MEASURING AND MONITORING THE BIOLOGICAL, PHYSICAL AND CHEMICAL ATTRIBUTES IN THE RIPARIAN AND AQUATIC ECOSYSTEMS OF HUGHES BROOK, NEWFOUNDLAND (Part IV)

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DISCLAIMER

The data, views, conclusions and recommendations in this report are those of the authors. The data collected are only as good as the methodologies and the instrumentation employed. The conclusions reached are those of the study team based on the best data available. It is acknowledged that other researchers reviewing similar data may reach different conclusion; such is the nature of science. The views expressed do not imply that these are the views of the Aquatic Centre for Research and Education or any of its various partners or sponsors. This is a report produced by a student study team working during ten weeks in the summer of 2003.

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ABSTRACT

Commencing in the summer of 2000 and continuing to date, the Aquatic Centre for Research and Education (ACRE) has headed up research on Hughes Brook and surrounding ecosystems. This research is aimed at monitoring and inventorying the aquatic habitats and the surrounding riparian vegetation. Through such analysis, factors most heavily influencing the habitation of wildlife (i.e. Atlantic salmon) can be gauged. One of ACRE's main research interests is analysing Atlantic salmon stocks and providing information that can be helpful in assessing factors that most heavily influence the health of salmon populations. For six weeks in the summer of 2003 a number of physical, biological and chemical attributes of Hughes Brook were studied. This was accomplished through the use of relevant, available technical equipment. Over the six-week field season, a total of 2 kilometres of Hughes Brook was studied. Such physical attributes as channel width; wetted width, bank height and flood height were studied at randomly sampled plots. The pH, dissolved oxygen concentration and temperature were all taken at the same plots along with a random sample of invertebrates using a Surber sampler. Much of the data collected were compared to the factors that influence Atlantic salmon residency and spawning. It was found that all river and riparian zone attributes seem to favour salmon inhabiting the Hughes Brook system. However, this work also provides researchers with qualitative and quantitative baseline data, which can be used for a wide range of studies.

ACKNOWLEDGEMENTS

On behalf of all members of the ACRE research office we would like to thank the following groups and individuals for providing us with the much needed support for this year (and previous years') research.

Primarily, the structure of this year's river inventory was very different from that of previous years. While 2000, 2001, and 2002 student researchers focused on a detailed qualitative assessment of Hughes Brook and surrounding terrestrial habitat, this year's research efforts were more quantitative. Rather then assessing the entire ecosystem, representative statistic samples were taken of different sections of the river. Guidance and advice for carrying out this new research protocol came from individuals from the Inland Fish and Wildlife Division, Provincial Government of Newfoundland and Labrador. For their assistance we would like to extend our thanks and gratitude to the following individuals: Claudia Hanel, for supplying us with plant presses and botanical advice, Shelley Pardy for her invertebrate sampling expertise, and especially Robert Perry and his colleague for instructing us on this new sampling method and serving as a great source of support and advice.

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Finally, the research team would like to extend a personal thanks to the ACRE board of directors for giving us the opportunity to work in such an enlightening atmosphere both in the office and in the field.

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INTRODUCTION

Located on the North Shore of the Bay of Islands, Hughes Brook watershed is one of the few areas in Western Newfoundland (refer to Appendix A for Hughes Brook map) that is being intensively studied. Research techniques and methodologies used in Hughes Brook are being refined annually, and research protocols used to analyse this river system can be applied to other river systems in Newfoundland and Labrador. The Aquatic Centre for Research and Education (ACRE), the lead research organization, focuses on producing ongoing applied research on Atlantic salmon (*Salmo salar*) and the aquatic system in which they inhabit. ACRE's goals include attracting widespread research programs and to develop a better understanding of the Hughes Brook wildlife, river and riparian zone attributes. ACRE is also interested in applying the tools used in the pilot studies of Hughes Brook and knowledge of Atlantic salmon habitat to other river systems throughout the province.

In order to understand the complexity of salmon populations in Newfoundland Rivers, it is important to gather baseline data on the ecosystems in which the salmon inhabit. Physical and chemical aspects of a river system as well as the presence or absence of Atlantic salmon predators and prey all are indicative of the health of the habitat and the overall salmon population. Chemical attributes, such as pH and dissolved oxygen, are important for optimal faunal growth and tolerance. Physical measurements such as stream morphology, substrate composition and meso-habitats are necessary characteristics to determine the salmons' survival and spawning rate.

Salmon restocking programs, such as those that have occurred since the mid-1980's in Hughes Brook, have not yet been proven to significantly increase the salmon population in Hughes Brook. Through the combining of habitat data collected from Hughes Brook and other Newfoundland and Labrador rivers, we hope to determine how to effectively gauge factors most influential to Atlantic salmon populations and in-turn attempt to manage and improve the stream ecosystem quality.

