

Fisheries and Marine Service  
Technical Report 785

June 1978

PHYSICAL CHARACTERISTICS OF ATLANTIC SALMON  
SPAWNING GRAVEL IN SOME NEW BRUNSWICK STREAMS

by

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This is the one hundred and eleventh Technical Report from the  
Biological Station, St. Andrews, N.B.

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## ABSTRACT

Peterson, R. H. 1978. Physical characteristics of Atlantic salmon spawning gravel in some New Brunswick streams. Fish. Mar. Serv. Tech. Rep. 785, iv + 28 p.

Gravel composition and permeability were measured in actual and potential salmon spawning habitats in 7 N. B. streams. Particular emphasis was placed on the St. Croix River. Typical particle size distribution of spawning gravel (for a 15-cm core sample) was: cobble (22.2-256 mm), 40-60%; pebble (2.2-22.2 mm), 40-50%; coarse sand (0.5-2.2 mm), 10-15%; fine sand (0.06-0.5 mm), 0-3%. Gravel was stratified with more fine material in the deeper sediments. Permeabilities were usually <2000 cm/hr with some Waweig River and Digdeguash River gravels averaging >5000 cm/hr. Permeability was weakly correlated with amount of sand in the gravel ( $r = 0.6$ ).

St. Croix River gravels were found to be of higher permeability and lower sand content in the more downstream study areas. Percent of fry emergence from eggs planted in various gravel bars in the St. Croix varied from 0 to 4%. No emergence was obtained in gravel with mean permeability as low as 600 cm/hr.

Key words: Atlantic salmon, permeability, emergence, sand, New Brunswick, streams

## RÉSUMÉ

Peterson, R. H. 1978. Physical characteristics of Atlantic salmon spawning gravel in some New Brunswick streams. Fish. Mar. Serv. Tech. Rep. 785, iv + 28 p.

Nous avons mesuré la composition et la perméabilité du gravier de frayères à saumons de fait ou éventuelles dans 7 cours d'eau du Nouveau-Brunswick, en mettant principalement l'accent sur la rivière Ste-Croix. La granulométrie typique du gravier s'y présentait comme suit: galets 22,2 à 256 mm), 40 à 60%; cailloux (2,2 à 22,2 mm), 40 à 50%; sable grossier (0,5 à 2,2 mm), 10 à 15%; sable fin (0,06 à 0,5 mm), 0 à 3%. Les couches plus profondes du gravier comportaient aussi des strates de sédiments plus fins. La perméabilité était habituellement de moins de 2000  $\text{cm}\cdot\text{h}^{-1}$ , mais certains bancs des rivières Waweig et Digdeguash avaient une perméabilité supérieure à 5000  $\text{cm}\cdot\text{h}^{-1}$ . On a déterminé une faible corrélation entre la teneur en sable du gravier et sa perméabilité ( $r = 0,6$ ).

Sur la rivière Ste-Croix, les bancs de gravier de nos stations situées les plus en aval avaient une plus grande perméabilité et une teneur en sable plus faible. Le pourcentage d'éclosion d'oeufs déposés sur divers bancs de gravier de la rivière Ste-Croix variait 0 à 4%. Aucune éclosion n'a été observée sur des bancs de gravier à faible perméabilité moyenne de 600  $\text{cm}\cdot\text{h}^{-1}$ .

Mots clés: Saumon atlantique, perméabilité, éclosion, sable, Nouveau-Brunswick, cours d'eau.

## INTRODUCTION

Increased siltation of stream beds may occur through alteration of streamside habitat, as in logging, road-building, and agricultural practices (Cordone and Kelley 1961; Saunders and Smith 1965). The deleterious effects of increased accumulation of fine sediments in gravels utilized by spawning salmonids have been documented many times, particularly for West Coast streams (Shaw and Maga 1943; Shapovalov 1937; Hobbs 1937). Little information is available on the physical characteristics of gravels in New Brunswick (N.B.) salmon spawning areas.

The main stem of the St. Croix River, forming part of the Maine-N.B. boundary, flows into Passamaquoddy Bay-Gulf of Maine. The erection of sawmills, pulp and paper, and textile mills, and hydroelectric dams served to eliminate stocks of anadromous Atlantic salmon from the St. Croix 50-150 yr ago with the last fish disappearing in the 1920's (McCabe 1976).

In 1974, interest in re-establishing anadromous Atlantic salmon in the main stem of the St. Croix River was generated by the U.S. Fish and Wildlife Service, North American Salmon Research Center, and Canadian Fisheries and Marine Service, coincident with pollution abatement proposals and cessation of stream-driving of pulp wood.

As a result of the renewed interest in the St. Croix River, it was decided to survey some of the physical characteristics of actual and potential spawning areas in several New Brunswick streams, placing particular emphasis on the St. Croix. Specifically, gravel permeability, gravel composition and fry emergence success were examined.

### TOPOGRAPHY AND GEOLOGICAL HISTORY OF SOUTHWESTERN N.B. STREAMS

All of the streams studied, except the N. W. Miramichi and Tomogonops rivers, flow through southwestern N. B. into Passamaquoddy Bay or the Bay of Fundy (Map 1). Southwestern N. B. consists of a plain of low relief, bounded by two arms of the granitic N. B. highlands system (Gadd 1971). The northern arm (A, Map 2) extends in a northeasterly direction from Vanceboro at the Maine-N. B. border to the Saint John River near South Hampton. The southern arm (B, Map 2) runs east-northeast from just south of St. Stephen, through the Chamcook or Bocabec area in the vicinity of Lake Utopia, passing to the north of Pennfield coastal plain. The two arms of the highland system converge in the vicinity of Mt. Washington, Me.

The headwaters of the two largest streams of the area (St. Croix and Magaguadavic) arise from lake systems lying in the northern arm of the highlands. The Digdeguash River drainage also arises on the southern flank of these

highlands, but with no notable lake system. The Magaguadavic and Digdeguash rivers flow in a south-southeasterly direction across the plain, then through passages through the southern highland arm.

Dennis Stream and Waweig River arise in the lower half of the plain and drain into a common estuary with the St. Croix River east of St. Stephen. The St. Croix flows between the eastern flank of the northern highland arm and an extensive system of drumlins (hence Scotch Ridge, Basswood Ridge, etc.) deposited by the recession of the most recent glaciation, until it reaches the northern flank of the southern highland arm. It flows south along this northern flank, then forms an estuary in a gorge passing through the highlands. These southwestern N. B. streams all have a similar geological history (Gadd 1971). They were all formed as glacial outwash streams as the most recent glaciation receded in a northerly direction. They all flow through channels cut through more extensive outwash channel deposits formed during the glacier recession. These deposits were mainly coarse angular boulder and gravel with some sand. The Magaguadavic River near Brockway and the Dennis near Maxwell Crossing have fairly extensive outwash deltas of gravel and sand with some silt.

The N. W. Miramichi arises from seepages and small lakes in the north-central N. B. highland area and flows in a southeasterly direction until its confluence with the S. W. Miramichi at Douglstown. Stream discharges and widths are given in Table 1 along with approximate area of lakes in the headwaters.

### STUDY AREAS

Widths, discharges and lake areas of the headwaters of the various streams studied are given in Table 1, and locations of the study areas are shown in Maps 3-11. Some additional features of the study areas are noted below. All study areas were gravel bars in "riffle" areas, usually at the foot of a pool.

One edge of the "Digdeguash 3" study area formed a sandy beach along the east bank, and much of the study area had more fine material than any other study area. The point of the gravel bar was in the fastest current, and its composition was coarser.

The "Magaguadavic 1" study area was not a particularly suitable spawning area as it consisted of pockets of gravel filled in around boulders.

The "NW Miramichi" study area was a gravel bar extending from the west bank to mid-stream at the foot of a large shallow pool locally known as "42" pool. Scattered permeability measurements were also made farther upstream.

The "Palfrey 1" study area was a shallow layer of gravel over ledge rock and its use was

discontinued. The "Palfrey 2" study area was used extensively by landlocked salmon for spawning.

Eleven study areas were sampled on the St. Croix at one time or another, all between the Spednik Lake dam and the confluence of the St. Croix and Canoose Rivers, a distance of 50 km (Map 10). These study areas are Vanceboro 1 (0.5 km below the Spednik Lake dam and just upstream of the railroad bridge), Vanceboro 2 (0.6 km below the dam and about 0.1 km below the bridge), Mile Rips (7 km below the dam), Hall's Rips (14 km), Duck Point (20 km), Scott Brook (24 km) at the foot of Tyler Rips, Albie's Rips (28 km), Rocky Rips (32 km), Gravel Island (foot of Rocky Rips), Meetinghouse Rips (37 km), and Canoose Rips (47 km). Several of these study areas are described in more detail by Peterson (1975-1976).

Vanceboro 1 was not utilized very much as the substrate was too coarse and the water too swift and deep.

Vanceboro 2 was a large gravel bar extending from the Canadian shore across four-fifths of the stream at which point the main flow cut a deeper channel. A portion of the bar was exposed at low water levels.

The Mile Rips study area included two gravel bars. A smaller upstream bar projected from a point of land on the east bank, while the other formed an extensive bar across the width of the stream where the fast water tailed off into a deadwater area.

The Hall's Rips, Albie's Rips, Tyler Rips, and Scott Brook study areas were typical bars at the foot of pools. The apex of the bar at Scott Brook was exposed at low water levels.

The Duck Point and Gravel Island study areas included bars extending from larger, permanent islands.

The Meetinghouse Rips study area began at the mouth of Simsquish Brook and extended downstream to an extensive stream-wide bar.

The Canoose Rips study area was a series of bars formed at the confluence with the Canoose River. The main flow of the Canoose River was downstream of the study area, but a small branch emptied into the St. Croix upstream. All sampling sites were outside any influence of the Canoose River.

The mid-summer temperature regimes of most of the streams in southwestern N. B. are probably similar (Table 2). Mid-day temperatures typically rose to  $24^{\circ}\text{C} \pm$  a degree or two on warm days. Palfrey brook probably, and the NW Mframichi undoubtedly, had maxima 2 or  $3^{\circ}\text{C}$  lower than the other streams. Symons and Harding (1974) and Symons (1975) have documented more complete temperature records for the Waweig, Dennis, and Canoose streams.

## MATERIALS AND METHODS

Permeabilities were measured using the method developed by Terhune (1958) and Wickett (1958). The method involved driving the perforations of a specially constructed standpipe to a depth of 20 cm (25 cm, as suggested by Terhune, was found unsuitable for N. B. streams) into the gravel, then measuring the rate of percolation from the surrounding gravel into the standpipe under a 1-inch (2.5-cm) pressure head. The pressure head was maintained by pumping water out of the top of the standpipe. The volume of water pumped out in a given time (usually 30 sec) provided a measure of percolation rate into the sink created in the standpipe. The flow rates were converted to standard permeabilities (cm/hr) at  $10^{\circ}\text{C}$  as described by Terhune (1958). Permeabilities were measured at 1-m intervals along transects across the gravel bars studied. The number of measurements (usually at least 10) was a function of gravel bar size. Intra-gravel water velocities were measured by a dye-dilution technique (Terhune 1958) in a few instances.

The gravel was sampled with a 75-cm length of galvanized stovepipe 15 cm in diameter. The pipe was marked off in 2.5-cm graduations. Two handles bolted to one end of the pipe through a supporting iron ring 2.5 x 0.3 cm were used to work the pipe into the gravel. Standard sampling depth was 15 cm. The gravel sample in the pipe was scooped by hand into plastic quart containers. Three containers (each filled with 2.5 cm of the core) were required per sample. The contents of each container were sieved individually to obtain an estimate of vertical stratification in the gravel. The total dry weight of the sample from the pipe was usually 4-5 kg.

