3.0 ATLANTIC SALMON HABITAT ON PRINCE EDWARD ISLAND

O'Grady et al (2000) suggest that "a stream's capacity to support salmonids is primarily dictated by a combination of four factors: mean (x) summer volume discharge, stream bed gradient or slope, the nature of the bed material and the quality of the riparian zone." On Prince Edward Island, the spring-fed streams usually maintain good summer flows but stream volume may be impacted in some drainage basins by extraction of water, either for row crop irrigation or water extraction for municipal use. Most watercourses have at least some reaches where stream bed gradients are too low for good salmon production. Bed material is often lacking adequate gravel and cobble and is inundated with much sediment. The quality of riparian zones along salmon rivers on Prince Edward Island may vary dramatically from reach to reach or stream to stream. Long sections of some rivers have few pools and poor juxtaposition of spawning, nursery and parr habitat. Classic over-wintering habitat is lacking in many stream reaches. Blockages that may affect instream movement or migration patterns of Atlantic salmon or other anadromous fish are common in most rivers and water quality problems are present in some watercourses.

3.1 Riparian Zones

Settlement and transportation were closely tied to the coastline and rivers on Prince Edward Island and watercourses often served as property boundaries. Springs and brooks were highly valued for watering livestock. Most of the original forest cover was removed along accessible streams and natural succession favoured white spruce and alder (*Alnus rugosa*) growth. A few of our streams still have small sections bordered by original Acadian forest vegetation, such as the "horseshoe" on the West River. Some river reaches have considerable numbers of yellow birch lining their banks, as seen on portions of Carruthers Brook, Trout River (Coleman) and Cains Brook, but the woodland along most streams is usually a mix of conifer and shade-intolerant hardwoods. Most of the white spruce are short lived on Prince Edward Island (40-60 years) and these conifers frequently collapse into streams. This large woody debris can be a great asset to the stream ecosystem if managed properly, not simply cut and piled above high water mark. New riparian buffer zone legislation severely limits any cutting or disturbances in a 15 metre buffer zone on each side of a watercourse.

Watershed groups have often planted trees in the riparian buffer zone as part of their habitat enhancement programs. Some groups even have small nurseries where trees are kept until large enough to reduce browsing problems from snowshoe hare (*Lepus americanus*) and meadow voles (*Microtus pennsylvanicus*). Currently, the provincial Department of Environment, Energy and Forestry grows trees and shrubs specifically for riparian planting by watershed groups. With available expertise within government and watershed groups, and with goals to re-establish native grass, trees, and shrubs that should normally grow well in each micro-climate, our riparian buffer zones should continue to improve in diversity and usefulness for all wildlife species.

In some instances, planting of trees and shrubs might prove counter productive, especially for brook trout populations. Brook trout often spawn in areas with deep-rooted grasses on stream banks. Overhanging grasses and undercut banks provide cover for the adult fish and in spring, the flooded grasses provide critical cover for young-of-the-year (0+) brook trout adjacent to the stream. Critical habitat for salmonids should be carefully recorded in each stream before extensive planting occurs.

Recommendation
Watershed groups should work closely with the Department of Environment, Energy and Forestry to ensure that the right native species of grasses, trees and shrubs are planted in the best locations in riparian zones to provide good vegetation survival, maximum diversity, bank stability, stream shading or sun exposure, and seasonal wildlife foods.

There is potential for severe erosion where ephemeral streams naturally flow through fields during spring runoff. Frequently, large quantities of soil end up in the adjacent watercourse due to run-off between autumn ploughing or harvest of row crops and spring planting. It would be desirable to encourage all landowners to consider these depressions (grassed waterways or otherwise) as part of the riparian buffer zone for the adjacent watercourse. Such ephemeral streams would be best diverted into wetlands or large sediment traps dug specifically to slow and temporarily hold large quantities of water so that settling of fines can occur.

Recommendation
Government assistance should be available to aid in water diversion from grassed waterways (or sites where grassed waterways are recommended) into constructed wetlands or "on land" sediment traps to encourage filtration and sediment reduction for the adjacent stream.

3.2 Blockages to Instream Fish Movements

For populations to thrive, anadromous fish species require the capability of instream movement in each life stage and in each season of the year. In many of the remaining salmon rivers in Prince Edward Island, the principal limiting factor for Atlantic salmon, as well as other anadromous fish, is the presence of blockages to fish movements. Some rivers have tributaries or even sections of the main stem blocked. Allowing blockages to fish migration to remain is akin to playing Russian roulette with our anadromous fish populations. With past management strategies, there was no way of knowing when a year class or even a complete run of Atlantic salmon might disappear because they could not reach appropriate spawning habitat.

3.2.1. Roadway Stream Crossings

Prince Edward Island has an enormous number of locations where private or public roads cross streams. At these road crossings, some culverts are poorly installed, at times suspended several feet in the air on the downstream side. Others have collapsed because of excess weight or have washed out in flood conditions. Even when properly installed, water flow can be so rapid in the culvert that some fish species cannot navigate upstream. Watershed groups, with the aid of a global positioning (G.P.S.) unit and a check sheet could help by doing a complete inventory of all stream crossings on all tributaries of the rivers that they are working on. On drainage basins where watershed groups are not active, the province should assign personnel to complete such a province-wide inventory.

> **Recommendation**:
> *After an exhaustive culvert stream crossing inventory is completed, there should be government monies allocated over a five year period to replace or repair stream crossings that are ineffective in permitting fish passage.*

While replacing hundreds of culverts may seem to be a very expensive venture, the cost of not repairing or replacing "blown out" culverts can be much more costly and the damage to the downstream fish habitat can be devastating.

