burlingame Bridge was opened with a much wider span. Gagnon side channel had been blocked by road fill for many decades and was now opened to flood flows. The side channel quickly evolved. Our first higher flow data collection effort in Gagnon did not occur until the spring runoff in June 2000 (Figure 1). On January 7, 2001, the Dungeness received a flood of record (7620 cfs). The main channel upstream of the Burlingame Bridge avulsed east and Gagnon for much of its length became a Hyporheic channel once more (Figure 3). The same flood scoured out Leaf channel, which now is evolving from a overflow channel to a low flow surface water connection to Gagnon side channel.

For East and West RR Bridge, the main channel has shifted from a meandering to a linear pattern which has converted these channels from surface water connection at moderate flows, to disconnection at all flows (Table 2, see Figure 4).

Dawley and Sequim Prairie (Sequim Prairie feeds into Dawley) are natural side channels where Sequim-Prairie Ditch Co. artificially maintains the connection to the mainstem. More recently Dawley has received increasing flow as a large logjam in the mainstem has diverted mainstem flow into Dawley, converting an overflow channel to a surface water connection at all flows. A 2000 LWD restoration project has also improved habitat. In 2002, for the first time, roughly 25 chinook (10 redds) spawned in Dawley side channel. Spring Creek is blocked by Dungeness Meadows dike.

Table 3. The connection of Gray Wolf side channels to the main channel over the two study years. Surface water means the upstream end of the side channel is connected to the river. Hyporheic means that it was not connected, but water was fed into the channel through groundwater or the hyporheic zone. See Appendix 1 for side channel locations.

Side channel	Study year	Approx. RM from confluence	Surface water	Hyporheic
Dungeness Forks	’97-‘98	0.0-0.2	All observed flows	
Dungeness Forks	’99-‘00	0.0-0.2		All observed flows
Leaning Cedar Tree	’97-‘98	0.2	All observed flows	
Leaning Cedar Tree	’99-‘00	0.2	All observed flows	
Coho	’97-‘98	0.3-0.4		Low flows
Coho	’99-‘00	0.3-0.4		Low flows
Mossy Rock	’97-‘98	0.7-0.8	All observed flows	
Mossy Rock	’99-‘00	0.7-0.8		Low flows
Acclimation Pond	’97-‘98	0.8-0.9	All observed flows	
Acclimation Pond	’99-‘00	0.8-0.9	All observed flows	
Left Bank	’97-‘98	~1.3	All observed flows	
Left Bank	’99-‘00	~1.3		All observed flows
Cat Creek/Beaver Pond	’97-‘98	~1.5		All observed flows
Cat Creek/Beaver Pond	’99-‘00	~1.5		Debris flow, buried
Right Bank	’97-‘98	~1.7	Not sampled	
Right Bank	’99-‘00	~1.7	All observed flows	

In the Gray Wolf, the most substantial change from ’97-’98 to ’99-’00 was the debris flow in Cat Creek/Beaver Pond side channel. The debris flow followed Cat Creek filling in very productive terrace tributary habitat. The other notable change was that Dungeness Forks shifted from surface water in ’97-’98 to hyporheic in ’99-’00.

1997-1998 and 1999-2000 Juvenile Sampling

During the ’99-00 study, 819 chinook, 4395 coho, and 522 trout were caught (Table 4). Also caught were modest numbers of sculpin, stickleback and bull trout/dolly varden. (Table 4). For both studies, by far the most common species was coho (Figure 5). Yet some feel that historically, the Dungeness was primarily a pink/chinook watershed with modest amounts of coho. Where coho were caught and why will be presented in the next section.

Table 4. Number of fish caught, percentage of total fish caught (italics), and total days sampled for the two studies. October 2000 will be discussed separately.

	Oct ’97-Sept ‘98	Nov ’99-Sept ‘00	October ’00 (Dawley)
Chinook	1134* *(24%)*	479 *(12%)*	340 *(19%)*
Coho	3147 *(67%)*	3213 *(79%)*	1182 *(68%)*
Trout	362 *(8%)*	309 *(7%)*	213 *(12%)*
Pink	10	0	0
Chum	20	0	0
Bull trout (Dolly varden)	5	6	0
Stickleback	0	10	5
Sculpin	2	40	0
Lamprey	3	0	0
TOTAL	4683	4051	1740
TOTAL DAYS SAMPLED	*71*	*40*	*12*

* Corrected number from Hirschi and Reed 1998.