The gravel samples were wet-sieved through a series of screens, 61 cm on a side, with the following pore sizes: 63.5 mm (on a side), 22.2 mm, 2.26 mm, 0.5 mm, and 0.06 mm. Hereafter, sediment retained on the two coarsest screens will be termed cobble, and sediment retained on the three finer screens will be termed pebble, coarse sand, and fine sand respectively. After they were sieved, all samples were oven dried at  $105^{\circ}\text{C}$ , then weighed to the nearest mg. In addition, the coarse and fine sand fractions were ashed at  $550^{\circ}\text{C}$ , then weighed a second time. (The difference between the last two weighings provided an estimate of organic matter.) The sampling method was inadequate to sample silts and clays quantitatively.

Sampling sites were selected subjectively on the basis of being considered suitable areas for spawning by salmon. The site had to have gravel that appeared to be of a reasonable coarseness, and had to be located in a suitable flow configuration. The sites were all located where the water velocity was accelerating and the depth decreasing (in a downstream direction) at the tail of a quiet stretch or pool. As a

check for uniformity among streams, the mean water current velocities and water depths were measured at most of the study areas within a period of a week under summer low flow conditions (Table 3). The mean velocities ranged from 0.36-0.76 m/sec with most values falling within 0.50-0.65 m/sec. Depths were usually 20-30 cm.

Salmon eggs were obtained from parents of Magaguadavic River origin by stripping and "dry" fertilization of the ova. Mean egg diameters were 6.3 mm. Salmon eggs were planted within 24 h of fertilization, and were refrigerated prior to planting. A hole about 1/2 m in diameter and 15 cm deep was dug in the chosen gravel bar. A 30-cm diameter stovepipe was then worked into the hole until stable in the current. Gravel was then built up around the base of the pipe. The required number of eggs were placed in the pipe and allowed to settle. Several shovelfuls of gravel were then placed in the pipe to cover the eggs to a depth of 12-15 cm, after which the pipe was withdrawn gently. The egg deposit was then mounded up with gravel to simulate a natural redd with the eggs an estimated 20-30 cm deep. Each egg deposit was marked with boulders numbered with fluorescent orange paint. Samples from the eggs used in the St. Croix planting experiments were brought back to the lab and reared under hatchery conditions to control for egg viability.

In spring, emergent fry from eggs planted the previous fall were sampled using emergence traps similar to those described by Porter (1973). The traps consisted of a dome (1-m diameter) formed from iron hoops, the upstream half of the dome covered with netting and downstream half with canvas. The dome was placed over the egg deposit. The dome was surrounded by a canvas apron which was covered with gravel from the stream bed to hold the trap in place and prevent escape of fry. Water flowing into the dome through the netting was funneled into a canvas tunnel trailing downstream from the dome. This tunnel (0.6 m long) was also supported by iron hoops to prevent collapse. A box trap attached to the end of the tunnel collected fry moving down the tunnel.

For streams where discharge data were unavailable, the discharge in late summer 1976 was estimated (Table 1). Current velocities and depth were measured at 1-m intervals. Discharge L/sec was then calculated from mean velocities and depths.

## RESULTS

### GRAVEL COMPOSITION

The substrate for 28 areas was sampled in the 9 streams. For most areas, three samples were taken (Table 4). The samples from the various study areas are ranked in Table 4

according to coarseness of the sediment; those with the highest percentage of cobble ranked at the top. The range in percent cobble is considerable (12.1-82.5%, dry weight basis), but most samples fall within the 40-60% range. The pebble fraction varied from 14.7-61.7%, the coarse sand from 2.4-19.0%, and the fine sand from 0.1-3.0%. The organic content of the sand fractions is usually 1-3%, the higher values usually obtained from samples with a low sand content. The organic content of the coarser sediments was not measured, but would be two or three orders of magnitude less than that for the sand fractions. The sediments in the study areas were stratified with more sand occurring in the lower strata and a "pavement" of larger stones on the surface (Fig. 1). This stratification is documented in Appendix 1 but, for the present discussion, mean values for the full 15-cm depth are utilized.

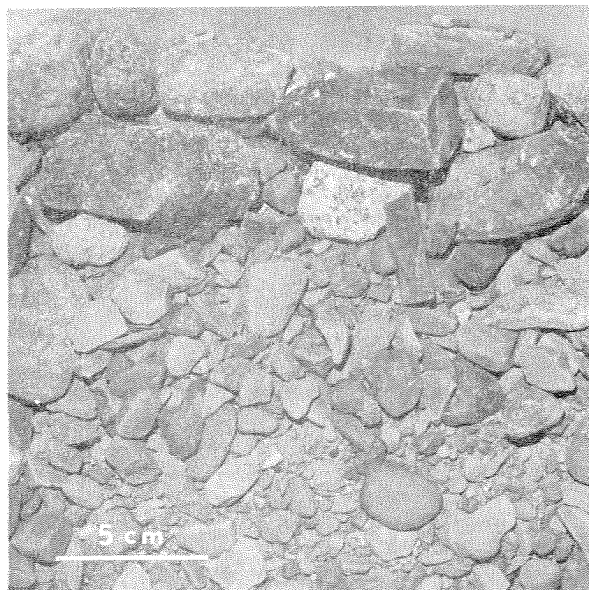


Fig. 1. Photograph of typical stratified gravel deposit from a study area. Top 5 cm - cobble: 97%, pebble: 2.5%, sand 0.5%. Middle 5 cm - cobble: 27%, pebble: 62%, sand: 11%. Bottom 5 cm - cobble: 11% pebble: 64%, sand: 25%.

When the percent cobble is plotted vs percent sand (coarse and fine combined) (Fig. 2), percent sand increases as percent cobble decreases. This, of course, is to be expected - the finer the sediment, the more sand. The scatter of points in this case is more interesting than the general trend. Samples from certain streams are consistently at the lower edge of the scatter (e.g., Waweig 1, 2 and Digdeguash samples). The St. Croix, particularly Vanceboro 2, and Magaguadavic samples, are consistently near the upper edges of the scatter. Therefore, gravel of equivalent coarseness (i.e., similar percent cobble), and in areas of similar flow configuration, may systematically vary in sand content among different streams.

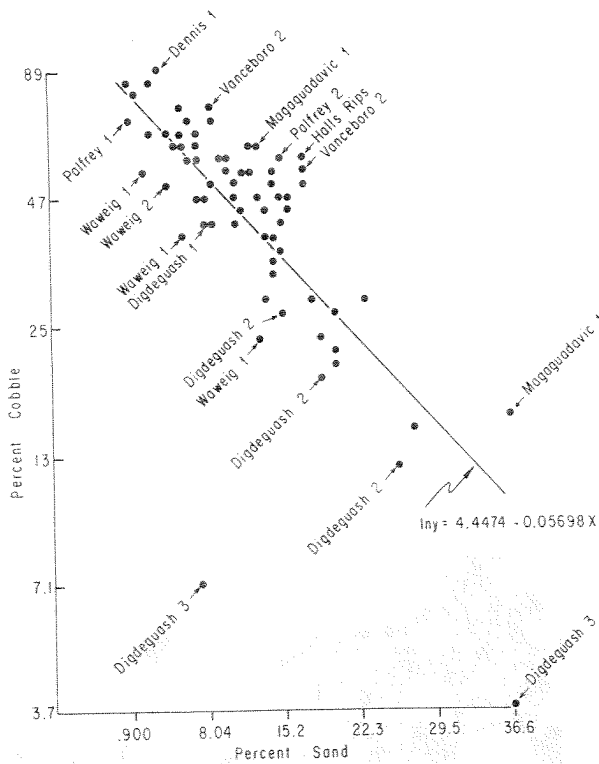


Fig. 2. Percent cobble (lnY) is plotted vs. percent sand (X) for various gravel core samples which were sieved for particle size analysis. Note that samples from Waweig and Digdeguash study areas typically had lower than average amounts of sand present. Correlation coefficient = 0.75.

The various streams were ranked with respect to gravel quality (Table 5a) by averaging the distance to left or right of the regression line of Fig. 2 that the points for various streams fall. The St. Croix River was sampled most extensively, and the gravels of the various St. Croix study areas are also rated (Table 5b) according to Fig. 2. Vanceboro 2 had the poorest rating, averaging 4.8% more sand than the mean as given by the regression line (Table 5b). The gravels tend to have relatively lower sand content with increasing distance downstream.

In Fig. 3, the gravel composition of the coarsest and finest sediments analyzed in this study are compared with the results of gravel analyses performed in Alaska (McNeil and Ahnell 1964) and in Scotland (Campbell 1977). Since the amounts of material < 0.06 mm were not analyzed in this study, it was assumed to be equal in amount to the fine sand fraction. The data of McNeil and Ahnell (1964) indicate that this is generally true and the error in this assumption should be no more than ca. 2%.

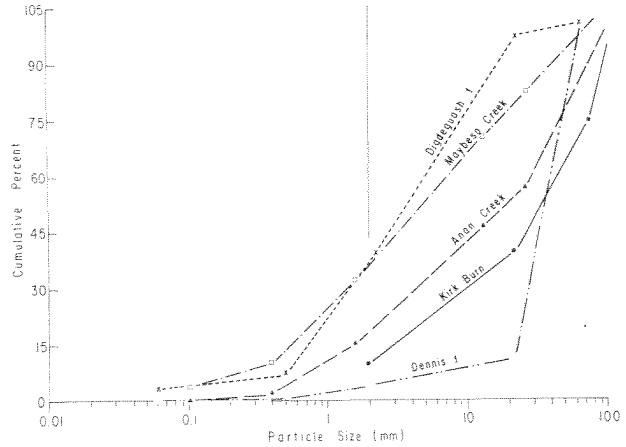


Fig. 3. Cumulative percent of total sample weight is plotted as a function of increasing particle size. Particle sizes to the left of the vertical solid line are sand or silt and may be regarded as detrimental to gravel permeability. Maybeso Creek and Snow Creek data are from McNeil and Ahnell (1964); Kirk Burn data are from Campbell (1977).

Sediments < 2 mm in size (to the left of the vertical line in Fig. 3) are considered as detrimental to permeability, and therefore to gravel quality as spawning material. Most of the gravels analyzed for N. B. streams contain 12-15% of sediment < 2 mm, thus falling near the Anan Creek gravel analyzed by McNeil and Ahnell (1964).

#### PERMEABILITY

The permeabilities measured among the different study areas varied widely (Table 6). The differing number of measurements at different study areas reflect the differing sizes of the study areas. For most of the study areas, most permeabilities were < 2000 cm/h, with scattered measurements in the higher categories. Notable exceptions were Waweig 1 and Digdeguash 1 where more than half the measured permeabilities were > 6000 cm/h.

In three of the study areas sand content and permeability bore a definite correlation with stream bed configuration. For example, at the Magaguadavic 2 study area (Fig. 4), the greatest permeabilities were associated with parts of the transect where the gravel was relatively low in sand content (transect nos. 5-7 in Fig. 4). These parts of the transect were where the main water currents flowed between higher parts of the gravel bar. The lowest permeabilities and highest sand content were found just upstream of exposed bars or islands.

The geometric means of the permeabilities for the study areas generally varied in inverse proportion to the percent sand in the gravel (Fig. 5). Most of the values can be fitted

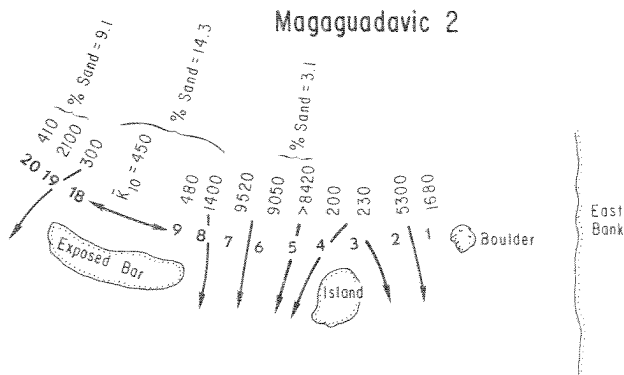


Fig. 4. Variations in permeability ( $\bar{K}_{10}$  in cm/hr) are documented along a transect at Magaguadavic 2. The percent sand in core samples from three different parts of the transect with differing permeabilities is also illustrated.

reasonably well to a single curve ( $\bar{K}_{10} = 3437-186X$ , correlation coefficient = 0.6).<sup>10</sup> The Digdeguash permeabilities are higher relative to the amounts of sand present than are those of other streams, and are fitted to a separate line (by eye). The third set of data on Fig. 5 is from McNeil and Ahnell (1964). In their study the sediments were mixed, then placed in a vertical cylinder. The permeability was measured as the volume of water passing through the cylinder under a 2.5-cm pressure head. These values probably may be regarded as near the relationship obtained under minimum conditions of compaction. The scatter in the stream data is understandably considerable as many other factors (degree of compaction, angularity of gravel particles, local variability in gravel composition) can influence permeability. The regression line relating permeability to percent sand accounts for about 35-40% of the variability. The data indicate that, regardless of other factors, if the sand content is >20% by weight, mean permeability is reduced to near zero.

