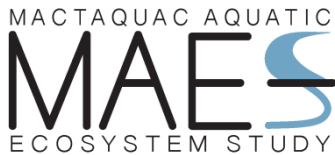


**Mactaquac Aquatic Ecosystem Study
Report Series 2016-053**



**ASSESSMENT OF AMERICAN EEL
OCCURENCES IN THE SAINT JOHN
RIVER BASIN UPSTREAM OF
MACTAQUAC, NEW BRUNSWICK**

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12 January 2017



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EXECUTIVE SUMMARY

This report provides a review of published and unpublished data regarding American Eel (*Anguilla rostrata*) occurrences in the Saint John River basin with emphasis on locations upstream of the Mactaquac Generating Station (MGS). The earliest published reports of American Eel in the upstream reaches were released by the Department of Fisheries and Oceans (DFO) in the late 1960's and throughout the 1970's. These surveys revealed that upstream densities were decreasing over time while remaining substantially lower than densities in the downstream tributaries. The Saint John River Basin Board also released reports on species presence in the early 1970's with several recorded occurrences of American Eel in the tributaries upstream of the MGS. Considerable declines in eel counts were observed at Beechwood and Tobique generating stations over the last 40 years, most notably at Beechwood during the 1970's when numbers declined from >30,000 to less than 1,000 per year, and further to less than five per year in the last 15 years. Despite several extensive stream fish surveys from 1995-2016, eels were rare and they have not been reported since 2000.

1 INTRODUCTION

The American Eel (*Anguilla Rostrata*) is a migratory, snake-like fish that occupies an extensive range along the eastern coast of North America. They are panmictic (members of a single population) and catadromous spawning in the North Atlantic Ocean before migrating to freshwater as elvers (glass eels). American Eel elvers typically enter southwestern New Brunswick watersheds between early May and late June where they reside in estuaries as well as rivers and streams further inland (Jessop 1998). They have been historically fished in the Maritimes Region by indigenous peoples for food, social and ceremonial purposes. The commercial fishery in the Maritimes Region is the only active eel fishery in Canada (Bradford 2016). American Eel habitat is under protection as part of the Canadian Fisheries Act and their status was classified as threatened following a 2012 assessment (COSEWIC 2012).

The Saint John River is managed for hydropower production by a provincial owner-operator, the New Brunswick Power Corporation (NBP). NBP operates a number of hydropower facilities in the Saint John River basin, and the largest are the Mactaquac, Beechwood, Tobique-Narrows, and Grand Falls generating stations. This report aims to inform NB Power about American Eel presence in the middle to upper reaches of the Saint John River basin with focus on assessments conducted upstream of the Mactaquac Generating Station (MGS). Data from the pre-construction period (prior to the 1960's) was not published in reaches upstream of the MGS and are limited to downstream commercial data released in the Federal Fisheries Branch Annual Reports (1868-1917) and again by Smith (1959). Post-construction data (1970's to present) are more common and have been compiled herein from both published and unpublished sources. Francis (1980) surveyed 19 sites upstream and another 29 downstream via electrofishing while Meth (1973) catalogued American Eel presence in the middle and upper reaches of the basin. Smaller tributaries were assessed by private consultants as part of Environmental Impact Assessments (EIA's) for the Trans-Canada Highway upgrades from 1994 to 2005. Fish passage has been monitored at both the Tobique-Narrows and Beechwood generating stations and records include published and unpublished data. Lastly, unpublished data was collected from the Canadian Rivers Institute (CRI) as well as the Department of Fisheries and Oceans (DFO), where Gautreau (2011) and Bradford (2016) assessed tributaries upstream and downstream of the MGS from the early 1990's to present.

2 DATA REVIEW

2.1 PRE CONSTRUCTION DATA

Data collected and published prior to the construction of the MGS in the 1960's consists only of commercial data released in the annual reports by the Federal Fisheries Branch from 1868 to 1917. These reports only record American Eel catches (tonnes) in the tidal waters of the Saint John River (i.e. from Gagetown to Saint John). Smith (1959) also collected commercial data downstream of the MGS in the 1960's.