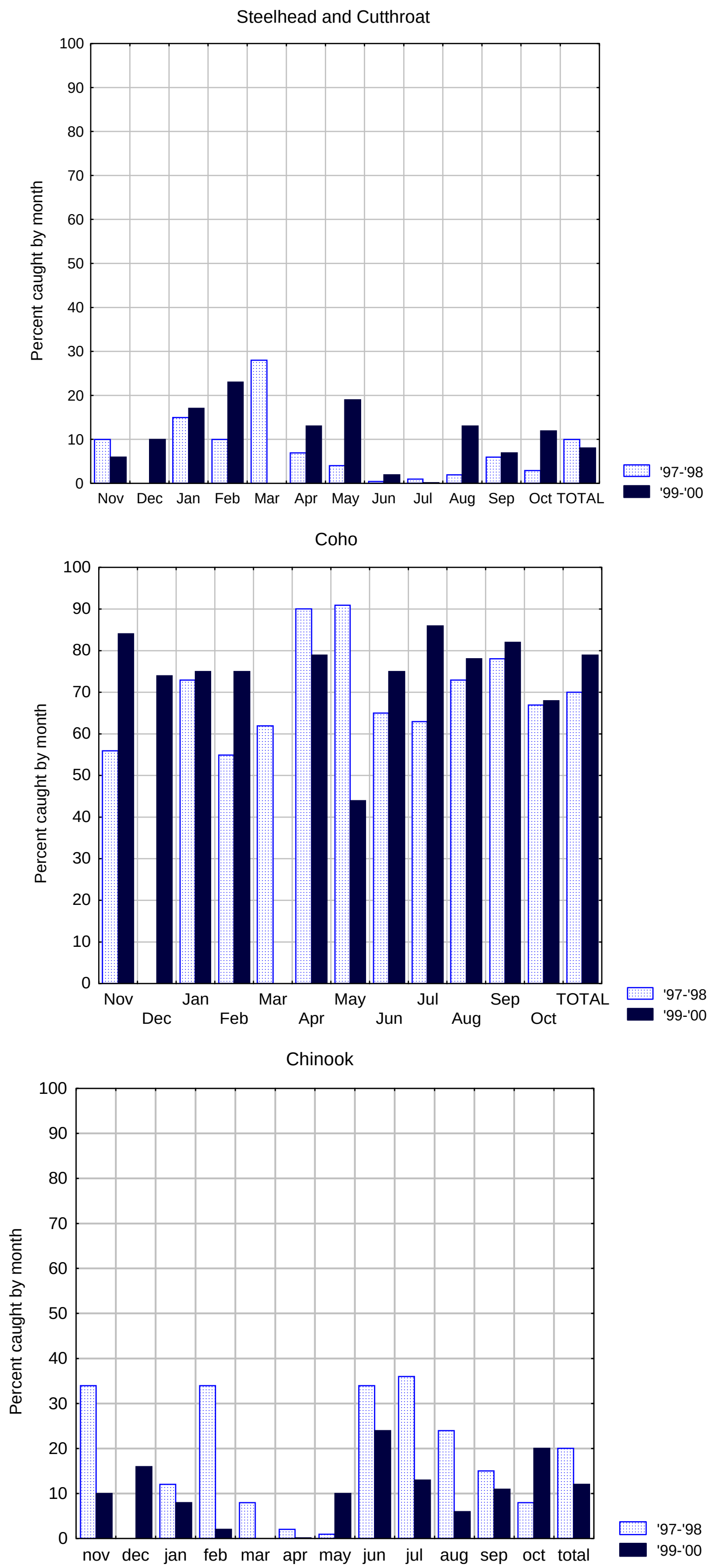


Figure 5. Percent of trout (cutthroat and steelhead), coho, and chinook juveniles caught at all sites for each month and study period.

Table 5. Number of fish (and percent by species in italics) caught at selected side channels that are hyporheic or surface water at all flows for 2000 (see Tables 2 and 3). Hyporheic channels were East RR Bridge, Spring Creek, Left Bank Channel (Gray Wolf), and Dungeness Forks (GW). Surface water channels were Anderson, Dawley, Sequim Prairie, Acclimation Pond (GW), and Right Bank channel (GW).[5]

	Chinook	Coho	Trout	Bull trout	Sculpin	Stickle -back	TOTAL
Hyporheic	12 *(2%)*	1123 *(36%)*	88 *(23%)*	2	0	0	1225 *(30%)*
Surface water	535 *(98%)*	2025 *(64%)*	298 *(77%)*	2	11	9	2880 *(70%)*

Coho

Coho were found in all side channel and mainstem locations; their numbers dominated all species especially in hyporheic channels (Table 4, Table 5). Coho (and fall chum, steelhead, and pink) were observed spawning in all Surface water channels ('99-'00). For hyporheic channels they were observed spawning in Spring Creek, the lower reaches of East RR Bridge, and the Leaf Channel. In the late spring clouds of newly emerged coho were often found at shallow channel margins. For Surface water channels, fry would move from channel margins to pools when velocities dropped and their swimming ability allowed. Hyporheic channels were by definition low velocity (Figure 3); in these channels coho would be spread through the water column. Coho primarily reared for one year and exited the system in May (Appendix 4). A handful of yearling coho remained for a second year before outmigrating (see Nov '99, Dungeness side channel, Appendix 4). These may be coho that were too small to have reached the threshold smolt size the preceding fall, assumed to be between 90-100 mm (Weatherly and Gill 1995). Note the number of small coho in the 50 mm size class in Dungeness side channels during the fall of 2000 (Appendix 4).

In the past given the relatively steep channel gradient and assumed large substrate size, the Dungeness was considered primarily a chinook stream, with poor coho spawning conditions. Currently, coho dominate juvenile populations (Table 4). Why do coho dominate: weak chinook and pink stocks due to climate and poor habitat, unintended spawning from hatchery coho, or because coho always had a strong escapement to the watershed?

The S'Klallams historically harvested coho (Gunther 1927), suggesting coho were present at fishable levels. The Dungeness continues to be a river rich in side channels (Bountry et al 2002), providing coho spawning and rearing habitat. A 1915 map of the Dungeness showed numerous side channels (Bountry et al. 2002). In contrast, results from the EDT modeling place historical chinook escapement at over 8000 (Mobrand Biometrics, draft). Additionally, the Dungeness had a strong pink run (Lichatowich 1993). Pink favor spawning gravel with average diameters smaller than both chinook and coho (Kondolf and Wolman 1993). What is fairly certain is that destroyed or severely degraded salt marsh and tidal slough habitat from the Dungeness mouth east to and including Graysmarsh has limited production for all species.

Coho is currently a hatchery production fish, with smolt releases recently reduced from 800,000 to 500,000 fish (HSRG 2002). If the hatchery coho smolt release has favored coho over chinook and pink, this could be limiting chinook and pink recovery. A research project to evaluate the current release levels on naturally produced pink and chinook stocks is needed (HSRG 2002).