3.2.2 Man-made Impoundments and Fish Ladders

There are some 600 man-made impoundments (dams) on Prince Edward Island. At one time, many impoundments were built to provide water power for operation of various types of mills but more recently they have been constructed for other purposes (Section 2.2).

Impoundments are costly to build and to maintain, as the infrastructure disintegrates over time. Many impoundments are old and infilled with sediment, others have limited fish passage, and some act as impenetrable barriers to anadromous fish movements. Fish ladders, if incorporated into the dam structure, will often not pass fish like rainbow smelts. They may become blocked by beaver sticks or natural debris or stop logs may not function properly. These ladders are sometimes not checked for months at a time to ensure that they are functioning properly. Drawdown capability (the ability to draw down the pond) is often not present and water quality in the impoundment can be problematic (ASE Consultants and U.P.E.I. Biology Department 1997).

> **Recommendation**
> *All major "man-made" impoundments on Prince Edward Island should be classified using parameters such as structural integrity, drawdown capability, fish passage capability, summer and winter water quality and lentic:lotic watercourse ratios. Those that rank high should be properly maintained while others may have to be decommissioned unless resources for repairs are greatly increased or dam washouts may occur.*

> **Recommendation**
> *Government should identify an individual to regularly check, and if necessary clean, each provincially-managed fishway once per month from March to December to ensure that they are functioning to pass fish. An annual written report of these monitoring and maintenance activities should be submitted to the Forests, Fish and Wildlife Division.*

3.2.3 Beaver Blockages

There have been many scientific papers written on the role of beavers in drainage basins. Some authors suggest that beavers improve habitat for salmonids, especially in cold water streams. Other authors have not been so complimentary. The impact of beavers on stream habitat and thus fish populations on Prince Edward Island will vary dramatically depending on stream size, gradient, and trapping pressure. Beavers find that small streams, such as headwater tributaries where many brook trout spawn, are easy to dam. Larger streams such as the Dunk River downstream from Scales Pond or the Morell River downstream from Grants Bridge are too wide and water velocity too great for beaver dams to hold, so the animals have to rely on bank denning at deep pools. Beaver dams on reaches of streams with steep gradients provide little surface area of water and the animals soon have to move on to find food. However, beaver dams that are constructed on low gradient portions of streams can flood enormous areas of adjacent land, killing trees and shrubs. These dams may hold back water for many years, cause extensive damage to forest or agricultural land, and often convert forests to brush marshes.

Some managers argue that with many trappers and high pelt prices, beaver populations can be managed on watercourses through regular trapping pressure. However, on Prince Edward Island, the number of trappers has been declining for decades and pelt prices remain low. Consider the following case: With high pelt prices in the 1980s and with many more trappers than today, beaver populations expanded to such an extent in the Grovepine/Big Brook Branch of the Fortune River that a stream crew had to remove approximately 180 beaver dams to restore somewhat normal flow patterns (Cheverie, pers. comm.). Needless to say, with these multiple blockages, water quality and access to spawning sites was compromised so severely that Atlantic salmon and most sea run trout disappeared from the system. This story of beaver dams blocking the movements of many species of anadromous fishes has been repeated over and over across Prince Edward Island. Most of the remaining Atlantic salmon rivers, with the exceptions of the North River and West River, have many beaver blockages. Thus, without a sudden change in beaver management strategies, most will soon join the long list of rivers where salmon have been extirpated because of the 1949 introduction of beavers to Prince Edward Island.

Beaver dams may block both upstream and downstream passage of fish. The author has witnessed dead salmon smolts entangled in beaver dams when moving downstream in spring as well as numbers of grilse and salmon prevented from moving upstream in autumn (and occasionally downstream in spring). On numerous occasions, the author has seen movements of other anadromous fish species, such as the rainbow smelt, alewife and brook trout, completely blocked by beaver dams. Many die trying to navigate these obstacles and in some cases, blockages are completely impassable and population levels are affected.

One compromise that was agreed to many years ago on the Morell River involved the establishment of a “beaver-free” zone in the lower reaches of the river (approximately one-third of the total length of all stream tributaries. In the upper reaches, beavers could only be killed by trappers during the open season. We learned quickly that the old beaver dams on the upper reaches did not wash out and subsequently, the trees preferred by beaver, such as trembling aspen (*Populus tremuloides*), could not regenerate in the altered wet soils. Having created poor beaver habitat, the animals then moved to "beaver free" zones where they proceeded to alter much of the treed riparian buffer zone, changing some areas into extensive grassy beaver meadows (Section 5.2.4). Killing of beavers during the summer was prohibited and with inadequate trapping during the open season, eventually every major branch of the Morell River in the beaver-free zone was blocked with beaver dams.

At a February 21, 2009 meeting between members of the Souris Branch of the P.E.I. Wildlife Federation and the P.E.I. Trappers Association, beaver and anadromous fish conflicts were discussed. Five issues became blatantly obvious during the course of the active discussion.

- Too little dialogue was occurring among concerned interest groups and much distrust existed.
- Life history information about various fish and wildlife species and their inter-relationships were not well understood.
- Trappers expressed a passionate sense of entitlement but were willing to accept altered regulations such as a longer trapping season. They were adamantly opposed to watershed groups killing beavers in summer even though they were informed about extensive damage that beavers are causing to anadromous fish populations, private woodland property and numerous private and public road crossings.
- Trappers seemed unaware of beaver dam locations on several rivers with active watershed groups. They would like groups to provide them with the location of beaver colonies, but watershed groups often finish work for the summer before some beavers set up their dams in autumn.
- Trappers seemed unaware of the location of beaver dam locations on rivers without an active watershed group, for example the Midgell River. Both the manager and director of the provincial Fish and Wildlife Section were informed of G.P.S. locations and the problems that these dams would cause to anadromous fish if the beaver colonies were not removed. This may reflect the result of the manager's comment, "I only have six people working for me" and obviously each of them already has a full platter or it may require more communication with trappers.
- Some trappers feel that they would trap in remote places for free while others feel financial assistance would be necessary. I believe that the P.E.I. Trappers Association should have some policy that is agreeable to its membership.