2.2 POST CONSTRUCTION DATA

2.2.1 FRANCIS (1980)

This DFO report mainly focused on summarizing juvenile Atlantic salmon populations but also recorded counts of other species including the American Eel. Major tributaries were assessed from 1968 to 1978 and ranged from Salmon River in the Grand Falls system to the Saint John River valley (Table 1). Barrier nets enclosing approximately 100m² were put up on opposite ends of each site and the area was electrofished five times in succession by boat and backpack; captured fish were placed in live wells on shore after each pass. Habitat information was also collected at each site.

Sampling sites were relatively uniform in structure, consisting of riffles, runs and pools with coarse substrates (i.e. gravel to cobble). Sites fished upstream of the MGS from 1968 to 1970 were omitted from comparisons because of low sample sizes (less than three sites per year). Densities (#/100m²) upstream declined from 1.13 to 0.12 (10%) from 1971 (N=14) to 1978 (N=12), respectively (Figure 1a). Conversely, densities downstream showed an overall increasing trend with values ranging from 2.05 in 1970 (N=5) to 12.8 in 1977 (N=24; Figure 1b). Although more sites were assessed downstream of the MGS (+10), total average densities (i.e. sum of average densities/number of sites assessed) between upstream (0.53) and downstream (2.96) tributaries differed by 18%.

Table 1. Locations of sites assessed with American Eel presence. Electrofishing surveys were conducted from 1968 to 1978 at tributaries upstream (US) and downstream (DS) of the MGS.

System	River Name and Location	Relative Location	N (Years)	Years Assessed
Grand Falls	Salmon R.	US	4	1975-78'
Tobique	Wapskehegen R.	US	8	1971-78'
Tobique	Gulquac R.	US	8	1971-78'
Tobique	Campbell R.	US	7	1971, 1973-78'
Tobique	Little Tobique R.	US	8	1971-78'
Shikatehawk	Shikatehawk R. (Lockharts Mill)	US	5	1971-75'
Shikatehawk	Shikatehawk R. (Gordonsville)	US	6	1971-76'
Shikatehawk	Shikatehawk R. (West Glassville)	US	7	1971-76', 78'
Shikatehawk	Shikatehawk R. (Centre Glassville)	US	6	1971-76'
Shikatehawk	Shikatehawk R. (Kenneth)	US	6	1971-76'
Becaguimec	Coldstream (Bannon)	US	7	1971, 1973-78'
Becaguimec	Coldstream (East Coldstream)	US	8	1971-78'
Becaguimec	Coldstream (County Line)	US	8	1971-78'
Becaguimec	North Branch (Cloverdale)	US	8	1971-78'
Becaguimec	North Branch (Carlisle)	US	8	1971-78'
Nackawic	Northeast Nackawic R. (Upper Caverhill)	US	4	1975-78'
Nackawic	Northeast Nackawic R. (Millville)	US	5	1974-77'
Keswick	Keswick R. (Jones Forks)	DS	8	1968-69', 1971'-76'
Keswick	Keswick R. (Zealand Stn.)	DS	8	1968-69', 1971'-76'
Keswick	Keswick R. (Stoneridge)	DS	9	1968-76'
Keswick	Keswick R. (Iiayne)	DS	8	1968-69', 1971'-76'
Keswick	Keswick R. (Barton)	DS	9	1968-76'
Nashwaak	Penniack Stream (Penniack)	DS	8	1971-78'
Nashwaak	Nashwaak R. (Durham Bridge)	DS	10	1968-69', 1971'-78'
Nashwaak	Tay R.	DS	10	1969-78'
Nashwaak	McKenzie Brook	DS	8	1969, 1971-78'
Nashwaak	Nashwaak R. (Nashwaak Bridge)	DS	10	1969-78'
Nashwaak	Cross Creek	DS	8	1969, 1971-77'
Nashwaak	Nashwaak R. (below Stanley)	DS	10	1968-69', 1971-78'
Nashwaak	Nashwaak R. (above Stanley)	DS	10	1968-69', 1971-78'
Nashwaak	Nashwaak R. (Cedar Bridge)	DS	9	1969, 1971-78'
Nashwaak	Nashwaak R. (Doughboy Brook)	DS	9	1970-78'
River Valley	Hammond R. (Smithtown)	DS	5	1974-78'
River Valley	Hammond R. (Hanford Brook)	DS	5	1974-78'
River Valley	Kennebecasis R. (Penobsquis)	DS	7	1968-69', 1974-78'
River Valley	Kennebecasis R. (Goshen)	DS	5	1974-78'
River Valley	Nerepis R. (River George)	DS	4	1974-77'
River Valley	Nerepis R. (Dunn Road)	DS	4	1974-77'
River Valley	Belleisle Creek (Springfield)	DS	5	1974-78'
River Valley	Canaan R. (East Canaan)	DS	4	1974-77'
River Valley	Gaspereau R. (Upper Gaspereau)	DS	5	1974-78'
River Valley	Gaspereau R. (below bridge on route 123)	DS	2	1976-77'
River Valley	Salmon R.- Chipman (Big forks stream)	DS	5	1974-78'
River Valley	Salmon R.- Chipman (Little forks stream)	DS	4	1974-77'