[5] 1998 was not analyzed since Spring Creek and Dawley were combined on the Hirschi and Reed data sheets. These two channels dominate the hyporheic and surface water data respectively.

Chinook

Chinook were the second most numerous species (Table 4). Chinook were generally found in deep pools along with coho. Chinook preferred Surface-water side channels; a few were found in alcove pools at the downstream end of Hyporheic channels (Table 5). These findings echo the ’97-’98 results.

In the ’97-98 study, the only side channel with year-round chinook populations was Dawley side channel (Hirschi and Reed 1998). Our study did not find a similar pattern in Dawley (Appendix 3). Additionally, we found consistently fewer chinook at a given side channel than the ’97-98 study. This is inconsistent with expectations, since chinook spawning escapement had improved slightly with escapement of 50 in 1997, 110 in 1998, 75 in 1999, and 218 in 2000. Thus, one would have expected to observe more juvenile chinook. However, this observation may be explained by the size at release from the broodstock program (Appendix 5). Most (89%) of the 1.7 million chinook released (with the exception of July 14, 1997) were fingerling sized in 1997. In contrast, less than half (44%) of the 1.7 million chinook released were fingerling sized in 1999. There were ½ million more fingerlings in the river in ’97-98. This may account for the higher levels of chinook rearing in side channels and may account for the higher levels of chinook remaining in side channels during the ’97-98 fall/winter.

Lichatowich (1993) described five potential juvenile chinook life history pathways for the Dungeness based on other systems. These strategies and a similar table were also presented in Hirschi and Reed (1998). Lichatowich hypothesized that life history strategies 3, 4, and 5 dominated based on analysis of scale patterns and other watersheds. Hirschi and Reed (1998) suggests that life history 1 and 2 may also be important in the Dungeness.

Table 6. Potential juvenile Dungeness chinook life history strategies (Lichatowich 1993).

Life history number	Spawning location	In-river rearing (assume emerge April)	Outmigration
1	Gray Wolf	Remain in Gray Wolf	Spring as 1+
2	Upper Dungeness above confluence with Gray Wolf	Remain in Upper Dungeness	Spring as 1+
3	Gray Wolf	Rear in lower Dungeness and estuary through summer	Fall as 0+
4	Upper Dungeness above confluence with Gray Wolf	Rear in lower Dungeness and estuary through summer	Fall as 0+
5	Lower Dungeness and side channels	Rear in lower Dungeness and estuary through summer	Fall as 0+

To really understand this issue, we must ask what percentage of chinook overwintered from November to March (Table 7). Life histories 3, 4, and 5 dominate with 69.5% and 84.4% for ’99 and ‘97. However, 15.6% and 30.5% overwintering is significantly higher than expected. Juvenile chinook were almost exclusively found in the lower river, either in the mainstem or side channels. Adult return studies from watersheds on the west side of the Olympics, found around 5% of returning chinook overwintered (Chitwood personal communication). Unfortunately we do not have comparable juvenile data from the west side. Other Puget Sound spring chinook basins have high percentages of overwintering. These range from 20% in the White River to 80% in the North Fork Nooksack (Cramer et al. 1999).

It appears that Hirschi and Reed (1998) were correct in that overwintering chinook is an important strategy. Whether overwintering chinook originated from the Gray Wolf or Upper

Dungeness (life history 1-2), or from the middle or lower river (additional life histories) is unknown.

Table 7. Percentage of overwintering chinook compared to total chinook caught by location. Overwintering is defined as all chinook caught from November-March.

Location	’97-‘98	’99-‘00
Dungeness mainstem	9.5%	9.6%
Gray Wolf mainstem	0	0.7%
Dungeness side channels	37.7%	23.0%
Gray Wolf side channels	No data	3.3%
TOTAL	**30.5%**	**15.6%**

Finally, the role of the Dungeness estuary and nearby salt marsh habitat for potentially additional chinook life history strategies is also unknown. Preliminary results from the sampling of very small tidal creeks and independent salt marsh habitat in Hood Canal suggest they may be important for rearing juvenile salmonids (Hirschi et al. 2003).

Trout

A total of 884 trout were caught during the ’99-’00 study (Table 4).[6] Most trout were caught in higher velocities found in Surface water channels. For example in Dawley side channel, trout favored a pool that consistently had high velocities and strong eddies. Besides trout, we would find only a few large coho in this pool.

Dawley side channel sampling

During October 2000, we used a LWD restoration project in Dawley side channel to sample all (or nearly all) fish within the 900 ft long restoration site. The reason for this was to check the accuracy of our sampling methods and to see if the proportion of species caught was similar to the study results. The area was trapped 9 days between October 7 and 17 (Table 4). We had two small freshets during the 11-day period. It is possible that some downstream migrating fish were able to float around one end of the upstream trap. It is very unlikely that any fish were able to move upstream above the lower trap due to the presence of gravel bars.

Over the 11-day period, 1740 juvenile fish were caught. Since these were the first higher flows of the fall, it is likely that juveniles were moving through the Dawley side channel system. I expect that the numbers in Table 4 may be inflated from downstream migrants out of Spring Creek and Sequim Prairie. However, the amount of water that did flow around the smolt fence at several instances was a trickle compared to the total flow in the side channel. In addition, in the Spring of 2000, we caught over 300 juvenile fish rearing in an 18 ft, 36 inch culvert just upstream of the project area (although we unfortunately didn’t record this data). This was for a Sequim Prairie bypass channel fish blockage removal. So I believe it is certainly possible that this area was supporting this density of fish. This portion of Dawley side channel had deeply undercut banks with plenty of habitat for rearing fish.