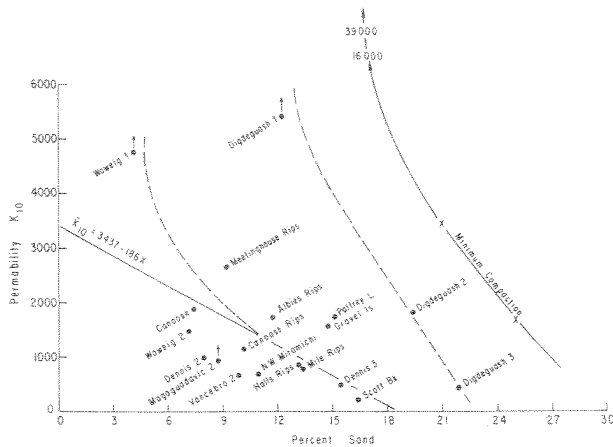


Fig. 5. Permeability (standardized to 10°C =  $\bar{K}_{10}$ ) (mean of 10-20 measurements) is plotted vs. percent sand (X) (mean of three core samples) for the various study areas. The regression line (solid straight line) is derived from all points, except the Digdeguash study areas for which a separate line has been fitted (by eye). The solid curved line is derived from data from McNeil and Ahnell (1964) for newly mixed gravel samples; permeability measured in a piece of plastic pipe. Correlation coefficient = 0.6.

The general relationship between percent sand and permeability also holds for the various St. Croix study areas (Tables 6 and 7). The combined permeability for four upstream study areas in the St. Croix (Vanceboro 2, Hall's Rips, Mile Rips, and Scott Brook) was 600 as compared to 1745 for four downstream study areas (Albie's Rips, Gravel Island, Meetinghouse Rips, and Canoose Rips). The upstream study areas have been shown above to have higher amounts of sand relative to gravel coarseness.

The intragravel water velocity was measured by the dye-dilution technique (Terhune 1958) at a few standpipe penetrations in the St. Croix River. In general, velocity was greater at areas of greater permeability (Table 8), (although other factors (hydraulic head, local flow patterns) can also affect velocity.

SALMON FRY EMERGENCE

The percentage of fry emerging at various study areas in the St. Croix River ranged from 0 to 13 (Table 9). Eggs planted in the fall of 1976 were considered to be of poor quality, possibly due to the inclusion of eggs from a female that was over-ripe at stripping. A sample of these eggs, when reared under laboratory conditions, experienced 40% mortality (as compared to the usual 5-10%). Therefore, the emergence values are corrected to account for this increased mortality. Two of the traps set at Gravel Island in 1976-77 were dislodged during high water conditions. Vanceboro 2 had the lowest permeability (620 cm/h) of any of the St. Croix fry planting sites measured, and no emergence was obtained. The mean permeability for Gravel Island-Albie's Rip study areas was 1600 cm/h and that for Canoose Rips 1100 cm/h. The corresponding mean emergences were 3.6% and 1.8% respectively. The emergence data from the St. Croix plantings are compared with data obtained from Wickett (1958) for chum and pink

salmon emergence in some West Coast streams (Fig. 6). The method of estimating emergence for the chum and pink salmon was different. Egg deposition was based on knowledge of migrating females to the spawning area, thus permitting estimation of potential egg deposition. Emergence success was estimated by capture of fry migrating to sea.

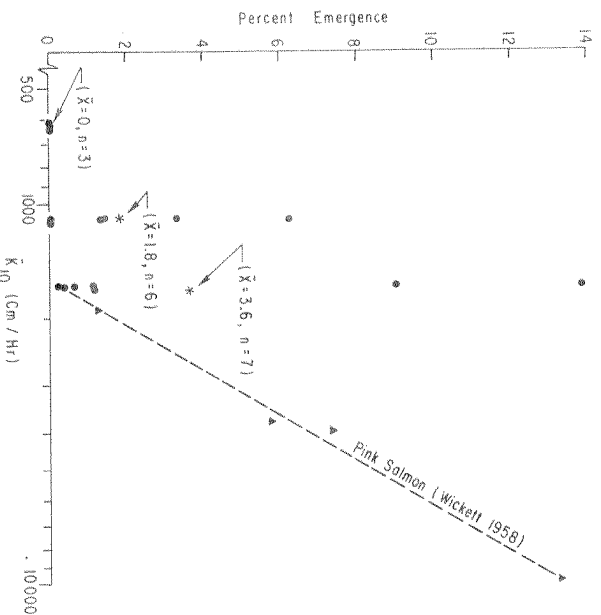


Fig. 6. Percent emergences of Atlantic salmon fry from green eggs planted the previous fall plotted vs. permeabilities of the respective study areas in the St. Croix River where the eggs were planted. Asterisks indicate the mean emergence. Data for pink salmon represented by the triangles and the dotted line are from Wickett (1958).

#### UTILIZATION OF STUDY AREAS BY SALMON

Most of the study areas were investigated at least once during 1974-77 in late October-early November for the presence of redds or digging activity by native Atlantic salmon (Table 10). Eleven of the 13 study areas, exclusive of the main St. Croix, had been utilized by spawners. Palfrey 2 was the most heavily utilized spawning area studied. The large numbers of landlocked salmon spawning in the area could be the reason for the relatively high permeability despite the high sand content, possibly by decreasing the degree of compaction. The Digequash and Waweig study areas are also probably used regularly, although the density of spawners would be much less than at Palfrey 2. The NW Miramichi study area was inspected early and digging had just begun, so that the occurrence of spawning there is not known. Dennis 3 was utilized in 1973-74, but not in 1974-75, possibly because a lot of brush

and trash had lodged in this area due to stream-side cutting of alders and bridge work just upstream in late summer. Open pits but no completed redds were found at Waweig 2. Finished landlocked redds were observed at Vanceboro 2 and Mile Rips study areas. The study areas are large (>100m<sup>2</sup>) and not heavily worked. The lower St. Croix study areas exhibited no evidence of spawning activity.

While subsurface water chemistry was not a part of this study, a few measures of O<sub>2</sub> content of water sampled from the standpipe were performed in mid-August 1974. Values averaged 65% of air saturation (range 56-75%, n = 5).

#### DISCUSSION

##### SELECTION OF SPAWNING SITES

The stream habitat selected by Atlantic salmon and other salmonids has been well documented (e.g., Beidling 1934; Needham and Taft 1934; White 1942). Most redds are built at the tail of pools on the upstream edge of a gravel bar where the water depth is decreasing and the water current is accelerating. Detection of acceleration and upwelling water currents in these areas may be important cues in selection of suitable areas (White 1942; Tautz and Groot 1975). Beidling (1934) also noted a tendency for salmon to spawn near banks. The presence of aquifers may influence spawning in such areas. The tendency to spawn where aquifers occur has been particularly demonstrated for brook trout (White 1930; Webster and Eiriksdottir 1976).

Field observations supported the thesis that the study areas were selected on the basis of being spawning areas. Eleven of the 13 study areas, exclusive of the main St. Croix, were utilized to some degree (Table 10), although unfinished redds only were noted at the Northwest Miramichi and Waweig 2 study areas. The Maguadavic 1 site may have been too far upstream for the anadromous salmon population inhabiting that river; however, the landlocked population should have had access to it. The gravel of the study area was probably too scattered and intermingled with large boulders. The study area was being excavated by brook trout in late October, but no finished redds were present. Spawning may have occurred there later. The Palfrey 1 study area had a shallow gravel bar overlying ledge rock, and was probably of insufficient depth to be a spawning area.

Occasionally redds were located in areas other than those described above, however. In the fall of 1977, several redds were observed in a long pool upstream of Waweig 1. At Dennis 1, in 1974, a redd was constructed at the edge of the pool above the study area very near the bank. Under conditions where there are excessive numbers of spawners, less than optimal areas are probably utilized to a greater degree.

The presence of aquifers may also have affected distribution of these latter redds.

The Digdeguash River has a population of sea-run brown trout (*S. trutta*) as well as Atlantic salmon. It is therefore possible that some of the redds observed in this stream were formed by brown trout. Since the redds were large, it is considered probable that they were formed by salmon.

#### GRAVEL COMPOSITION IN SPAWNING AREAS

The typical spawning medium for the southern N. B. streams, averaged over the top 15 cm, has a cobble:pebble ratio of 0.5-2.0 (typically near unity). Sand content is 10-15%. The range of gravel composition sampled from the study areas is similar to spawning gravels analyzed from pink salmon and brown trout spawning areas (Fig. 3, McNeil and Ahnell 1964; Campbell 1977). The gravel is quite stratified, consisting of a superficial "pavement" of cobble with increasing amounts of sand and pebble with increasing depth (Fig. 1). For typical spawning gravel, the percent composition of sand at depths of 15-25 cm (approximate depth of egg deposition) would be 20-30% by weight. The gravel is stirred and mixed during excavation and covering of the redd; however stratification would probably be re-established very quickly and certainly before hatching the following spring.

Silts would represent a very small fraction of the sediments in spawning habitat, unless the streams were subjected to very heavy additions of silt such that the transport capabilities of the streams are exceeded (Cooper 1965). Silt is normally deposited mainly along stream banks under normal stream conditions (Cooper 1965; Hanson 1971). This is due to the fact that most of the sediments <0.06 mm in particle size would be transported as suspended load rather than bed load (Cooper 1965).

The coarser material composing the gravel bars in the study areas is stable for the most part since in most streams the tractive force required to move stream gravel is rarely generated (Cooper 1965). (Formation of anchor ice and ice gouging in spring may disturb gravel bars, however.) Since the sand is protected by a "pavement" layer of larger stones, it is relatively stable as well. Digging by adult salmon would contribute additional sand to the bed load. Characteristically a "tail" of sand extending from the downstream end of the redd is visible. The extent of movement is probably not great, although freshets at appropriate times could possibly increase the distance such sand is transported.

The consistent variability in sand content among streams (Fig. 2) may be due to several factors. Stream size may be important. Larger streams with lower hydraulic gradients (Flint 1974) would naturally have higher sand content, other factors being equal. (This may be a

factor of importance in considering small vs. large streams as nursery areas.) Most of the streams at the lower edge of the scatter in Fig. 2 are in fact smaller streams. Large natural sand deposits in the stream drainage area (such as those which occur at Brockway on the Magaguadavic and at Maxwell Crossing on the Dennis) would result in a greater sand component in the bed load. Land clearing, logging or other human activities can also result in increased addition of sand into the streams. This is possibly the case at Vanceboro 2, for example. This study area is about 100 m downstream of the railroad bridge at St. Croix-Vanceboro. Large amounts of sand entered the stream channel here as a result of bridge repair and railroad bed improvements in 1976. Palfrey 2 and N. W. Miramichi study areas are in locations which are being extensively cut over - possibly resulting in increased sand in the bed load.