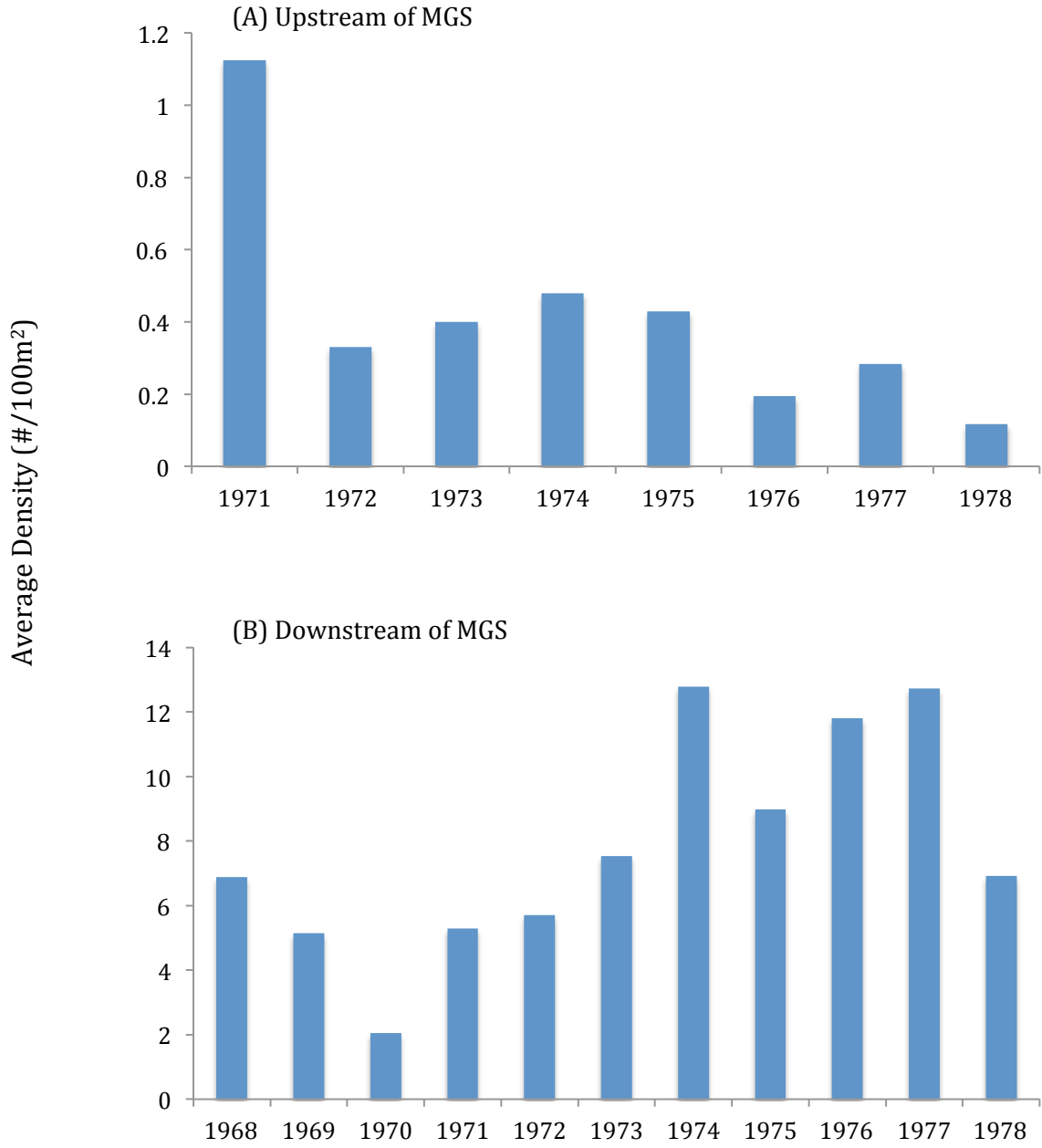


Figure 1. Average densities (#/100m²) recorded in tributaries upstream (A) and downstream (B) of the Mactaquac Generating Station (MGS) in the Saint John River basin (source: Francis 1980).

2.2.2 METH (1973)

The Saint John River Basin Board released a report series in the early 1970's on the ecology of fish species in the basin with Atlantic salmon at the forefront. Within these reports was a map catalogue with arrows used to indicate the presence of certain species. Information for this catalogue was gathered from a number of sources including the New Brunswick Department of Natural Resources (DNR) and the Resources Development Branch of the Federal Fisheries Service (Environment Canada). A variety of capture techniques were employed including seine and trap nets in the headponds and lakes as well as electrofishing in the more riverine sites. American Eel were encountered as far upstream as Fish River (Edmundston area) and were recorded 27 more times throughout the Saint John River basin upstream of the MGS. Only 11 occurrences of American Eel were recorded in the downstream reaches of the basin (Table 2).

Table 2. Locations of American Eel presence from surveys conducted in tributaries upstream and downstream of the MGS (source: Meth 1973).

River/Lake	Relative Location	Occurrences (#)
Fish R.	US	1
Aroostook R.	US	1
Tobique R.	US	2
Odell R.	US	1
Wepskehegen R.	US	1
Gulquac Lake	US	1
Trousers Lake	US	1
St. John R.	US	2