This data confirms as expected that we were significantly sub-sampling the population in Dawley side channel, but it also suggests that we may have been under sampling chinook in general. The ’97 study caught 24% chinook, our main study had 12%, and the Dawley 2000 sampling caught 20% chinook (Table 4). However approximately 50% of the chinook caught in the Dawley

[6] The “trout” numbers combine steelhead, cutthroat, and those juveniles too small (generally less than 60 mm) to differentiate. They were combined for comparison and to maintain continuity with Hirschi and Reed (1998).

sampling were at or near smolt size (Appendix 4c), and we also observed an unknown number of smolts. For chinook, about half of the fish appeared to be the last of fall outmigrants and we may have sampled the smolts leaving with the beginning of the fall rains.

Conclusion and Recommendations

The purpose of this study was to gather more juvenile data and compare the two study periods. Were chinook patterns consistent? While we did not capture the densities of chinook that were captured in '97-98, we did find consistent patterns. Chinook favored flowing Surface water channels, mainstem pools, or were found in alcove pools at the downstream end of Hyporheic channels.

Research that is needed now is to further resolve the question of chinook overwintering and in general the timing and density of outmigration for all species. What percentage of chinook outmigrate in the spring vs. fall? What percentage of fish overwinter? Do habitat conditions contribute to downstream migration?

The next step to resolve the question of chinook is more detailed studies. General outmigration patterns could be resolved with the placement of a screw-trap from April to October in the lower mainstem Dungeness. In conjunction with the screw trap, downstream movement of fish could be tracked with snorkel surveys.

Snorkel surveys could also be used for further study the overwintering questions. Snorkel surveys are cost effective and have minimal impact. While visibility is usually low in the Dungeness at flows above approximately 400cfs, there are generally winter base flow periods with clear water. Snorkel surveys are being used in other large systems (Elwha, Stilliguamish, Cedar) to answer similar questions.

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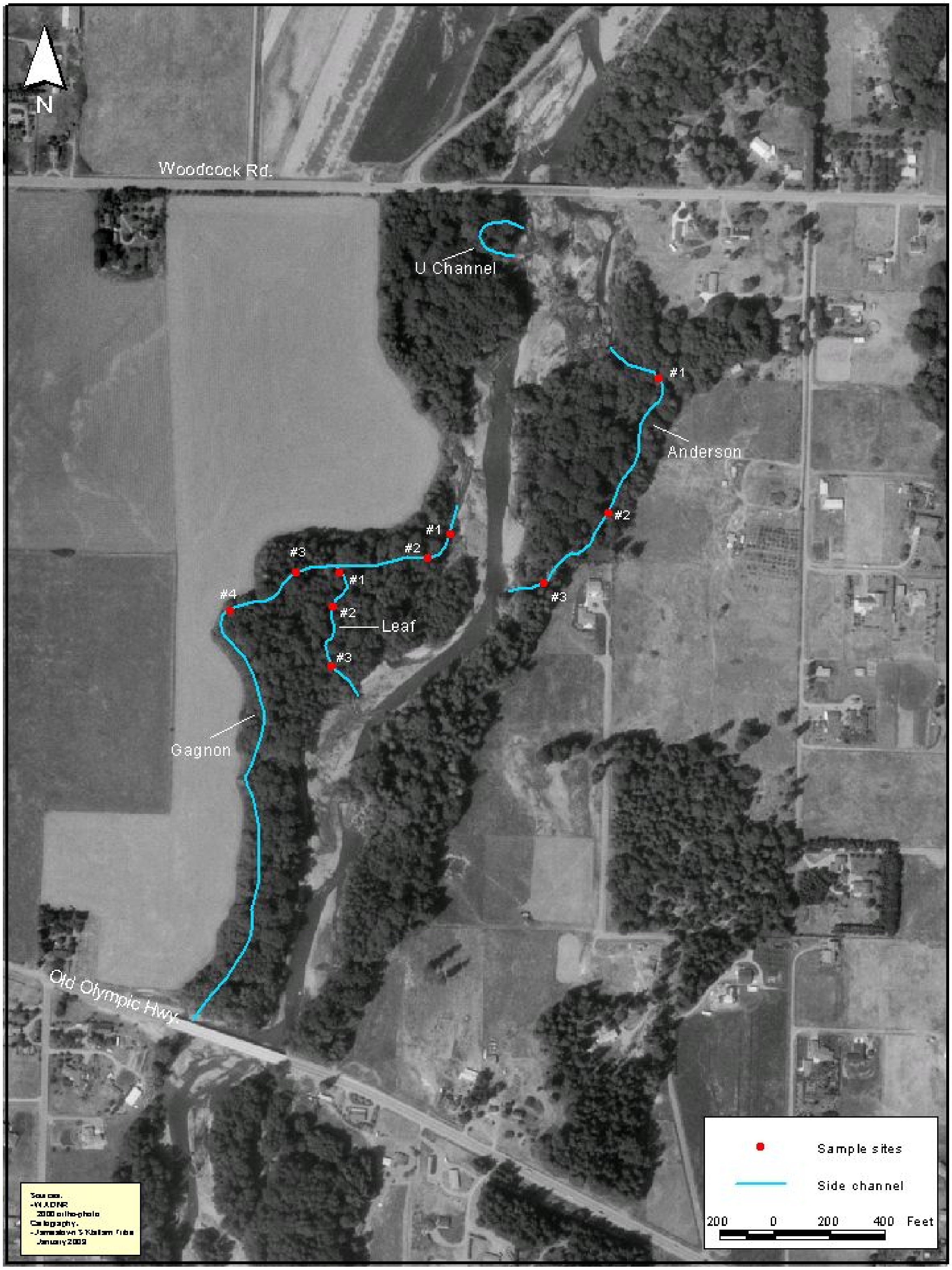
Appendices