#### SUB-GRAVEL WATER CURRENTS

Vaux (1962) has demonstrated that interchange of water between surface and subgravel components is influenced by stream bed surface profile, gravel permeability, gravel bed depth and irregularity of the stream bed surface. No interchange will occur if permeability and gravel depth are constant, the profile is not curved and the stream bottom is smooth. If the stream profile is convex, as is the case on the upstream side of a mounded salmon redd, then water is accelerated as it passes over the redd and there is a force vector directing water downward into the gravel (Fig. 7). Conversely, in a concave stream profile (as on the downstream side of the redd diagrammed in Fig. 7) the flow of water is directed out of the gravel. Irregularities, such as large stones can have marked effects on entry of water into and movement within the subgravel component (Cooper 1965). A redd appropriately placed upstream or downstream from such a stone could benefit from its "focussing" effect on subgravel water flow.

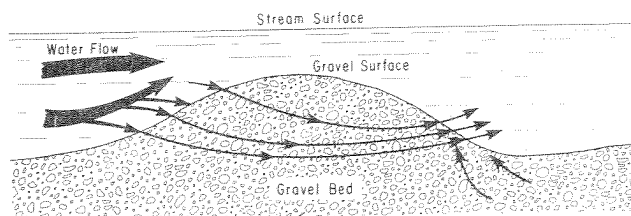


Fig. 7. Diagram of probable water current patterns through a salmon redd (modified from Vaux (1962) and Cooper (1965)).

The oxygen concentration of the sub-gravel water, and the velocity with which it flows by

eggs deposited in the gravel are critical factors determining survival of salmon eggs (Coble 1961; Daykin 1965). The  $O_2$  values were obtained when water temperatures (18-20°C) and benthic community biomass levels were near maximal, hence the metabolic and BOD demands on the subgravel oxygen would be greatest. For most of the period of egg incubation, temperatures have been near 0°C, rising to near 5°C at hatching. Oxygen levels of water supply to the eggs probably would not fall below 70% air saturation (ca. 8-10 ppm). It has been estimated (Terhune 1958) that, for water with equivalent  $O_2$  levels, a minimal sub-gravel water velocity of 5 cm/h would be required to permit any survival of Pacific salmon eggs to the fry stage. It should be pointed out that this value of water velocity is a mean. True interstitial water velocity, which cannot be measured (Terhune 1958; Cooper 1965), can vary considerably about this value.

#### SUB-GRAVEL VELOCITY AND PERMEABILITY

For a given stream profile and hydraulic gradient, mean sub-gravel water velocity is proportional to gravel permeability. Permeability measurement has been proposed (Wickett 1954, 1958; Terhune 1958) to establish a figure of merit for spawning gravel quality. It has the advantage of being independent of variations in hydraulic pressure head due to variable stream flow.

The permeability measurements were made from May through October. There is no correlation between permeability and month of measurement (App. 1).

The permeabilities obtained for N. B. streams average somewhat lower than those available from studies on the West Coast (Wickett 1958, 1959; McNeil and Ahnell 1964). The difference cannot be attributed to differences in gravel composition, as the compositions appear similar (Fig. 3).

#### PERMEABILITY AND FRY EMERGENCE

The lower limits of permeability permitting emergence of salmon alevins is probably somewhere between 500 and 1000 cm/h. No emergence was obtained at Vanceboro<sup>2</sup> which had a mean permeability of about 600 cm/h. The corresponding minimal sub-gravel velocities (Table 8) would lie between 4.5 and 12 cm/h, thus agreeing fairly well with the value of 5 cited by Terhune (1958).

The percent emergence of fry obtained from eggs planted in various St. Croix study areas was highly variable. The data at hand suggest that the distribution of percent emergence values may resemble log-normal (many low values clustered with a few scattered high values). The mean percent emergence was higher where mean permeability was also higher (Fig. 6). From the data at hand, a permeability of about 1500 cm/h should yield a mean percent emergence of 2-3%.

The emergence estimates for the St. Croix egg deposits are probably underestimates, since losses of emergent fry may occur through fry dispersal in the gravel or holes under the trap apron. The latter error is probably the greater. Phillips and Campbell (1962) report that emergence of coho salmon and steelhead trout was correlated with ambient sub-gravel  $O_2$  concentration, but not permeability. The permeabilities of their study areas were very high, and so permeability was probably not a limiting factor.

The permeability of the gravel bar studied was correlated with the amounts of sand (sediments <2 mm) present. Similar relationships have been shown elsewhere (McNeil and Ahnell 1964; Terhune 1958), but for artificially mixed gravels. The scatter (Fig. 3) is understandably considerable in this study as other factors such as compaction, shape of gravel particles, presence of large rocks, will affect permeability. The data indicate that, if the sand content of natural gravel bars is more than 20%, then the permeability will be near zero, irrespective of other factors. It is probable that fry survival will be very low at permeabilities less than 1000 cm/h, which corresponds to a sand content of 12-15% for the study areas used here.

The data obtained on fry emergence are insufficient to compare with Pacific salmon for permeability effects. Atlantic salmon eggs have smaller egg diameters, however, so there is some reason to expect that they might survive better in gravel of low permeability. This is because oxygen diffusion into the egg becomes limiting at lower water velocities for smaller eggs (Silver et al. 1963; Daykin 1965).

#### CONCLUSIONS

1. Amounts of sand in stream gravels are correlated with coarseness of the gravel sampled (i.e., more sand in less coarse gravels).
2. Study areas in some streams, such as the Waweig and Digdeguash, have cleaner gravels (less sand) than study areas of other streams such as the St. Croix and Magaguadavic. This relationship may be related to stream size.
3. Gravels in the more upstream St. Croix study areas had proportionately more sand than the downstream study areas.
4. Permeabilities of study areas in most streams studied were low (1000-2000 cm/hr) with the Waweig and Digdeguash study areas having higher permeabilities.
5. Gravel permeability was weakly correlated with amount of sand present. Other factors, such as compaction, are probably important

as well.

6. Percent fry emergence from green eggs planted in various study areas in the St. Croix varied from 0 to 3.6%. Gravels of higher permeability produced more fry.

#### ACKNOWLEDGMENTS

I wish to acknowledge the assistance of the late George Welock and his wife, Jean, and guides J. Keddy and E. Wright, for providing canoes and guide service for much of the St. Croix sampling. Mr W. P. Wickett and Mr L. D. B. Terhune provided advice and equipment. The Magaguadavic brook stock were collected and stripped by the staff of the North American Salmon Research Centre under the direction of Dr R. L. Saunders. Mrs J. L. Metcalfe and Mrs A. Ramsomair assisted in permeability measurements and gravel sieving. Messrs C. Metcalfe, P. Harmon, J. Martin, G. Fawkes, D. Hennesey, and B. Young assisted in planting the eggs and installing emergence traps. Mrs Brenda McCullough and Mrs Jeanine Hurley performed the typing. P. W. G. McMullon did the drafting and photography. Mr P. J. G. Carrothers and Mr J. W. Saunders criticized the manuscript.

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+ App.

Table 1. Stream discharges, widths, and lake areas in headwaters for streams in the study.

Stream	Discharge in L./sec. (Date)	Approx. width (m)	Approx. area of lakes in headwaters (ha)
Waveig R.	400 (June, 1974) <sup>a</sup>	5	0
Digdeguash R.	2500 (Aug., 1976)	30	1.2
Dennis Str.	950 (June, 1974) <sup>a</sup>	10	1.2
Canoose R.	1800 (June, 1974) <sup>a</sup>	20	7.5
Palfrey Bk.	1100 (Sept., 1976)	8	7.5
NW Miramichi (est.)	5-10,000	50	2.5
Magaguadavic R.	7000 (Aug., 1976)	50	18
St. Croix R.	20000 (mean of 46 yrs. @ Spednik L.) <sup>b</sup>	70	50 (Spednik)

<sup>a</sup>Symons (1975)

<sup>b</sup>McCabe (1976)

Table 2. Mid-day temperatures (°C) for various streams studied, April-November.

	St. Croix	Waveig	Dennis Str.	Digdeguash	Magaguadavic	Canoose	Palfrey Bk.
April	7.0 (1)	-	-	-	-	-	-
May	8.5-17.5 (8)	6.0-14.0 (2)	13.0-17.5 (2)	-	-	12.0 (1)	-
June	15.0-20.5 (7)	-	14.5-17.0 (1)	16.5-22.0 (3)	-	15.0 (1)	-
July	19.0-24.0 (6)	18.5	-	-	21.0 (1)	20.0-22.0 (2)	19.0-21.0 (2)
Aug.	20.0-25.5 (9)	-	19.0-22.0 (2)	24.0-27.0 (1)	24.0 (1)	22.0-23.5 (2)	19.0 (2)
Sept.	13.5-18.5 (10)	-	-	11.0-15.0 (2)	15.0 (1)	15.5 (1)	11.0 (1)
Oct.	8.5 (1)	-	-	-	-	-	-
Nov.	3.0- 5.0 (1)	-	-	-	-	2.0 (1)	-

Table 3. Water current velocities (2.5 cm above gravel surface), and water depths at various study areas for August, 1976.

Study site	Mean velocity m/sec (range)	Depth cm (range)	n	Date
Magaguadavic 1	0.44 (0.38-0.59)	24 (16-39)	6	13.VIII.76
Digdeguash 2	0.55 (0.45-0.74)	15 (10-19)	3	13.VIII.76
Palfrey 1	0.64 (0.47-0.96)	22 (15-29)	4	16.VIII.76
Canoose R.	0.36 (0.20-0.44)	12 (9-16)	4	16.VIII.76
Dennis 1	0.62 (0.50-0.81)	25 (20-33)	4	16.VIII.76
St. Croix				
Vanceboro 1	0.58 (0.45-0.63)	40 (38-43)	6	23.VIII.76
Vanceboro 2	0.71 (0.62-0.79)	30 (27-37)	6	18.VIII.76
Mile Rips	0.67 (0.45-0.98)	28 (23-36)	6	18.VIII.76
Hall's Rips	0.76 (0.51-1.01)	38 (35-41)	6	20.VIII.76
Duck Pt.	0.55 (0.38-0.76)	24 (19-38)	6	20.VIII.76
Scott Bk.	0.50 (0.34-0.70)	27 (20-33)	6	20.VIII.76
Albie's Rips	0.53 (0.39-0.67)	30 (22-40)	6	23.VIII.76
Gravel Is.	0.68 (0.50-0.81)	30 (24-40)	6	19.VIII.76
Meetinghouse	0.58 (0.38-0.75)	25 (21-32)	6	18.VIII.76
Rips				
Canoose Rips	0.59 (0.39-0.78)	24 (21-29)	6	17.VIII.76

Table 4. Gravel composition in the various study areas. Cobble: 64-256 mm, pebble: 2.2-64 mm, coarse sand 0.5-2.2 mm, fine sand: 0.06-0.5 mm. Ranges are given in parentheses. Asterisks indicate St. Croix study areas.