Monquart R.	US	1
Presque Isle R.	US	2
Shikatehawk R.	US	1
Becaguimec R.	US	2
Little Presque Isle R.	US	1
Meduxnekaeg R.	US	2
St. John R.	US	1
Eel River	US	1
Nackawic R.	US	1
St. John R.	US	1
Davidson Lake	US	1
Lake George	US	1
St. John R.	US	1
Mactaquac R.	US	2
Keswick R.	DS	1
Nashwaak R.	DS	1
Grand Lake	DS	1
Yoho Lake	DS	1
Oromocto Lake	DS	1
Oromocto R.	DS	1
St. John R.	DS	1
St. John R.	DS	1
St. John R.	DS	1

2.2.3 TRANS CANADA HIGHWAY EXPANSION STUDIES

A total of 93 tributary crossings were assessed prior to upgrades along the Trans-Canada Highway for fish presence in five reports by private consultants from 1994 to 2005. The following list describes their locations and references:

- Grand Falls to Aroostook (Jacques Whitford 2004);
- River de Chute to Florenceville (ACER 2003);
- Florenceville Interchange (AMEC 2005);
- Route 95 (Jacques Whitford 2005);
- Perth-Andover to Woodstock (Jacques Whitford 2004);
- Woodstock to Meductic (Washburn and Gillis 1994); and
- Pokiok to Longs Creek (Jacques Whitford 2003).

These tributaries were mostly small streams that ranged from Grand Falls to Longs Creek; each stream was electrofished for approximately 500 metres on either side of the proposed crossing. In combining all of these studies, only one (1) eel was captured and that was just south of Woodstock in Bulls Creek (Washburn and Gillis Associates LTD., 1994). A comprehensive table of the site names that were surveyed in these reports is listed in the appendices (Table 4).