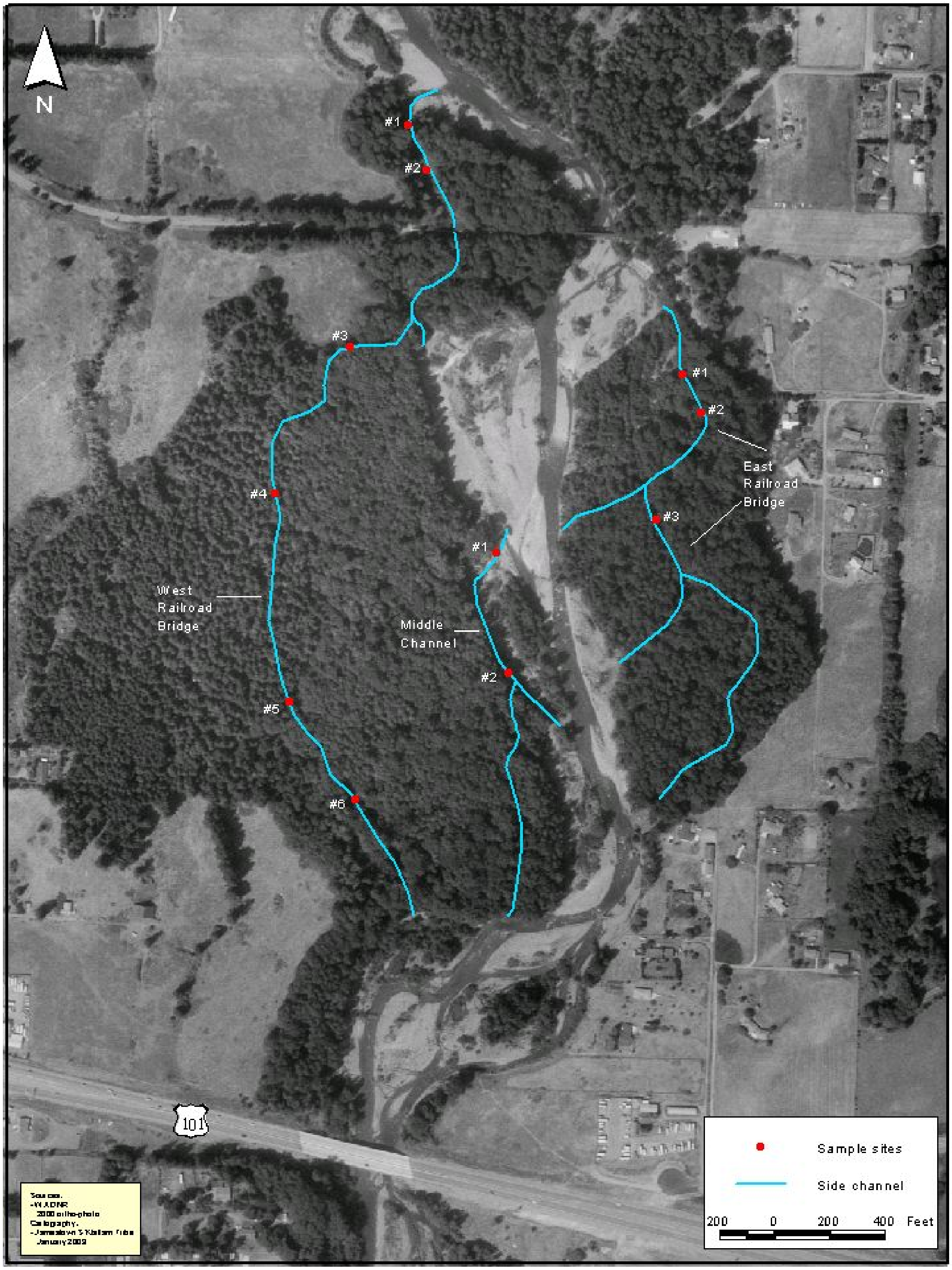
1. Location of side channels and sampling pools within the study area.
   Dungeness
    a. E. Towne Dike
    b. U-channel, Anderson, Gagnon, and Leaf channel
    c. East and West RR Bridge
    d. Dawley, Sequim Prairie, and Spring Creek
    e. East Crossing

   Gray Wolf
    f. Dungeness Forks, Leaning Tree, Coho Channel, Mossy Rock, and Acclimation Pond
    g. Left Bank, Cat Creek-Beaver Pond, Right Bank
2. Maximum and minimum water depth and width for each sampling location-Gray Wolf side channels.
3. Comparison of the total fish caught at each location for ’97-’98 and ’99-‘00
    a. Dungeness Mainstem
    b. Gray Wolf Mainstem
    c. Dungeness Side Channel
    d. Gray Wolf Side Channel
4. Histograms for coho, chinook, and trout
    a. Dungeness mainstem
    b. Gray Wolf mainstem
    c. Dungeness side channel
    d. Gray Wolf side channel
5. Dungeness Hatchery chinook broodstock releases—1997-2000