METHODOLOGIES

The 2003 Hughes Brook river inventory study was carried out in a different manner from what were done in 2002, 2001 and 2000. Research in 2003 was carried out by Elizabeth Jones, Amanda Parsons and Richard Carroll (returning post-secondary students) as well as Tara Saunders and Mandy McLean (WISE students). Our research team chose to conduct the research in a more quantitative manner than was done in previous years on the recommendation and guidance of several scientists from the Inland Fish and Wildlife Division, Provincial Government.

Our sampling methodology consisted of a two-step survey of the Hughes Brook river system. Hughes Brook is located in Western Newfoundland on the northshore of the Bay of Islands, approximately 15kms from the city of Corner Brook. The river empties into the estuary of the much larger Humber River, the second largest river in Newfoundland. The first step towards our field research was a gross survey and classification of 2kilometers of the Hughes Brook river system. This involved walking the length of the study site (4980m to 6980m), measuring and dividing the river into 20meter study plots. A 30m-fibreglass tape measure was used to measure off 20-meter plot sections along the river and each plot was denoted with flagging tape. Four UTM (universal transverse mercator) co-ordinates of each 20m plot were taken and recorded using a Global Positioning System (Garmin "personal navigator"). Use of the GPS system was necessary so that plots of interest could be relocated throughout the study season. In this initial survey each 20 meter river section was numbered from 1 to 100 and given a designation of type I, II, III or IV (See Appendix B). This rating is a quick reference classification that designates stream sections according to predominant stream morphology and water features. This classification system gave us a method of breaking the stream into smaller sections and focusing on samples of each section for further study.

Upon completion of the initial gross survey we selected a representative sample of the plots for a more extensive analysis. Of the 28 plots initially surveyed there were 12 type I's, 7 type II's, 3 type III's and 6 type IV's. We choose 25% of each plot type to sample and plots were selected randomly by drawing plot numbers, according to classification type, from a hat. On the river we located, via GPS coordinates, each of the selected plots and analyzed them individually going in an upstream (estuary to headwaters) direction. After recording the date, cloud cover and watercolor at the time of the study, our first step was to take a tape measure and position it parallel to the river. This was used in order to measure the length of the study plot and demark the length of the plots into 5-meter intervals (0m, 5m, 10m, 15m and 20m). At each 5-meter interval three river depths were measured using a standard meter stick at ¼, ½ and ¾ distances across the river and recorded on designed data sheets (see Appendix C for sample data sheet).

The next series of measurements were taken at the waters edge on both the left and right hand sides of the river. The height of the bank (which includes from the waters edge to first level landing), and the flood height (which includes the average level to which the water rises during spring thaw) were measured using the meter stick. The channel width (from left side of waters edge to right side of waters edge), and wetted width (saturated soil on left to saturated soil on right) were measured using a measuring tape placed across the river. At each depth measurement, dissolved oxygen, water temperature and water pH readings were taken at constant subsurface levels (about 0.5meters below the surface) at each plot. A Hannah Instruments Portable Waterproof Microprocessor Dissolved Oxygen Meter, unit 9143 was used to gauge dissolved oxygen and temperature (See Appendix D for a critical analysis) while the acidity of the water was measured using a Ph Tester1, waterproof probe.

Upon completion of these physical and chemical measurements we used a Surber sampler (31.0cm x 26.5cm) to randomly sample invertebrates at each plot. At 5m intervals along the length of the river and at random locations across the River's width invertebrate samples were taken. The Surber sampler's quadrant was placed directly on the riverbed, with the samplers mesh bag oriented downstream, and the substrate encompassed by the quadrant was agitated manually to loosen any inhabiting or adhering invertebrates. Organisms inhabiting the sampling area were then captured in the Surber's sampling mesh and then flushed, with water, into white plastic containers (20cm x 16.5cm) for analysis. Individual organisms were removed from the container using tweezers, and then placed within an isopropyl rubbing alcohol solution contained in a glass vial for preservation. The organisms were inventoried for identification and quantification in the laboratory. Most organisms were identified to species, with the exception of a few organisms that were identified to genus.

In the riparian zones the use of pit-fall traps were employed. A small hole was dug using a spade and a mason jar was placed in the hole to the extent that the jar's opening was flush with the ground. Four pitfall traps in total were placed in sample plots; one on each side of site 1, which was a type I location and one at each side of site 68, which was a type II location. These traps were set, left for a few days, and when checked the specimens were collected, preserved and identified in the same manner as for the aquatic invertebrates sampled.