2.2.4 FISH PASSAGE AND UNPUBLISHED DATA

Fish passage has been monitored at the Tobique-Narrows and Beechwood generating stations with data compiled from both published and unpublished sources. American Eel were observed using the Tobique-Narrows fishway prior to the construction of the Mactaquac and Beechwood generating stations but no counts were recorded (Smith 1979). Unpublished counts recorded by Jones (2014) reveal that only 33 eels passed through the Tobique-Narrows fishway since 1990. Counts at the Beechwood generating station were recorded since 1972 where initial records showed marked declines in the first 10 years from over 30,000 to 831 in 1982 (Ingram 1987). Annual counts continued to plummet in the 1990's and no more than four eels per year have been recorded in the past 15 years (Table 5 of appendices). American Eel records at the MGS were not counted due to their passage through larger mesh sizes at the counting facility (Ingram and Ensor 1990).

The most recent information on American Eel presence throughout the Saint John River basin comes in the form of unpublished data compiled from the Canadian Rivers Institute (CRI) and the Department of Fisheries and Oceans (DFO). Both CRI (Gautreau, unpublished) and DFO (Bradford, 2016) have collected presence and density data in tributaries surrounding the MGS since the early 1990's. Although published data on species presence are available in the State of the Saint John River Report (CRI), little information was provided on precise years when each species was recorded. To resolve this, raw data was compiled from electrofishing surveys conducted by the CRI in 2011 and summary results of locations upstream of MGS where American Eel were found are presented in Table 3. In addition to these data, 40 more tributaries upstream of the MGS were assessed in 2015 and 2016 with no records of American Eel presence- the site names of these tributaries are listed in Table 4 of the appendices. Data provided by the

CRI indicates that the American Eel has gone undetected in the upstream reaches of the MGS for the past 16 years. Furthermore, electrofishing surveys conducted upstream of the MGS from 1992 to 2012 by Bradford (2016) recorded only two captures of American Eel in 1996 and 2000 from the Tobique and Meduxnekaeg Rivers, respectively. The same capture methods were employed in eight tributaries downstream of the MGS during the same time period with over 5,000 eels recorded (3,886 of which were captured in the Nashwaak River alone). The corresponding density tables are presented in the appendices (Table 6).

Table 3. Locations of American Eel presence from electrofishing surveys conducted in tributaries upstream of the MGS (source: Curry and Munkittrick 2005).

River/Lake	Year	Relative Location	Occurrences (#)
Nictau Lake	1998	US	1
Saint John River – Hartland	2000	US	1
Saint John River – Nackawic	2000	US	1
Tobique River – Reservoir	2000	US	1
Saint John River - Woodstock	2000	US	1

3 DISCUSSION AND RECOMMENDATIONS

The data presented in this report indicates an overall declining trend in eel presence and abundance in tributaries upstream of the MGS. Density data presented by Francis (1980) and presence data catalogued by Meth (1973) indicate that the American Eel was likely an established species in the upstream reaches prior to construction of the MGS in the 1960's. Annual counts recorded at the Beechwood generating station in the 1970's are an indication of how abrupt these declines were following construction where numbers dropped by nearly 30,000 over a 10-year period. These declines have culminated in recent times with the absence of American Eel from data records collected by private consultants, the CRI and DFO in the last 15 to 25 years while the population continues to thrive in tributaries downstream, most notably in the Nashwaak River.

Similar declines in American Eel presence and abundance have also been observed throughout the 1980's and 90's, most notably in the northernmost part of their range in the upper St. Lawrence River and Lake Ontario (Casselmann 2003). The earliest indicator of the declines in this region came from records of juvenile eels ascending the R.H. Saunders dam on the St. Lawrence River where counts were reduced by ~10,000 from the early 1980's to 1990's (Castonguay et al. 1994). Significant negative trends in abundance of American Eel were also found in data sets from the Hudson River basin in New York and Virginia (Haro et al. 2000).

