Sustut River Steelhead Overwinter Mortality Study
(Skeena Steelhead Chevron Compensation)
Habitat Conservation Trust Fund
Account Number #811-28611
Progress Report to August 24, 1999.
Mark C. Beere

Skeena Report SK-162

1. Sustut River Experiment:

i. Objective:

The spawning population of wild summer run steelhead in the Skeena River watershed is estimated as the total aggregate stock size entering the river (as determined by the Tyee Test Fishery) less Native fishery catches and mortality incidental to the catch and release sport fishery. Natural overwinter mortality is not factored into this estimate; the result is an inflated assessment of the number of spawners. We chose to investigate overwinter mortality by radio tagging steelhead in the upper Sustut River (Figures 1., 2.) and monitoring their survival between the beginning of September, 1998 and spawning in June, 1999. Somass River summer steelhead were tagged with dummy radio transmitters at the Robertson Creek Hatchery as an experimental control to address the possible effects of capture, handling and tagging.

ii. Tag Application:

Sixty upper Sustut River summer run steelhead were captured at a floating fish enumeration weir (Figure 3.) located on the Sustut River, approximately 500 meters upstream of its confluence with Moosevale Creek. Fish were dipnetted from the weir (Figure 4.) and anaesthetized with tricaine methanesulfonate (50mg/L, buffered with sodium bicarbonate, 50 mg/L; Figure 5.) prior to tag application. Fish were esophageally implanted with radio transmitters between August 28 and September 3, 1998 (Figures 6.,7.). Radio tagged steelhead were also anchor tagged (Figure 8.); each radio tagged fish was anchor tagged twice, while steelhead not radio tagged received a single anchor tag, prior to release upstream of the fence (Figures 9.,10.). Radio tagged steelhead ranged from 690 mm to 940 mm in fork length. The sex ratio was 24 males to 36 females, or 0.67:1 (Figure 11.).

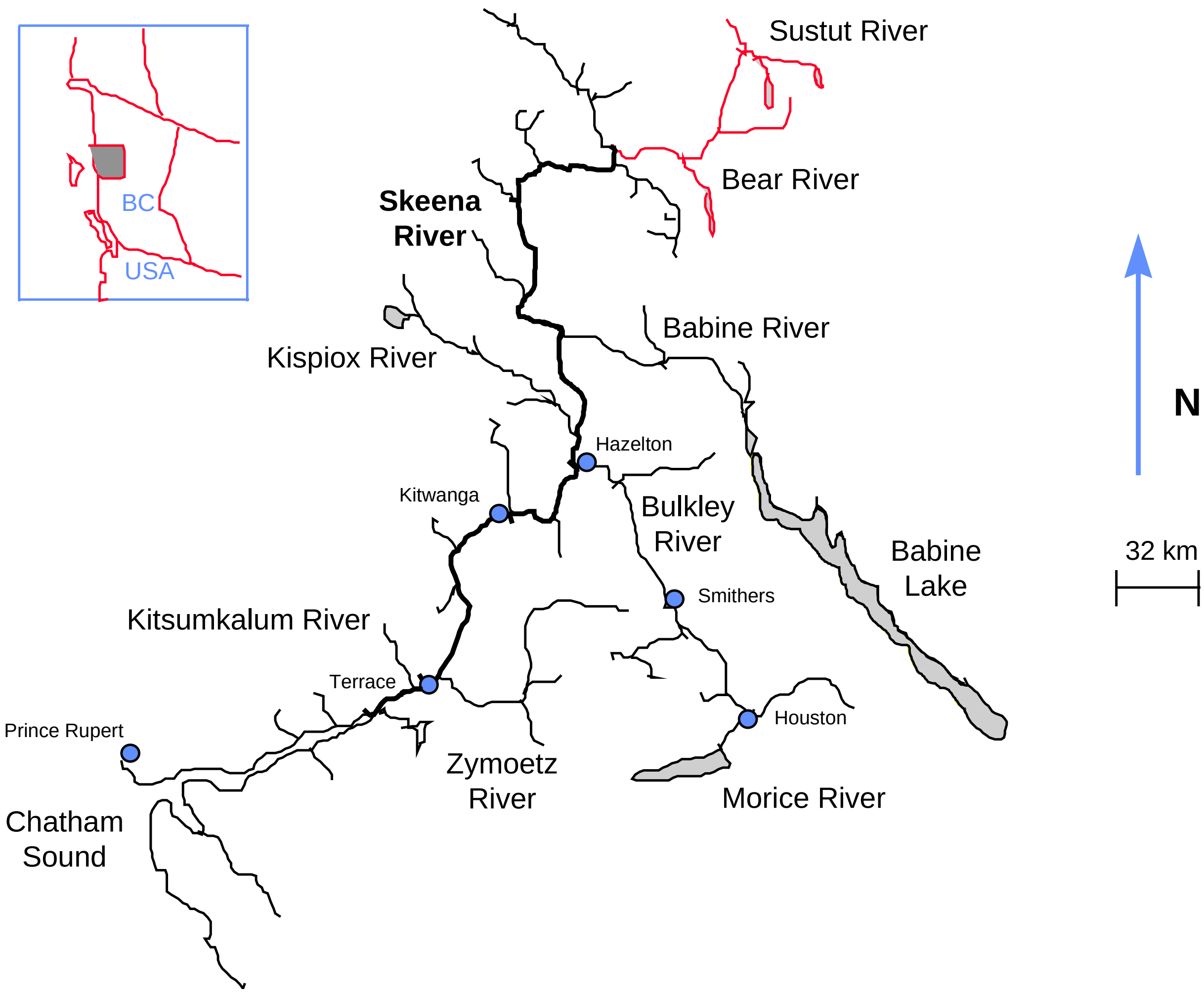


Figure 1. The Skeena River watershed showing the location of the Sustut River and Johanson Creek (study area in red).