Our next measurements involved the analysis of river substrate and channel patterns. We assessed each sampled plot based on the substrate types present, and the proportion of each substrate type found within a given plot. A similar type of evaluation was done for stream morphology, whereby percentages of pool, rapid, glide etc. were recorded (See Appendix E). Following this, we measured water velocity at the centre of each plot. This was done by placing a meter stick on the water's surface, dropping a tennis ball into the water next to the meter heading down river, and recording the time it takes (with a stopwatch) for the ball to travel a distance of 1 meter which gave us a meter/second reading (velocity). Next we evaluated the percentage of overhanging vegetation and bank erosion present on both sides of 20meter length sample plots. Once this was complete the next parameter to analyze and record was the soil type (gravel, mud, silt or organic) on both sides of the stream as well as the moisture content of such substrate (dry, moist, wet or flooded).

Our final evaluation was to assess the vegetation composition in 5meter wide riparian zones along each side of the each river plot. Species were identified in the riparian zones and classified into one of the following categories: bog plants, grasses, ferns, mosses, trees, shrubs, herbs, and other wild flowers (See Appendix F for definitions provided by the Inland Fish and Wildlife, Provincial Government). Each vegetation category was assigned a percentage value according to amount of coverage. Unidentifiable samples were stored in plastic bags, labelled with the site number, and later pressed, mounted and identified at the lab.

RESULTS

A total of 2kilometres of Hughes Brook and surrounding environment were studied this year, 2003. The area included meter 4980 to meter 6980 upstream (from estuary to headwaters). Results were grouped by sites of a particular classification (refer to Appendix B) and by analyzing the data in relation to the optimal environmental parameters essential to salmon's survival.

Substrate

The river was initially classified or divided into habit types (run, riffle, pool etc.) (Refer to Appendix B & E for habitat class). Each habitat type had a characteristic water flow pattern and resulting substrate. Determining the substrate type within each plot type was important (See Appendix G for substrate size). In a type I plot the primary substrate consists of gravel, cobble, larger rocks or boulder. Our research indicates that Hughes Brook has a large percentage of type I habitat. This habitat type was found to be the dominant type (43%) in the 2kilometer section of river studied. The substrate found in a type I habitat serves as good salmonid spawning and rearing habitat, often with some feeding pools for larger age class fish.

A type II habitat generally consists of run, riffle, pocket-water and pool. The substrate is said to be composed of larger cobble, rubble, bedrock, some gravel and pockets between larger rocks. There were many type II areas in the 2kilometers that we studied. Type II habitat is the second most prevalent (25%) habitat type in the study area and characteristically contains good salmonid rearing habitat with limited spawning area, usually only in isolated gravel pockets, but good feeding and holding areas for larger fish in deeper pools, pockets or eddies.

Type III habitats consist of runs, pocket-water and cascades. The substrate is composed of large rock, boulders and bedrock. These areas are poor rearing habitat for salmon with a lack of spawning areas. These habitats are used mainly for migratory purposes. We estimated 3 sites out of the 28 surveyed (11%) constituted this type III habitat.

The general type IV habitat consists of flats, pools and glides; in these areas soft sediment or sand with an occasional large boulder or bedrock are present. These areas are poor juvenile salmonid rearing habitat with no spawning capability. They also provide shelter and feeding habitat for larger, older salmonids. These areas were the third most frequent (21%) type present in the study site (habitat which is suitable for older salmon but not for growing fry (See Appendix H for salmonid lifecycle)).

Physical and Chemical Parameters

In our cross sectional study of the sample plots we recorded various physical and chemical measurements of the river. Grouping the physical measurements by habitat type would not be a good comparison between types as the river has many twists, turns, and bends that have no effect on the type in which it is classified. Generally, by measuring the water heights now and in subsequent years we can see possible evidence of rises and falls. We can gauge the changes within Hughes Brook over the years. There is evidence that Hughes Brook has evolved and changed greatly over the past 2-3 decades, as there is evidence of washouts, landslides and significant erosion. As well, the amount of debris that was measured on the shoreline tells us there has recently been a large flood in the area. Water levels have risen to new heights, washing out over the regular flood banks and creating ponds in the usual riparian bogs.

The water property information collected in each plot was organized by habitat type and statistically analyzed. The maximum, minimum and average temperature, dissolved oxygen and pH values at each site were determined, and the average value was recorded and compared with the optimal levels in which a salmon can grow and survive.

The type I habitat, figures for Hughes Brook include:

Table 1.1: Statistical Results of Type I habitat data

Temp (° C)		Sample Size
Max	20.6	
Min	16.9	
Aver.	17.7	12

DO (mg/L)		Sample Size
Max	9.78	
Min	6.46	
Aver.	8.6	12

pH		Sample Size
Max	8	
Min	7.2	
Aver.	7.8	12

The optimal temperature level for normal salmonid growth is 15°C - 19°C. It is evident that our results, collected in July and August, approximate that range, indicating that the temperature is suitable for fish. The average dissolved oxygen concentration is 8.6mg/L. We took several DO measurements in the 6-7mg/L range, which indicates a low dissolved oxygen concentration in that particular area at that particular time. These measurements were taken in areas of the sample plots containing pools with little or no water movement. In theses areas aquatic vegetation tends to use the oxygen faster then it can be replenished. Low DO readings may also have been taken at times when the water temperature was very high, changing the subsequent DO content. The optimal pH range for an aquatic ecosystem supporting biological life is from 6.5 – 8.2. The average pH in the type I plots sampled was 7.8, well within the range for a healthy river.