Recommendation

A revised beaver management policy should be blended with a new anadromous fish policy with input from representatives of the recreational and commercial fisheries, various provincial government departments, the Department of Fisheries and Oceans, the P.E.I. Trappers Association, the P.E.I. Wildlife Federation, watershed groups and landowners to establish a better balance of resource management and landowner riparian zone protection.

Recommendation
The Atlantic Salmon Advisory Committee established by the Department of Fisheries and Oceans should be asked to take a lead role in the management of "beaver-free" zones. This Committee, composed of representatives from non-government organizations and government agencies, can meet regularly to discuss fish passage issues on each salmon river, should assign responsibilities for monitoring designated "beaver-free" zones, and could facilitate the removal of dams and beavers in these areas. The preparation of an annual report, with maps outlining beaver activity in designated beaver-free zones, would be beneficial.

3.2.4 Water Quality

Water depth and water quality may affect fish movement and survival. Normally, we expect that our first and second order streams will flow throughout the summer. However, in many watersheds, lack of extensive forest cover and wetlands often contributes to fast snow melt and "flashy" streams. Some upland springs can dry up in summer. These conditions can lead to reduced summer flow and in some cases, ephemeral streams. Streams may also run dry for other reasons, such as over-extraction of ground water which happens on a regular basis in the upper reaches of Winter River, the drainage basin which provides Charlottetown's municipal water supplies.

Water quality parameters, such as temperature and dissolved oxygen, not only act as a barrier to fish movement, but can also be a significant cause of mortality in some river reaches if a refuge is not available. Younger age classes of salmonids cannot afford to move to a cooler water refuge or the consequences may be death by predation from larger fish (MacMillan 1998). Levels of oxygen too low for salmonid survival may occur in summer, when the water temperature is high, or in winter when vegetation decay under the ice can severely reduce oxygen levels, especially in lower depths.

An indepth study of the impact of man-made and beaver impoundments on fish species on Prince Edward Island was commissioned by the federal Department of Fisheries and Oceans (ASE Consultants and U.P.E.I. Biology Department 1997). Since then, little action has been taken on recommendations geared to remedy water quality problems in our freshwater streams. For instance, there were occasions during the summer of 2008 that all of the salmon rivers draining into St. Peters Bay - Morell, Marie, Midgell and St. Peters - had some tributaries or their main stem impacted by low oxygen and high temperature levels.

3.3 Sediment Input into Watercourses

Sediment is a term used to describe soil particles made up mostly of clay, silt and sand. Clay particles are so tiny that they feel greasy between the fingers. Silt is the size of dust and sand is considerably larger and has a gritty texture. Often clays become suspended in the water column and can be carried great distances before settling out. Sometimes silt will be deposited in depressions on fields or in still water. Sand is heavier so it drops out of the water column sooner but can often be seen bouncing along the bottom on its way downstream to rest in a pool or other slow water. In his comprehensive book, "Sediment in

Streams", Waters (1995) summarizes the effects of deposited sediment on fish habitat as follows:

> Beyond the problems of successful reproduction and sufficient food resources for growth, both of which are susceptible to the deleterious effects of sediment, is the problem of deposited sediment effects on physical habitat – space of adequate quantity and quality to provide for fish needs. These needs include roughness elements on the streambed to provide winter protection for fry against aquatic predators, foraging territories, and sufficient water depths to provide overhead cover for juveniles and adults. Stream features affording these elements constitute rearing habitat; all are subject to severe reductions caused by deposited sediment.
>
> The rearing habitat for juveniles is the most critical. It is well known that the greatest mortality of a given year class or cohort occurs in young stages, and that the strength of a year-class is most often set in some early critical phase (Elliott 1989). Consequently, the sedimentation of juvenile rearing habitat is decisive in it's capability to ultimately damage adult fish populations.

Cassie and Arseneau (2002) reported that in the maritime rivers studied, the percent fines on stream bottoms were much higher in the Morell River, Prince Edward Island. Cairns (2002) estimated densities of brook trout and Atlantic salmon from electrofishing surveys in various Prince Edward Island rivers. He suggested that brook trout may avoid some of the negative effects of sediment by using ground water seeps in which to spawn but sediments where salmon spawn are probably sufficient to affect successful reproduction.

Figure 1. After heavy rainfall in August, the Crabbe Road section of North River rose by about 2 metres, causing extensive erosion and sediment input to the river.

In many drainage basins, the presence of sediment is very detrimental to salmon spawning and nursery areas. Even though the eggs are laid in a depression that has been dug in gravel substrate in relatively fast water (and therefore more or less cleaned of sediment), sand, silt and clay particles can infiltrate the redd (egg nest). The developing fish embryos need a good flow of oxygenated water to obtain enough oxygen and get rid of metabolic wastes. If enough sediment particles plug up the pores between gravel particles, and clay coats the egg membranes, excessive mortality can occur before hatching.