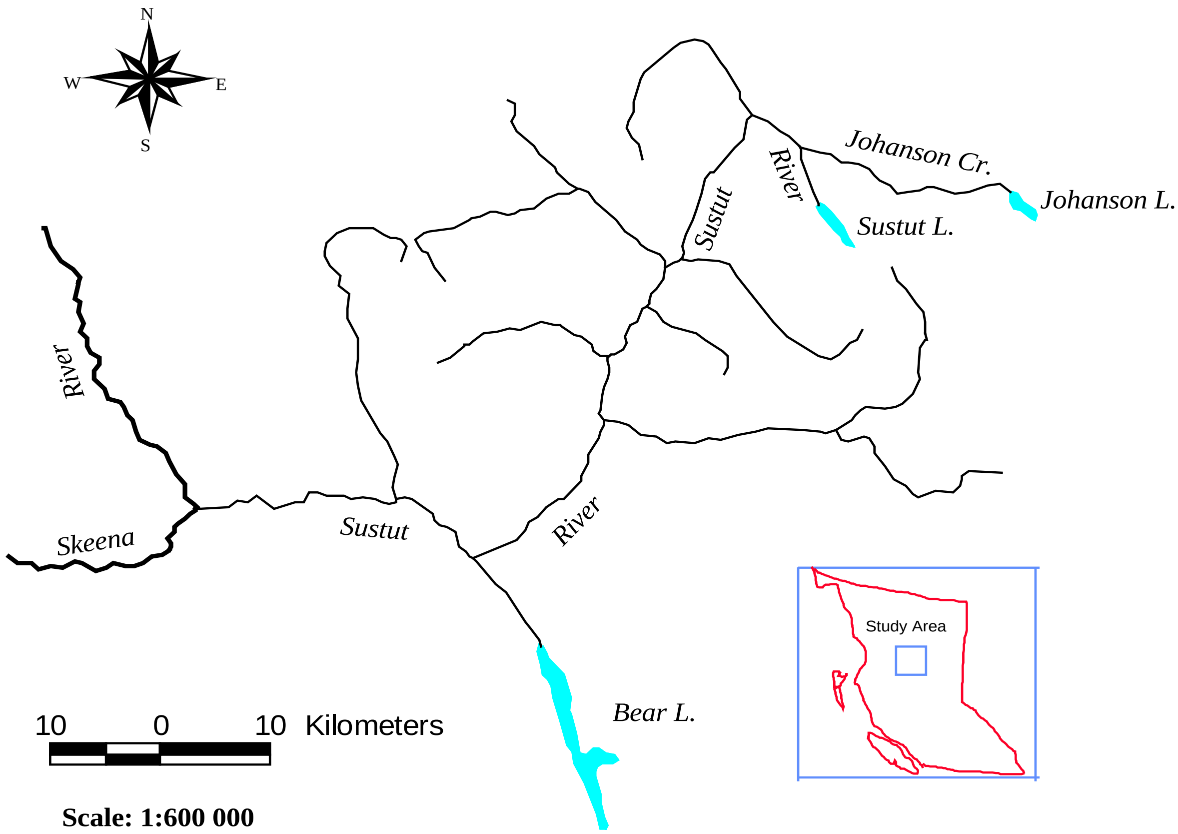


Figure 2. The Sustut River watershed.

Figure 3. The upper Sustut River floating fish enumeration weir, located approximately 500 meters upstream of the Sustut River-Moosevale Creek confluence.

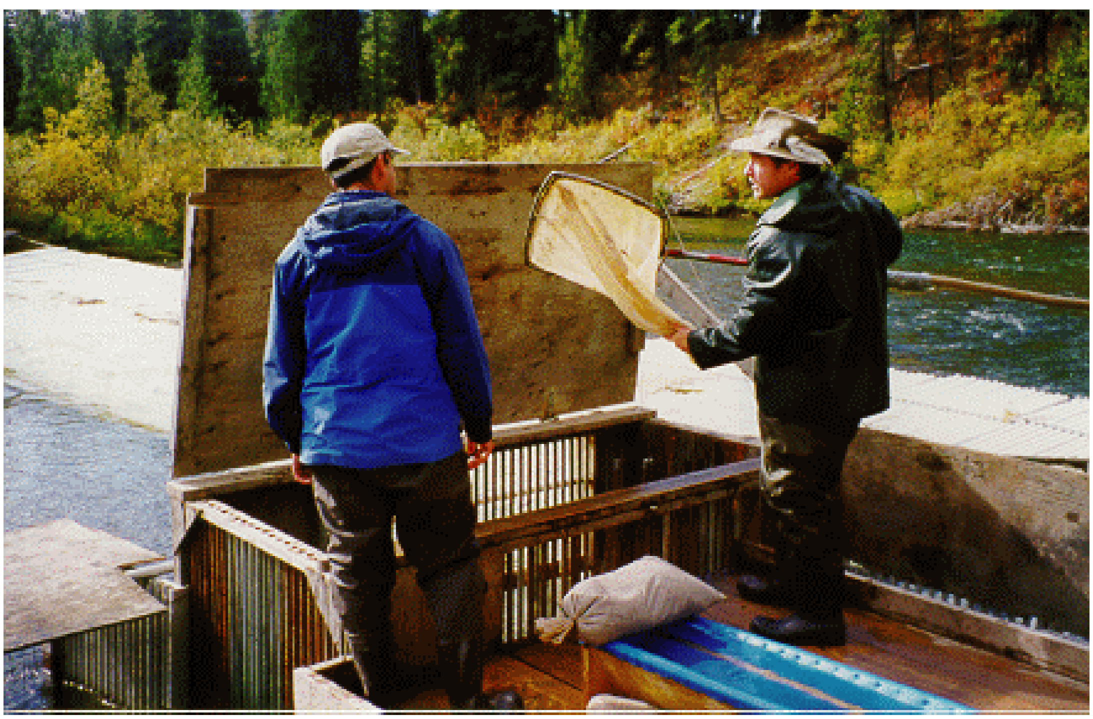


Figure 4. Preparing to dipnet steelhead from the upstream trap at the floating fish enumeration weir.

Figure 5. Steelhead in anaesthetic bath of tricaine methanesulfonate buffered with sodium bicarbonate.

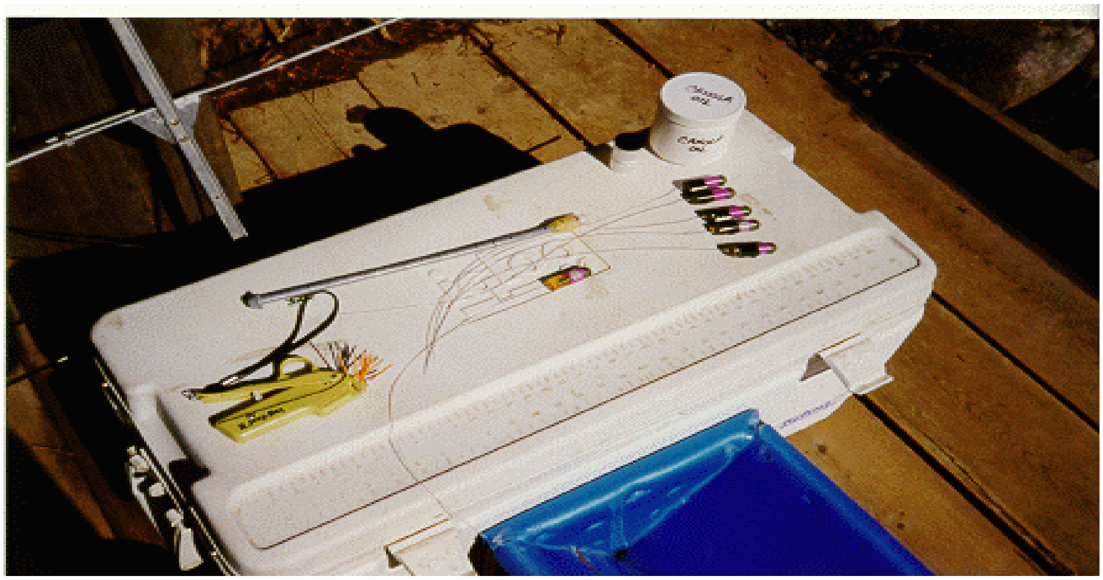


Figure 6. Radio and anchor tagging equipment. From left: anchor tagging gun with tags, implementation device (long rod), radio transmitters (beneath rod with magnet removed, others with magnets attached), anaesthetic (in film canister) and lubricant for transmitter insertion.