For the type II habitat, figures for Hughes Brook include:

<u>Table 1.2</u>: Statistical Results of Type II habitat data

Temp (° C)		**Sample Size**
Max	22.6	7
Min	17.6	
Aver.	18.8	

DO (mg/L)		**Sample Size**
Max	11.07	7
Min	8.18	
Aver.	9.3	

pH		**Sample Size**
Max	7.9	7
Min	6.4	
Aver.	7.7	

Compared with average Newfoundland temperatures, this year was a very hot year and the river water temperature rose to a high of 22.6°C. This situation can be harsh for juveniles but tolerable for larger salmon. When a high temperature is achieved and maintained for prolonged periods, a river is normally shut down to recreational fishing because of the stress that high temperatures impose on the fish. When water temperatures are high, dissolved oxygen levels should be low but in our case they remained at an average acceptable level. Also, the pH range remained at optimal values.

Hughes Brook was not made up of many type III areas; therefore, rather than sampling 25% of all type III's, all were surveyed.

<u>Table 1.3:</u> Statistical Results of Type III habitat data

pH		**Sample Size**
Max	7.9	3
Min	7	
Aver.	7.7	

Nearing the end of our research, the DO meter became damaged beyond repair, and having a limited amount of time left to conduct the DO and temperature readings, both had to be abandoned (for a detailed look at what went wrong with the equipment, see Appendix D). The pH, was obtainable. The results we found in the type III area were well within the optimal range.

The type IV habitat, figures for Hughes Brook include:

Table 1.4: Statistical Results of Type IV habitat data

Temp (° C)		**Sample Size**
Max	20.2	6
Min	17.1	
Aver.	18.6	

DO (mg/L)		**Sample Size**
Max	9.78	6
Min	6.04	
Aver.	8.4	

pH		**Sample Size**
Max	8	6
Min	7.1	
Aver.	7.8	

A type IV habitat area has suitable substrate and general living habitat for fish. The temperature did rise to 20.2°C because of the above average summer conditions, but the DO and pH levels remained at optimal levels, 8.4mg/L and 7.8 respective fully.

Invertebrates

There were a variety of invertebrates collected this sampling year. A detailed list can be found in Appendix I. A large number and variety of organisms shows that Hughes Brook is thriving with food resources and life. Organisms that we have identified in past Hughes Brook studies were collected as well as a few new ones such as earwig larvae, water mites and common skimmers. When identifying the insects, a problem encountered was finding the species name as we collected immature larvae rather than adult insects, the latter would be easier to identify.

Riparian

Hughes Brook has a variety of common and rare tree and plant species (see Appendix J). The river's edge is made up mainly of shrubs, small trees, ferns and plants with the exceptional tree. This year the new species identified included: sedges, fireweed, bull rush, mosses, pondweed and pin cherry. The initial Hughes Brook survey began at the estuary, 5 km away from the 2003 study area. Now that we are moving towards deeper wooded areas, we are encountering different species that were found towards the end of the river. This indicates that the soil surrounding the river's edge is capable of supporting a wide variety of riparian species. All vegetation was grouped into categories (see Appendix F for definitions). Hughes Brook was found to contain all categories with a new wild flower category added. The dominant category found was shrubs, which consist of small trees 5meters or less.

CONCLUSION

The ACRE research team has created, with the help of Inland Fish and Wildlife, an ideal method for surveying a river. Research nuances were easily worked out creating understandable, user-friendly data that also has scientific validation. The substrate identified in Hughes Brook was found to be of good quality for various salmonid lifecycle stages and survival and, there is an abundant food source and riparian shelter. The chemical properties, such as temperature, dissolved oxygen and pH, have shown to be within all normal limits with no drastic fluctuation. The Hughes Brook river system is capable of supporting various species of plants, trees, animals and wildlife. As to why the adult salmon rate of return has not been increasing remains a mystery; therefore, more testing of specific parameters such as water quality studies should be initiated.

The presence and absence of particular indicator species may help researchers better understand the state of the Hughes' Brook tributary. Disturbances to the environment such as logging, siltation, erosion and pollution may be observed and interpreted, using our research as a benchmark. This kind of study will allow future research to be carried out that will complement that of the past. Our survey gives us a better look into all zones of the Hughes Brook tributary. The surface water, water column, benthic and even hyporheic and phreatic zones can hopefully be better assessed using our method as a benchmark.

