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# ASSESSMENT OF CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) HABITAT AND POPULATION IN CROOKED CREEK

PREPARED FOR

THE STEWART VALLEY SALMON FOR THE FUTURE SOCIETY

AND

THE YUKON RIVER PANEL

BY

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ABSTRACT

Spawning, rearing and migrating habitat of Chinook salmon was evaluated in Crooked Creek in July and August of 1997. The juvenile population and spawning population of chinook salmon was also assessed during this time. Habitat preference of juveniles was investigated. These findings will help determine if wild stock restoration is appropriate in this area.

Habitat was studied by helicopter surveys and hiking the creek. Physical parameters pertaining to chinook salmon were measured at regular intervals along the creek from the mouth to 45 km upstream. Juvenile chinook salmon population was assessed by trapping fry in G-type minnow traps over this same distance.

The spawning population was assessed by counting migrating chinook salmon, by documenting spawning sites, and by counting carcasses. This was done by hiking and from a helicopter.

Extensive areas of suitable spawning and rearing habitat for chinook salmon was found in Crooked Creek. There were no obstructions to salmon migration.

Juvenile chinook salmon were trapped over the entire study area, indicating that there is an abundant juvenile population in Crooked Creek. Juvenile chinook salmon distribution appeared to be limited by water velocity and the presence of instream and overstream cover.

Twelve chinook salmon were observed spawning in Crooked Creek, and 40 chinook salmon were seen migrating. Thirteen carcasses were found. The chinook salmon spawning population estimate is not considered to be reliable due to visibility problems while flying the creek. Also, only half the creek was surveyed by helicopter during spawning season.

Before formulating wild stock restoration plans for Crooked Creek, further studies are necessary to reliably estimate chinook salmon spawning population.

TITLE: Assessment of Chinook salmon (*Oncorhynchus tshawytscha*) habitat and population in Crooked Creek.

INTRODUCTION:

The Stewart River originates in the Hess Mountains near the Yukon-NWT border. It flows westward across the Stewart Plateau until it reaches Stewart Crossing, where it enters the Tintina Valley and flows northwest until it joins the Yukon River, 100 km upstream of Dawson. It is the largest sub-basin in the Yukon.

The Stewart sub-basin is considered an important producer of chinook salmon. Based on radio-tagging studies (Milligan *et al.*, 1985) estimated that approximately 17% of the total upper Yukon River chinook salmon escapements were found in the Stewart sub-basin. There are several known spawning areas in the sub-basin (Ennis *et al.*, 1982; Herron, 1994; Smith, 1996). Traditionally, NND First Nations people fished for chinook salmon on the Stewart River. Native elders in the Mayo community, interviewed by Buchan (1993) identified several fishing camp sites on the Stewart River.

Native elders speak of decreasing numbers of chinook salmon in the Stewart River today than in their youth (Buchan, 1993). This opinion is shared by many old-timers in the Stewart Valley.

There has been some salmon habitat degradation in the Stewart sub-basin, such as that caused by the construction of the hydroelectric dam on the Mayo River in 1954, or that caused by placer mining activity in the McQuesten watershed. However, most tributaries of the Stewart River have not been damaged by man. Therefore, a good deal of the decreased number of chinook salmon is likely due to increased fishing pressure.

If salmon numbers are less than they were fifty years ago because of increased fishing, and adequate spawning and rearing habitat exists in the Stewart sub-basin, then this seems a good opportunity for wild stock restoration.

Before an area can be considered for stock restoration, an assessment of current salmon spawning and rearing habitat must be undertaken. The available habitat for spawning, rearing and migrating must also be evaluated. Beginning a restoration project without proper assessment of the area might result in negative impacts or an ineffective program that does not increase salmon numbers.

Crooked Creek is one of many tributaries of the Stewart River. It is a known salmon spawning area (Ennis *et al.*, 1982), however the size of the spawning population is not known. Local people, who often see salmon in the creek, consider it substantial. A traditional Nacho Nyak Dun First Nations fish camp was located on the Stewart River near the mouth of Crooked Creek (Buchan, 1993). This area is still fished today.

This study evaluated the spawning, rearing and migrating habitat for chinook salmon in Crooked Creek. It also attempted to determine the current chinook salmon spawning and rearing population in the creek. This assessment will determine if restoration is appropriate.

OBJECTIVES:

1. To assess chinook salmon spawning, rearing and migrating habitat in Crooked Creek.
2. To restore chinook salmon habitat if necessary by removing obstacles in the creek that block migration.
3. To assess the chinook salmon spawning population in Crooked Creek by documenting spawning sites, by counting migrating and spawning salmon, and by counting and sexing carcasses.
4. To assess the chinook salmon rearing population in Crooked Creek by trapping juveniles in a variety of habitats.
5. To determine habitat preference of juvenile chinook salmon.
6. To assess possible enumeration weir sites on Crooked Creek.

## STUDY AREA

Crooked Creek arises 15 km south of Ethel Lake and flows west and north-west for 45 km before it is joined by North Crooked Creek. Together they flow north-west for 18 km and empty into the Stewart River at Stewart Crossing. The Klondike highway crosses Crooked Creek 15 km south of Stewart Crossing.

Crooked Creek is accessible by trails from its mouth to 5 km upstream. Also, the road to the Stewart Crossing dump continues past the dump to the creek, approximately 6 kilometers from the mouth. The creek is also accessible where it crosses the Klondike Highway, and 8 km south of the bridge, a side road goes close to the creek.

At the bridge on the Klondike Highway, on the east side of the road, there is an small area designated as Nacho Nyak Dun Site Specific Settlement Lands.

Crooked Creek and North Crooked Creek form the boundaries of the McArthur Wildlife Sanctuary.

METHODOLOGY:

On July 3, 1997 reconnaissance of Crooked Creek was conducted from a helicopter. The creek was studied from the mouth to the headwaters, including North Crooked Creek. On the basis of this survey, as well as topographical map contours and ground truthing, Crooked Creek was partitioned into reaches of similar physical features.

Ground truthing began just after the time of high water. This consisted of hiking the creek and measuring physical parameters at intervals of approximately 1 km in Reach 1 and 2 km in Reach 2 as determined by GPS. Crooked Creek was hiked from the mouth to the upper limit of Reach 2. Reach 3 and North Crooked Creek were not hiked due to time constraints.

Measurements and observations recorded at each site were:

1. Location as determined by GPS.
2. Stream gradient measured with a Sunto clinometer.
3. Water velocity measured with an electronic current meter or by recording the time it took an orange to float a known distance. When this second method was used, three readings were taken and averaged to get water velocity. The two methods of determining velocity were compared at the same site, and the results were similar.
4. Channel width
5. Channel depth
6. Water temperature
7. Water turbidity, which was measured by lowering a meter stick into the water until the tip disappeared.
8. Type of substrate, which was determined by a visual estimate of the percent composition of fines (less than 0.1 cm), small gravel (0.1-4.0 cm), large gravel (4.0-10.0 cm), cobbles (10.0-30.0 cm) or boulders (30† cm).
9. Nature of the flow was categorized as to whether it was a pool, riffle, run or rapids. Pools are deeper than surrounding areas and have a low velocity. Riffles are regions where the water surface is broken into waves by bed material. Runs are regions of flowing water where the surface is not broken by bed material. Rapids are a very rapid whitewater cascade.
10. The amount and type of overstream cover.
11. The amount and type of organic debris in streams.
12. Type of riparian vegetation.

Possible obstructions to salmon migration, such as logjams, beaver dams or fallen trees, were noted along the entire length of the creek. Before spawning season, it was difficult to know if these would block migration. It was decided that something would be considered an obstruction if salmon were seen trying and failing to get beyond it.

Near the lower end of the creek, possible sites for an enumeration weir were evaluated. An important criteria for a weir site is that it is downstream from chinook salmon spawning activity. Other parameters measured to evaluate weir site were:

1. Stream gradient.
2. Water velocity.
3. Water depth.
4. Stream width.
5. Substrate stability.
6. Accessibility.

Throughout July and August, G-type minnow traps were baited with salmon roe and set in a variety of habitat types in Reach 1 and Reach 2. A total of 43 traps were set. Traps were checked in 24 hours. Captured chinook salmon fry were counted. From each trap, a subsample of six chinook salmon fry were anesthetized by placing them in a bucket in which Alka Seltzer (1 tablet per 2 liters of water) had been dissolved. The fork lengths (distance from the fork in the tail to nose tip) of these fish were measured to the nearest millimeter. Anesthetized fish were revived in a bucket of fresh water and released. Species other than chinook salmon that were captured were counted but not measured.

During August, portions of the creek were hiked daily to count salmon swimming upstream, to locate and map spawning grounds and to locate, count and sex carcasses. Carcasses were chopped in half so they wouldn't be counted twice. Locations of spawning sites and carcasses were identified with a GPS. The physical parameters pertaining to salmon habitat were measured at the spawning sites, and G-type minnow traps were placed nearby.