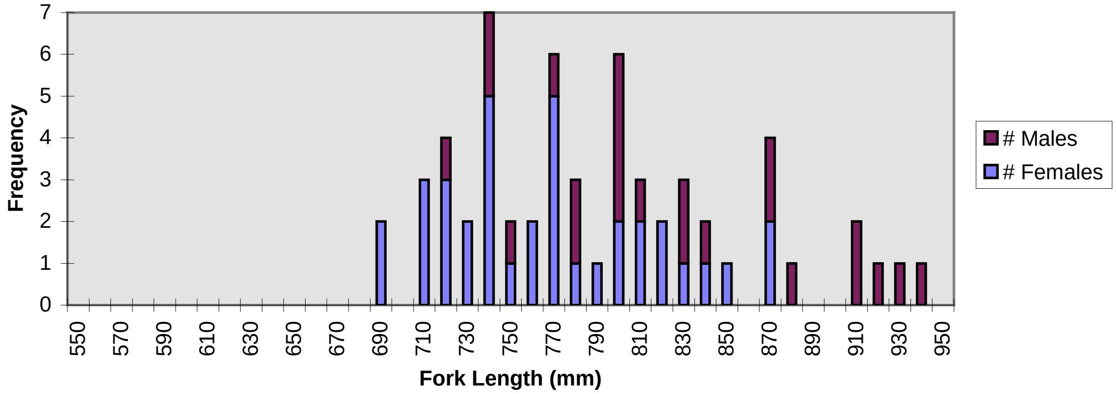
Figure 7. Implanting a radio transmitter into the stomach of a steelhead. Note foam lined, water filled measuring trough, and sandbag (barely visible in foreground) for covering fish eyes (when not tagging fish).

Figure 8. Anchor tagging a steelhead.

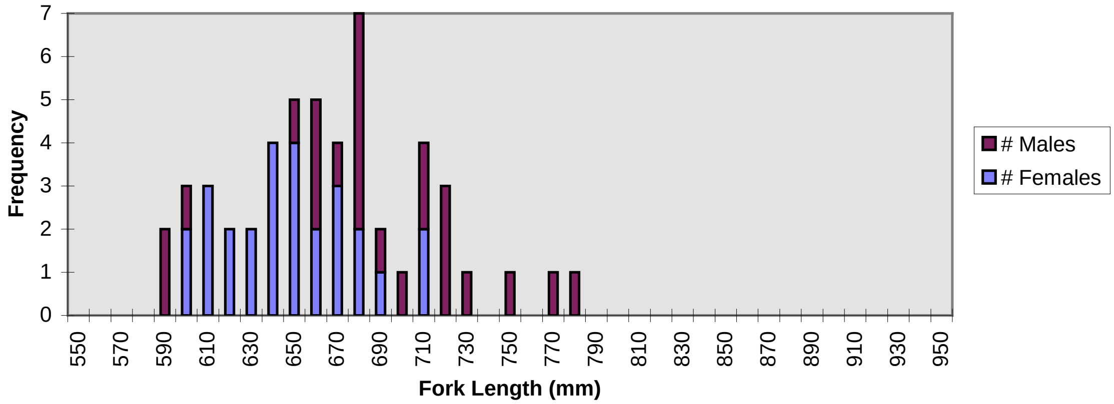
Figure 9. Releasing a radio tagged steelhead upstream of the fence.

Figure 10. A recently released steelhead holding upstream of the fence. Note plywood cover on right, where fish could hold and rest, sheltered from direct sunlight, before continuing upstream.

Length-Frequency Histogram for Sustut River Summer Steelhead Radio Tagged at the Sustut Fence



Length-Frequency Histogram for Somass River Summer Steelhead Tagged with Dummy Radio Transmitters



Experiment	
Mean	78.63
Standard Error	0.83
Median	77.75
Mode	73.50
Standard Deviation	6.46
Sample Variance	41.77
Skewness	0.51
Range	27.00
Minimum	66.50
Maximum	93.50
Count	60.00
Confidence Level(95.0%)	1.67

Control	
Mean	66.46
Standard Error	0.63
Median	66.00
Mode	65.00
Standard Deviation	4.50
Sample Variance	20.28
Skewness	0.44
Range	19.00
Minimum	59.00
Maximum	78.00
Count	51.00
Confidence Level(95.0%)	1.27

Figure 11. Length-frequency histograms for experiment and control steelhead.

iii. Tag Monitoring:

Radio tagged fish were tracked via helicopter flights and by four fixed receiver stations located in the upper Sustut-Johanson watershed (Johanson Lake outlet; Mud Lake outlet (Mud Lake is immediately downstream of Sustut Lake; Sustut-Johanson junction and Bear-Sustut junction)(Figure 12.). Tracking flights were conducted on September 2, 8, 15, 28, October 13, 23, November 16, December 19, 1998 and January 12, February 16, March 9, April 9, May 3, 12, 21, June 5, 10, 18, 28 and August 29, 1999.

Steelhead migrated from the point of capture (Moosevale fence) to the Sustut-Johanson junction receiver station (a distance of 4.6 km) in as little as 5.2 hours and as much as 98.2 hours. The mean migration time was 23.0 hours at a mean rate of 4.8 km/day. Sustut fish, on average, took longer to reach the junction than did Johanson fish (Table 1.)

Radio tagged steelhead spent as little as 0.3 hour and as much as 941.7 hours at the Sustut-Johanson junction (mean residency time of 207.2 hours). Sustut fish averaged considerably more time at the junction than did Johanson fish (Table 1.) making them more vulnerable to the Native snag fishery that occurs at that location (Figure 13.). It is hypothesized that both temperature (Figure 14.) and discharge influence this behaviour. The water temperature of Johanson Creek was more resilient to fluctuations than was the Sustut River; this is thought to be so because Johanson Lake is deeper (mean depth of 16 meters) than Sustut Lake (mean depth 6 of meters). The presence of the shallow Mud Lake immediately downstream of Sustut Lake also contributes to the wider fluctuations noted, as the water is quicker to warm from solar radiation. The Johanson Creek discharge was greater than the Sustut River discharge at the junction for most of the study period which may have made upstream migration for Johanson fish easier and consequently account for the shorter residency time at the junction for Johanson fish.

Fish migrating from the Sustut-Johanson junction to Sustut Lake (a distance of 5.9 km) did so at a slower rate (3.0 km/day vs. 6.7 km/day) than those migrating from the junction to Johanson Lake (a distance of 28 km) (Table 1.).