Despite the fact that American Eels are capable of passing considerable natural barriers (e.g. waterfalls and weirs), dams may pose as a more serious limitation where eel numbers have often been found to decrease upstream of dams and subsequently increase immediately downstream, often disrupting community structure (Machut et al. 2007). Eel removals upstream could account for ~25% decreases in total fish biomass in smaller tributaries (Ogden 1970, Hitt et al. 2012) as

well as further limiting the amount of female eel production (Krueger and Oliveira 1999). On the other hand, increases in densities downstream may lead to greater competition, often resulting in decreases in growth and survival rates (Matchut et al. 2007).

Hitt et al. (2012) found that the removal of the Embrey Dam on the Rappahannock River in Virginia was directly correlated with significant increases in American Eel abundance in headwater tributaries from 2004 to 2010. Greater numbers of small-bodied eels (<300 mm) were also recorded in the upstream tributaries, suggesting that smaller size classes were most affected. Similarly, eel ladders have proven to be an effective method for reducing the density of small American Eels (<20 cm) as well as potentially enhancing the productivity of sexually mature eels (Schmidt et al. 2009).

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5 APPENDICES

Table 4. Site names of electrofishing locations surveyed by private consultants during upgrades to the Trans-Canada Highway from 1994 to 2005 and by the CRI as part of the Mactaquac Aquatic Ecosystem Study (MAES) in 2015 and 2016. Sites are arranged in order from upstream tributaries in the Grand Falls area to Longs Creek in the Mactaquac headpond.

Site Name	Trans-Canada Highway	MAES
OtterSlide Brook		X
Bogan Brook		X
Mooney Brook		X
Foley Brook		X
Godin Brook		X
Godin Brook		X
Outlet Brook		X
Tributary to Rapide de Femme Stream	X	
Rapide de Femme Stream	X	
Rapide de Femme Stream	X	
Rapid de Femme	X	
Tributary to Rapide de Femme Stream	X	
Tributary to Rapide de Femme Stream	X	
Tributary to Saint John River	X	
Tributary to Saint John River	X	
Tributary to Boutot Brook	X	
Boutot Brook	X	
Boutot Brook	X	
Boutot Brook		X
Tributary to Mill Brook	X	
Tributary to Saint John River	X	
Tributary to Saint John River	X	
Little River		X
Limestone Stream		X
Aroostook River	X	
Tributary to Saint John River	X	
Little River		X
Bishop Brook		X
Wark Brook	X	
Tributary to Saint John River	X	
Tributary to Saint John River	X	
Tributary to Saint John River	X	
Tributary to Saint John River	X	
Tributary to Saint John River	X	
Plant Brook	X	
Demerchant Brook	X	
Bryson Brook	X	

Table 4. Continued

Site Name	Trans-Canada Highway	MAES
Graham Brook (Access Road)	X	
Graham Brook (Bishops Lake)	X	
Graham Brook	X	
Tributary to River de Chute	X	
River de Chute		X
River de Chute	X	
Muniac Stream		X
Muniac Stream		X
Tributary to Upper Guisiguit Brook	X	
Upper Guisiguit Brook	X	
Tributary to Upper Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Shikatehawk		X
Shikatehawk Mouth		X
Bumfrow Stream		X
Bumfrow Stream		X
Tributary to Leith Lake	X	
Headwaters for Leith Lake	X	
Tributary to Hunters Brook	X	
Tributary to Hunters Brook	X	
Hunters Brook	X	
Tributary to Upper Guisiguit Brook	X	
Upper Guisiguit Brook	X	
Upper Guisiguit Brook	X	
Tributary to Upper Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Tributary to Lower Guisiguit Brook	X	
Monquart Stream		X
Monquart Stream		X
Little Shikatehawk		X
North Shikatehawk		X
Tributary to Watercourse #5	X	
Headwaters for Watercourse #5	X	