RECOMMENDATIONS

To ensure that additional surveys of Hughes Brook are thorough, the following procedures should be implemented:

1. Bacterial testing of the water to combine with the pH and DO readings that seem at times to be a little off.
2. A suitable flow meter is requested and should be purchased.
3. Total Sustainable Dissolved Solid levels and heavy metal levels would be interesting to determine because of possible effluent/runoff from the area farm.
4. Also, other chemical attributes are important to analyse such as nitrate, phosphate and chloride, which would not be foreign to the area because of the variety of animals and the farm products present.

With the addition of the data mentioned above to what is already known about Hughes Brook we could achieve a better understanding of the quality of the river, and the affects of certain parameters on fish health and survival. Corrections can then be made to attempt to solve problems that were not apparent before.

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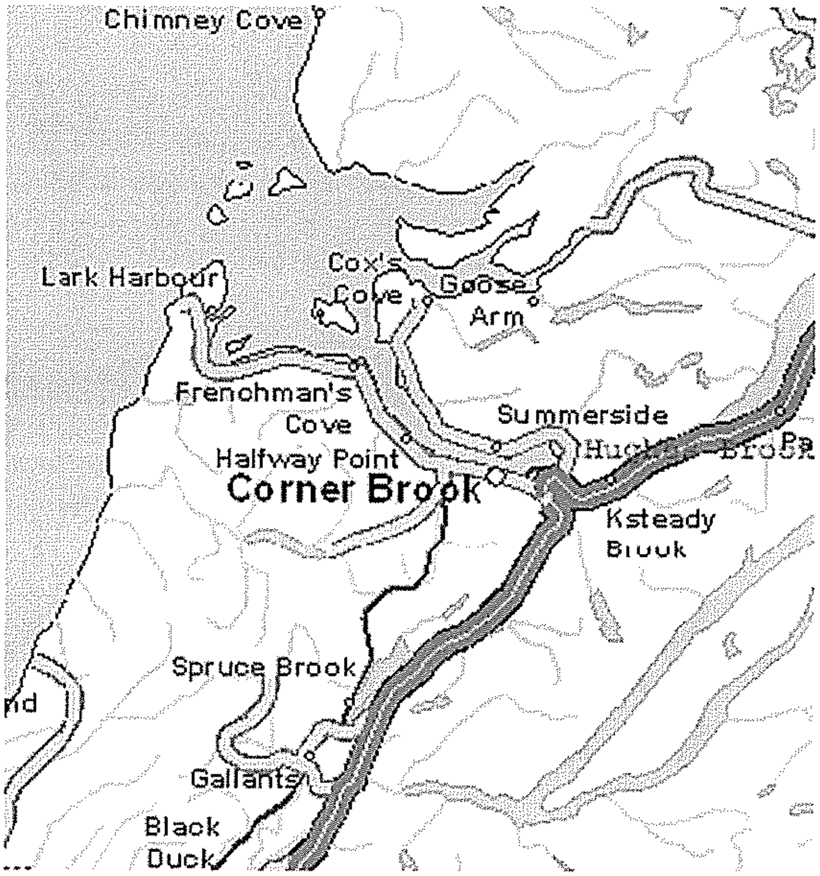
APPENDIX A

Figure 1.1: Map of West Coast of Newfoundland, Hughes Brook is indicated.



APPENDIX B

Table 1.1: Characteristics of the Four Habitat Classification Types

Type 1	Good salmonid spawning and rearing habitat; often with some feeding pools for large age classes: Flow: moderate riffles Current: 0.1 - 0.3 m/s Depth: relatively shallow, 0.3 – 1 m Substrate: gravel to small cobble size rock, some larger rocks or boulders General habitat type: primarily riffle, pool
Type 2	Good salmonid rearing habitat with limited spawning, usually only in isolated gravel pockets, good feeding and holding areas for larger fish in deeper pools, pockets or backwater eddies: Flow: heavier riffles to light rapids Current: 0.3 – 1 m/s Depth: variable form 0.3 – 1.5 m Substrate: larger cobble/ rubble size rock to boulders and bedrock, some gravel pockets between larger rocks General habitat type: run, riffle, pocket water, pool
Type 3	Poor rearing habitat with no spawning capabilities, used for migratory purposes: Flow: very fat, turbulent, heavy rapids, chutes, small waterfalls Current: 1 m/s or greater Depth: variable, 0.3 – 1.5 m Substrate: large rock and boulder, bedrock General habitat type: run, pocket water, cascade
Type 4	Poor juvenile salmonid rearing habitat with no spawning capability, provides shelter and feeding habitat for larger, older salmonid (especially brook trout): Flow: sluggish Current: 0.15 m/s Depth: variable but often 1 m Substrate: soft sediment or sand, occasionally large boulder or bedrock, aquatic macrophytes present in many locations General habitat type: flat, pool, glide

APPENDIX C

Table 1.2: Data Collection Sheet

A.C.R.E. Data Sheets

Date:		GPS: Top L		Bottom L	
Site#:	CC:				
		R		R	

Substrate

Type(1-4):	Color:	Velocity:

Habitat Type	Percent	Habitat Type	Percent	Substrate Type	Percent	Substrate Type	Percent
Run		Pool		Bedrock		Pebble	
Riffle		Cascade		Large Bou		Gravel	
Pocket		Glide		Small Bou		Sand	
Flat				Rubble		Clay/Mud	
				Cobble		Silt	

Cross Section

#	Distance	Channel Width	Wet. Width	**L** Bank Height **R**		**L** Flood Height **R**	
1	0						
2	5						
3	10						
4	15						
5	20						

#	1/4 Depth	Temp./D.O./Ph	1/2 Depth	Temp./D.O./Ph
1				
2				
3				
4				
5				

#	3/4 Depth	Temp./D.O./Ph
1		
2		
3		
4		
5		

Invertebrates

Organism	Bottle #	Collection Method	Quantity

Vegetation	Left	Right
% Erosion		
% Overhang		

		Left	Right
Moisture:	dry		
	moist		
	wet		
	flooded		
Soil:	gravel		
	mud		
	silt		
	organic		

Species

Left	**Sample #**	**Right**	**Sample #**

Left Type	Grass	Fern	Moss	Tree	Shrub	Flower	Herb
%							

Right Type	Grass	Fern	Moss	Tree	Shrub	Flower	Herb
%							

APPENDIX D

Hanna Instruments Portable Waterproof Microprocessor Dissolved Oxygen Meter Critical Analysis

Before attempting to use the Hanna 9143 Dissolved Oxygen Meter, it is imperative that the user read carefully the instruction manual provided. Calibration alone, which must be done every time the system is turned on, requires either memorization of the instructions, or someone to read them as another attempts to calibrate the instrument. It is unsure whether the results obtained are accurate or not, as there is no other way to check against the data collected, and there were many problems throughout it's use. Unlike systems utilized in the past, this system is convenient in that it only has one probe to perform two tasks. The dissolved oxygen probe doubles as a thermometer as it has a built in thermistor for temperature measurement.

When first using the system, one will discover that the calibration time is quite lengthy. Unlike what is described in the instructions as approximately a five minute procedure, the calibration will often take an average of 5-10, and will occasionally extend well past fifteen minutes. This issue turns into a larger problem when taken into account the fact that calibration has to be done every time the system is turned off. As well, the system would sporadically shut off while in use. It is unsure whether or not this was a manufacturer's defect or a special feature of the system, nothing was mentioned to this effect in the Hanna Instruments 9143 instruction manual.

Not only is calibration a time consuming effort, but slow data collection is also associated with this particular dissolved oxygen meter. The dissolved oxygen meter requires a long time to stabilize (approximately 4 minutes) once it is submerged in the river. Quite often the dissolved oxygen meter will not stabilize at all, and it is necessary to take an estimate of the readings. This discourages accuracy in the field.

With this system in particular, problems arose with the connection of the probe to the actual microprocessor unit. The wires connecting the probe to the microprocessor are enclosed in a waterproof casing, and connected to the unit via a metal holder. After repeated use, it is suspected that the wires became frayed inside the waterproof casing. This led to a reading of 0.0% for the dissolved oxygen percent saturation. When the wires were manually adjusted, the percentage would read random numbers and begin to stabilize. This caused problems, as the research team had to use extra precaution to keep the wires from moving too much. After a short time, the system became inoperable where no further dissolved oxygen or temperature readings are recorded. It is suspected that the wires have been completely severed inside the waterproof casing, causing the dissolved oxygen readings to remain unchanged at 0.0%.

Another strange thing noticed on this particular Hanna Instrument is that when new batteries were installed in the microprocessor, it would continue to read low battery on the display. This may be a defect in the particular system, and not a problem for all Hanna Instruments Dissolved Oxygen Meters.

This system is more suitable for all-day field research than it's predecessor, the Vernier Labpro. It is waterproof (whereas Vernier was not), and uses fewer probes than Vernier to perform similar tasks. Besides those setbacks mentioned above, the Hanna Instruments Portable Waterproof Microprocessor Dissolved Oxygen Meter worked well, relative to past equipment, and should be considered again for next year's survey team.

APPENDIX E

Table 1.3: General Habitat Types Based on Water Flow

Habitat Type	Definition
Run	Swiftly flowing water with some surface agitation but no major flow obstructions, coarser substrate (gravel, cobble and boulder).
Riffle	Shallower section with swiftly flowing, turbulent water with some partially exposed substrate (usually cobble or gravel dominated).
Pocket water	Turbulence increased greatly by numerous emergent boulders that create eddies or scour holes (pockets) behind the obstructions.
Flat (or steady)	Water surface is smooth and substrate is made up of organic matter, sand, mud and fine gravel. This habitat type generally has a flat bottom.
Pool	Deeper area comprising full or partial width of stream, due to the depth or width flow velocity is reduced. Pool has rounded surface bottom.
Cascade (rapids)	Areas of steeper gradient with irregular and rapid flow, often with turbulent white water. Rapids are primarily associated with larger stream sections and rivers. In larger rivers it is recommended that the survey crew not attempt to conduct cross sections in these areas.
Glide	Wide, shallow pool flowing smoothly and gently, with low to moderate velocities and little or no surface turbulence. Substrate usually consists of cobble, gravel and sand.