Sediment in many of our rivers will often "glue" the gravel/cobble/boulders in place, leaving little exposed space for shelter or food. Thus, sediment may severely reduce the quality of stream habitat and even prevent salmon parr from finding desirable over-wintering cover. In some sections of streams, for example the Emerald reach of the Dunk River, sediment is so deep that it is treacherous to walk in the river wearing chest waders for fear of getting stuck.

3.3.1 Impact of Agriculture

In drainage basins where salmon runs still exist on Prince Edward Island, the percentage of land base in forest cover varies from only 18% in North River to 86% in Priest Pond Creek (Figure 1). Most of the drainage basins in northeastern Prince Edward Island are heavily forested and thus have relatively little impact from agriculture. The greater the percentage of land in a drainage basin in row crops, the greater the likelihood that sediment will be a problem in streams. Factors that may play a role in determining how much sediment from agricultural activities in a drainage basin ends up in watercourses are:

a) percent slope of fields in row crops;
b) level of soil organic matter in cultivated fields;
c) length of crop rotation;
d) use of winter cover crops and recommended levels of mulching on harvested potato fields;
e) presence of appropriate grassed waterways draining into wetlands or other filtering vegetation;
f) autumn ploughing or cultivation of potato land;
g) unusual weather events when cropland is inadequately protected (winter thaws, heavy rains after planting or harvest, strong winter winds with frozen exposed soil);
h) amount of cultivated land with appropriate strip cropping and terracing.

Figure 2. Drainage from a potato field in Mill River carved a gully as it exited a highway culvert, carrying sediment to the stream.

Riparian buffer zones may help to reduce the amount of sediment reaching watercourses if they are situated on relatively flat terrain, are wide and have appropriate vegetation, but when enough water concentrates, it will carry clay and silt particles of sediment very long distances. Clay particles may remain suspended in run off water for days and eventually reach salt water off the P.E.I. coast.

In Prince Edward Island, some sediment will always reach watercourses in areas of intensive row cropping. However, if farmers followed the recommendations in the Action Committee on Agricultural Runoff Control report (1999), sediment input should not be great enough to cause major stream habitat deterioration or fish kills and nutrient levels would be reduced in our watercourses.

3.3.2 Beavers and their Activities

Beavers dams on Prince Edward Island can be built anywhere from the head of tide to the sources of the uppermost tributaries. Each dam is constructed of sticks, usually alders, and plastered with mud to make the dam more or less impermeable to water. Lateral channels are usually dug within in the beaver impoundment to assist in transport of food and to provide escape routes while the animals are on land. Water often spills over the dam in several locations and each of these "braids" can carve a new channel until the braid reaches the old stream bed. Sediment drops out of the water column as the water slows and as a result, deposition occurs on the stream bottom of the beaver impoundment. Within a couple of years, trees within the impoundment die and are often blown over to expose sediment from root masses. Downstream from the beaver dam, sediment accumulates from the new channels cut by the braids, and should the beaver dam ever wash out, much sediment can be washed downstream. The stream within a breached inactive beaver impoundment is usually wide and shallow with no overhead shade and little instream cover.

Beavers are also known to plug outlets to ponds constructed with "drop inlets" or block bypass channels where the pond water exits. When blockages occur, water level rises and may erode a notch in the top of the dam. In extreme cases, the dam washes out, causing extensive movement of soil material into the watercourse. Frequently, beavers will dam culverts at road crossing sites. I spoke with one backhoe operator who told me that recently, he has been getting more frequent calls to remove beaver blockages from culverts (he cleared out one culvert no less than five times during summer 2008). Often, a "beaver fence" is constructed around a culvert opening to prevent beavers from plugging it. However, being ingenious at construction, the beavers frequently flood the road or cause the soil around the culvert to soften which may lead to culvert replacement or in worse case scenarios, cause the road to wash out, carrying massive quantities of sediment downstream.

In 2005, a report was drafted for the Souris and Area branch of the P.E.I. Wildlife Federation entitled, "A Fish and Fish Habitat Stewardship Strategy for Prince Edward Island. Pilot Project: Eastern Kings, P.E.I." (Foster 2005). This project was supported by the federal Department of Fisheries and Oceans and the provincial Department of Environment, Energy and Forestry. The report does an excellent job of describing the impact of beavers in rivers in eastern Kings County and offers management suggestions, as outlined in the paragraphs below (Foster 2005).

> Beaver dams present a serious fish habitat issue in the six priority watersheds and their management will be critical to the success of the stewardship plan. Beaver dams not only interfere with fish movement, they alter riffle-pool complexes and runs, increase stream depth, cause stream braiding, increase water temperature, and block sediment transport. Abandoned and active beaver dams rarely get blown out in the spring time due to the Island's short stream systems and low gradient topography. In the past, beaver management has been promoted on the lower reaches. However, we now recognize the importance of first and second order streams to salmonids in terms of spawning and maintenance of water quality.
>
> Intensive beaver management will be given high priority to ensure the continued survival of salmon in five of the seven rivers. Beaver management areas have been identified and mapped based on existing knowledge of salmonid habitat. Within these zones, regular monitoring will be required to identify beaver dams. Volunteers serving as "river monitors" will contact the Department of Environment, Energy and Forestry when dams are located and the Department will arrange to have the dams AND the beavers removed. These management zones can change if additional information becomes available.
>
> Both Cross River and North Lake Creek continue to have excellent habitat and good runs of Atlantic salmon. While beavers are present in these systems, they have not yet achieved the high numbers found in surrounding rivers, e.g. Bear River and Hay River. Considering the precarious status of Atlantic salmon on Prince Edward Island, it is imperative that the entire stream length of both Cross River and North Lake Creek be considered a "beaver management" area. It would be naïve to assume that all beavers can be prevented from living within these watersheds. However, with regular monitoring and the cooperation of local trappers, the influence of beaver in these watersheds can be kept to a minimum.