Locality	% cobble	% pebble	% coarse sand	% fine sand	% organic		N
					Fine sand	coarse sand	
Dennis 1	82.5(73.7-89.0)	14.7( 7.1-23.4)	2.4( 1.0- 3.6)	0.1(0 -0.1)	10.5(4.2-22.4)	2.3(1.4-4.0)	3
Palfrey 1	68.1(67.6-68.6)	29.4(28.4-30.5)	2.4( 0.9- 3.8)	0.1(0 -0.2)	4.2(4.0- 4.5)	1.8(1.7-2.0)	2
Vanceboro 2*	66.1(54.6-73.5)	23.8(20.6-27.9)	8.9( 5.6-14.8)	1.1(0.2-2.7)	-	-	3
Waveig 3	62.1(37.4-86.8)	29.2(11.1-47.3)	8.0( 1.8-14.1)	0.5(0.2-0.7)	4.6(2.4- 6.7)	2.6(2.4-2.7)	2
Canoose	61.7(55.7-65.4)	30.6(28.3-34.3)	7.0( 5.6- 9.4)	0.4(0.3-0.5)	8.2(2.3-20.0)	2.1(1.8-2.5)	3
Waveig 1	58.7(39.8-84.4)	38.4(14.8-54.8)	2.5( 0.7- 4.8)	0.3(0 -0.5)	7.5(2.2-16.2)	2.0(1.3-2.4)	3
Meetinghouse Rips*	58.4(54.4-66.2)	33.3(24.6-41.7)	8.3( 6.7-10.1)	0.9(0.4-1.4)	1.9(1.4- 2.9)	1.4(1.3-1.4)	3
Palfrey 2	56.4	28.2	14.1	1.1	1.6	1.0	1
Tomogonops 1	56.1(45.7-66.5)	35.2(26.2-44.1)	7.8( 6.6- 9.0)	0.8(0.6-1.0)	1.9(1.8- 2.0)	1.8(1.6-1.9)	2
Maguadavic 2	55.9(32.6-72.5)	35.2(18.3-53.1)	7.7( 2.8-12.4)	1.1(0.3-1.9)	-	-	3
Albie's Rips*	55.1(49.3-62.8)	32.9(30.8-36.8)	11.1( 5.7-14.6)	0.7(0.2-1.2)	1.8(1.6- 2.0)	1.5(1.1-2.1)	3
NW Miranichi	54.2(43.9-70.0)	34.7(22.9-44.5)	10.0( 6.4-13.2)	1.0(0.6-1.2)	1.5(1.2- 1.8)	1.2(1.0-1.7)	3
Tyler Rips*	51.3(43.6-59.0)	36.7(32.0-41.4)	10.6( 8.6-12.5)	1.3(0.4-2.1)	1.6(1.5- 1.8)	1.6(1.3-1.8)	2
Dennis 2	50.7(43.1-59.6)	41.2(35.4-48.4)	7.6( 4.8-10.1)	0.4(0.1-0.6)	4.9(2.7- 9.0)	1.8(1.7-2.1)	3
Hall's Rips*	50.2(46.9-52.4)	36.3(29.0-43.1)	12.5( 9.3-18.5)	0.8(0.6-0.9)	2.9(2.1- 3.4)	1.9(1.5-2.5)	3
Mile Rips*	50.0(41.7-55.9)	36.5(29.8-45.4)	13.0(12.4-13.9)	0.5(0.2-1.2)	2.1(1.7- 2.6)	0.9(0.7-1.2)	4
Duck Pt*	49.6(40.4-57.7)	39.5(31.0-46.5)	12.0(11.5-12.4)	1.3(0.7-2.1)	2.2(1.5- 2.9)	1.8(1.7-1.8)	3
Scott BK*	47.9(28.9-56.9)	40.6(33.8-47.3)	14.0( 7.8-20.2)	2.4(1.6-3.3)	2.6(2.1- 3.0)	1.4(1.3-1.6)	2
Canoose Rips*	46.5(28.7-56.3)	42.4(35.8-52.9)	9.2( 6.4-16.0)	0.9(0.3-2.1)	2.2(1.3- 3.4)	1.5(1.3-1.7)	2
Rocky Rips*	46.0(23.0-69.1)	41.4(24.9-57.8)	10.8( 5.4-16.3)	1.5(0.4-2.6)	1.6(1.4- 1.7)	1.2(0.9-1.4)	2
Waveig 2	45.7(24.1-64.9)	46.9(30.7-63.1)	5.1( 4.1-11.2)	0.6(0.1-1.3)	2.2(0.8- 3.3)	1.9(1.1-2.4)	3
Gravel Is*	43.2(16.0-65.1)	41.9(30.3-56.8)	12.8( 4.1-22.5)	2.0(0.5-4.4)	1.6(1.0- 2.3)	1.3(1.2-1.4)	3
Maguadavic 1	41.5(19.1-60.0)	45.5(26.3-45.5)	17.2(10.2-29.7)	2.7(1.2-5.2)	1.5(1.4- 1.5)	1.2(1.1-1.4)	3
Tomogonops 2	41.4(35.9-47.0)	45.1(39.3-50.9)	12.2(12.0-12.3)	1.1(1.0-1.2)	1.4(1.4- 1.5)	1.6(1.6-1.7)	3
Digdeguash 1	40.2(31.0-49.5)	47.3(35.3-55.7)	11.1( 8.4-13.8)	0.9(0.3-1.2)	2.4(2.4- 2.5)	1.4(1.2-1.5)	3
Dennis 3	30.2(19.9-46.4)	53.9(45.2-59.4)	13.2( 7.6-17.2)	2.3(0.5-3.2)	3.3(1.5- 6.6)	1.4(1.2-1.5)	3
Digdeguash 2	20.5(12.6-29.2)	59.7(57.6-60.8)	17.0(11.6-21.7)	2.4(1.3-4.4)	2.5(1.9- 3.4)	1.8(1.8)	3
Digdeguash 3	12.1( 3.6-26.3)	61.7(53.4-85.0)	19.0( 7.1-33.2)	3.0(1.2-3.9)	2.0(1.3- 3.0)	1.7(1.4-2.2)	3

Table 5. A. Quantities of sand present in gravels studied in the various streams relative to the mean levels for all streams studied. Numbers are derived by determining percentages of sand higher or lower than level given by regression line in Fig. 2 for gravel of given percent cobble. Negative numbers indicate less sand, higher numbers more.

B. Similar figures for various study areas in the St. Croix River study areas are listed from most upstream to most downstream. Column at right, headed by an asterisk, is a running average.

A.		B.	
1. Digdeguash:	-7.6	1. Vanceboro 2:	+4.8
2. Waweig:	-3.3		+4.4*
3. Dennis:	-1.2	2. Mile Rips:	+4.0
4. Tomogonops:	+1.0		+4.2
5. Canoose:	+1.1	3. Hall's Rips:	+3.9
6. St. Croix:	+2.8		+3.9
7. Magaguadavic:	+2.8	4. Duck Pt:	+2.9
8. Palfrey:	+3.0		+3.7
9. NW Miramichi:	+3.3	5. Tyler Rips:	+3.0
			+3.5
		6. Scott Bk:	+2.6
			+3.6
		7. Albie's Rips:	+4.1
			+3.7
		8. Rocky Rips:	+3.9
			+3.3
		9. Gravel Is:	+0.3
			+3.2
		10. Meetinghouse Rips:	+2.5
			+2.8
		11. Canoose Rips:	-1.4

Table 6. Permeability distributions (cm/hr) of gravels in the various study areas.

Site	Permeabilities ( $k_{10}$ )				Geometric mean	N	Date
	0-2000	2-4000	4-6000	>6000			
Waweig 1	2	3	1	8	>4710	14	21.V.75
Waweig 2	4	0	1	0	1460	5	21.V.75
Dennis 2	6	3	0	0	990	9	16.V.75
Dennis 3	21	2	0	0	490	23	15.V.75
Digdeguash 1	0	5	5	12	>5400	22	18.VI.75
Digdeguash 2	8	3	1	0	1780	12	19.VI.75
Digdeguash 3	17	0	0	1	400	18	16.IX.75
Lower Palfrey	7	1	2	2	1700	12	15.VII.75
Canoose	8	1	3	1	1850	13	16.VII.75
NW Miramichi	13	3	0	0	670	16	28.VII.- 9.X.75
Magaguadavic 2	12	2	2	4	>910	20	28.VIII.77
St. Croix							
Vanceboro 2	5	1	0	0	620	6	19.VIII.77
Mile Rips	8	1	1	0	770	10	5.IX.75
Hall's Rips	8	2	0	0	830	10	8.VII.75
Scott Bk	15	0	0	0	180	15	17.IX.75
Albie's Rips	6	2	1	1	1720	10	9.VII.75
Gravel Is	8	7	0	0	1540	15	23.VII.75
Meetinghouse Rips	3	4	1	2	2620	10	4.IX.75
Canoose Rips	10	5	0	1	1100	16	24.VII.75
St. Croix Totals	(63)	(22)	(3)	(4)	(1150)	(92)	

Table 7. Permeabilities (cm/hr), % sand and % cobble for four upstream and five downstream study areas on the St. Croix River. Ratings are determined as for Table 5.

% Cobble	% Sand	Sand rating	Permeability	Study areas
54.2(17)	13.1(17)	+3.6	600(41)	St. Croix (upstream)
49.8(14)	11.6(14)	+1.9	1745(51)	St. Croix (downstream)

Table 8. Sub-gravel water velocities determined (at end of fry emergence) for gravels of different permeabilities in the St. Croix River. Ranges in parentheses.

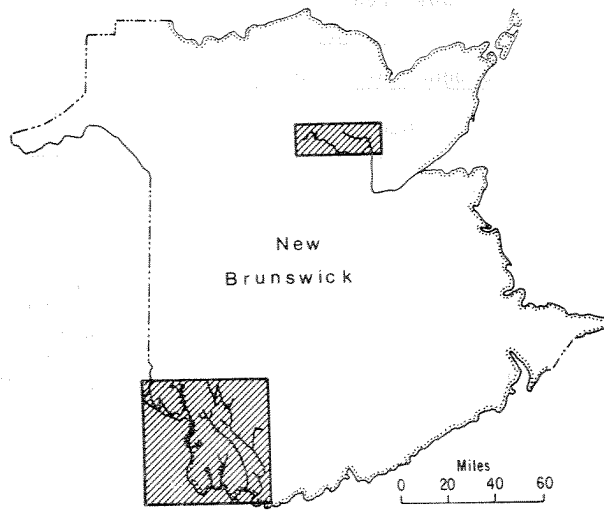
$\bar{K}_{10}$	Velocity (cm/hr)	N
0- 500	4.5(3-7)	4
500-1000	12.4(8-19)	5
1000-2000	12	1
2000	15(10-20)	2

Table 9. Percent emergence of salmon fry from green eggs planted the previous fall at various study areas in the St. Croix River. Corrected percent emergence takes into account the increased egg mortality in the laboratory in 1976-77.

Site	Year	% Emergence	Mean	Corrected % emergence	Mean	% Mortality in lab	Total no. of eggs deposited
Gravel Is	1975-76	0.2,9.0,13.8	7.7		7.7	10	3550
Canoose Rips		0 ,1.3, 6.2	2.5		2.5		5150
1976-77							
Albie's Rips		0.4,0.2,0.8	0.5	0.6,0.3,1.1	0.7		4500
Gravel Is		0.8	0.8	1.1	1.1	40	500
Canoose Rips		1.0,2.3,0	1.1	1.4,3.3,0	1.6		4500
Vanceboro 2		0 ,0 ,0	0	0 ,0 ,0	0		4500

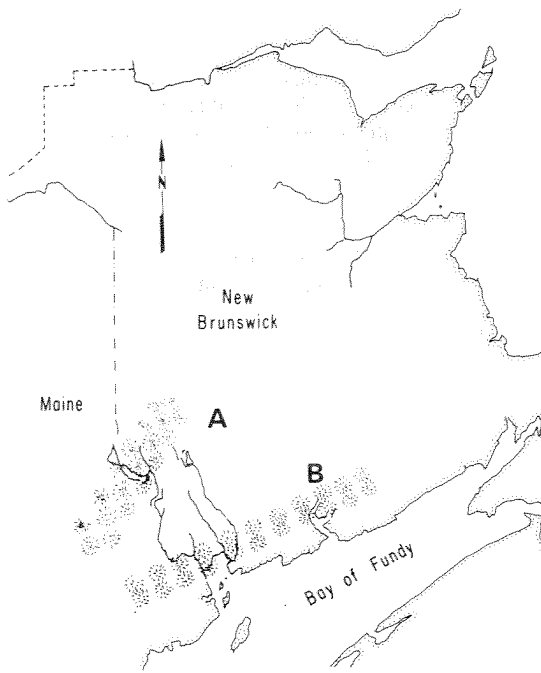
Table 10. Summary of observations of natural Atlantic salmon spawning activity in the various study areas.