Table 1. A comparison of migration rates of steelhead migrating to Sustut Lake versus Johanson Lake.

	Mean Migration Time Tagging to Sustut-Johanson junction (4.6 km) **(hrs)**	Mean Migration Rate to Junction **(km/day)**	Mean Residency Time at Junction **(hrs)**	Junction to Sustut (5.9 km) or Johanson Lake (28 km) **(hrs)**	Mean Migration Rate to Lakes **(km/day)**
Sustut Fish (n=44)	24.8	4.5	223.7	46.8	3.0
Johanson Fish (n=12)	16.6	6.7	26.5	101.1	6.7

Three (5%) of the sixty radio tagged steelhead regurgitated their transmitters. All three were subsequently recovered 2, 4 and 5 days after tagging 20, 100 and 150 m upstream of the fence, respectively, using a Plexiglas bottomed viewing box (Figures 15, 16.).

A further two (3.3%) were captured and killed in the Native snag fishery at the Sustut-Johanson junction pool (one of these steelhead had already regurgitated its radio transmitter). These fish were reportedly killed seven and nine days after tagging.

Figure 12. The fixed receiver station at the outlet of Mud Lake, immediately downstream of Sustut Lake. Note antennas on mounted on trees, solar panel at right (in profile) and waterproof enclosure box housing receiver and 12 volt battery. The receiver is being downloaded to a laptop computer.

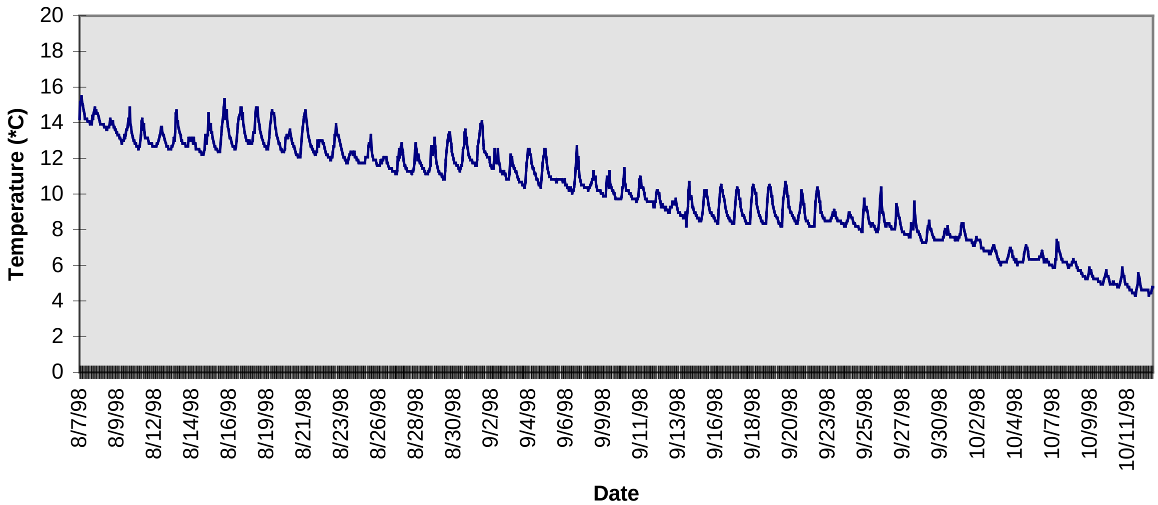
Figure 13. The Sustut River-Johanson Creek junction, looking upstream. This is the site of the Native snag fishery where two radio tagged steelhead were killed.

Three (5%) more radio tagged females moved downstream after already migrating upstream past the Mud Lake fixed station. The first was detected at Mud Lake on September 8,1998, before emigrating from the Sustut River (passing the Bear-Sustut junction fixed station on October 8, 1998). Two others also moved downstream of the Mud Lake station after being detected there on September 5 and September 8, 1998, respectively. The first was repeatedly located at the Sustut River approximately 10 km downstream of Moosevale Creek while the second was repeatedly tracked to a point approximately 1 km upstream of the Sustut-Johanson junction. The latter fish migrated downstream over the fence not long after it was tagged on August 28, 1998 (losing a single anchor tag in the process) before passing through the fence a second time on September 5, 1998.

The 53 (88.3%) remaining radio tagged fish overwintered in Sustut (41 of 53; 77.4%), Johanson (11 of 53; 20.8%) (Figures 17, 18) and Darb (1 of 53; 1.9%) lakes.

It is notable that one of the steelhead that overwintered in Johanson Lake had previously been detected at the Mud Lake fixed receiver station, and five others that had been detected in Johanson Creek (5, 9, 16, 17 and 17 kilometers upstream of the Sustut River-Johnson Creek junction) overwintered in Sustut Lake.

Water Temperature of Johanson Creek at the Outlet of Johanson Lake



Water Temperature of Sustut River at the Outlet of Mud Lake

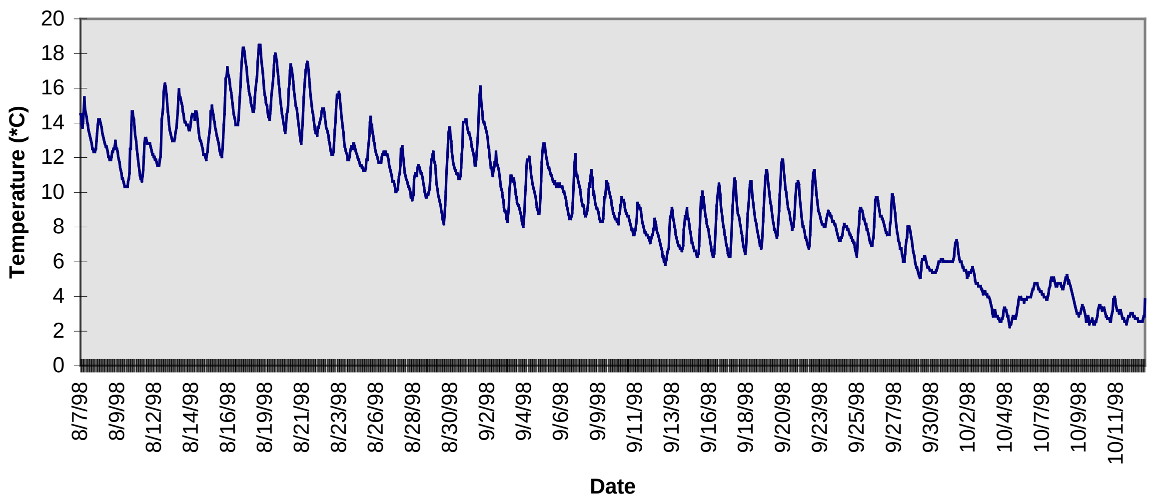


Figure 14. Water temperatures in the Sustut River, at the Mud Lake outlet, and Johanson Creek, at the Johanson Lake outlet, August 7 to October 13, 1998.

Figure 15. Site where a regurgitated transmitter was located with the aid of a viewing box, approximately 100 meters upstream of the fence.