Unfortunately, in northeastern Kings County, salmon no longer exist in Hay River, Bear River, Cow Creek, Fortune River or Souris River and beaver blockages are preventing salmon from accessing most of the Naufrage River and Priest Pond Creek. The two gems recommended to be completely free of beavers and beaver dams in their complete drainage basins (Cross River and North Lake Creek) still have beaver blockages. The objectives of the Foster report have not been achieved and the salmon and beaver conflicts have grown grievously worse.

3.3.3 Unpaved Roads, Stream Crossings and Road Maintenance

Some drainage basins, for example the West River, have many sites where unpaved roads and stream crossings are point sources of large quantities of sediment after every heavy rainfall or during snow melt in winter or spring thaws. Upgrading of unpaved roads (which often means shale resurfacing) can, in the long term, reduce erosion if side slopes of ditches are shaped properly, mulch is immediately applied, proper spacing occurs between check dams, and hydro-seeding is done soon after the upgrades are completed. Unfortunately, it is rare that all of the above are done and regular maintenance, such as cleaning check dams after heavy rainfall events and in spring, is not usually conducted until check dams overflow with sediment.

Figure 3. Clay roads are prone to erosion and check dams must be cleaned regularly.

Sometimes, clay roads become so eroded that the road shoulders are higher than the center of the road, for example the Cape Breton Road on Clarks Creek or Greenans Road on the Dunk River. This situation can be very challenging, especially if extra water is diverted from adjacent fields via grassed waterways onto the road surface.

Recommendation:
The local watershed groups should try to engage landowners and respective government departments to develop long term solutions to point sources of sediment reaching watercourses at stream-road crossings.

3.3.4 Old Pond Basins and Unstable Stream Banks

When man-made dams wash out or are breached, the former pond basins are often covered with several feet of deposited sediment. The amount of sediment that collects over many years in pond basins can be mind boggling. When Mooneys Pond on the Morell River was cleaned out to develop a semi-natural rearing facility, 1,100 tandem truck loads of spoils were removed. This did not include the upper end of the pond which was left untouched because hymacs were getting stuck. By the time Marchbanks Pond on the Wilmot River was about 75% cleared of sediment, 4,400 tandem truck loads of sediment had been excavated (Hill, pers. comm.).

When dams are breached, water flowing through the pond basin rapidly cuts trenches into the sediment until more solid substrate is reached. The banks of the new channel are often steep and unstable for many years. Grasses and alders soon colonize, but in flood conditions, the banks can become undercut and clumps of alders uprooted, causing even more erosion. Partial blockages from overgrown alders or uprooted vegetation will often result in additional erosion from the adjacent bank during flood waters.

Recommendation:

In pond basins where dams no longer exist, growth of deep-rooted grasses should be encouraged, natural stream meanders could be reinforced with cobble along the "long" shoreline (opposite point bar), and planting of shrubs such as red-osier dogwood (Cornus stolonifera) that stabilize without blocking flow would be desirable.

3.4 Limiting Factors in Spawning and Nursery Areas

For a comprehensive list of habitat suitability indices for Atlantic salmon and other anadromous fish on Prince Edward Island, see Appendix I. The challenges in spawning and nursery habitat are presented in the descriptions of each drainage basin (section 5.0).

Atlantic salmon return from sea to their natal river to spawn. Female Atlantic salmon dig redds (nests) in gravel, usually at the tail end of pools where the water starts to speed up. The female "cuts" a depression with her tail in the substrate and deposits eggs which are then fertilized by the male (which may be a grilse, multi-sea winter fish or even a precocial parr). It is preferable that the gravel is deep enough to deposit eggs 20 to 40 cm below the surface. Gravel size may vary but a mixture of stones from thumb to fist sized seems desirable. Cobble or large woody debris in the substrate can prevent gravel movement during flood conditions. Gravel which has a lot of sediment in it will be cleaned by the digging action of the female. However, if a continuous input of fines occurs, they will infiltrate the gravel over the course of egg incubation and may limit the amount of oxygen supplied to the developing embryos. When working in the LaHave River in southwestern Nova Scotia, Gray et al. (1989) reported the following characteristics of ten spawning areas which consistently had high salmon fry densities. "Substrate composition: 5-10% sand (mean 6.4); 40-80% gravel (mean 58.0); 10-40% cobble (mean 11.7)." The authors continue with their description of good spawning habitat as "… those areas which had less than 10% sand; 40-80% gravel with 10-40% cobble and occasional boulders (less than 20%); stream velocities of 58-98 cm/sec and stream depths of 30-48 cm at spawning; stream gradient were usually greater than 0.5% and stream sections consisted of at least 50% riffle and run."

The first challenge facing Atlantic salmon returning to spawn in Prince Edward Island streams is navigating around or over stream blockages. Rarely are fallen trees, even big "jackpots of woody debris, obstacles to fish passage but beaver dams frequently block movement upstream (section 3.2.3). When such blockages occur, salmon often spawn in less desirable locations. If the blockage is near the head of tide, no spawning occurs in the river that year and the year class of salmon is subsequently absent.

In many rivers, traditional salmon spawning sites are known to be used each year. For instance, salmon traditionally spawn immediately downstream from the former bridge crossing at Leards Pond on the Morell River. These are mostly large fish and spawning success is probably high, since the stream bottom is relatively clean (because of Leards Pond acting as a gigantic sediment trap) and the substrate composition appears ideal for spawning. In the late 1980s, it was observed that salmon of Rocky Brook (Miramichi River) origin, stocked from the semi-natural rearing pond on the Morell River, concentrated their spawning much further upstream than Leards Pond, sometimes in tributaries a mere 2 metres wide. The Rocky Brook origin fish usually completed spawning one to two weeks earlier than fish using traditional sites.