On August 18, which was considered to be the height of spawning, a helicopter flight to count spawning salmon was made over Crooked Creek. Following the sinuous flow of the creek required more flight time than anticipated. Therefore, due to budget constraints, only the upper half of the creek was surveyed. Carcass and redd locations were identified by GPS.

RESULTS:

Habitat Assessment

Crooked Creek consists of alternating sections of riffle, run and pool, with very few rapids and no steepwalled canyons. Crooked Creek was divided into three reaches (see Map 1). Reach 1 (Map 2) extends from the mouth to the confluence with North Crooked Creek. Reach 2 (Map 3) covers the area from the confluence with North Crooked Creek to the confluence with Woodburn Creek. The headwaters of Crooked Creek make up Reach 3.

Reach 1 was accessible at several points by roads and trails, which kept hiking legs to a distance that could be covered in one day. Reaches 2 and 3, however were only accessible by road at one point, which meant overnight hiking trips. Due to the long distance from an access point, Reach 3 was not hiked. The values for habitat parameters measured in this study are included in the appendix.

At the mouth of Crooked Creek there was a section that could almost be considered a separate reach. This section of the creek was similar to the Stewart River. The channel was wide and divided around islands. The water was too deep to measure stream width or depth by wading. Turbidity was high. The end of a yard stick disappeared 5 cm into the water. The substrate was 100% fines and the stream gradient was 0%. The flow was a slow run (0.20 m/s), which was uniform across the width of the creek, with no divisions into riffles or pools.

At approximately 500 m from the Stewart River, the flow of Crooked Creek changed to a series of riffle, run and pools. The channel narrowed to 14.8 m, the stream gradient was .5%, the substrate was large and small gravel, and the water became clear. These features were more representative of the rest of Reach 1.

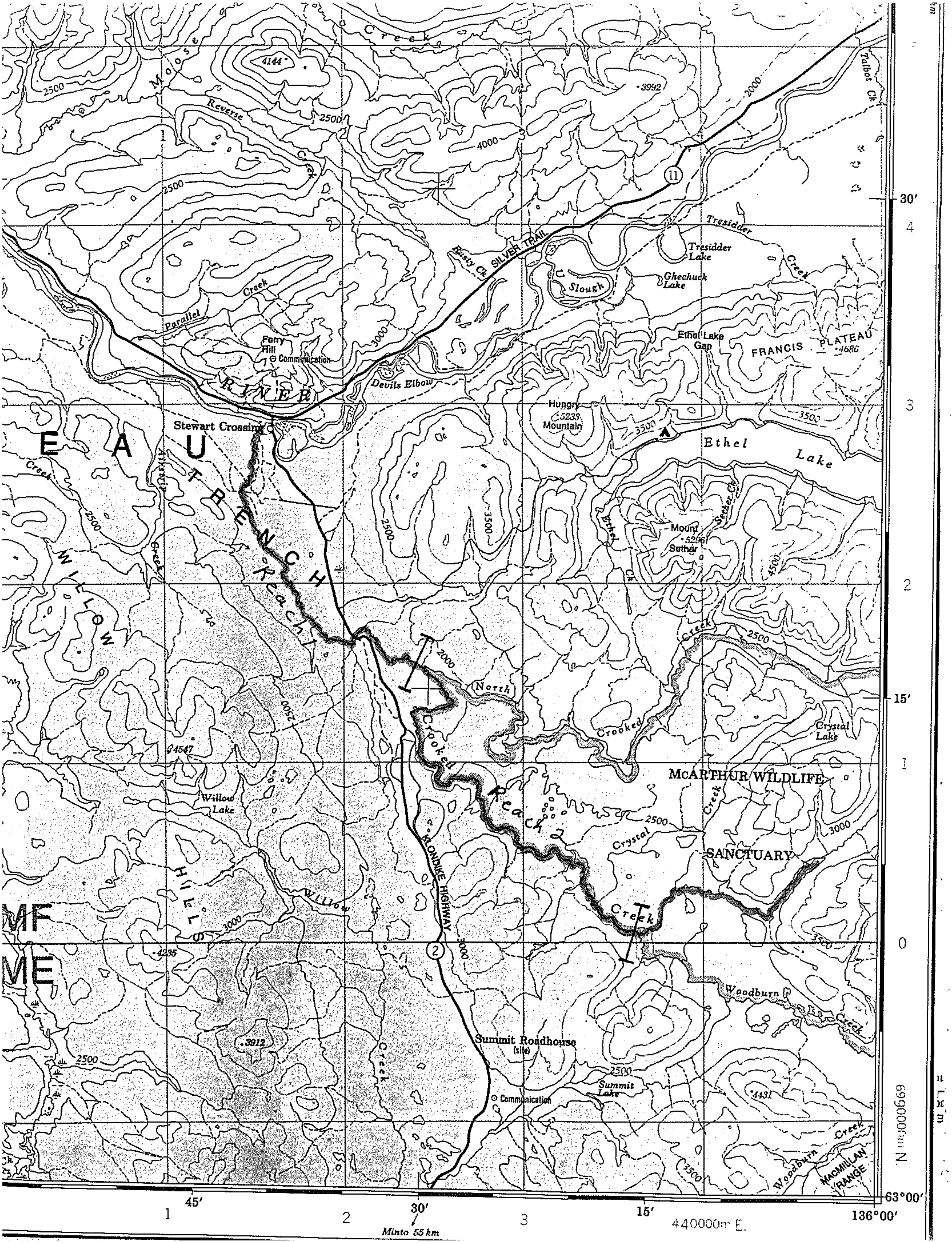
In general, Reach 1 followed a sinuous course, often doubling back on itself. In many places, the creek's flow was divided by islands.

The average channel width of Reach 1 was 13.7 m, with widths ranging from 5.0 - 20.0 m. The creek's depth ranged from 0.25 - 0.80 m, with an overall average depth of 0.49 m. Water velocities ranged from 0.20 - 1.72 m/s. The average water velocity was 0.64 m/s. At several sites there was considerable variation between the water velocity of near shore and mid-stream regions.

Stream gradients ranged from 0% near the mouth to 2% in one location. In most places, stream gradient was 0.5% or 1%. The area where the stream gradient was 2% corresponded to one of the faster stream velocities (1.43m/s).

Near the mouth, the substrate in Reach 1 was 100% fines, however the substrate in the remainder of Reach 1 was primarily a mixture of small gravel and large gravel, with some cobbles. Cobbles were seen in areas of higher

Map 1.
Scale is 1:250,000
Crooked Creek is highlighted
Reach breaks are marked.