<u>Incidence of spawning</u>				
Site	Date	Incomplete pits	Complete redds	Comments
NW Miramichi	8.X.74	2	0	
Dennis 1	7.XI.74	0	1	(nearer bank than areas sampled)
Dennis 2	1.V.75	0	1	(possible, somewhat indistinct)
Dennis 3	4.VI.74	0	1	(several emergent fry in depression on upstream end of redd)
	7.XI.74	0	0	
Digdeguash 1	22.X.74	0	1	(3 others just downstream of study area)
Digdeguash 2	22.X.74	3	1	
Digdeguash 3	22.X.74	2	1	(very large redd, in strongest current)
Magaguadavic 1	22.X.74	0	0	(a lot of attempted digging by small fish, presumably by brook trout-none apparently complete)
Waweig 1	22.X.74	2	1	
	31.X.77	1	1	7-10 completed redds upstream of Roix Rd.
Waweig 2	22.X.74	2	0	
	31.X.77	0	0	
Waweig 3	22.X.74	0	1-3	(indistinct, run together)
	31.X.77	1	1	
Palfrey 2	6.XI.74	1	1	(50 finished (landlocked) redds in 30 m stretch)
	31.X.77			(approx. 40 finished redds in 30 m stretch)
Palfrey 1	6.XI.74	0	0	
<u>St. Croix</u>				
Vanceboro 2	10.XI.76	0	2	(landlocked salmon)
Mile Rips	1.XI.75	2	4	(landlocked salmon)
Gravel Is	7.XI.74	0	0	
	29.X.75	0	0	
	5.XI.76	0	0	
Meeting-house Rips	1.XI.75	0	0	
Albie's Rips	5.XI.76	0	0	
Canoose Rips	31.X.75	0	0	
	11.XI.76	0	0	



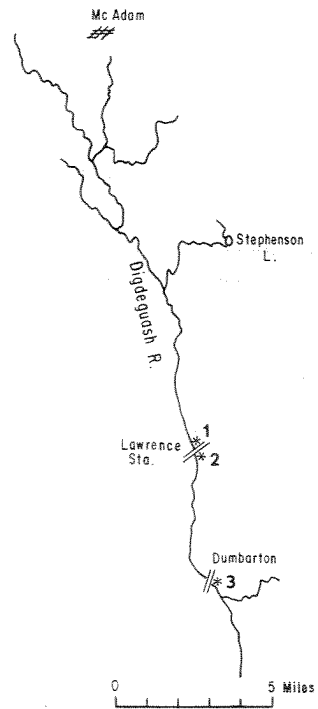
Map 1

1. Map of N. B., indicating areas of the province where streams were studied (hatched).



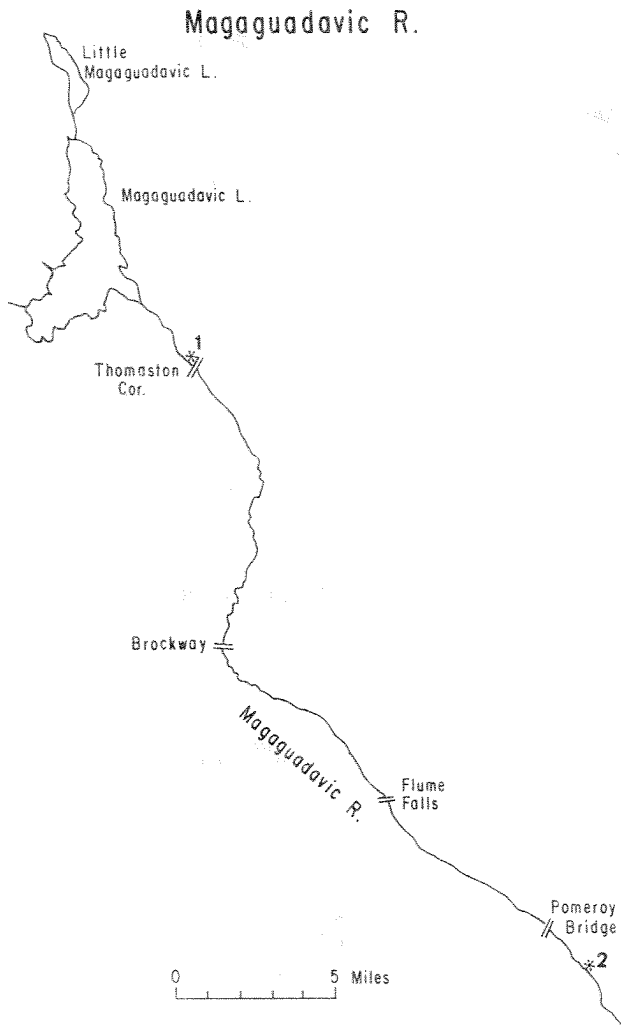
Map 2

### Digdeguash R.

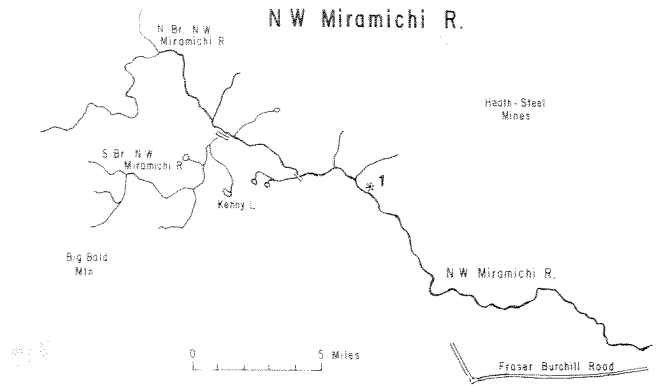


Map 3

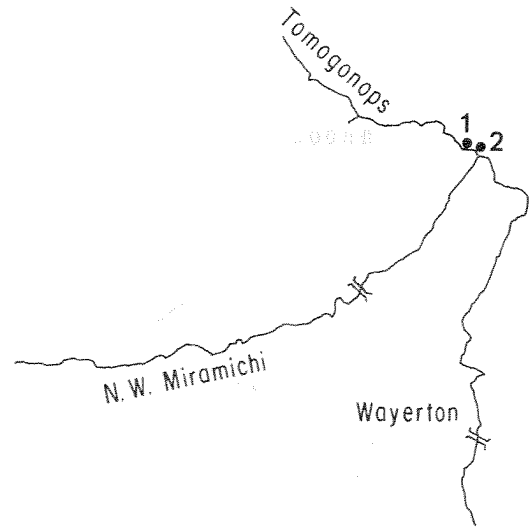
2-11. Maps of individual streams studied. Numbers and asterisks indicate study areas.



Map 4



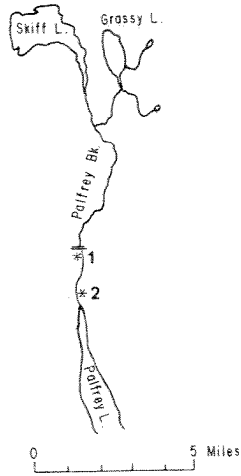
Map 5



Map 6

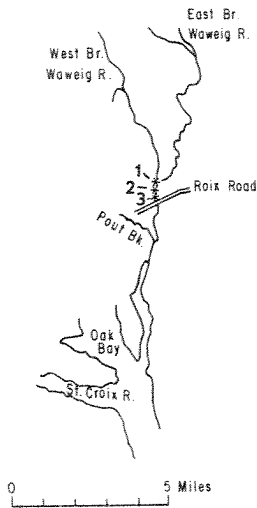
2-11. Maps of individual streams studied. Numbers and asterisks indicate study areas.

### Palfrey Brook



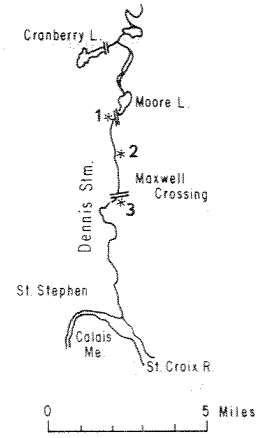
Map 7

### Waweig R.



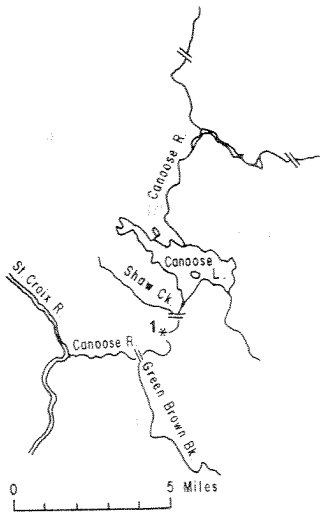
Map 8

### Dennis Stream



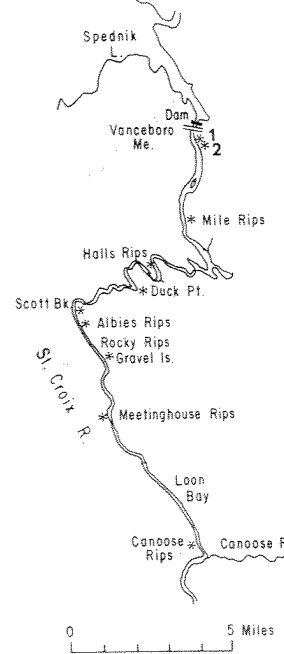
Map 9

### Canoose R.



Map 10

### St. Croix R.



Map 11

2-11. Maps of individual streams studied. Numbers and asterisks indicate study areas.

Appendix 1. Results of core sampling for the various study areas. Top, middle, bottom refer to the top, middle, and bottom 5 cm of the core samples. (Wt. = total sample weight (g)). Other figures are given as percentages of total sample weight. Means are weighted according to differing weights for different strata in the cores.

Locality	Date	Wt	Cobble	Pebble	Organic				
					Coarse Sand	Fine Sand	Coarse Sand	Fine Sand	Silt
Waweig 1	Top	28.V.74	1555.59	78.6	21.3	0.078	0.0045	1.61	12.5
	Middle		1433.93	91.1	7.40	1.45	0.028	0.90	20.0
	Bottom			84.8	14.3	1.1	0.016	1.26	16.2
Mean									9.5
Waweig 1	Top	26.VII.74	1459.32	95.5	4.44	0.032	0.012	2.17	5.56
	Middle		1972.18	39.1	60.2	0.60	0.066	2.03	3.79
	Bottom		1477.69	25.8	67.0	6.10	0.95	2.70	2.92
Mean			53.4	43.9	2.2	0.34	2.3	4.1	14.1
Waweig 1	Top	11.IX.74	1427.24	58.4	41.5	0.08	0.01	2.54	2.27
	Middle		1609.57	38.2	57.7	3.62	0.35	2.26	2.43
	Bottom		1178.51	20.3	66.3	11.7	1.28	2.50	2.02
Mean			39.0	55.2	5.1	0.5	2.4	2.2	12.0
Waweig 2	Top	28.V.74	1448.00	71.7	28.1	0.14	0.07	0	0
	Middle		1480.36	25.8	64.9	7.78	1.37	1.11	0.83
	Bottom			48.8	46.5	3.9	0.72	1.1	0.83
Mean									8.3
Waweig 2	Top	26.VII.74	1478.82	51.7	45.1	3.09	0.045	2.16	4.35
	Middle		1729.50	76.6	18.0	5.07	0.22	2.15	2.28
	Bottom			64.2	31.6	4.1	0.13	2.2	3.3
Mean									15.4
Waweig 2	Top	11.IX.74	1488.71	49.0	47.8	2.76	0.34	2.37	2.71
	Middle		1551.28	14.1	69.0	14.5	2.01	2.54	2.07
	Bottom		1335.41	7.56	73.4	17.0	1.56	2.28	2.30
Mean			23.6	60.1	11.4	1.3	2.4	2.4	15.1
Waweig 3	Top	28.V.74	1562.21	99.9	0.013	0.045	0.014	4.05	12.0
	Middle		3058	100	0	0	0	0	0
	Bottom		1487.93	45.6	46.0	7.43	0.90	0.53	1.47
Mean			81.8	15.4	2.5	0.3	2.7	6.7	10.2
Waweig 3	Top	26.VII.74	1556.57	55.1	42.6	2.12	0.15	2.45	2.45
	Middle		1537.83	18.6	52.4	26.9	1.36	2.34	2.34
	Bottom			36.8	47.5	14.5	0.76	2.4	2.4
Mean									15.4
Dennis 1	Top	4.VI.74	1567.85	86.0	13.4	0.47	0.053	2.75	30.8
	Middle		546.78	34.4	55.5	9.37	0.42	2.33	14.0
	Bottom			60.2	34.4	4.9	0.23	2.5	22.4
Mean									28.1
Dennis 1	Top	7.VIII.74	1599.93	99.9	0	0.024	0.013	2.56	4.54
	Middle		1627.12	99.6	0.36	0.31	0.013	7.41	8.70
	Bottom		1515.25	66.2	22.0	11.25	0.39	1.40	1.81
Mean			88.7	7.4	3.7	0.14	4.0	5.0	18.2
Dennis 1	Top	12.IX.74	1544.02	100.0	0	0.02	0.01	0.33	0
	Middle		1502.51	89.1	10.8	0.11	0.01	2.42	5.00
	Bottom		848.32	48.6	46.7	4.47	0.13	1.61	3.51
Mean			79.2	19.2	1.5	0.05	1.4	4.2	2.80
Dennis 2	Top	4.VI.74	1439.78	98.3	1.67	0.01	0.005	0	0
	Middle		1547.25	55.1	43.5	1.31	0.04	1.75	7.81
	Bottom		1446.95	25.6	60.4	13.3	0.33	2.47	10.25
Mean			59.6	35.2	4.9	0.12	2.1	9.0	29.4