Some Prince Edward Island streams have few holding pools for adults and salmon may resort to spawning in shallow, swift water near any available cover or often, at the top end of shallow pools. Reaches of many streams have gravel so shallow that numerous “scrapes” are made in poor quality substrate before a suitable depth of gravel is found above the subsurface hardpan. The distribution of suitable spawning gravel has been shown to limit salmonid populations (Kondolf and Wolman 1993) and this is probably affecting spawning success in many Prince Edward Island streams.

Good nursery areas for newly hatched Atlantic salmon should occur immediately downstream from spawning sites. Young-of-the-year salmon prefer a gravel substrate from 1.6 – 6.4 cm in diameter in rather shallow water (Symons and Heland 1978). Older parr choose habitat that has a high component of larger cobble/boulder material which normally occurs where higher stream velocities prevail. Un-embedded cobble substrate in salmon streams is of critical importance as sheltering areas for parr in autumn and winter (Cunjak 1988; Rimmer et al. 1984) and for sheltering in summer (Gries and Juanes 1998).

Figure 4. Atlantic salmon parr.

The optimal temperature for incubation of Atlantic salmon eggs is about 6˚C (Peterson et al. 1977). On Prince Edward Island, water temperatures are much lower than this during egg incubation. Upper reaches of many streams do not freeze over because of the amount of spring water input. However, when redd surveys were being conducted on Prince Edward Island in late November 2008, there were several days when water temperatures were between 1˚C and 2˚C and surface ice was present. Witzel and MacCrimmon (1983) have noted that water temperature within trout redds can be considerably warmer than on the substrate surface. It would be expected that the deeper the salmon eggs are buried, the warmer they would remain during incubation, especially if there are any ground water seeps in the nearby upstream areas. Some stream reaches have multiple springs in the adjacent riparian zone or seeps on the stream bottom which flow into the watercourse all winter. Water coming from springs up to several hundred metres from streams can be noticeably warmer at the stream entry point than the rest of the river water. Some research suggests that low dissolved oxygen levels in long residence ground water could have negative impacts on incubating salmonid eggs (Youngson et al. 2004). However, with the nature of the fractured sandstone bedrock on Prince Edward Island, ground water is unlikely to have low levels of oxygen and concentrations recorded in springs on the Morell and other rivers have been high.

All streams on Prince Edward Island are affected, to some degree, by sediment and in many watercourses, poor quality substrate is likely limiting salmon populations. Sections of stream that have the best habitat for juvenile salmonids are usually found downstream from impoundments or sediment traps designed for regular removal of sediment. In other reaches of stream, it is common to have gravel, cobble and even boulders partly or completely covered by bottom sediments. This limits the number of juvenile salmon that can use this habitat in summer and may play a major role in winter survival with disappearance of sheltering sites within the streambed. In early summer, 2008, I surveyed two river systems, Clarks Creek and North River, and documented a considerable quantity of potential spawning and nursery habitat. However, during the salmon redd survey in November, both systems were found to have much of the quality habitat covered with sediment, likely from torrential rainfall events in late summer. On the other hand, in rivers like North Lake Creek, the amount of sediment does not appear to change (unless a beaver impoundment is established), salmon spawn in the same places each year and nursery areas in the runs downstream from the redds have abundant young-of-the-year salmon the following summer. Unusually heavy rainfall events occurred in 2008, especially in August, but this will likely become the norm in future as global climate change takes place. Therefore, one of the major thrusts for improving Atlantic salmon populations on Prince Edward Island has to be soil stabilization in all seasons on the uplands and sediment consolidation or removal within the stream system.

3.5 Interactions with other Freshwater Fish Species

According to federal government reports, rainbow trout were first stocked in Pisquid Pond and O'Keefes Lake in 1924. Rainbow trout broodstock were taken from these sites and fry were frequently moved from mainland hatcheries and released in various locations on Prince Edward Island. Many rivers are suspected to have received their stocks of rainbow trout as escapees from aquaculture operations located on various drainage basins or estuaries. In some watercourses, such as the Dunk River, Wilmot River, Bradshaw River, and West River, rainbow trout flourished and in some parts of these rivers, their population levels are now comparable to those of brook trout. In other rivers where rainbow trout were released, such as the Morell River and St. Peters River, the populations have disappeared. Currently, there are rainbow trout in nine of the remaining twenty-two rivers which have Atlantic salmon on Prince Edward Island.

Rainbow trout share similar habitat to Atlantic salmon and it has long been suspected that they might out-compete other salmonids in certain circumstances. For instance, in 2002 following at least two farm pesticide runoff events in which thousands of fish died in the Wilmot River, a much higher percentage of rainbow trout survived than brook trout (Gormley 2003). I have observed that in cold headwater streams, brook trout normally appear to be more abundant than rainbow trout, while in very warm reaches of some rivers, where summer water temperatures range from 20-25˚C, Atlantic salmon are much more abundant than brook trout. To date, little information is known about the interaction and competition between rainbow trout and Atlantic salmon on Prince Edward Island and therefore, studies should be conducted to determine whether or not rainbow trout are actually detrimental to salmon populations.

Recommendation

Research should be conducted, perhaps as a Masters study, to determine the impact of introduced rainbow trout on populations of Atlantic salmon and brook trout on Prince Edward Island.