Moose Creek
Reverse Creek
Talbot Ck
SILVER TRAIL
Rusty Ck
Tresidder Creek
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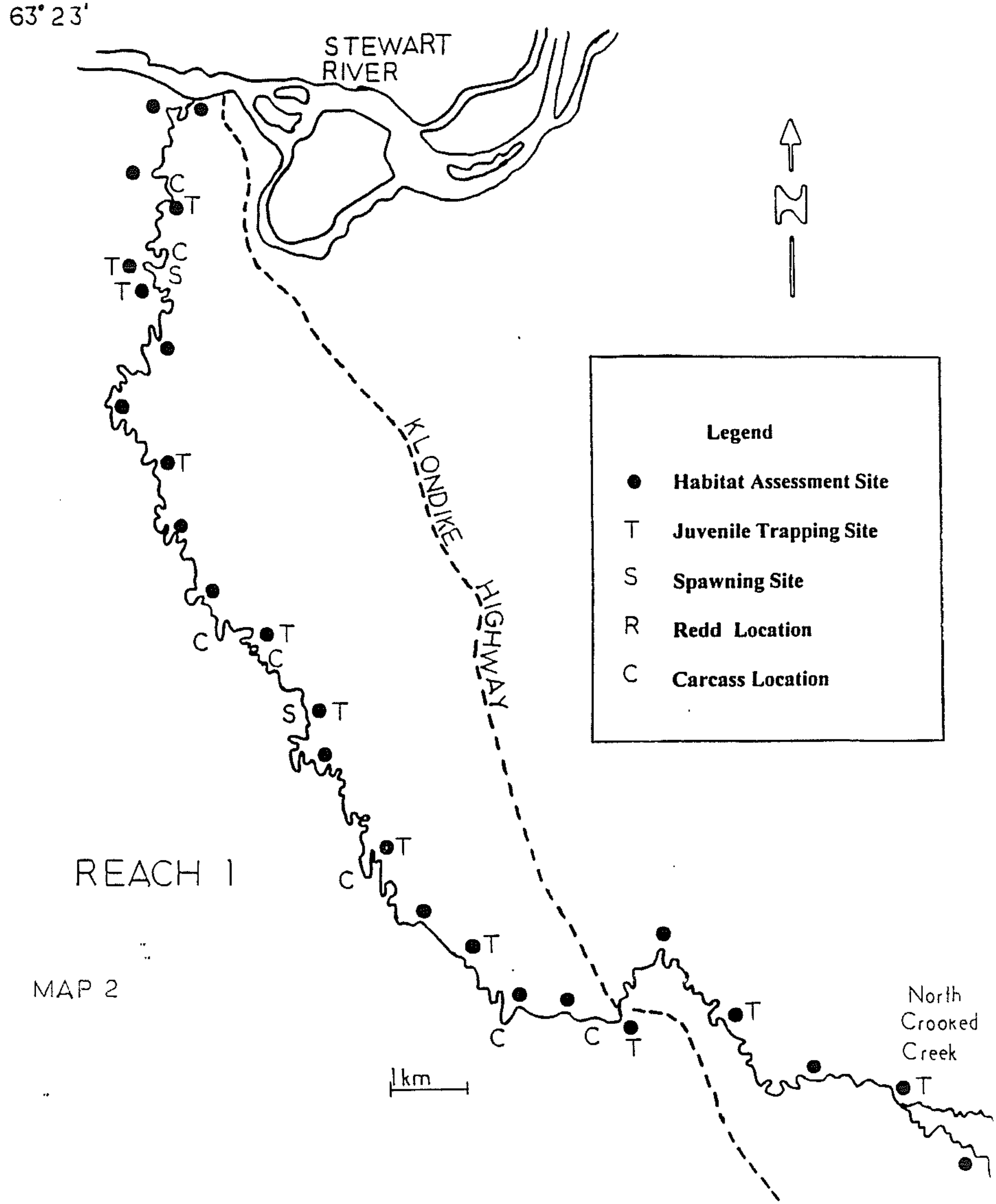
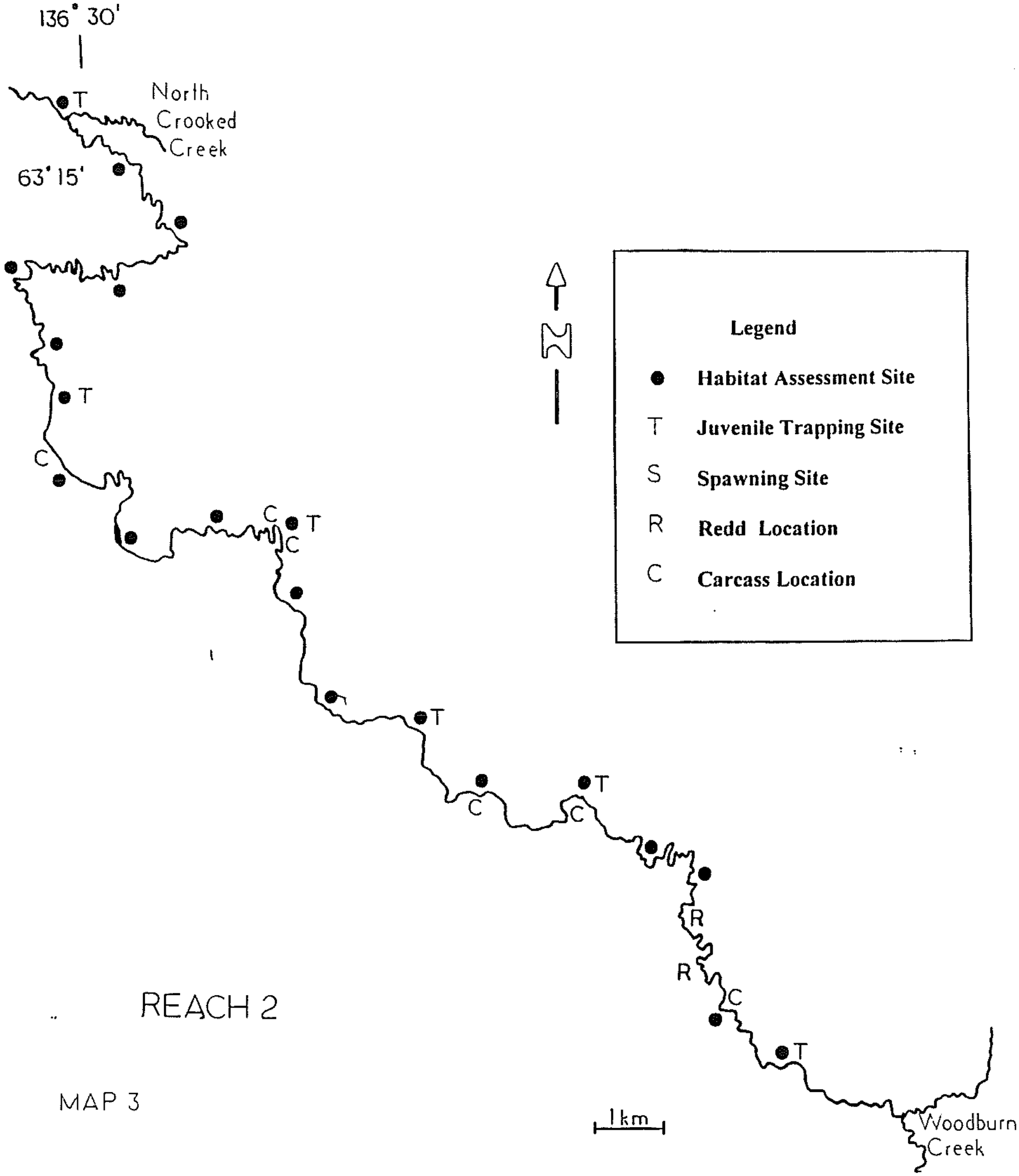
Ghechuck Lake
U Slough
Parallel Creek
Ferry Hill
Communication
RIVER
Devils Elbow
Ethel Lake Gap
FRANCIS PLATEAU
Hungry Mountain
Stewart Crossing
Ethel Lake
Mount Sether
Sether Ck
Ethel Ck
TRENCH
Reach
North
Crooked Reach
Crooked Creek
Crystal Lake
McARTHUR WILDLIFE SANCTUARY
Crystal Creek
WILLOW HILLS
Willow Lake
Willow
KLONDIKE HIGHWAY
Woodburn Creek
Summit Roadhouse (site)
Summit Lake
Communication
MACMILLAN RANGE
Minto 55 km
440000m E.
6990000m N.
63°00′
136°00′
30′
15′
45′


63° 23'
STEWART RIVER
KLONDIKE HIGHWAY
Legend
Habitat Assessment Site
T Juvenile Trapping Site
S Spawning Site
R Redd Location
C Carcass Location
REACH 1
MAP 2
1km
North Crooked Creek


136° 30'
63° 15'
North Crooked Creek
T
C
R
Legend
Habitat Assessment Site
T Juvenile Trapping Site
S Spawning Site
R Redd Location
C Carcass Location
N
1km
Woodburn Creek
REACH 2
MAP 3

velocity. In pools and at the inside of bends, substrate was small gravel and fines.

During early July, the creek was clear, with no turbidity. However, during heavy rainfall in late July and early August, the creek became silty and dark. The siltiness cleared after approximately two weeks, but the water remained tea-colored until the last week of August. This applied to all reaches of the creek.

Vegetation along the creek in Reach 1 was primarily polar, willows and white and black spruce. Willows and trees often grew out at an angle and leaned over the creek, shading the water below.

In many places along the creek, unstable banks due to water erosion had caused trees to fall into the stream, often across the channel. None of these wholly or partially submerged trees blocked water flow or salmon migration, but many slowed the water and formed pools on the downstream side. They also provided areas in the creek where juveniles could find cover.

Overstream cover was also provided in many places by the creek bank being undercut by water erosion forming an overhang.

In the middle section of Reach 1, there was an area where logging had taken place several years ago. In this section, there were several small logjams formed by cut logs, however none were obstructing creek flow. A larger logjam, approximately 1 km downstream from the bridge over the Klondike Highway, also partially blocked creek flow. Another partial obstruction to creek flow was caused by a beaver dam and lodge in the middle section of Reach 1.

As none of these fallen trees, logjams or beaver dams blocked salmon migration, habitat restoration was not necessary.

Reach 2 was somewhat different than Reach 1. Although the creek's course in Reach 2 was winding, it was less tortuous than that of Reach 1. There were less islands in Reach 2 than in Reach 1. Much of the flow in Reach 2 was categorized as a run, but there were also sections of rapids. Since Reach 2 was above the confluence with North Crooked Creek, the stream here was smaller than in Reach 1. The average channel width in Reach 2 was 8.8 m with widths ranging from 6.0 - 10.4 m. Channel depth ranged from 0.32 - 0.74 m. The average depth was 0.48 m.

Water velocity in Reach 2 ranged from 0.38 - 1.6 m/s, with an average velocity of 0.77 m/s. The lowest stream gradient in Reach 2 was 0.5%, the highest was 2%. Most sections had a gradient of 1%. The sections of 2% gradient were in areas of rapids. The highest velocity of Reach 2 (1.16 m/s) was found in an area of 2% gradient.