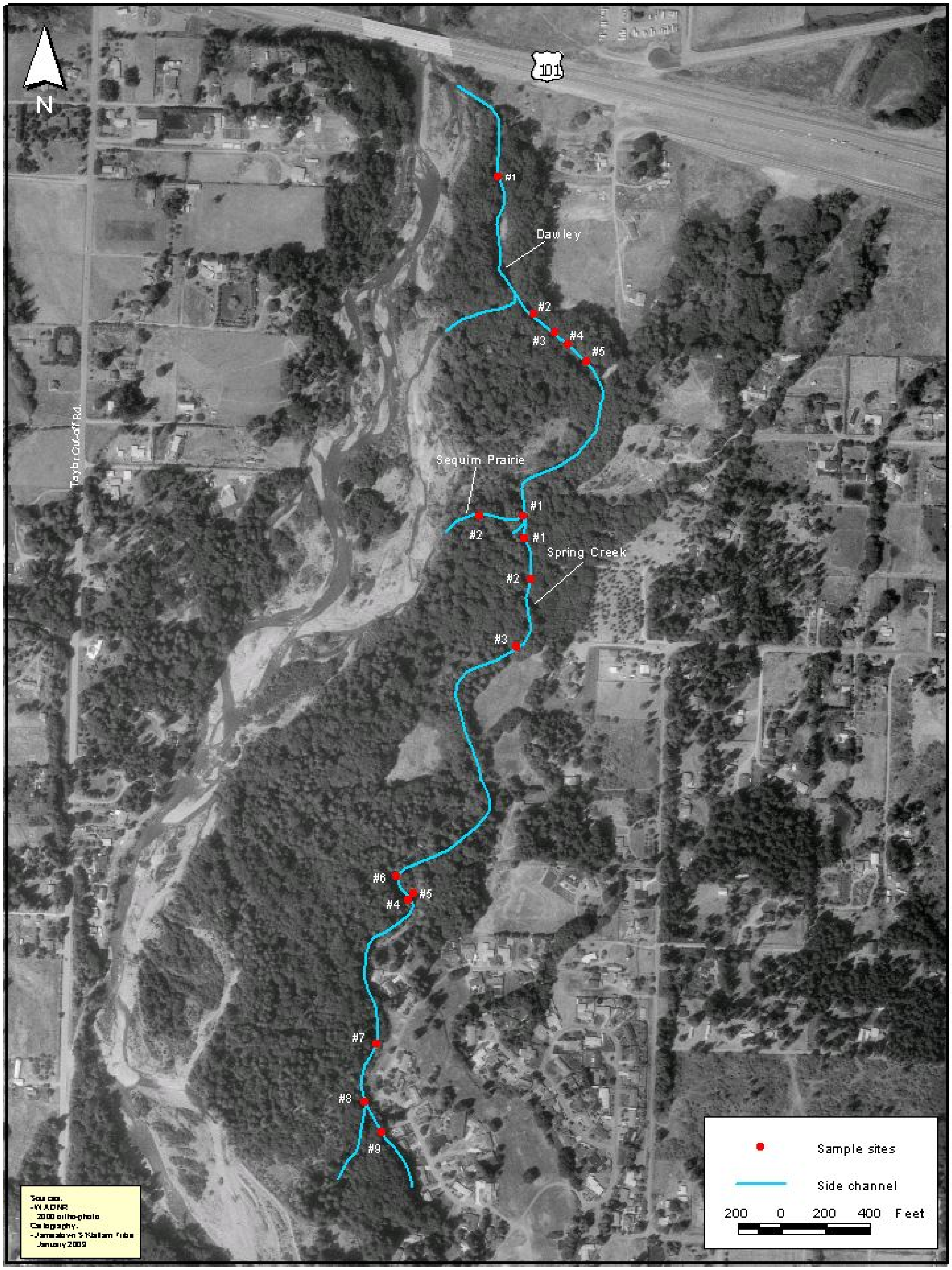
Appendix 1a. East Towne Rd. dike.



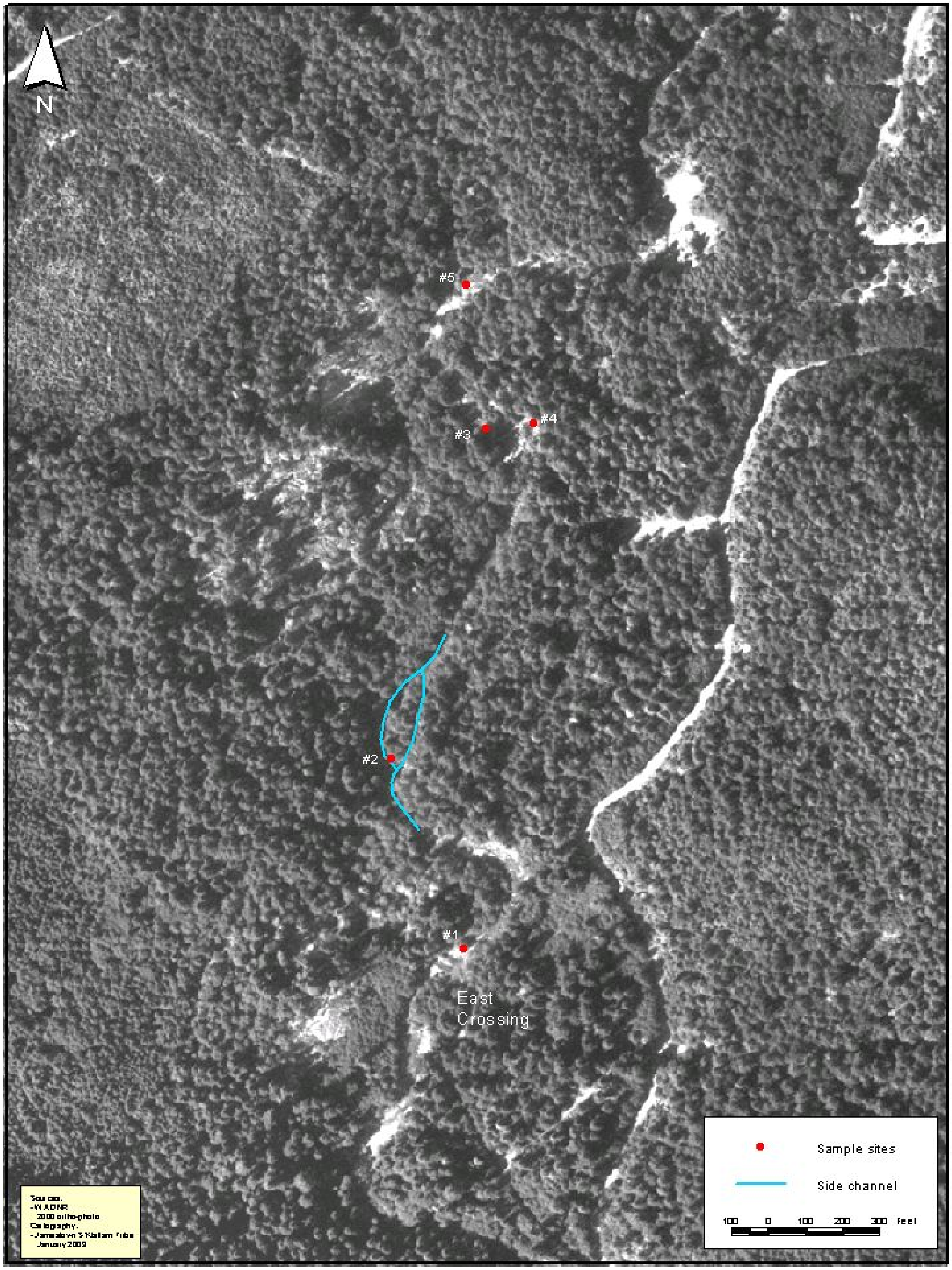
Appendix 1b. Gagnon, Leaf, Anderson, and U side channels