Table 4. Continued

Site Name	Trans-Canada Highway	MAES
Headwaters for Leith Lake	X	
Buttermilk Brook	X	
White Marsh Creek (Downstream site)	X	
White Marsh Creek (Upstream site)	X	
Whitemarsh Creek		X
Whitemarsh Creek		X
Gregg Brook		X
Unnamed Tributary to Mill Brook	X	
Unnamed Tributary to Mill Brook	X	
Unnamed Tributary to McQuarrie Brook	X	
Unnamed Tributary to McQuarrie Brook	X	
McQuarrie Brook	X	
Unnamed Tributary to Mill Brook	X	
McQuarrie Brook (Plymouth Road)	X	
Unnamed Tributary to Morrison Lake (Route 540)	X	
Hales Brook		X
Hales Brook		X
Cold Stream		X
Becaguimec Stream		X
Big Presque Isle Stream	X	
Big Presque Isle Stream		X
Tributary to Big Presque Isle Stream	X	
Tributary to Little Presque Isle Stream	X	
Little Presque Isle Stream	X	
Little Presque Isle Stream	X	
Little Presque Isle		X
Acker Brook		X
Lanes Creek	X	
Tributary to Harpers Brook	X	
Tributary to Harpers Brook	X	
Harper Brook	X	
Meduxnekaeg River		X
Tributary to Meduxnekeag	X	
Bulls Creek		X
Bulls Creek		
Lilly Brook	X	
Lilly Brook	X	
Hays Brook	X	
Gibson Brook		X
Unnamed Tributary	X	
Jewetts Creek	X	
Jewetts Creek	X	

Table 4. Continued

Site Name	Trans-Canada Highway	MAES
Peter Smith Brook	X	
Unnamed Tributary	X	
Waterloo Creek	X	
Joslin Creek	X	
Tweedie Brook	X	
Allandale Brook	X	

Table 5. Annual American Eel counts at the Tobique and Beechwood generating stations in the middle reaches of the Saint John River basin (source: Jones 2014, unpublished data).

Year	Tobique	Beechwood
1990	23	563
1991	1	0
1992	0	8
1993	0	59
1994	0	44
1995	0	35
1996	0	17
1997	0	8
1998	4	19
1999	0	8
2000	1	0
2001	2	1
2002	1	1
2003	0	3
2004	0	3
2005	0	0
2006	1	0
2007	0	1
2008	0	0
2009	0	0
2010	0	0
2011	0	3
2012	0	4
2013	0	0
2014	0	4

Table 6a. Average annual American Eel catch (#/100m²) within tributaries located upstream of the MGS (source: Bradford 2016, unpublished data).

Year	Becaguimec	Meduxnekeag	Salmon (Vic)	Shikatehawk	Tobique
1990	-	-	-	-	-
1991	-	-	-	-	-
1992	-	-	-	0	0
1993	0	0	0	0	-
1994	0	0	-	0	0
1995	0	0	0	0	0
1996	0	0	0	0	0.01
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0.01	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	-	-	-	-	0
2005	-	-	-	0	0
2006	-	-	-	-	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0
2012	-	-	-	-	0

Table 6b. Average annual American Eel catch (#/100m²) within tributaries located downstream of the MGS (source: Bradford 2016, unpublished data).

Year	Keswick	Nashwaak	Nerepis	Canaan	Gaspereau	Hammond	Kennebecasis
1990	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-
1992	2.37	0.57	-	-	-	-	-
1993	1.36	1.47	-	-	-	-	-
1994	0	0.46	-	-	-	1.91	0
1995	2.11	0.62	-	-	-	-	-
1996	0.88	1.39	-	-	-	0.8	1.22
1997	0.47	1.04	-	-	-	0.95	-
1998	1.6	1.22	0.68	-	1.69	0.52	0.16
1999	0.87	0.7	0.92	0	1.94	0.73	0.29
2000	0.17	1.37	-	-	-	0	0.17
2001	1.49	1.5	-	-	1.36	0.66	-
2002	1.71	1.36	-	-	1.99	0.23	-
2003	1.13	0.52	-	-	1.85	0.77	-
2004	-	2.05	-	-	-	-	-
2005	-	1.47	-	-	-	-	-
2006	-	0.85	-	-	-	-	-
2007	-	1.43	-	-	-	-	-
2008	-	1.27	-	-	-	-	-
2009	-	1.09	-	-	-	-	-
2010	-	1.08	-	-	-	-	-
2011	-	0.62	-	-	-	-	-
2012	-	1.73	-	-	-	-	-