Figure 16. Regurgitated radio transmitter on the river substrate (pink and yellow object, center) located with the aid of a viewing box.

Figure 17. Johanson Lake, October, 1998.

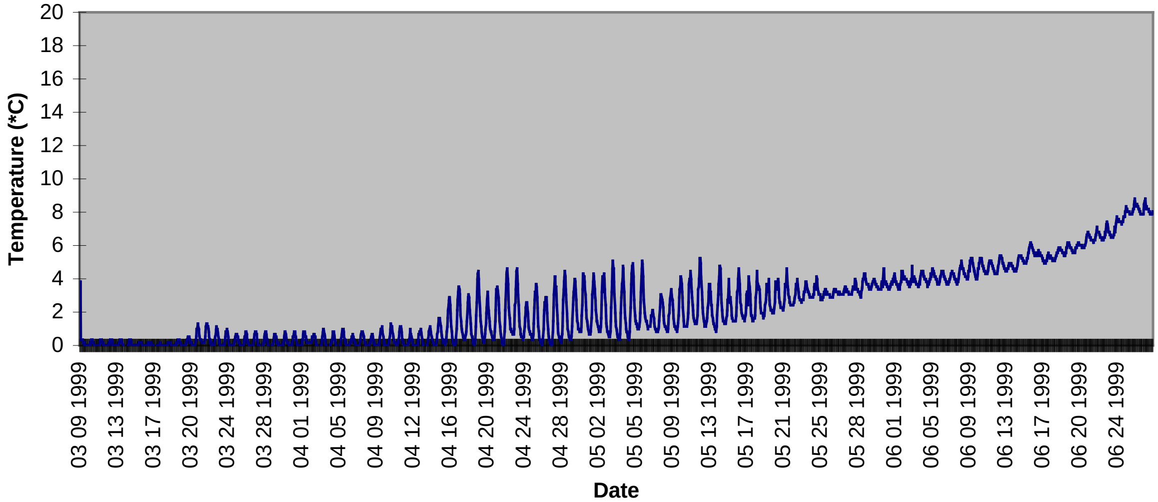
Figure 18. Johanson Lake, December, 1998.

On May 21, 1999, the first radio tagged steelhead to emigrate from Sustut and Mud lakes was detected at the Mud Lake outlet fixed station. Emigrations from Sustut/Mud lakes continued until June 5, 1999. Thirty five (85%) of the 41 radio tagged steelhead that overwintered in Sustut Lake emigrated from the lake. The first radio tagged steelhead to emigrate from Johanson Lake was detected at the Johanson Lake outlet fixed station on May 25, 1999. Emigrations from Johanson Lake continued until June 15, 1999. All twelve (100%) of the radio tagged steelhead that overwintered in Johanson Lake emigrated from the lake. Overall, 47 (89%) of the 53 radio tagged steelhead that overwintered in the lakes emigrated in the spring. Tagged steelhead that failed to emigrate from the lakes in the spring were assumed to be overwinter mortalities. Four steelhead were found either on shore or on the frozen lake surface that appeared to have been predated upon by otter (*Lontra canadensis*) and bald eagle (*Haliaeetus leucocephanlus*). Pre-spawn, overwinter mortality is estimated to be 11%.

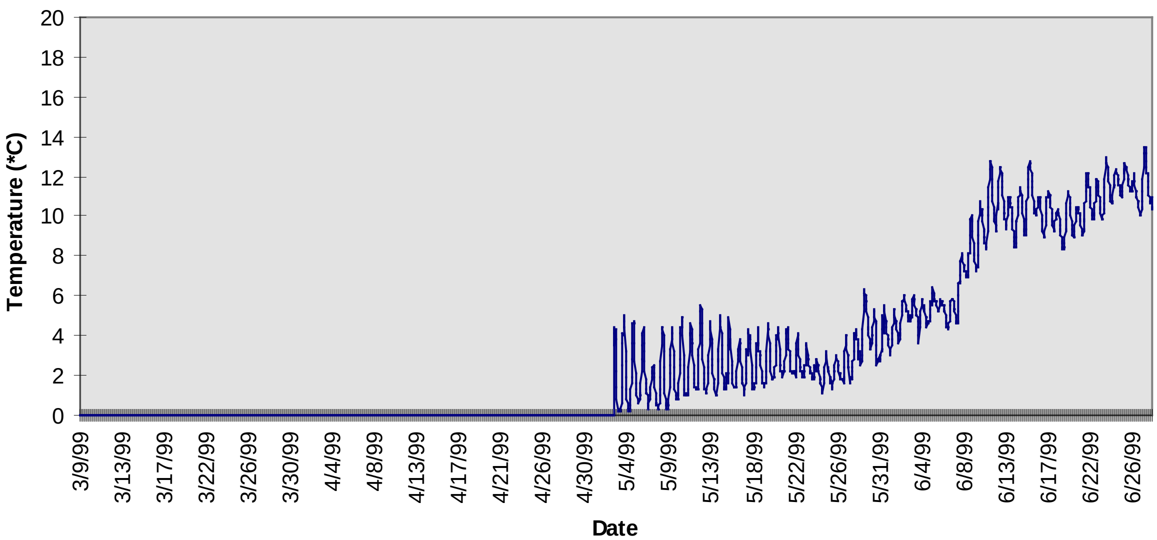
Steelhead were found spawning in sites identified previously by Bustard (1993, 1994). Spawning densities were highest in the 1.5 kilometer section of the Sustut River upstream of the Sustut-Johanson junction; an estimated 250 to 300 steelhead spawned there. Radio tagged steelhead were also found in Johanson 'Tributary Creek C', which enters Johanson Creek approximately 2 km downstream of Johanson Lake, and 'Gorgeous Creek', a tributary to Johanson Creek entering the Johanson near kilometer 412 of the Omineca Mining Access Road. The Tributary C fish (a 705 cm ♀) was found in the road culvert on June 18, 1999, approximately 600 meters upstream of its confluence with Johanson Creek; this fish emigrated past the Bear River-Sustut River fixed station on July 2, 1999. The Gorgeous Creek radio tag (originally implanted in an 815 cm ♀) was found near a jaw bone approximately 2 km upstream of its confluence with Johanson Creek on August 24, 1999.

Emigrant kelts were first detected at the Bear River-Sustut River confluence on June 1, 1999. The last kelt was detected passing the fixed station on July 6, 1999. Thirty two (24♀:8♂; 68%) of the steelhead which overwintered in and emigrated from Sustut or Johanson lakes passed the downstream most receiver site. The remaining 15 (32%) of 47 tagged fish are assumed be post spawn mortalities; eleven (73%) males and 4 (27%) females died after spawning.