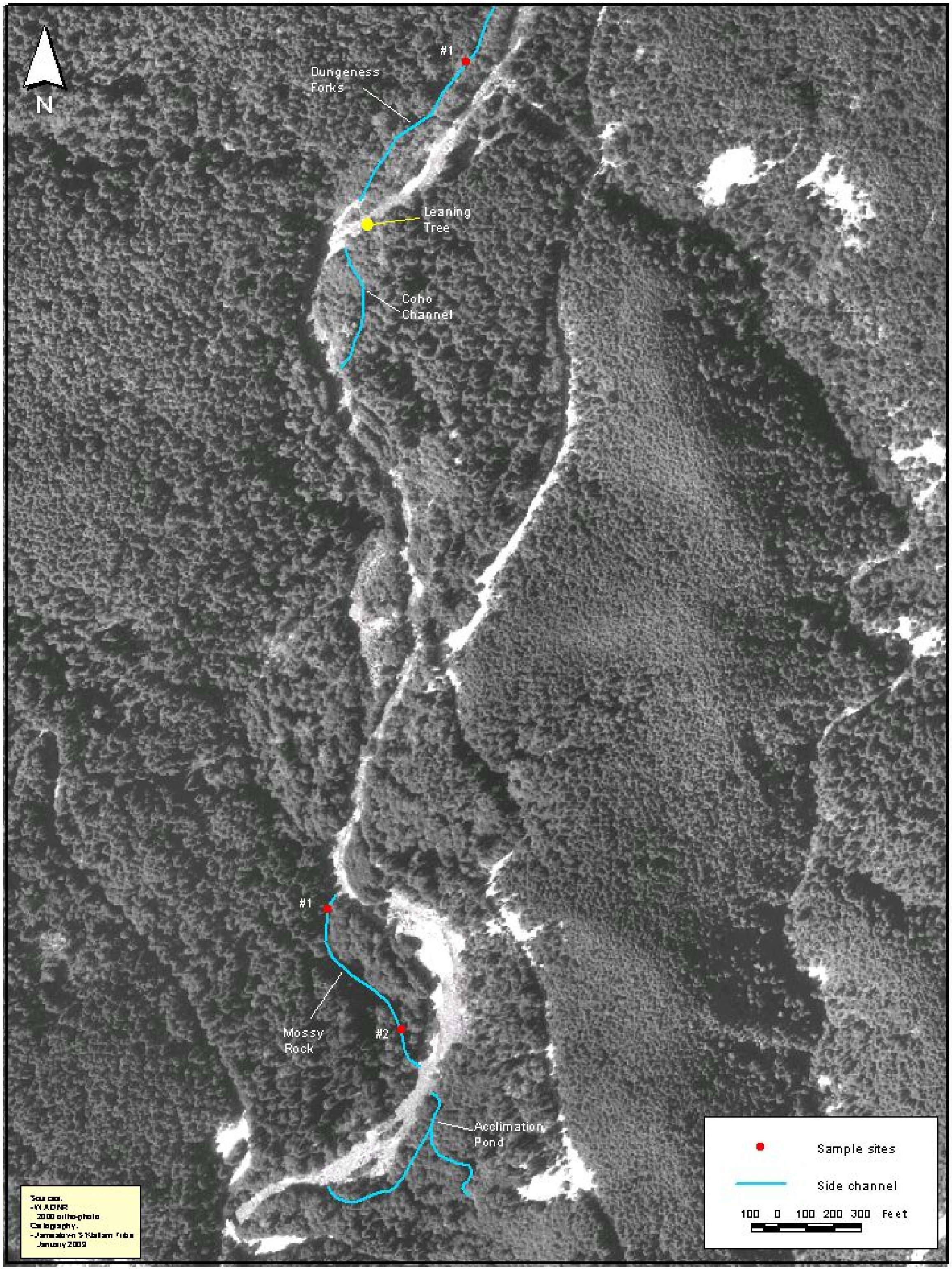
Appendix 1c. East and West RR Bridge.