Other fish species, such as smelts, gaspereau and blue-backed herring share the same river reaches as juvenile Atlantic salmon in spring and are undoubtedly a benefit to the salmon. The prodigious quantities of eggs deposited by these species will, in many locations, be eaten by salmon parr or trout. It is not unusual for anglers fishing the Morell River in June to catch trout and young salmon filled with eggs. At one time, the runs of smelts, gaspereau and blue-backed herring on the Morell River were so large that sections of the river would become slippery from the volume of deposited eggs. In rivers where blockages prevent upstream migration of these fish, salmonids can be deprived of an abundant food source.

3.6 Over-wintering Habitat

The lack of suitable over-wintering habitat may be a limiting factor for Atlantic salmon in some Prince Edward Island rivers. During the winter of 1996-1997, I was involved in a study in which incubation baskets containing gravel and salmon or trout eggs were buried in various regions of the Morell River. Gravel from each site was sieved before being placed in the incubation baskets. By mid-June 1997, sediment had infiltrated all of the baskets and in some cases, a “plug” was formed at the top which prevented juvenile salmon from emerging. If it is assumed that most parr would require winter sheltering space under or beside large cobble-sized substrate, then the amount of sediment and embeddedness of cobble would certainly degrade over-wintering habitat in many river reaches on Prince Edward Island. Salmon parr have been encountered in pools during winter electrofishing activities, but with large trout also present, life must be rather precarious for the smaller salmon parr in these areas.

Winter weather conditions which influence river water levels, and often sediment impact into streams, can vary dramatically from year to year or sometimes even from county to county. From 2000-2005, there were no mid-winter thaws that lasted for more than a day or two and stream water levels under such conditions can lower substantially as the water table drops and ground water input into the stream decreases. There are no data available on Prince Edward Island to suggest how such climatic conditions would affect Atlantic salmon. However, I have observed that in years with minimal mid-winter thaws, brook trout had hatched before spring run-off and the densities of juvenile brook trout were high the following summer.

On larger rivers on Prince Edward Island, the upper reaches, being spring fed, are usually free of ice in winter. In lower reaches, slow water areas such as pools may be ice covered but sections with spring water input and faster moving riffles may stay open, even when air temperatures are many degrees below 0˚C. In some cases, frazil ice forms when the water temperature approaches 0.0˚C and water is bounced into the cold air with the turbulence found in riffles. Downstream, the super-chilled frazil ice then tends to clump and stick to any object, often coating even a small branch or stone to become a grotesque structure sometimes a foot or two in diameter. The formation of frazil and anchor ice likely occurs in other salmon rivers in winter, as reported by Cunjak and Caissie (1993) in the Northwest Miramichi River in New Brunswick.

I do not know how frequently frazil ice or anchor ice occurs in Prince Edward Island streams in winter or how it affects Atlantic salmon redds or juveniles. However, in the winter of 1992-93, the phenomena was observed on three different days on the Morell River, once below Mooneys Pond and on two different occasions, upstream from Indian Bridge. On all occasions, every object within the stream channel appeared to be coated with enormous quantities of ice and the river was overflowing its banks, yet the river depth returned to normal levels downstream from springs. This anchor ice phenomenon can result in considerable movement of sediment and gravel when bright sunshine causes the ice to lift and move downstream, dropping its substrate cargo in areas "warmed" by inputs of ground water. In both locations on the Morell River where this was observed, good summer populations of Atlantic salmon parr occur and the Mooneys Pond site had many redds during the previous autumn.

3.7 Migration to Sea

After spawning, adult salmon drop downstream to deep pools or a pond to spend the winter. In many of our Prince Edward Island streams, these kelts (black salmon) are frequently seen in pools near the head of tide during the first week of the angling season which starts on April 15th of each year. At this time, rainbow smelt have started their upstream ascent in many watercourses and they provide abundant food for the kelts. The seaward movement of Atlantic salmon smolts is dependent upon water temperature and on Prince Edward Island, at least on the Morell River, this outward migration seems to be particularly prominent during the first two weeks of May. From the former semi-natural rearing site at Mooneys Pond, exiting smolts were counted and although a few might leave the pond at any time during day or night, the bulk of movement appeared to be between sundown and midnight, especially on warm, wet nights. Movement downstream from Mooneys Pond was rapid, with marked smolts (adipose fin clipped) arriving near the head of tide within two to three days. We have no information as to how long it took salmon smolts to leave the Morell River estuary, but there is a relatively short window of time to reach the sea for good sea survival (Bley 1987), and various researchers have found that there is no period of adjustment needed before moving into salt water (McCleave 1978, Moose et al. 1995). In the Morell River estuary, it is unlikely that either birds or mammals would have much luck preying upon migrating smolts because of the high number of anglers, both on shore and in boats during the first month of the angling season. However, in some Prince Edward Island estuaries, angling activity is light and both double-crested cormorants (*Phalacrocorax auritus*) and harbor seals (*Phoca vitulina*) are abundant. If there is a strong run of rainbow smelts, the estuarine impact of the predator gauntlet on salmon smolts or post smolts may be diluted; if not, it might be desirable to consider daytime disturbance of the birds so they move to other feeding areas during the smolt run.

Prior to stocking smolts on the Morell River, care was taken to ascertain that no blockages would prevent the fish from moving downstream. Dead salmon parr, smolts and even adults have been found entangled in beaver dams. On one occasion, a beaver dam below Kennys Bridge not only prevented smolts from descending in spring but many kelts from the previous autumn were also present in the beaver impoundment in early June. In such cases, even if the dam were breached, the "window of opportunity" for smolt movement to sea would have closed.