Water Temperature of Johanson Creek at the Outlet of Johanson Lake



Water Temperature of Sustut River at the Outlet of Mud Lake



2. *Robertson Creek Hatchery Control:*

i. Objective:

In order to assess the effects of capture, handling and tagging, dummy transmitters of the same dimensions and mass as the radio transmitters used in the Sustut River (but without internal battery and circuitry) were implanted in fish as an experimental control using the same methodology. We chose the nearest available holding facility (hatchery) for summer run steelhead and implanted the dummy transmitters to determine the impacts of doing so in a relatively controlled environment. The remaining steelhead being held at the hatchery provided a second control, as these fish which were not handled were also monitored, and mortality was assessed to find if our procedure caused a significantly different lethality

ii. Tag Application:

On November 2, 1998, 51 Somass River hatchery summer steelhead were dipnetted from hatchery troughs (Figures 19, 20.), anaesthetized and esophageally implanted with dummy radio transmitters (Figure 21.) at Robertson Creek Hatchery near Port Alberni, Vancouver Island. These fish were captured after having migrated into the hatchery and were anchor tagged (single tag) in the same manner as the Sustut River experiment fish. Radio tagged steelhead ranged from 590 mm to 780 mm in fork length. The sex ratio was 24 males to 27 females, or 0.88:1 (Figure 11.)

iii. Tag Monitoring:

Tagged fish were held in a concrete raceway (Figure 22.) and monitored by hatchery staff. Mortalities were removed and frozen for later analysis. Regurgitated dummy transmitters or lost anchor tags were also recovered and reported by hatchery staff. The 51 dummy tagged fish were held in concrete raceways at the hatchery until February 9, 1999, when those still alive (32 or 62.7%) were killed by hatchery staff for later autopsy. Between November 2, 1998 and February 9, 1999, 16 (31.4%) of the fish died (7 females:9 males). Eight carcasses were discarded and not frozen, and a further three (5.9%) fish were unaccounted for.

iv. Control Fish:

Five hundred and fifty summer steelhead that were being held at the hatchery comprised the second control group. Fish which received dummy transmitters were selected from this group. By February 9, 1998, 49 (8.9%) of the 550 fish had died. This result was found to be significantly different (Chi Squared analysis with 95% confidence, Binomial Probability analysis, Figure 23.) from the first control group of 51 dummy tagged fish.

Figure 19. Dipnetting steelhead from a raceway at Robertson Creek hatchery.

Figure 20. Preparing the tagging trough for application of a dummy transmitter. Note the anaesthetic bath (green tank in right foreground).

Figure 21. Implanting a dummy transmitter into a Somass River hatchery steelhead.

Figure 22. Steelhead holding in concrete raceway after dummy transmitter application.

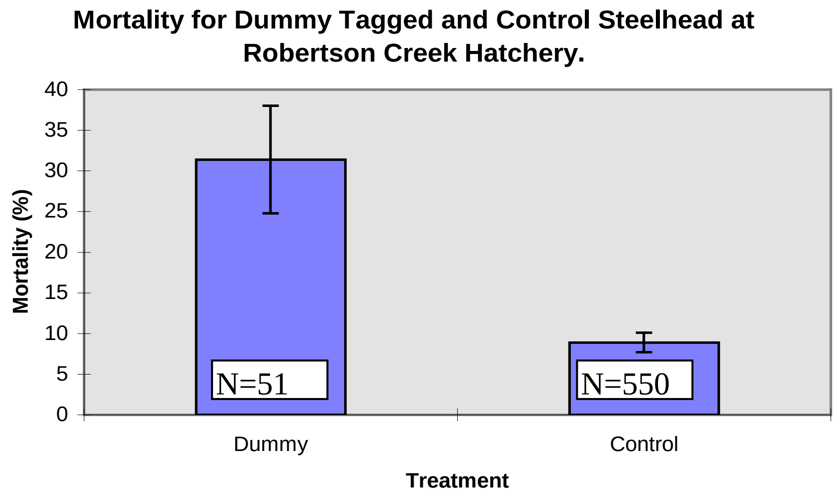
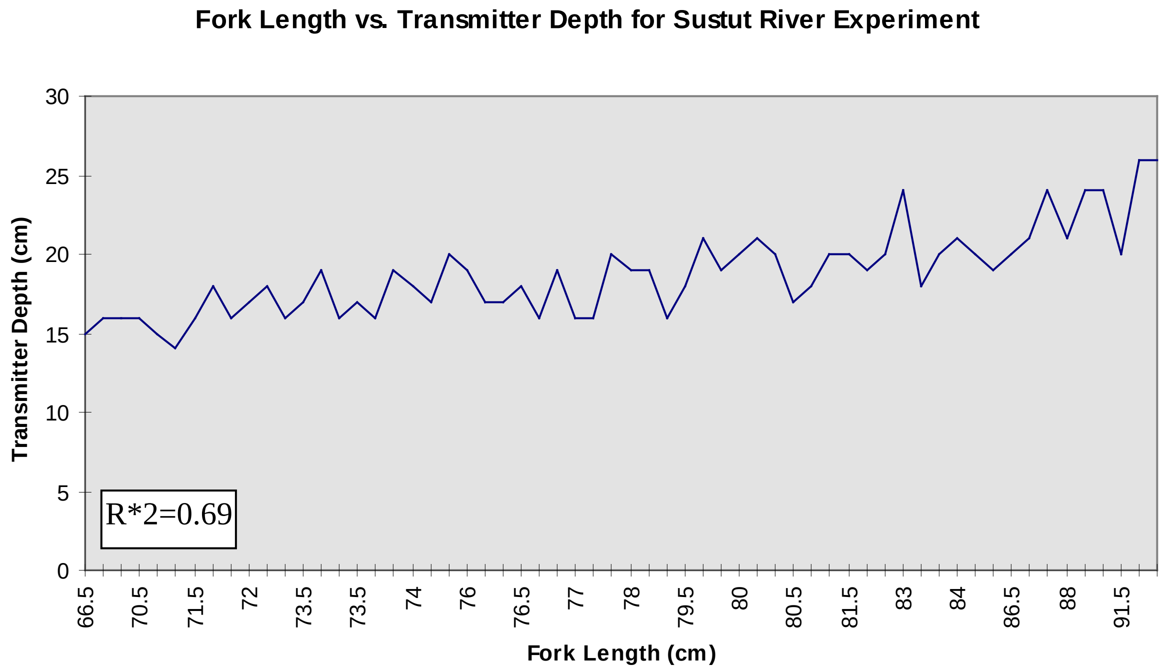


Figure 23. Mortality for dummy tagged and control steelhead at the Robertson Creek Hatchery.

v. Autopsies:

Forty (78.4%;19 females:21 males) of the fish were autopsied between February 24-26 at the B.C. Environment fish pathology laboratory in Nanaimo. The fate of three (5.9%) fish is unknown and they could have possibly jumped from the holding trough and later been discarded by hatchery staff that were unaware of our request to hold and freeze mortalities.