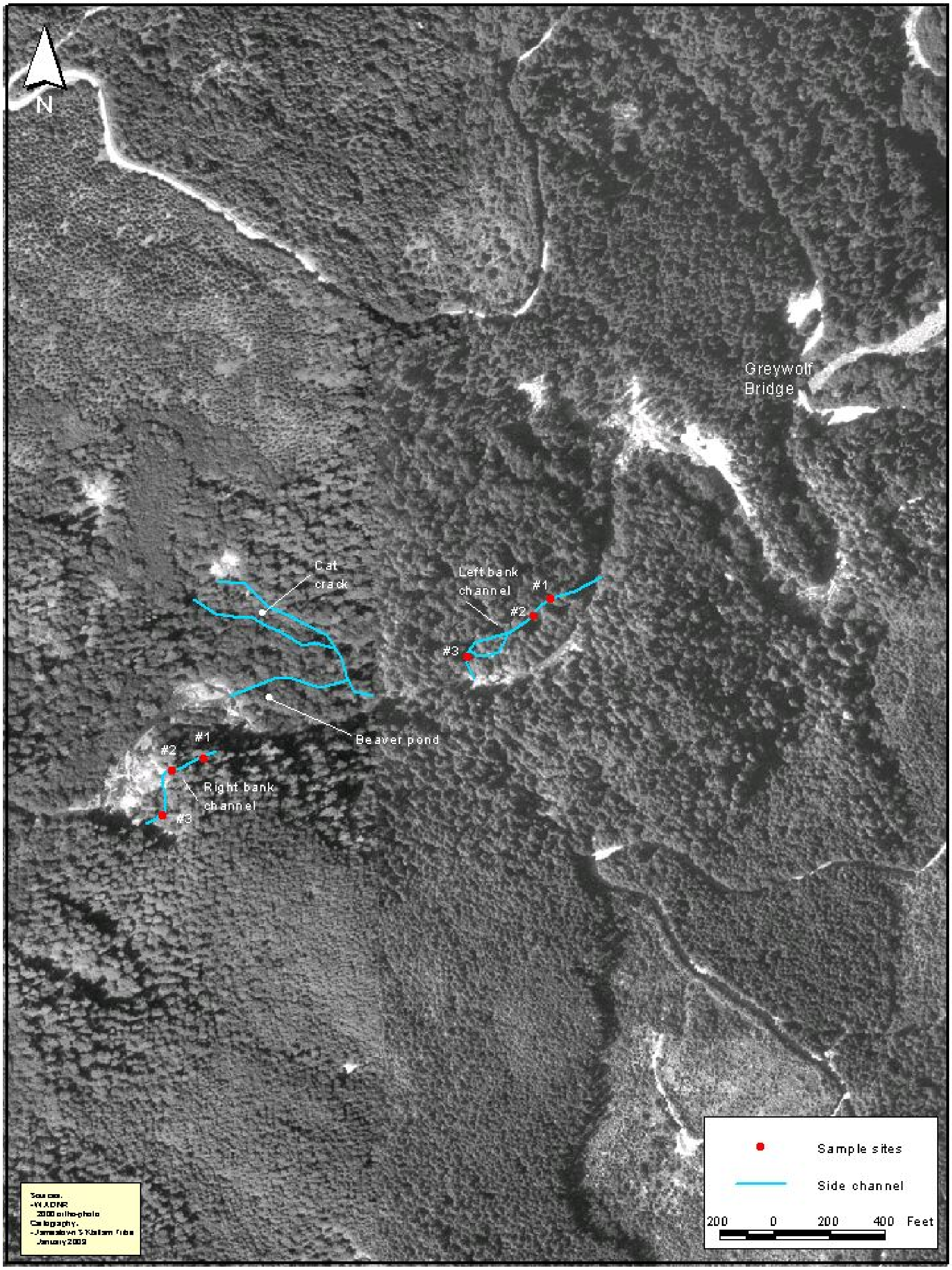
Appendix 1d. Dawley, Sequim Prairie, and Spring Creek.



Appendix 1e. East Crossing campground (marked) and downstream habitat.



Appendix 1f. Dungeness Forks, Leaning Tree, Coho Channel, Mossy Rock, and Acclimation Pond.



Appendix 1g. Left bank, Cat Creek/Beaver Pond, Right Bank

Appendix 2. Maximum and minimum water depth and width collected for each sampling location for Gray Wolf side channels.

Side channel	Location	Maximum water depth (cm)	Minimum water depth (cm)	Average water depth (cm)	Maximum water width (m)	Minimum water width (m)	Average water width (m)
2 mile camp	1	59	30	49	9	3	6
2 mile camp	2	94	82	88	15	9	12
2 mile camp	3	70	70	70	8	8	8
2 mile camp	4	70	46	58	8	8	8
Acclimation pond	1	30	28	29	1	1	1
Acclimation pond	2	53	42	48	8	2	5
Coho channel	1	35	24	30	4	2	2
Coho channel	2	28	28	28	2	1	2
Dungeness Forks	1	45	45	45	2	2	2
Dungeness Forks	2	42	42	42	5	5	5
Left Bank channel	1	97	45	69	5	2	3
Left Bank channel	2	60	42	49	4	2	3
Left Bank channel	3	55	35	43	4	2	3
Mossy rock	1	26	25	26	2	1	2
Mossy rock	2	28	25	26	2	2	2
Right Bank channel	1	43	37	40	2	2	2
Right Bank channel	2	71	52	60	5	2	4
Right Bank channel	3	55	52	54	5	5	5