The substrate in Reach 2 varied more than that in Reach 1. Near the lower end of the reach, the substrate was a mixture of small and large gravel, with some cobbles. Farther upstream, where the gradient increased and the flow was rapids, the substrate was mostly cobbles, with some boulders. In the upper sections of the reach, the substrate once again became a mixture of large and small gravel. In pools and the inside of bends, the substrate was fines.

Riparian vegetation in Reach 2 was primarily black spruce and willows. The upper section of Reach 2 was in a narrow valley with spruce trees growing close along the creek bank. In many places, the trees leaned over the creek providing overstream cover. There were also many places where trees and willow were lying in the creek, providing instream cover.

In Reach 2 there were three large logjams, two located at sharp bends of the creek, and another spread out for thirty meters along the creek. There was also an area where six spruce trees had fallen into the water side by side. None of these were blocking salmon migration, so habitat restoration was not necessary.

Reach 3, which was only surveyed helicopter, was narrower than the other two reaches, and the flow was mostly run and riffle. The substrate appeared to be fines and small gravel.

## Chinook Salmon Spawning

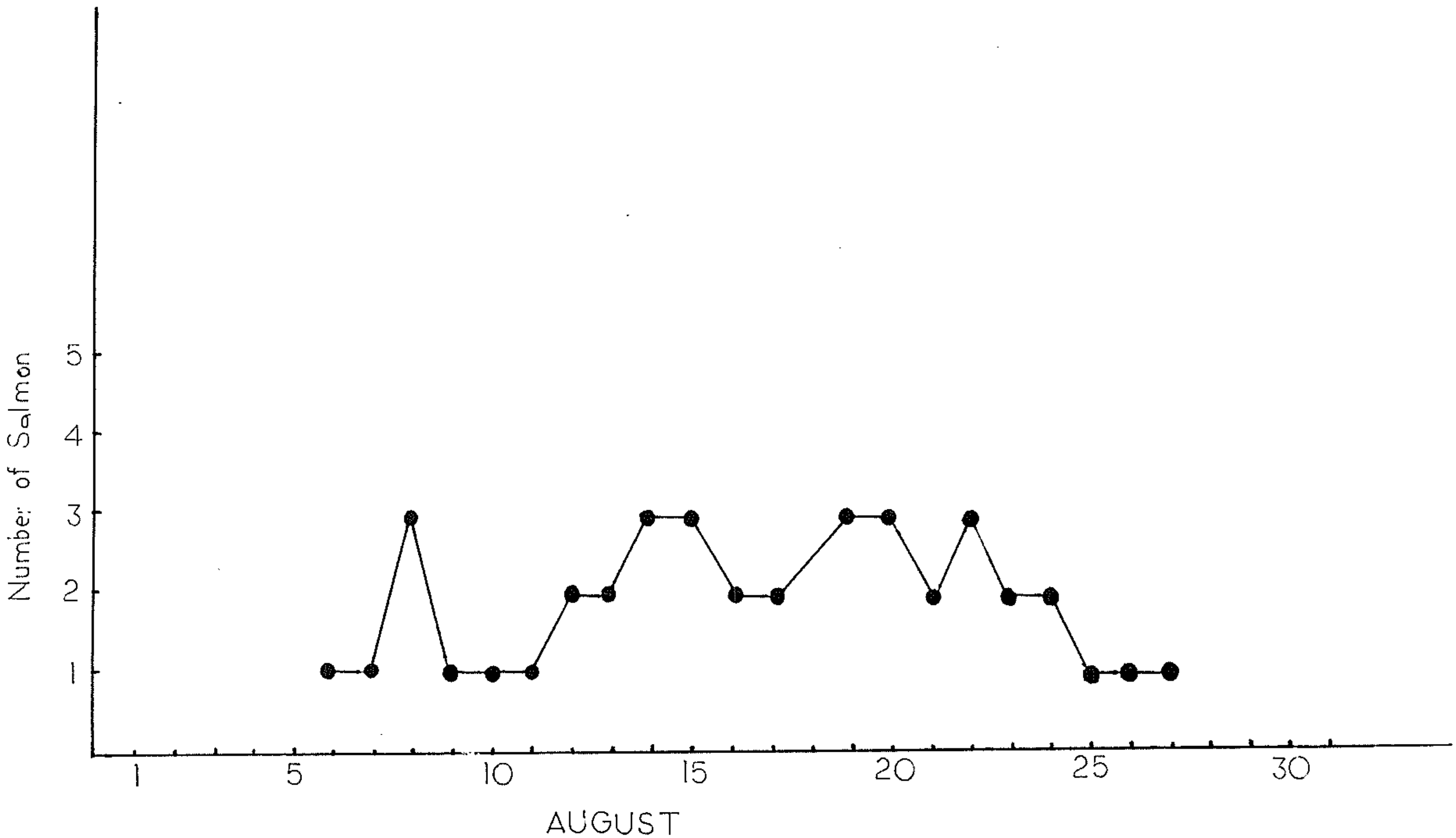
During the first week of August, the water in Crooked Creek was turbid due to runoff from heavy rainfall. This reduced visibility, making it difficult to spot migrating salmon. On August 6, the first chinook salmon was seen swimming upstream in Crooked Creek. Sections of the creek were hiked daily in August, and during this time 40 salmon were counted migrating upstream or holding in pools (See Table 1).

The timing of the Crooked Creek run is plotted in Figure 1. This run doesn't have a peak. The salmon numbers remain fairly constant from Aug 6 to Aug 27.

On August 18, the upper half of Crooked Creek was surveyed by helicopter. Unfortunately, overcast conditions and dark water decreased visibility. In many areas, we were unable to see into the water. No live salmon were spotted migrating or spawning. Six carcasses and two unoccupied redds were seen. (See Map 3; coordinates of carcasses and redds are given in the appendix). Three of the carcasses

Table 1. Chinook Salmon Spotted Swimming Upstream in Crooked Creek in August, 1997.

| Date | Number of Fish |
|---|---|
| Aug 1 | 0 |
| Aug 2 | 0 |
| Aug 3 | 0 |
| Aug 4 | 0 |
| Aug 5 | 0 |
| Aug 6 | 1 |
| Aug 7 | 1 |
| Aug 8 | 3 |
| Aug 9 | 1 |
| Aug 10 | 1 |
| Aug 11 | 1 |
| Aug 12 | 2 |
| Aug 13 | 2 |
| Aug 14 | 3 |
| Aug 15 | 3 |
| Aug 16 | 2 |
| Aug 17 | 2 |
| Aug 18 | non-hiking day |
| Aug 19 | 3 |
| Aug 20 | 3 |
| Aug 21 | 2 |
| Aug 22 | 3 |
| Aug 23 | 2 |
| Aug 24 | 2 |
| Aug 25 | 1 |
| Aug 26 | 1 |
| Aug 27 | 1 |
| Aug 28 | 0 |
| Aug 29 | 0 |
| Aug 30 | 0 |
| Aug 31 | 0 |
| | |
| Total | 40 |




CROOKED CREEK SALMON RUN 1997

were caught in logjams. The redds were in relatively shallow areas where gravel was visible.

Since hiking was difficult in the upper reaches of the creek, and we hadn't flown over the lower half of the creek, the decision was made to limit hiking to the lower half of the creek for the remainder of the study.

On August 19, a spawning site with three chinook salmon on redds was found in Reach 1. (See Map 2; coordinates of spawning sites are given in the appendix). The site was revisited on August 20 and three G-type minnow traps were set in the area and habitat parameters were measured. On August 20 and 21, two more salmon were spotted spawning at this site. (See Table 2).

On August 22, four chinook salmon were seen occupying redds in an area farther upstream in Reach 1. (See map 2). The spawning area extended for forty meters. The site was revisited on August 23 and 24, and three more salmon were seen spawning. Three G-type minnow traps were set in the area at this time.

No further spawners were seen on subsequent visits to either spawning site. A total of twelve chinook salmon were observed spawning.

Water velocity at the lower spawning site was 0.62 m/s and the water depth was 0.52 m. (See Table 3). Substrate here was a mixture of small gravel (25%), large gravel (50%), and cobbles (25%). At the upper spawning site, the water velocity was 0.44 m/s and the depth was 0.38 m. The spawning substrate was 50% small gravel and 50% large gravel.

Six carcasses were spotted from the helicopter and 7 were found while hiking to make a total of 13 carcasses seen in Crooked Creek. (See Maps 2 & 3; for coordinates of locations see appendix). Four of the carcasses found while hiking were female, three were male. Two of these carcasses were caught in logjams.

## Juvenile Trapping

At each trapping area, between 2-4 traps were set within a short distance in order to sample all available types of habitat. Juvenile trapping areas are shown on Maps 2 & 3. (Coordinates of trapping sites, trapping dates and trapping results are given in the appendix).