Recommendation
In all rivers on Prince Edward Island with Atlantic salmon, tributaries that would likely have salmon smolts should be visited in early April with the intent to identify and remove any blockage that would prevent migration of smolts to sea.

3.8 From Sea to Fresh Water

Salmon returning from sea no longer have to run the gauntlet of salmon berths – the last of which were bought back in St. Peters Bay several decades ago. With the exception of a few fish in the Dunk, Morell and West rivers, the salmon returning to Prince Edward Island waters are late-run fish which often do not appear in fresh water until October and November. Thus, the salmon do not have to contend with estuaries which go anoxic during summer months. However, this does not mean returning salmon have a free ride through the estuaries. In some places, for example the entrance to Charlottetown harbor, large numbers of seals can pose a threat to the migrating fish.

In some rivers, such as Carruthers Brook, regular deep pools occur close to spawning sites, providing shelter for Atlantic salmon before they spawn. In other streams, there is a scarcity of pools which likely limits spawning distribution and makes waiting salmon vulnerable to predation, especially by bald eagles (*Haliaeetus leucocephalus*).

In order to detect trends in salmon spawning attempts, redd surveys were conducted each year on all major tributaries of the Morell River for almost a decade and thereafter, they were done more sporadically. Likewise, various other rivers were occasionally surveyed for redds but no complete salmon redd survey of Prince Edward Island salmon streams has been attempted until 2008. The "window" for doing redd surveys usually extends from about the second week in November until freeze-up. Before November 11, a traditional starting time for redd surveys on the Morell River, some salmon will not yet have spawned. However, if there is an early freeze-up, conducting redd surveys in December may not be practical. Normally, streams on Prince Edward Island are late to freeze because of the large proportion of 7˚C ground water in autumn. However, in 2008, very cold weather came early, along with considerable snow and ice. The cold weather was interspersed with heavy rainfall events so conducting redd surveys was challenging. With the help of volunteers, assistants and students from Holland College (they surveyed all three tributaries of the Morell River) all rivers with salmon runs were checked. Complete surveys for Priest Pond Creek, Trout River

(Coleman), Cains Brook and Carruthers Brook were not practical, although sections of each of these streams were checked to ensure that blockages were not preventing salmon from reaching preferred spawning regions. Table 2 indicates numbers of redds counted on each drainage basin in 2008 and presents data from other years when several rivers were surveyed. The locations of redds in each river is shown on maps in section 5.0. Redd maps are not included for those rivers where salmon redds could not be found.

All individuals helping to count redds in 2008 were given a “trial run” by the author to ensure consistency in data collection, namely:

- Good visibility (substrate clearly seen);
- Polarized glasses worn by surveyors;
- Where practical, counts were done by two people walking upstream;
- Redds counted had an obvious deep depression at the upstream end;
- Redds counted were 0.5 metres or more in width and 1.0 metre of more in length;
- Scrapes were distinguished from redds (usually the result of hardpan under gravel) and not counted.

Along with counting salmon redds, surveyors also noted major trout spawning areas and blockages which could prevent movement of fish within the stream reach. Beaver blockages often stop upstream migration of salmon, and redd counts reflect how far fish can go before the blockage occurs. For instance, no salmon redds were observed on the Vernon River in 2008, likely because of a blockage near the head of tide. Also, salmon were prevented from ascending to some traditional spawning areas in Bristol Creek, Cross River, Head of Hillsborough, Midgell River, Naufrage River, Priest Pond Creek, St. Peters River and Trout River/Bank Brook (Tyne Valley).

Figure 5. Atlantic salmon stacked in a pool downstream from Mooneys Pond, Morell River, awaiting autumn spawning season.

Table 2. Number of Atlantic salmon redds counted in Prince Edward Island rivers in 1992, 1993, 2004, 2005 and 2008.

River	**Number of Salmon Redds**				
	2008	**2005**	**2004**	**1993**	**1992**
Class I					
Cains Brook	58*	n/a	n/a	n/a	n/a
Carruthers Brook (Mill River)	152*	n/a	n/a	311	n/a
Cross River	120	n/a	n/a	n/a	n/a
Naufrage River	100	n/a	53	32	n/a
North Lake Creek	200	68	84	36	200
Pisquid River	38	17	14	n/a	n/a
Priest Pond Creek	11*	n/a	n/a	n/a	n/a
St. Peters River	53	n/a	n/a	93	n/a
Trout River (Coleman)	2*	n/a	n/a	58	33
West River	141	n/a	18*	165	274
Class II					
Clarks Creek	0	n/a	n/a	n/a	n/a
Dunk River	17*	n/a	n/a	6	n/a
Midgell River	69	n/a	64	77	n/a
Morell River	328	n/a	71*	377	917
Vernon River	0	n/a	n/a	n/a	n/a
Class III					
Bristol Creek	7	11	15	41	n/a
Cardigan River	0	n/a	n/a	n/a	n/a
Head of Hillsborough	0	n/a	n/a	n/a	n/a
Little Trout River	11	12	5	n/a	n/a
North River	18	n/a	n/a	n/a	n/a
Wilmot River	0	n/a	n/a	n/a	n/a
Trout River/Bank Brook (Tyne Valley)	14	n/a	n/a	n/a	n/a

* Incomplete Count

Data for 2008 – collected by D. Guignion, Kirk Roach, Fred Cheverie, Erica MacIsaac, Cathy Gallant, Christina Pater and Holland College students

Data for 1992 and 1993 – collected by Dave Biggar, Cindy Crane, Todd Dupuis, D. Guignion and Rosanne MacFarlane

Data for 2004 and 2005 – collected by D. Guignion and Rosanne MacFarlane