All of the fish that died prior to the end of the experiment on February 9, 1999, had fungal infections. All fish examined lost body length (mean fork length was reduced by 1.4 cm) over the course of the three month control period, and it is very possible that the stress of this part of the animal's life history could be responsible, independent of our influence. The mean length of all mortalities was larger (68 cm) than the mean length of all fish tagged (66.5 cm). The depth at which the transmitter was inserted into the esophagous was measured for all fish during tagging, and the mean insertion depth for fish that died (17 cm) was the same as the mean for survivors as well as for all fish tagged. Figure 24 compares fork length with transmitter insertion depth for both Sustut River fish and Robertson Creek Hatchery dummy tagged fish. Examination of the ratio of size of fish to depth of transmitter revealed similar results; the transmitter was not inserted relatively as deep for mortalities as it was for survivors (fish fork length/transmitter insertion depth, 4.10 versus 4.04 respectively). Only 3 (15.8%) of the nineteen females autopsied had eggs still in skeins (Figure 25.); the remainder were fully mature and dropping eggs. Eggs or remnants thereof were found in the gastrointestinal tracts of sixteen (40%) of the fish examined (Figures 26, 27). Only one (6.3%) of the natural mortalities were found to have ingested eggs. The time in anaesthetic bath, handling time and recovery time was less in the group that died prior to February 9 that the overall average in all three categories.



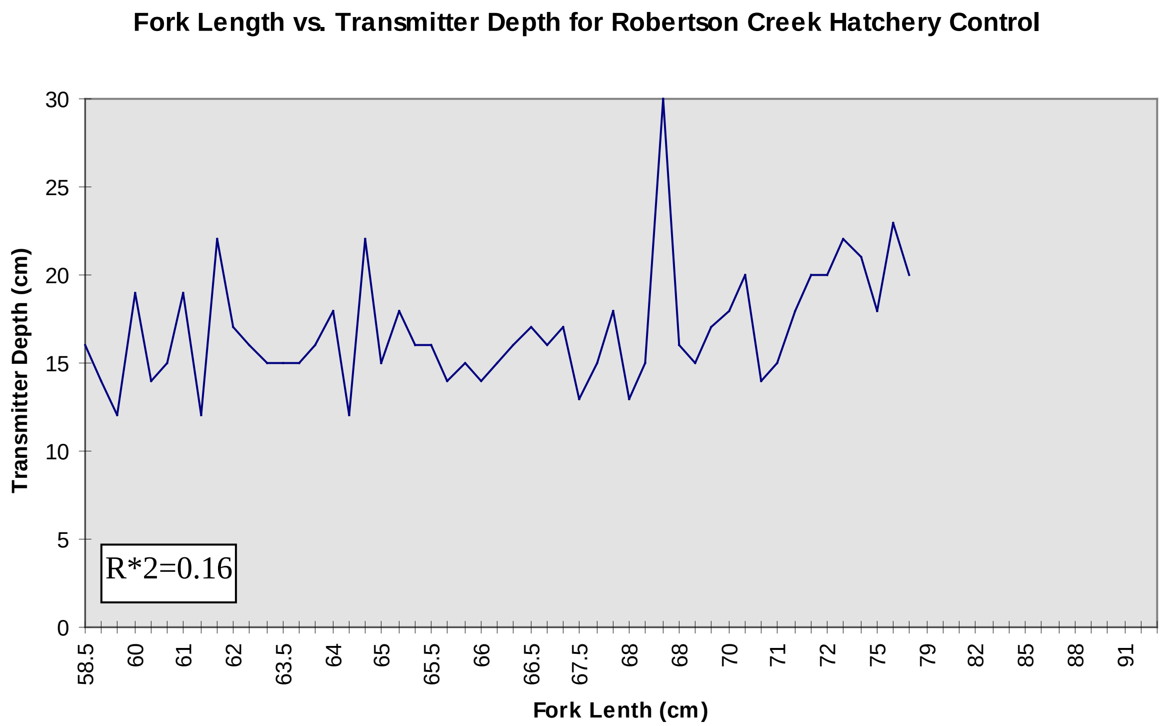


Figure 24. Fork length versus transmitter insertion depth; a comparison between Sustut River and Robertson Creek tagged fish.

Figure 25. Eggs still in skeins in autopsied female. Note the location of the transmitter (in intestine near vent, arrow) and the presence of eggs around it.

Figure 26. Stomach of autopsied steelhead male, swollen with eggs and transmitter.

Of interest is the incidence of fish that passed the transmitter through the pyloric valve of the stomach and into the intestine (Figure 27.). The transmitter was found near the vent (within 8 cm) in six (15%) fish. None of these fish died. Five (83.3%) of six were female, and they were smaller than the mean length of all fish tagged (63.1 cm versus 66.5 cm, respectively). This is consistent with results previously reported in the literature (Summerfelt and Mosier, 1984; Chisholm and Hubert, 1985; Marty and Summerfelt, 1986; Helm and Tyus, 1992.).

Four (10%) regurgitated the dummy transmitter and 1 (2%) lost its anchor tag. The mean length of fish that regurgitated was identical to the mean length of all fish tagged (66.5 cm).

Three (7.5%; 1 female:2 males) of the fish examined had damaged tissue in the lining of the stomach (Figures 29, 30.). The damage is believed to have been caused by mechanical pressure from the transmitter on the stomach wall, which damaged the mucosa and caused bleeding within the tissues (Sally Goldes, Fish Health Biologist, B.C. Fisheries, Nanaimo; personal communication). All of these fish died prior to the end of the holding period. Steelhead were extremely sensitive to stomach tissue damage and peritonitis appears to have been the result.