APPENDIX F

Table 1.4: Riparian Vegetation Classification

Type	Definition
Hardwood	Mature deciduous (trees that lose their leaves in winter) trees, including maples, birch etc.
Softwood	Mature coniferous (trees that maintain their foliage year-round) trees, including spruce, fir, pine etc.
Alders etc…	Larger, hardwood shrubs such as mountain ash (dogwood), willow, aspen etc. up to 2 m in height.
Shrubs	Smaller, softwood shrubs, including Labrador Tea, blueberry, fireweed, ferns, etc.
Grasses	All natural grasses on the stream edge and in association with surrounding vegetation.
Bog	All surrounding wetland including bogs and ferns.

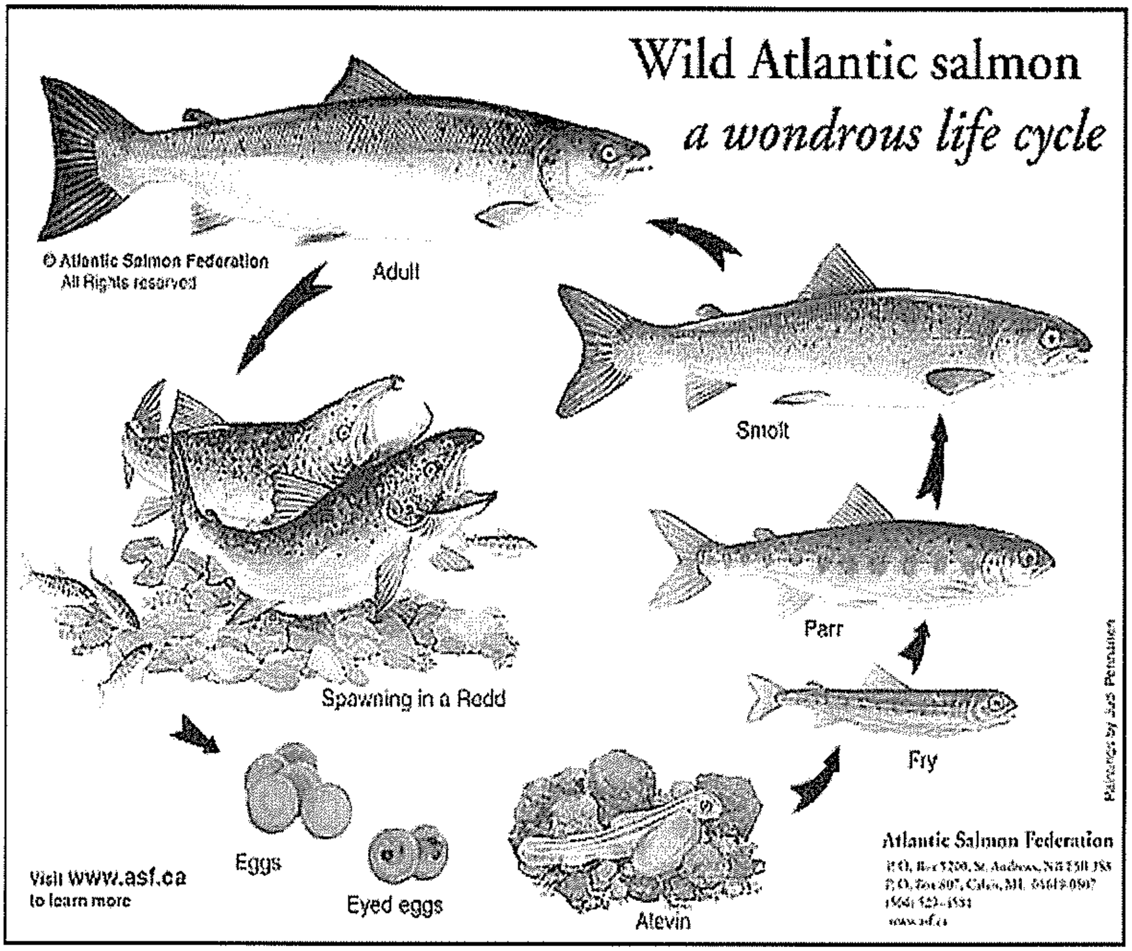
APPENDIX G

Table 1.5: Quantifying Substrate

Substrate Type	Definition/ Size
Bedrock	Continuous solid rock exposed by the scouring forces of the river/ stream.
Large Boulder	Large boulder sized rocks greater than 1 m in diameter.
Small Boulder	Boulder sized rocks from 25 cm to 1 m in diameter.
Rubble	Large rocks from 14 t0 25 cm in diameter.
Cobble	Moderate to small sized rocks from 6 to 13 cm in diameter.
Pebble	Small rocks to stones from 3 to 5 cm in diameter.
Gravel	Small stones from 2 mm to 3 cm in diameter.
Sand	Sand sized deposits frequently found on margins of streams or between rocks and stones, from 0.06 to 2 mm in diameter.
Clay/ Mud	Very fine deposits from mud to silt on stream margins, between rocks, and on top of other substrates.
Siltation	The relative degree of siltation in the section should be described and it should be determined if there is much silt deposit on top of and between other substrate rocks. This could be either descriptive or defined as a percentage of the substrate by silt and to what depth.

APPENDIX H

Figure 1.2: The Life Cycle of the Atlantic Salmon.



APPENDIX I

Table 1.6: Invertebrates found

Species Name	**Common Name**
Class Arachnida	
Order Acarina	
Family Hydrachnellae	Water Mite
Order Opiliones	
Family Phalangiidae	
Leiobunum spp.	Eastern Daddy-long-legs
Class Gastropoda	
Family Arionida	
Arion hortensis	Slug
Class Insecta	
Order Coleoptera	
Family Carabidae	
Pterostichus spp.	Common Black Ground Beetle
Family Tenebrionidae	
Blapstinus metallicus	Water Beetle
Order Diptera	
Family Ceratapogonidae	Punkies/ Biting Midges
Family Culicidae	Mosquito larvae