Appendix 1 (Continued)

Locality	Date	Wt	Cobble	Pebble	Coarse Sand		Fine Sand		organic		
					Coarse Sand	Fine Sand	Coarse Sand	Fine Sand	Coarse Sand	Fine Sand	Silt
Dennis 2	7.VIII.74	1784.60	97.5	2.52	0.006	0.015	8.3	0.0015	3.57		
			Middle	27.0	62.2	10.1	0.54	1.59	3.48		
			Bottom	11.0	64.0	23.0	1.52	1.80	2.30		
			Mean	45.2	42.9	1.0	0.7	1.7	2.9	35.4	
Dennis 2	12.IX.74	1488.92	67.6	32.4	0.05	0	2.44	0	9.09		
			Middle	43.8	49.1	6.76	0.29	1.62	2.86		
			Bottom	14.2	66.0	18.5	0.89	1.73	2.57		
			Mean	41.9	49.2	8.4	0.4	1.7	2.7	33.3	
Dennis 3	4.VI.74	1686.96	94.1	5.86	0.02	0.004	25.0	0.004	20.0		
			Middle	24.9	68.3	6.34	0.34	0.80	10.5		
			Bottom	20.3	61.6	16.5	1.27	1.50	2.86		
			Mean	46.3	44.9	7.6	0.5	1.2	6.6	20.0	
Dennis 3	7.VIII.74	1581.28	47.6	47.9	3.80	0.63	1.49	0.63	1.68		
			Middle	9.75	66.1	19.6	4.21	1.69	1.75		
			Bottom	10.2	57.4	26.4	5.56	1.25	1.37		
			Mean	22.5	57.1	16.6	3.4	1.4	1.5	14.0	
Dennis 3	12.IX.74	1565.16	8.83	72.2	15.7	2.97	1.50	1.57	4.88		
			Middle	26.2	55.2	15.8	2.60	1.61	2.15		
			Bottom	25.1	50.2	20.4	4.02	1.40	1.27		
			Mean	20.0	59.2	17.3	3.2	1.5	1.7	17.0	
Digdeguash 1	5.VI.74	1674.45	70.8	28.7	0.52	0.02	1.02	0.02	4.88		
			Middle	37.4	52.5	9.62	0.32	1.65	2.52		
			Bottom	17.3	68.1	13.9	0.52	0.90	0.28		
			Mean	41.8	49.8	8.0	0.28	1.2	2.5	0.0	
Digdeguash 1	13.VIII.74	1440.21	55.8	42.2	1.92	0.11	1.56	0.11	3.14		
			Middle	16.8	63.2	1.79	1.74	1.45	1.79		
			Bottom	13.7	65.5	18.6	1.90	1.41	2.26		
			Mean	28.8	56.9	12.8	1.2	1.4	2.4	29.6	
Digdeguash 1	17.IX.74	1521.14	98.1	1.79	0.02	0.01	2.00	0.01	3.22		
			Middle	25.0	55.0	18.2	1.32	1.43	2.41		
			Bottom	17.2	54.2	25.8	2.24	1.53	2.09		
			Mean	46.8	37.0	14.7	1.2	1.5	2.4	31.2	
Digdeguash 2	5.VI.74	1479.57	27.8	64.6	6.81	0.55	2.18	0.55	4.03		
			Middle	16.9	57.5	22.7	2.45	1.48	2.19		
			Bottom	14.6	60.6	22.8	1.59	1.68	4.09		
			Mean	19.8	60.9	17.4	1.5	1.8	3.4	30.0	
Digdeguash 2	13.VIII.74	1378.94	26.2	52.1	18.0	3.28	1.81	1.84			
			Middle	2.67	64.0	27.1	5.56	1.90	1.76		
			Bottom	7.49	68.6	19.3	4.19	1.82	2.00		
			Mean	12.3	61.6	21.4	4.4	1.8	1.9	29.6	

Appendix 1 (Continued)

Locality	Date	Wt	Cobble	Pebble	Coarse Sand	Fine Sand	organic		
							Coarse Sand	Fine Sand	Silt
Digdeguash 2	Top	1347.80	54.4	42.6	2.70	0.22	1.59	2.32	
	Middle	1132.11	5.75	75.4	16.6	1.86	1.86	2.45	
	Bottom	618.84	17.6	57.5	21.8	2.86	1.66	1.84	
Mean		25.9	58.5	13.7	1.6	1.6	2.2	31.2	
Digdeguash 3	Top	1018.64	10.8	86.7	2.26	0.19	2.13	4.06	
	Middle	1503.61	4.95	85.7	7.91	1.22	2.50	2.86	
	Bottom	1664.39	5.25	83.5	9.14	1.84	2.14	2.14	
Mean		7.0	85.3	6.3	1.1	2.2	3.0	11.5	
Digdeguash 3	Top	1368.36	8.98	53.2	26.8	3.36	1.28	2.17	
	Middle	1530.81	0	54.1	41.5	3.62	1.70	1.95	
	Bottom	1643.27	2.22	61.8	31.1	4.38	1.50	1.13	
Mean		3.7	56.5	32.8	3.8	1.5	1.8	12.5	
Digdeguash 3	Top	1494.20	45.8	47.0	6.11	1.00	2.02	1.71	
	Middle	1432.61	20.1	57.4	17.6	4.52	1.29	1.28	
	Bottom	1517.87	12.7	56.0	24.6	6.25	1.33	1.39	
Mean		26.2	53.5	16.1	3.9	1.4	1.3	22.2	
Magaguadavic 1	Top	1613.33	96.5	3.45	0.01	0.01	-	-	
	Middle	1884.83	35.4	46.6	15.7	2.04	1.18	8.79	
	Bottom	2003.18	54.3	25.4	17.5	2.67	1.00	1.20	
Mean		6.21	25.2	11.1	1.6	1.1	1.5	18.4	
Magaguadavic 1	Top	1726.35	93.6	6.39	0.05	0.02	2.50	3.13	
	Middle	1705.98	24.2	54.6	18.8	2.12	1.06	1.61	
	Bottom	1601.26	16.7	69.7	11.9	1.51	1.65	1.26	
Mean		44.8	43.6	10.2	1.2	1.4	1.4	18.9	
Magaguadavic 1	Top	1597.40	25.2	45.2	25.2	4.03	1.23	1.47	
	Middle	1628.82	23.8	41.2	29.3	5.33	0.94	1.74	
	Bottom	880.71	0	53.7	38.6	7.15	1.02	1.38	
Mean		16.3	46.7	31.0	5.5	1.1	1.5	12.5	
Magaguadavic 2	Top	1527.5	83.3	16.7	0.06	0	-	-	
	Middle	1738.0	66.3	33.1	0.5	0.1	-	-	
	Bottom	2786.5	38.5	53.1	7.7	0.8	-	-	
Mean		62.7	34.3	2.75	0.3	-	-	-	
Magaguadavic 2	Top	1747.5	47.6	46.0	5.9	0.5	-	-	
	Middle	1773.0	27.3	58.3	12.5	1.9	-	-	
	Bottom	1940.0	22.9	55.0	18.9	3.2	-	-	
Mean		32.6	53.1	12.4	1.9	-	-	-	
Magaguadavic 2	Top	1432.0	95.9	4.1	0	0	-	-	
	Middle	1679.5	82.4	14.7	2.4	0.4	-	-	
	Bottom	1795.0	39.3	36.2	21.4	3.1	-	-	
Mean		72.5	18.3	7.9	1.2	-	-	-	

Appendix 1 (Continued)

Locality	Date	Wt	Cobble	Pebble	organic				
					Coarse Sand	Fine Sand	Silt		
Upper Palfrey Top	9.VII.74	1489.43	98.4	1.50	0.04	0.02	3.13	8.00	
Middle		1612.17	51.0	45.3	3.54	0.17	-	-	
Bottom		419.82	18.5	61.9	18.6	0.78	0.90	1.22	
Mean			56.3	36.1	7.3	0.32	2.0	4.5	62.5
Upper Palfrey Top	21.VIII.74	1636.10	98.1	1.85	0.02	0.02	2.50	3.85	
Bottom		1583.16	39.0	59.2	1.73	0.03	0.99	4.17	
Mean			68.6	30.5	0.87	0.02	1.7	4.0	0.0
Lower Palfrey Top	29.VIII.74	1645.35	86.0	1.39	0.05	0.01	5.00	7.14	
Middle		1559.83	38.8	39.9	19.6	1.41	0.79	1.50	
Bottom		1589.15	44.5	30.8	22.7	1.78	0.96	1.56	
Mean			56.4	28.2	14.3	1.07	1.0	1.6	30.0
Canoose Top	9.VII.74	1548.26	96.9	3.0	0.04	0.01	3.23	55.6	
Middle		1653.66	54.8	40.2	4.63	0.20	2.25	2.88	
Bottom		1566.07	42.6	42.1	12.8	0.57	1.98	2.20	
Mean			65.7	28.3	5.8	0.26	2.5	20.0	26.3
Canoose Top	21.VIII.74	1298.75	99.7	0.26	0.03	0.01	2.27	2.73	
Middle		1465.45	49.1	45.0	5.60	0.22	1.61	2.15	
Bottom		1353.57	21.9	54.4	22.3	1.01	2.05	2.22	
Mean			55.70	33.0	9.3	0.4	2.0	2.3	35.3
Canoose Top	23.IX.74	1998.02	98.4	1.55	0.02	0.01	1.83	2.91	
Middle		1246.82	50.2	47.8	1.87	0.10	1.77	2.40	
Bottom		1291.33	28.8	51.4	1.77	1.76	1.88	1.73	
Mean			59.1	33.6	6.5	0.6	1.8	2.3	25.7
Vanceboro 2 Top	14.VIII.77	1637.5	93.8	6.1	0.12	0.03	-	-	
Middle		1516.5	42.8	46.6	9.9	0.8	-	-	
Bottom		3286.9	73.8	16.3	9.3	0.64	-	-	
Mean			70.1	23.0	6.4	0.5	-	-	
Vanceboro 2 Top	14.VIII.77	1500.0	100.0	0	0	0	-	-	
Middle		1650.0	88.2	9.9	1.8	0	-	-	
Bottom		1949.0	32.3	51.9	15.0	0.7	-	-	
Mean			73.5	20.6	5.6	0.2	-	-	
Vanceboro 2 Top	14.VIII.77	1827.2	100.0	0	0	0	-	-	
Middle		1581.0	55.0	32.3	10.8	1.9	-	-	
Bottom		1741.2	8.7	51.5	33.6	6.2	-	-	
Mean			54.6	27.9	14.8	2.7	-	-	
Mille Rips Top	10.VII.74	1678.68	84.9	14.9	0.10	0.02	1.98	2.20	
Middle		1736.42	49.3	34.3	16.1	0.23	0.85	2.23	
Bottom		1489.29	30.4	41.6	27.2	0.46	0.88	1.86	
Mean			54.7	30.2	14.4	0.23	1.2	2.1	0.0