Forty-three traps were set in this study. Of these, 14 captured no juvenile chinook salmon, 18 captured from 1-10 juveniles, 9 captured 10-50 juveniles and 4 captured more than 50 juveniles. (Table 4). Slimy sculpins were captured

Table 2. Daily number of new spawners at two spawning sites in Reach 1. (For coordinates of spawning sites see appendix.)

| Date | Lower Spawning Site | Upper Spawning Site |
|---|---|---|
| Aug 19 | 3 | not checked |
| Aug 20 | 1 | not checked |
| Aug 21 | 1 | not checked |
| Aug 22 | not checked | 4 |
| Aug 23 | not checked | 2 |
| Aug 24 | not checked | 1 |
| Aug 26 | 0 | not checked |
| Aug 27 | 0 | not checked |
| Aug 28 | not checked | 0 |
| Aug 29 | not checked | 0 |
| Total | 5 | 7 |

Total Spawners = 12

Table 3. Parameters of Spawning Sites. (SG = small gravel, LG = large gravel, C = cobbles)

| | Stream Gradient | Water Velocity (m/s) | Water Depth (m) | Substrate | Water Temperature |
|---|---|---|---|---|---|
| Lower Spawning Site | 1% | 0.62 | 0.52 | 25% SG<br>50% LG<br>25% C | 8.3°C |
| Upper Spawning Site | 0.5% | 0.44 | 0.38 | 50% SG<br>50% LG | 8.4°C |

at 14 trapping sites The range of their capture extended from the mouth to near the upper limits of Reach 2.

Chinook salmon fry were captured in both Reach 1 and Reach 2, although generally, traps in Reach 1 yielded more fry/trap than those in Reach 2. The highest number of fry/trap was 72. This was near the spawning site in lower Reach 1. The next highest number of fry/trap was 67. This was near the upper spawning site in Reach 1. Sixty-six fry were captured in one trap approximately 1.5 km from the mouth. The highest number of fry/trap in Reach 2 was 54.

In Reach 1, juveniles were trapped at velocities ranging from nil to 0.78 m/s. In Reach 2, fry were captured at velocities ranging from 0.18 m/s - 0.64 m/s. The traps that yielded the highest number of fry/trap (54-72 fry/trap) were located at velocities ranging from nil to 0.36 m/s. Although traps were set in areas with velocity greater than 0.78 m/s, no fry were captured in these traps.

Trapping sites were categorized according to the number of fry captured in each trap. (Table 4). Table 5 shows the average velocity of these groups of trapping sites. The sites where no juveniles were trapped had the highest average velocity (0.85 m/s) and the sites where more than 50 fry were captured had the lowest average velocity (0.2 m/s).

Fry were captured in areas with gradients ranging from 0.5% - 2%. No traps were set in areas of 0% gradient. Three trapping areas had no fry captured in any habitat type available. These areas had gradients of 1.5% - 2%. The sites that yielded more than 50 fry/trap had gradients of 0.5% - 1%.

Table 6 shows what type of flow and cover were present at each category of trapping site. The traps that captured more than 50 juveniles were all located in pools. In all cases, traps placed in sections of riffle near these pools with high numbers of juveniles yielded either no fry or very few. Runs in these areas consistently yielded more fry than riffle areas, but less than the pools. Seventy-eight percent of traps that captured 10-50 juveniles were located in runs, while traps that captured 1-10 juveniles were almost equally divided between riffle, run and pool. No fry were captured in areas of rapids.

Instream cover was divided into boulders and organic debris such as submerged logs. Overstream cover was divided into vegetation projecting over the creek and cutbanks formed by water eroding the base of the stream bank. Seventy-eight percent of sites where no juveniles were trapped had no overstream cover, while 100% of sites where more than 50 juveniles were trapped had either cutbanks or vegetation cover. Instream cover in the form of boulders or

Table 4. Trapping Sites Categorized with respect to the number of juvenile chinook salmon captured per trap.

| Fry/trap | Number of Trapping Sites |
|---|---|
| 0 | 14 |
| 1-10 | 18 |
| 10-50 | 9 |
| 50† | 4 |

Table 5. Average water velocities for trapping site categories.

| Fry/trap | Average Water Velocity (m/s) |
|---|---|
| 0 | 0.85 |
| 1-10 | 0.36 |
| 10-50 | 0.48 |
| 50† | 0.20 |

Table 6. Percentage of trapping Sites where Parameter Occurs.

| | Trapping Site Category | | | |
|---|---|---|---|---|
| fry/trap | 0 fry/trap | 1-10 fry/trap | 10-50 fry/trap | 50† |
| Stream Type | | | | |
| pool | 14% | 38% | 22% | 100% |
| riffle | 22% | 31% | 0% | 0% |
| run | 50% | 31% | 78% | 0% |
| rapids | 14% | 0% | 0% | 0% |
| Instream cover | | | | |
| organic debris | 13% | 44% | 55% | 100% |
| boulders | 13% | 6% | 0% | 0% |
| no instream cover | 74% | 50% | 45% | 0% |
| Overstream cover | | | | |
| vegetation | 22% | 50% | 33% | 75% |
| cutbank | 0% | 0% | 0% | 25% |
| no overstream cover | 78% | 50% | 67% | 0% |
| Combined cover | | | | |
| no cover | 50% | 19% | 22% | 0% |
| one type of cover | 50% | 81% | 78% | 100% |

organic debris was absent from 74% of those sites where no juveniles were captured, whereas instream cover was found at 100% of sites where more than 50 juveniles were trapped. Fifty percent of sites where no juveniles were captured had no form of overstream or instream cover, while no sites yielding more than 50 fry/trap were without cover.

The importance of cover is less straight forward in areas where traps yielded lesser numbers of fry. Between 45-50% of the trap sites where 1-50 fry were captured had no instream cover, and 50-67% of these sites had no overstream cover. However, approximately 80% of these sites had either instream or overstream cover.

Of the 43 traps set in this study, 13 were set in locations without any type of overstream or instream cover. Eight of these 13 locations (68%) yielded no fry. Three of the 5 locations without cover had 1-10 fry/trap. The two locations where 10-50 fry/trap were caught were near spawning areas.

These data have not been analyzed statistically, but it can be seen that there is a trend for higher numbers of juveniles to be captured in areas where there is some type of cover.

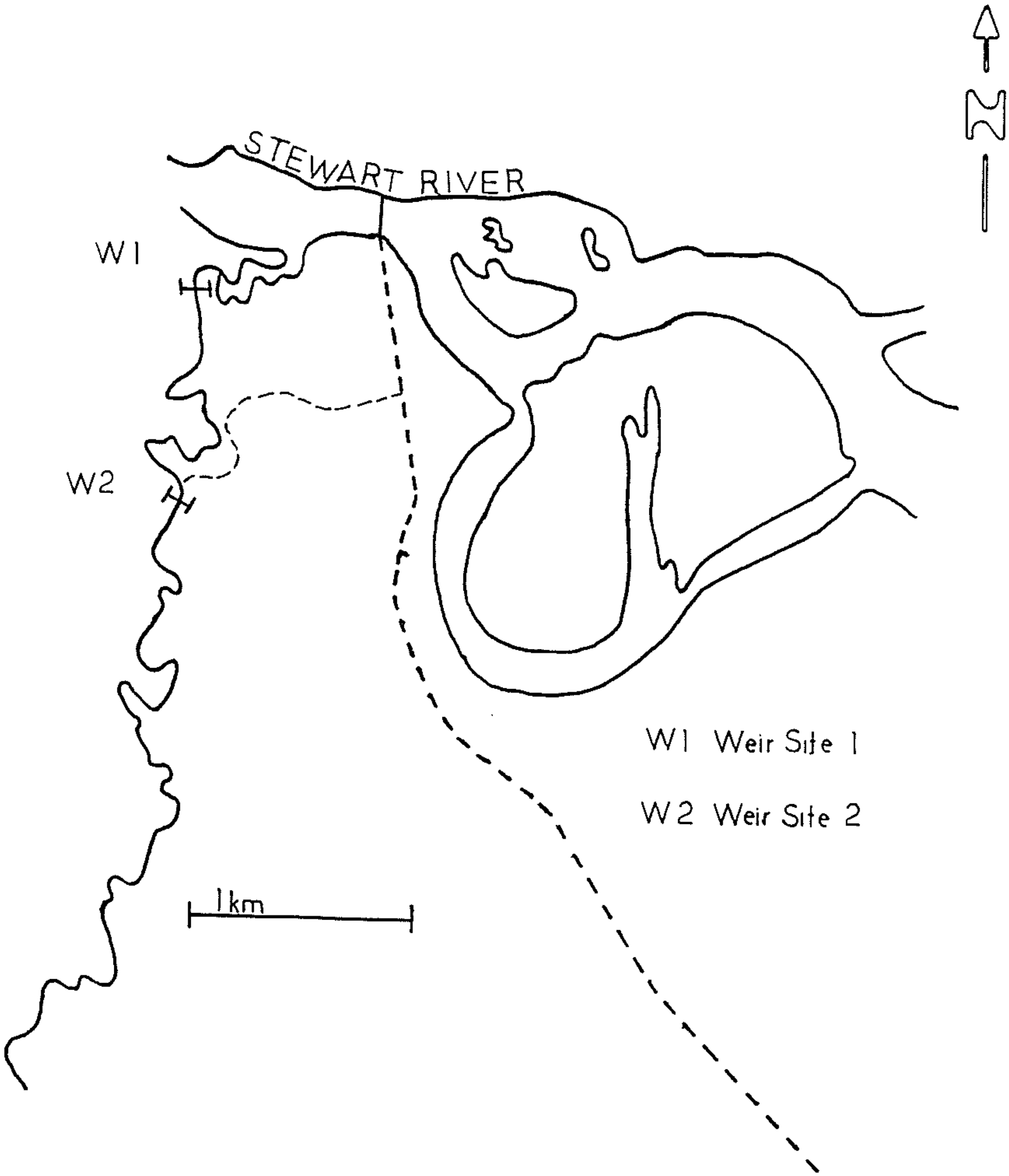
The overall average length of juvenile chinook salmon in Crooked Creek was 66.4 mm. Trapping took place over a period of 6 weeks. Fry caught toward the end of the study tended to be larger than those caught in the beginning, likely because they'd had more growing time. Because trapping took place over such a long time period, it was not possible to draw conclusions about sizes of fry near the mouth compared to those near the headwaters.