Order Ephemeroptera	
Family Baetidae	
Callibaetis spp.	Small Mayfly
Family Heptageniidae	
Heptagenia spp.	Stream Mayfly nymph
Order Odonata	
Family Coenagrionidae	Dragonfly nymph
Family Libellulidae	Common Skimmer
Order Plecoptera	
Family Perlidae	
Leuctra spp.	Common Stonefly
Order Protura	
Family Acerentomidae	
Acerentomon doderoi	Earwig
Order Trichoptera	
Family Brachycentridae	
Brachycentrus spp.	Trumpet-Net and Tube-Making Caddisfly

APPENDIX K

Table 1.7: Riparian Vegetation Found

Species	**Common Name**
Abies balsamea	Balsam Fir
Acer rubrum	Red Maple
Acer spicatum	Mountain Maple
Alnus crispa	Mountain Alder
Alnus rugosa	Speckled Alder
Aster nemoralis	Bog Aster
Betula lutea	White Birch
Betula papyrifera	Yellow Birch
Caltha palustris	Marsh Marigold
Carex sp.	Sedge
Chrysanthemum leucanthemum	Oxeye Daisy
Cirsium altissimum	Field Thistle
Cormus canadensis	Bunchberry
Cornus alternifolia	Alternate Leaved Dogwood
Cornus stolonifera	Red Osier Dogwood
Corylus cornuta	Beak Hazelnut
Epilobium angustifolia	Fireweed
Equisetum aruense	Horsetail
Eupatorium maculatum	Joe-Pye Weed
Fragaria vesca	Wood Strawberry
Fragaria virginiana	Wild Strawberry
Fraxinus nigra	Black Ash
Galeopsis tetrahit	Hemp-Nettle
Gaultheria hispidula	Creeping Snowberry
Habenaria dilatata	White Bog Orchis
Heracleum maximum	Cow Parsnip
Juncus sp.	Bull Rush
Krigia dandelion	Dwarf Dandelion
Osmunda claytoniana	Interrupted Fern
Picea glauca	White Spruce
Picea mariana	Black Spruce
Pleurozium sp.	Moss
Potamogeton sp.	Pondweed
Prunella vulgaris	Self-Heal
Prunus pennsylvanica	Pin Cherry
Prunus virginiana	Choke Cherry
Ranunculus acris	Tall Buttercup
Ranunculus repens	Creeping Buttercup
Ribes lacustre	Bristly Black Current
Rubus idaeus	Raspberry
Rubus pubescens	Dwarf Raspberry

Satureja vulgaris	Wild Basil
Senecio jacobaea	Tansy Ragweed
Sisyrinchium bermudianum	Blue-eyed Grass
Sorbus americana	American Mountain Ash
Solidago graminfolia	Golden Rod
Sparganium spp.	Bur-reeds
Stellaria spp.	Chickweed
Taraxacum officinale	Common Dandelion
Thalictrum polygamum	Tall Meadow Rue
Trifolium pratense	Red Clover
Tussilago farara	Coltsfoot
Typha latifolia	Common Cattail
Vaccinium uliginosum	Newfoundland Bilberry
Viburnum cassinoides	Wild Raisin
Viburnum triloban	Highbush Cranberry
Vicia cracca	Cow Vetch