Appendix 1 (Continued)

Locality	Date	Wt	Cobble	Pebble	organic			Silt
					Coarse Sand	Fine Sand	Fine Sand	
Mile Rips Top	3.IX.74	1500.5	78.9	20.3	0.69	0.03	0.95	9.09
Mile Rips Middle		1436.37	32.5	55.4	11.6	0.39	0.88	1.74
Mile Rips Bottom		1162.02	6.01	65.1	27.9	0.70	0.94	1.69
Mile Rips Mean			39.0	47.0	13.6	0.37	0.93	1.7
Mile Rips Top	26.IX.74	1333.53	84.1	15.4	0.40	0.04	0.37	3.45
Mile Rips Middle		1593.62	50.0	39.4	10.3	0.13	0.81	2.73
Mile Rips Bottom		1669.82	27.3	47.3	24.8	0.40	0.84	1.77
Mile Rips Mean			53.8	34.0	11.8	0.19	0.7	2.6
Hall's Rips Top	10.VII.74	1679.38	95.9	4.04	0.05	0.01	2.47	5.56
Hall's Rips Middle		1841.23	61.0	34.4	4.00	0.44	1.50	2.05
Hall's Rips Bottom		2240.53	9.18	44.0	44.6	1.93	0.77	1.72
Hall's Rips Mean			55.5	27.4	16.3	0.8	1.6	3.1
Hall's Rips Top	3.IX.74	1611.63	56.7	39.4	3.59	0.19	1.35	1.94
Hall's Rips Middle		1315.19	23.5	61.3	14.2	0.84	1.45	2.14
Hall's Rips Bottom		1019.76	61.5	25.5	12.0	0.81	1.62	2.14
Hall's Rips Mean			47.3	42.0	10.0	0.6	1.5	2.1
Hall's Rips Top	26.IX.74	1586.69	97.8	2.20	0.03	0.02	4.65	6.25
Hall's Rips Middle		1602.63	34.0	55.8	9.36	0.67	1.59	2.46
Hall's Rips Bottom		1708.01	26.9	51.5	19.3	1.98	1.40	1.57
Hall's Rips Mean			52.9	36.5	9.6	0.9	2.5	3.4
Mile Rips Top	3.IX.74	1498.35	87.3	12.4	0.27	0.01	1.46	4.76
Mile Rips Middle		1425.74	47.1	40.1	11.8	0.88	1.17	1.42
Mile Rips Bottom		1301.54	14.7	53.8	28.4	2.76	1.09	1.18
Mile Rips Mean			49.7	35.3	13.6	1.2	1.3	2.4
Duck Pt Top	10.VII.74	1545.24	97.4	2.5	0.05	0.02	0	3.45
Duck Pt Middle		1628.95	62.0	29.5	7.50	0.90	1.37	1.21
Duck Pt Bottom		1680.92	18.6	57.5	27.8	1.23	2.80	3.32
Duck Pt Mean			59.3	30.0	11.8	0.7	1.4	2.6
Duck Pt Top	3.IX.74	1525.13	63.8	33.0	2.96	0.25	1.70	2.06
Duck Pt Middle		1483.58	25.8	56.6	15.4	1.89	1.60	2.03
Duck Pt Bottom		829.72	23.7	53.1	20.4	2.31	1.75	2.14
Duck Pt Mean			37.9	47.7	13.0	1.5	1.7	2.1
Duck Pt Top	26.IX.74	1608.15	79.0	20.2	0.71	0.09	1.97	3.27
Duck Pt Middle		1674.41	44.7	41.7	11.5	1.80	1.76	2.23
Duck Pt Bottom		1618.87	10.1	61.1	23.7	4.39	1.75	3.28
Duck Pt Mean			44.6	41.0	11.6	2.1	1.8	2.9
Tyler Rips Top	3.IX.74	1554.71	93.3	6.71	0.03	0.01	2.38	1.18
Tyler Rips Middle		1509.29	42.8	47.0	9.68	0.41	1.54	1.75
Tyler Rips Bottom		595.33	7.85	61.7	28.5	1.46	1.50	1.70
Tyler Rips Mean			48.0	38.7	12.7	0.6	1.8	1.5

Appendix 1 (Continued)

Locality	Date	Wt	Cobble	Pebble	organic			
					Coarse Sand	Fine Sand	Silt	
Scott's Bk Middle Bottom Mean	4.IX.74	1574.87 1184.57 959.91 Mean	90.3	9.60	0.07	0.01	1.85	5.80
			49.3	41.5	7.52	1.55	1.76	
			11.8	63.2	20.4	4.15	1.61	
			50.3	38.3	9.3	1.9	3.0	15.8
Albie's Rips Top Middle Bottom Mean	11.VII.74	1527.09 1559.47 1343.77 Mean	98.6	1.33	0.02	0.02	0.59	2.50
			41.5	50.1	7.79	0.53	1.43	
			2.01	61.2	34.2	2.14	1.00	
			47.4	37.3	14.0	0.9	1.6	9.1
Albie's Rips Top Middle Bottom Mean	4.IX.74	1453.55 1622.43 949.38 Mean	95.4	4.54	0.06	0.04	3.41	1.92
			55.7	39.3	4.69	0.18	2.00	
			21.0	61.3	16.8	0.64	2.11	
			57.3	34.9	7.3	0.3	2.0	1.30
Albie's Rips Top Middle Bottom Mean	27.IX.74	1657.24 1645.62 1153.34 Mean	95.8	4.01	0.15	0.03	2.71	5.08
			37.8	42.3	18.6	1.12	1.87	
			13.5	53.4	29.8	2.90	1.96	
			49.0	33.3	16.2	1.3	1.9	16.1
Rocky Rips Top Middle Bottom Mean	11.VII.74	1523.41 1355.5 1109.24 Mean	84.0	15.3	0.60	0.03	1.20	2.08
			100.0	0	0	0	0	
			9.51	69.8	18.9	1.43	2.27	
			64.5	28.4	6.5	0.48	1.4	11.8
Rocky Rips Top Middle Bottom Mean	4.IX.74	1369.63 1483.15 1533.73 Mean	47.4	49.1	3.10	0.33	1.42	1.55
			16.0	64.3	17.0	2.36	1.49	
			7.18	59.4	27.9	5.08	1.89	
			23.4	57.6	16.0	2.6	1.7	14.7
Gravel Is Top Middle Bottom Mean	11.VII.74	1673.44 1728.69 1388.00 Mean	40.5	46.4	11.0	1.88	1.22	0.94
			2.04	64.9	27.4	5.23	0.84	
			3.33	59.4	30.5	6.27	1.30	1.17
			15.3	56.9	23.0	4.4	1.3	1.0
Gravel Is Top Middle Bottom Mean	4.IX.74	1352.56 1495.05 782.78 Mean	73.5	26.0	0.39	0.04	1.50	3.85
			76.0	19.9	3.59	0.44	1.32	1.64
			29.8	57.1	11.6	1.22	1.44	1.45
			59.4	34.3	5.2	0.6	1.4	2.3
Gravel Is Top Middle Bottom Mean	27.IX.74	1640.17 1563.93 1601.92 Mean	84.0	15.9	0.07	0.02	0.84	1.64
			40.0	47.1	11.5	1.19	1.69	
			21.1	53.1	23.4	1.98	1.31	1.40
			48.4	38.7	11.7	1.1	1.2	1.6

Appendix 1 (Continued)

Locality	Date	Wt	Cobble	Pebble	Coarse Sand			Fine Sand			organic		
					Coarse Sand	Fine Sand	Silt	Coarse Sand	Fine Sand	Silt	Coarse Sand	Fine Sand	Silt
Meetinghouse Rips	27.IX.74	1566.68	100.0	0	0.03	0.02	0.10	0	0.10	0	0	0	
			64.5	30.0	4.81	0.66	1.59	1.44	1.59	1.44	1.44	1.44	
			36.2	42.5	18.8	2.14	1.32	1.47	1.32	1.47	1.47	1.47	
			66.9	24.2	7.9	0.9	1.4	1.4	1.4	1.4	1.4	1.4	
Meetinghouse Rips	4.IX.74	1497.47	74.8	32.7	0.72	0.04	1.11	3.39	1.11	3.39	3.39	3.39	
			43.4	47.9	8.00	0.53	1.25	2.38	1.25	2.38	2.38	2.38	
			32.8	48.8	16.8	1.26	1.41	2.89	1.41	2.89	2.89	2.89	
			50.3	43.1	8.5	0.6	1.3	2.9	1.3	2.9	2.9	2.9	
Meetinghouse Rips	27.IX.74	1548.88	96.8	3.15	0.05	0.02	1.16	4.00	1.16	4.00	4.00	4.00	
			50.1	41.4	7.35	1.01	1.57	1.67	1.57	1.67	1.67	1.67	
			17.7	55.3	23.4	3.19	1.45	1.35	1.45	1.35	1.35	1.35	
			54.9	33.3	10.3	1.4	1.4	1.5	1.4	1.5	1.5	1.5	
Canoose Rips	12.VII.74	1379.79	88.6	11.3	0.05	0.02	2.74	3.03	2.74	3.03	3.03	3.03	
			67.6	31.0	1.35	0.07	1.04	0.87	1.04	0.87	0.87	0.87	
			11.0	70.5	17.4	0.80	1.50	1.59	1.50	1.59	1.59	1.59	
			55.7	37.6	6.3	0.3	1.7	1.8	1.7	1.8	1.8	1.8	
Canoose Rips	21.VIII.74	1497.27	97.9	2.06	0.02	0.008	2.94	7.69	2.94	7.69	7.69	7.69	
			31.6	59.3	8.51	0.45	1.19	1.28	1.19	1.28	1.28	1.28	
			42.9	43.5	12.6	0.79	1.31	1.49	1.31	1.49	1.49	1.49	
			47.3	35.0	7.1	0.4	1.7	3.4	1.7	3.4	3.4	3.4	
Canoose Rips	23.IX.74	1558.02	48.9	47.7	3.12	0.25	1.36	1.54	1.36	1.54	1.54	1.54	
			25.1	55.9	17.2	1.52	1.37	1.26	1.37	1.26	1.26	1.26	
			13.2	55.0	26.9	4.49	1.26	1.08	1.26	1.08	1.08	1.08	
			29.1	52.9	15.8	2.1	1.3	1.3	1.3	1.3	1.3	1.3	
Tomogonops	31.VII.74	1985.9	100	0	0	0	-	-	-	-	-	-	
			50.9	41.8	6.79	0.42	1.53	1.56	1.53	1.56	1.56	1.56	
			19.6	56.6	21.2	2.18	1.60	1.99	1.60	1.99	1.99	1.99	
			56.9	32.8	9.3	0.9	1.6	1.8	1.6	1.8	1.8	1.8	
Tomogonops	28.VIII.74	1691.17	83.1	16.6	0.22	0.02	2.84	2.44	2.84	2.44	2.44	2.44	
			30.8	59.1	9.09	0.81	1.28	1.70	1.28	1.70	1.70	1.70	
			11.2	64.4	21.3	2.65	1.69	2.05	1.69	2.05	2.05	2.05	
			41.7	43.4	10.1	1.1	1.9	2.0	1.9	2.0	2.0	2.0	