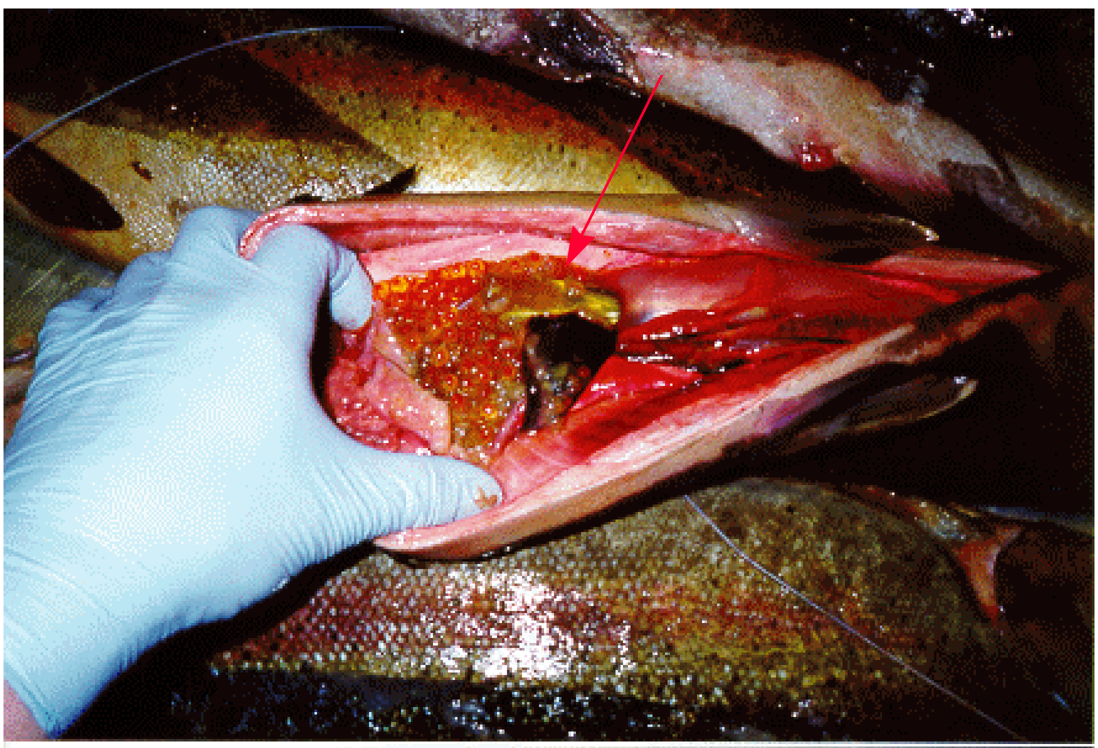


Figure 27. Steelhead eggs in stomach around 'dummy' transmitter (arrow) in this steelhead male.

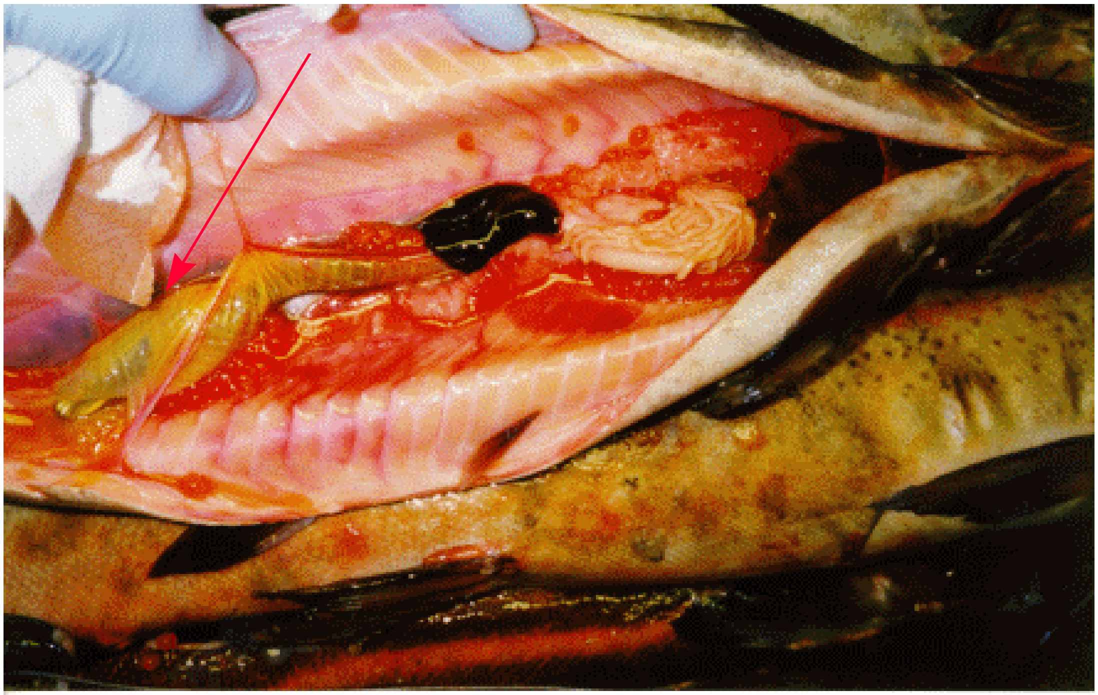


Figure 28. Dummy transmitter in female steelhead intestine near vent. A small incision was made to expose the posterior end of the transmitter for illustrative purposes.

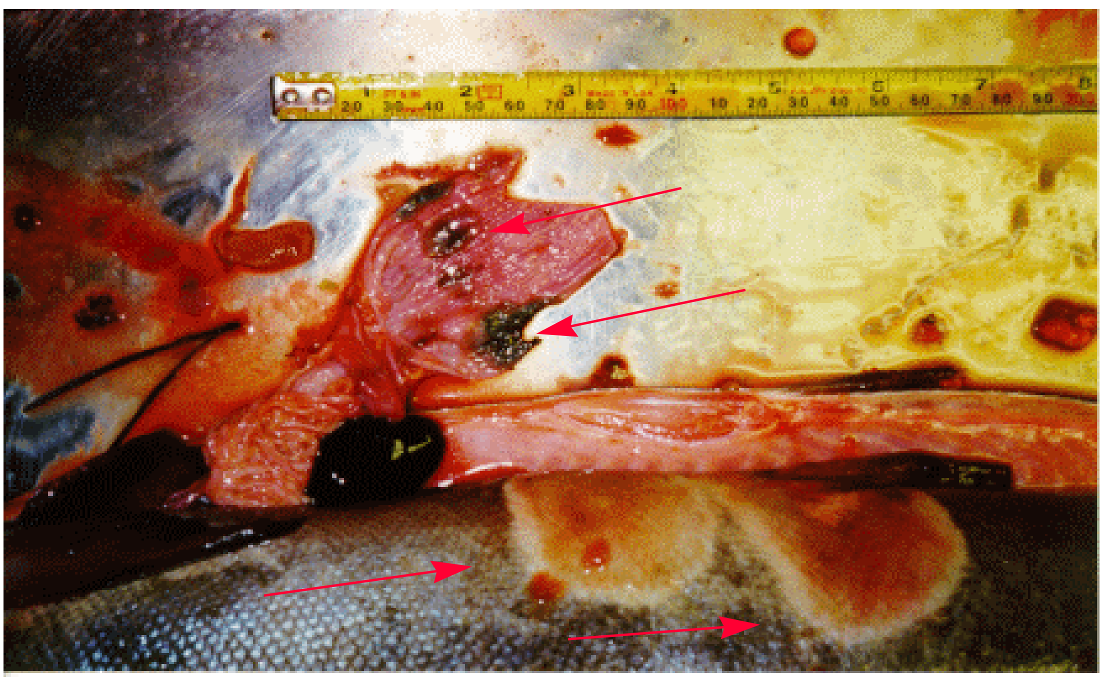


Figure 29. Photo illustrating blackened tissue (blood) on the stomach lining, secondary to an ulcer, probably caused by mechanical pressure. Note the actual perforations of the stomach lining (top arrows) and fungal infection (bottom arrows).

Figure 30. Note how the shape of the transmitter mirrors the pattern on the stomach lining.

Acknowledgements:

This study was conceived and directed by R.S. Hooton. D. Atagi and C. Parken assisted with fish capture and tagging. D. Adzich and T. Brooks at Canadian Helicopters piloted aircraft on telemetry tracking flights while T. Grant and T. Torunski ensured mechanical safety on those flights.

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