## Enumeration Weir Site Evaluation

Two locations that appear suitable for the installation of an adult chinook salmon enumeration weir were located in Crooked Creek. (See Map 4).

Site 1 is approximately 600 m upstream from the Stewart River. It is at a point just above the flooded mouth of Crooked Creek. It is doubtful that there is any spawning activity between this site and the river as the substrate in that section is 100% fines. This site is accessible by boat from the river, or by cutting a trail along the creek from the mouth. The riparian vegetation here is primarily dense willows.

The creek width at this point is 14.9 m, water velocity is 0.62 m/s, water depth is 0.48 m and the stream gradient is .5%. The substrate is a mixture of large and small gravel and appears stable.




MAP 4

Site 2 is approximately 1.5 km upstream from the mouth. This is a relatively long distance from the mouth for a weir, but extensive hiking during spawning season indicated that there was no chinook salmon spawning occurring between this site and the river. This site is attractive because of its accessibility by a seldom-used road. There are no other points accessible by road between here and the mouth.

The creek's width at this point is 14.4 m, water velocity is 0.68 m/s, water depth is 0.36 m and the gradient is 1%. The substrate is a mixture of large gravel and cobbles and appears stable.

## DISCUSSION

For a stream to support a productive chinook salmon population, it must provide adequate habitat for migrating, spawning and rearing. Crooked Creek appears to do that.

Although there are fallen trees, beaver dams and logjams in Crooked Creek, none are blocking salmon migration, therefore no habitat restoration was done on this creek. There is one area in Reach 2 where six large spruce trees have fallen across the creek side by side. If, at some time, these trees become jammed together, this might pose a problem for salmon migration.

Chinook salmon have spawning requirements with respect to substrate size, stream velocity and stream depth. Raleigh et al. (1986) suggests that gravel of 15 cm in diameter is approaching the upper usable limit of spawning substrate for chinook salmon, and that most spawn in gravel 4-10 cm in diameter. Crooked Creek has extensive areas in Reach 1 and Reach 2 where the substrate is of this size. The substrate in the spawning areas of Crooked Creek were a mixture of small gravel (0.1-4.0 cm), large gravel (4-10 cm) and some cobbles (10-30) cm.

According to Raleigh et al. (1986), the usable spawning and embryo incubation water velocity for chinook salmon ranges from 0.2 - 1.5 m/s, with an optimal range of 0.3 - 0.9 m/s. In a study on Janet Creek, a tributary of the Stewart River, spawning sites were found at velocities of 0.48 - 0.54 m/s (Smith, 1996). Other than the rapids in Reach 2 and a small section of Reach 1, all of Crooked Creek falls within the optimal spawning velocity range. The two spawning areas had velocities of 0.44 m/s and 0.68 m/s.

A minimal depth for spawning is required to prevent embryos from freezing or drying. For chinook salmon, an acceptable minimal spawning depth is 0.2 m (Raleigh et al., 1986). All habitats assessment sites in Crooked Creek had depths greater than 0.2 m. Spawning sites in Crooked Creek had depths of 0.38-0.52 m, which is slightly deeper than spawning sites in Janet Creek (0.30-0.39 m) (Smith, 1996).

This study indicates that much of Crooked Creek satisfies the habitat requirements for substrate size, water velocity and water depth that are necessary for successful chinook salmon spawning.

Rearing habitat for chinook salmon involves overwintering habitat as well as summer habitat for juveniles. This study did not assess overwintering habitat. An indirect indication that an area remains well oxygenated during the winter is the presence of slimy sculpins, a non-migratory fish. Slimy sculpins were captured along the entire length of Crooked Creek, extending as far upstream as the upper limits of Reach 2. This suggests that the oxygen level in the water of Crooked Creek remains high enough in winter to allow for fish survival.

Juvenile chinook salmon were captured in both reaches of Crooked Creek indicating the presence of rearing habitat to the upper limit of this study. Parameters that affect chinook salmon rearing habitat are stream gradient, stream velocity, turbidity, cover and physical barriers.

In a study on Upper Yukon River tributaries, Hunka (1988) found that turbidity, stream gradient and natural barriers limited juvenile chinook salmon distribution. The temporary increased turbidity due to runoff from heavy rainfall that occurred in the Crooked Creek area in early August was not a factor in determining juvenile chinook salmon distribution. Also, natural barriers did not appear to affect juvenile chinook salmon distribution in Crooked Creek.

Stream velocity more than stream gradient was an indicator of good rearing habitat in Crooked Creek. Areas where no juveniles were captured had an average velocity of 0.85 m/s, while areas where large numbers of juveniles were caught had a velocity of 0.2 m/s. Stream velocity was also important in juvenile chinook salmon distribution in Janet Creek (Smith, 1996).

Overstream cover from vegetation and cutbanks and instream logs and boulders have been found to be important habitat parameters for the survival of juvenile chinook salmon (Raleigh et al., 1986). In Janet Creek, the presence or absence of overstream or instream cover appeared to have no effect on the presence of chinook salmon fry (Smith, 1996). Hunka (1988) found that the amount of cover required by juvenile chinook salmon varied from creek to creek, and that over vegetation, cutbanks and deep pools were more important cover types for juvenile chinook salmon than instream logs and boulders. In Crooked Creek, juvenile chinook salmon seemed to prefer areas with either overstream or instream cover to areas without cover. All of the trapping sites that yielded more than 50 fry/trap had instream and overstream cover. It was not possible to say whether instream or overstream cover was most important to fry.

Pools were the areas most preferred by juvenile chinook salmon, but runs also produced significant numbers of juvenile chinook salmon. Areas of riffle yielded few juvenile chinook salmon, and no juveniles were captured in rapids.

Hunka (1988) found that juvenile chinook salmon were abundant in areas near documented spawning grounds. This was also the case in Crooked Creek, with traps yielding more than 50 fry/trap close to both spawning sites. Unfortunately, no traps were set near the redds spotted from the helicopter. Another trap that yielded more than 50 fry/trap was only 1.6 km from the mouth. This high number of fry close to the mouth might indicate that fry hatching in the Stewart River are using Crooked Creek as a rearing area.

In this study we documented 12 spawning chinook salmon and counted 40 migrating chinook salmon. This probably does not accurately estimate the spawning population. There are several reasons for this.

During the summer of 1997, there was heavy rainfall in the Crooked Creek area, and the water in the creek remained above normal throughout August, the spawning time. This made hiking slow, resulting in not all sections of the creek being monitored during peak season. Also, spotting migrating and spawning salmon was difficult because of deep water that was darker than normal. The dark color was likely due to tannins flushed from the soil by the heavy rainfall. Therefore, it seems probable that we missed some salmon.

The helicopter survey also failed to give a true picture of the spawning population in Crooked Creek. Due to budget constraints we were only able to cover the upper half of the creek by helicopter. In the section we flew over, visibility was hampered by the dark water and overcast conditions. In many places, we were unable to see into the water. We were unable to count any salmon migrating or spawning. We spotted only carcasses on the shore and unoccupied redds.

This paucity of live salmon seems unlikely for several reasons. The presence of carcasses and redds indicates that there are some salmon spawning in upper Crooked Creek. The flight was made at the estimated height of spawning, so it isn't likely that all salmon would have spawned at this time. Juvenile chinook salmon had been trapped in many places we flew over, with one location yielding more than 50 fry/trap. This high number of fry/trap was associated with spawning sites in other parts of the creek. Therefore, there is a good chance that this trapping site was also near a spawning site. Finally, we know there is adequate spawning habitat in the area we flew over. These reasons combined with the poor visibility conditions of our flight make it likely that there were spawning chinook salmon present that we failed to see.

Thirteen carcasses were spotted in Crooked Creek. Carcass recovery rates are estimated to be between 10% and 30%. This suggests the spawning population in Crooked Creek was from 43-130. Due to the length of Crooked Creek and the difficulty hiking it, as well as only covering half the creek by helicopter, the carcass recovery rate in the study was probably not as high as 30%. This would mean the spawning population was closer to 130 than 43.

This study attempted to assess the spawning population of Crooked Creek, in order to determine if this creek might be a site for future wild stock restoration. Since we failed to get a reliable estimate of the spawning population, more study is necessary before restoration plans can be made. Flying over the entire length of Crooked Creek at the height of spawning, or installing a counting weir would help determine how many chinook salmon are spawning in Crooked Creek.

Two sites were found to be suitable as locations for an enumeration weir. Both sites were fairly similar with respect to stream width, water velocity and substrate stability. The site nearest the mouth is accessible by boat or cutting a trail, while the site farther upstream is accessible by road.

In summary, this study found that Crooked Creek contains large areas of adequate spawning with no obstructions to salmon migration. Several areas along the entire length of the creek provided rearing habitat for juvenile chinook salmon. Juvenile chinook salmon appeared to be limited by stream velocity and the presence of overstream and instream cover. The creek supported a spawning population of at least 40 chinook salmon. More study is necessary to reliably estimate the chinook salmon spawning population in Crooked Creek.

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APPENDIX

Physical parameters of Reach 1. Sampling sites begin at the mouth and continue upstream to the confluence with North Crooked Creek. (F = fines, SG = small gravel, LG = large gravel, C = cobbles, b = boulders, * designates a spawning site; ** designates a weir evaluation site; *** designates areas too deep to measure by wading)

| Latitude/ Longitude | Gradient | Water Velocity (m/sec) | Channel Width (m) | Water Depth (m) | Flow Type | Substrate |
|---|---|---|---|---|---|---|
| 63° 22'45 N<br>136°41'17 W | 0% | 0.20 | *** | *** | run | 100%F |
| 63° 22'41 N<br>136°41'20 W | .5% | 0.62 | 14.9 | .48 | run | 50% SG<br>50% LG |
| 63° 22'31 N<br>136°42'28 W | 0% | 0.45 | 11.2 | .57 | run | 45%SG<br>45%LG<br>10%C |
| 63° 22'06 N**<br>136°42'01 W | 1% | 0.68 | 14.4 | .36 | run | 50%LG<br>50%C |
| 63° 21'46 N<br>136°42'10 W | 1% | 0.40 | 15.0 | .36 | run | 25%F<br>25%SG<br>25%LG<br>25%C |
| 63° 21'35 N*<br>136°42'00 W | 1% | 0.62 | 14.6 | .52 | run | 25%SG<br>50%LG<br>25%C |
| 63° 21'17 N<br>136°41'45 W | 1% | 1.62 | 5.0 | *** | run | 20%LG<br>80%C |
| 63° 20'33 N<br>136°42'41 W | 1% | 0.52 | 11.1 | .50 | run | 20%SG<br>80%LG |
| 63° 20'24 N<br>136°42'21 W | 2% | 1.43 | 20.2 | .46 | run | 50%LG<br>50%C |
| 63° 19'53 N<br>136°42'36 W | .5% | 0.60 | 12.8 | .52 | run/<br>pool | 50%F<br>50%SG |
| 63° 20'31 N<br>136°41'13 W | 1% | 0.26 | 11.8 | .45 | pool | 20%F<br>60%SG<br>20%LG |
| 63° 19'12 N<br>136°40'15 W | 1% | 0.78 | 8.0 | .80 | run | 40%LG<br>60%C |
| 63° 18'42 N*<br>136°39'38 W | .5% | 0.44 | 13.2 | .38 | run | 50%SG<br>50%LG |

| Latitude/ Longitude | Gradient | Water Velocity (m/sec) | Channel Width (m) | Water Depth (m) | Flow Type | Substrate |
|---|---|---|---|---|---|---|
| 63° 18'15 N 136°39'28 W | 1% | 0.52 | 13.0 | .40 | run | 20%SG 60%LG 20%C |
| 63° 17'40 N 136°40'16 W | .5% | 0.43 | 11.1 | .51 | run | 25%F 25%SG 25%LG 25%C |
| 63° 17'08 N 136°38'02 W | 1% | 0.60 | 12.3 | .48 | run | 20%SG 40%LG 40%C |
| 63° 17'00 N 136°37'15 W | 1.5% | 1.72 | 11.7 | .50 | run/ riffle | 20%LG 80%C |
| 63° 16'23 N 136°36'43 W | 1% | 0.43 | 17.0 | .25 | riffle | 50%SG 50%LG |
| 63° 16'19 N 136°35'42 W | .5% | 0.64 | 17.5 | .34 | run | 10%LG 80%C 10%B |
| 63° 16'07 N 136°35'23 W | .5% | 0.52 | 17.0 | .42 | run | 50%LG 50%C |
| 63° 16'23 N 136°35'19 W | .5% | 0.34 | 20.0 | .70 | run | 50%F 50%SG |
| 63° 16'45 N 136°34'14 N | 1% | 0.56 | 18.0 | .68 | run | 50%F 50%SG |
| 63° 16'30 N 136°33'16 W | 1% | 0.64 | 12.0 | .75 | run | 50%LG 50%C |
| 63° 15'50 N 136°31'46 W | 1% | 0.52 | 13.2 | .30 | riffle | 20%SG 60%LG 20%C |
| 63° 15'40 N 136°30'44 W | 1% | 0.48 | 13.0 | .60 | run | 50%LG 50%C |

Physical parameters of Reach 2. Sampling sites begin after the confluence with North Crooked Creek and continue upstream to the confluence with Woodburn Creek. (F = fines, SG = small gravel, LG = large gravel, C = cobbles, B = boulders; *** designates water too deep to measure by wading)

| Latitude/ Longitude | Gradient | Water Velocity (m/sec) | Channel Width (m) | Water Depth (m) | Flow Type | Substrate |
|---|---|---|---|---|---|---|
| 63° 15'12 N<br>136°29'11 W | 1% | 0.64 | 10.0 | .55 | run | 50%LG<br>50%C |
| 63° 14'44 N<br>136°28'40 W | .5% | 0.48 | 10.4 | .74 | run | 40%SG<br>40%LG<br>20%C |
| 63° 14'20 N<br>136°29'22 W | .5% | 0.54 | 9.8 | .66 | run | 40%SG<br>40%LG<br>20%C |
| 63° 14'20 N<br>136°31'07 W | 1% | 0.58 | 10.0 | .60 | run | 20%SG<br>50%LG<br>30%C |
| 63° 13'14 N<br>136°30'44 W | 1% | 0.42 | 9.7 | .40 | run | 20%SG<br>60%LG<br>20%C |
| 63° 13'18 N<br>136°30'43 W | .5% | 0.45 | 10.0 | .32 | run | 20%SG<br>70%LG<br>10%C |
| 63° 12'38 N<br>136°30'14 W | 1% | 0.38 | 9.2 | .50 | run | 70%LG<br>30%C |
| 63° 12'09 N<br>136°29'08 W | 1.5% | 1.56 | 8.0 | .42 | rapids | 10%C<br>90%B |
| 63° 12'17 N<br>136°27'45 W | 1.5% | 1.22 | 8.1 | .40 | riffle | 20%LG<br>60%C<br>20%B |
| 63° 12'17 N<br>136°26'43 W | 1% | 0.90 | 6.0 | * | run | 100%C |
| 63° 11'43 N<br>136°26'30 W | 1% | 0.47 | 9.4 | .40 | run | 40%SG<br>60%LG |
| 63° 10'51 N<br>136°26'06 W | 2% | 1.60 | 9.2 | .55 | rapids | 20%C<br>80%B |

| Latitude/ Longitude | Gradient | Water Velocity (m/sec) | Channel Width (m) | Water Depth (m) | Flow Type | Substrate |
|---|---|---|---|---|---|---|
| 63° 10'45 N<br>136°24'27 W | 2% | 1.20 | 8.8 | .50 | rapids | 40%C<br>60%B |
| 63° 10'11 N<br>136°23'28 W | 1.5% | 1.26 | 9.0 | .46 | rapids | 40%C<br>60%B |
| 63° 10'12 N<br>136°21'18 W | 1% | 0.64 | 9.0 | .42 | run | 20%SG<br>50%LG<br>30%C |
| 63° 09'43 N<br>136°20'15 W | 1% | 0.43 | 9.2 | .34 | run | 50%SG<br>50%LG |
| 63° 09'30 N<br>136°19'17 W | 1% | 1.31 | 6.0 | .60 | run | 60%LG<br>40%C |
| 63° 09'07 N<br>136°19'30 W | 1% | 0.47 | 7.8 | .42 | run | 50%SG<br>50%LG |
| 63° 08'30 N<br>136°19'06 W | 1% | 0.52 | 8.6 | .40 | run | 40%SG<br>60%LG |
| 63° 08'09 N<br>136°17'48 W | 1% | 0.38 | 8.0 | .36 | run | 30%SG<br>70%LG |

Carcass Location (* indicates position is approximate)

| Latitude/ Longitude | Number of Carcasses | Method of Discovery | Sex |
|---|---|---|---|
| 63° 22'06 N<br>136°42'01 W | 1 | hiking | F |
| 63° 21'04 N<br>136°41'31 W | 1 | hiking | F |
| 63° 19'05 N<br>136°41'00 W | 1 | hiking | M |
| 63° 19'01 N<br>136°40'03 W | 1 | hiking | F |
| 63° 17'26 N<br>136°38'45 W | 1 | hiking | M |
| 63° 16'23 N<br>136°36'43 W | 1 | hiking | M |
| 63° 16'19 N<br>136°34'45 W | 1 | hiking | F |
| 63° 12'20 N<br>136°30'00 W | 1 | helicopter | |
| 63° 12'17 N*<br>136°26'43 W | 2 | helicopter | |
| 63° 10'10 N*<br>136°23'45 W | 1 | helicopter | |
| 63° 10'06 N<br>136°22'00 W | 1 | helicopter | |
| 63° 08'30 N<br>136°19'06 W | 1 | helicopter | |

Location of Redds Spotted From Helicopter

| Latitude/ Longitude | Number of Redds |
|---|---|
| 63° 08'57 N<br>136°18°48 W | 1 |
| 63° 09'51 N<br>136°19'26 W | 1 |

Location of Spawning Beds

| | Latitude/ Longitude |
|---|---|
| Lower Spawning Site | 63° 21°35 N<br>136°42'00 W |
| Upper Spawning Site | 63° 18'42 N<br>136°39'38 W |

Location of Weir Evaluation Sites

| | Latitude/ Longitude |
|---|---|
| Site 1 | 63° 22'41 N<br>136°41'20 W |
| Site 2 | 63° 22'06 N<br>136°42'01W |

Trapping dates and coordinates of fry trapping sites

| Site | Latitude | Longitude | Date Trapped (in 1997) |
|---|---|---|---|
| A | 63°22'06 N | 136°42'01 W | July 15 |
| B | 63°21'46 N | 136°42'10 W | July 16 |
| C | 63°21'35 N | 136°42'00 W | August 21 |
| D | 63°20'24 N | 136°42'21 W | July 24 |
| E | 63°19'12 N | 136°40'15 W | July 29 |
| F | 63°18'42 N | 136°39'38 W | August 24 |
| G | 63°17'40 N | 136°40'16 W | July 31 |
| H | 63°17'00 N | 136°37'15 W | July 22 |
| I | 63°16'23 N | 136°35'19 W | July 22 |
| J | 63°16'30 N | 136°33'16 W | July 25 |
| K | 63°15'40 N | 136°30'44 W | July 25 |
| L | 63°13'18 N | 136°30'43 W | August 7 |
| M | 63°12'17 N | 136°26'43 W | August 7 |
| N | 63°10'45 N | 136°24'27 W | August 8 |
| O | 63°10'12 N | 136°21'18 W | August 8 |
| P | 63°08'09 N | 136°17'48 W | August 8 |

Results of Juvenile Chinook Salmon Trapping in Reach 1. Trapping areas are listed in order beginning near the mouth of Crooked Creek and continuing to the confluence with North Crooked Creek. Two - four traps were set in each area, in different habitat types. (Veg = overstream vegetation, organic = organic debris like submerged logs, JCS = juvenile chinook salmon, SS = slimy sculpin; * indicates that trap is near a spawning site).

| Site | Flow Type | Gradient | Water Velocity (m/sec) | Overstream Cover | Instream Cover | Fish/ Trap | Average Length (mm) |
|---|---|---|---|---|---|---|---|
| A-1 | run | 1% | 0.58 | none | organic | 4JCS<br>2SS | 64 |
| A-2 | riffle | 1% | 0.6 | none | none | 3 JCS | 63 |
| A-3 | pool | 1% | nil | cutbank | organic | 66 JCS<br>2 SS | 63 |
| B-1 | pool | 1% | nil | none | organic | 6 SS | |
| B-2 | pool | 1% | 0.17 | none | none | 0 | |
| B-3 | run | 1% | 0.5 | none | none | 0 | |
| C-1* | pool | 1% | 0.36 | veg | organic | 72 JCS | 75 |
| C-2* | run | 1% | 0.50 | none | none | 40 JCS<br>3 SS | 72 |
| C-3* | riffle | 1% | 0.52 | veg | none | 3 JCS | 74 |
| D-1 | pool | 2% | nil | veg | organic | 4 JCS<br>6 SS | 65 |
| D-2 | run | 2% | 1.35 | none | none | 0 | |
| D-3 | run | 2% | 0.62 | none | none | 2 SS | |
| D-4 | pool | 2% | 0.20 | veg | none | 4JCS<br>1 SS | 63 |
| E-1 | run | 1% | 0.78 | none | organic | 12 JCS | 70 |
| E-2 | pool | 1% | 0.28 | none | organic | 21 JCS<br>1 SS | 69 |
| F-1* | run | .5% | 0.44 | none | none | 25 JCS | 74 |
| F-2* | pool | .5% | 0.20 | veg | organic | 67 JCS<br>2 SS | 73 |

| Site | Flow Type | Gradient | Water Velocity (m/sec) | Overstream Cover | Instream Cover | Fish/ Trap | Average Length (mm) |
|---|---|---|---|---|---|---|---|
| F-3* | riffle | .5% | 0.68 | none | none | 0 | |
| G-1 | pool | .5% | nil | veg | organic | 2 JCS | 68 |
| G-2 | run | .5% | 0.43 | none | organic | 15 JCS | 69 |
| G-3 | riffle | .5% | 0.46 | none | organic | 2 JCS | 69 |
| H-1 | run | 1.5% | 1.72 | none | none | 0 | |
| H-2 | riffle | 1.5% | 1.60 | none | none | 0 | |
| I-1 | run | 1% | 0.40 | veg | none | 5 JCS<br>3 SS | 68 |
| I-2 | pool | 1% | nil | none | organic | 3 JCS | 66 |
| I-3 | run | 1% | 0.5 | veg | organic | 0 | |
| J-1 | run | 1% | 0.64 | none | organic | 6 JCS | 69 |
| J-2 | riffle | 1% | 0.60 | none | boulders | 2 JCS | 68 |
| J-3 | pool | 1% | 0.28 | none | none | 3 JCS | 69 |
| K-1 | pool | 1% | 0.22 | veg | none | 3 JCS<br>3 SS | 69 |
| K-2 | run | 1% | 0.48 | none | organic | 4 JCS<br>1 SS | 68 |
| K-3 | riffle | 1% | 0.52 | veg | none | 0 | |

Results of Juvenile Chinook Salmon Trapping in Reach 2. Trapping areas are listed in order beginning near the confluence of Crooked Creek with North Crooked Creek and continuing to the confluence with Woodburn Creek. Two - four traps were set in each area, in different habitat types. (Veg = overstream vegetation, organic = organic debris like submerged logs, JCS = juvenile chinook salmon, SS = slimy sculpin).

| Site | Flow Type | Gradient | Water Velocity (m/sec) | Overstream Cover | Instream Cover | Fish/ Trap | Average Length (mm) |
|---|---|---|---|---|---|---|---|
| L-1 | run | .5% | 0.45 | veg | none | 24 JCS<br>2 SS | 68 |
| L-2 | run | .5% | 0.45 | none | none | 10 JCS | 70 |
| M-1 | run | 1.5% | 0.90 | none | none | 0 | |
| M-2 | run | 1.5% | 0.09 | veg | none | 0 | |
| N-1 | rapids | 2% | 1.20 | none | boulders | 0 | |
| N-2 | rapids | 2% | 1.25 | none | boulders | 0 | |
| O-1 | pool | 1% | 0.30 | veg | organic | 54 JCS | 70 |
| O-2 | riffle | 1% | 0.57 | veg | none | 8 JCS | 69 |
| O-3 | run | 1% | 0.64 | veg | none | 28 JCS | 70 |
| P-1 | pool | 1% | 0.18 | veg | none | 12 JCS<br>3 SS | 70 |
| P-2 | run | 1% | 0.38 | veg | organic | 8 JCS | 69 |