

# COUNTS OF FISH CAPTURED FROM UPSTREAM FISH PASSAGE FACILITIES AT BEECHWOOD AND TOBIQUE DAMS, NEW BRUNSWICK, 1990-2019

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BEECHWOOD AND TOBIQUE DAMS, NEW BRUNSWICK, 1990-2019.

by

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## **ABSTRACT**

Beaumaster, R., Chateauvert, A., Anderson, L., Linnansaari, T., and Jones, R.A. 2020. Counts of fish captured from upstream fish passage facilities at Beechwood and Tobique dams, New Brunswick, 1990-2019. *Can. Data Rep. Fish. Aquat. Sci.* 1328: iii + 23 p.

This report summarizes the upstream migratory fish catches at the Beechwood and Tobique Narrows dams on the Saint John, also known as Wolastoq River of New Brunswick, Canada. Both dams have hydroelectric generating stations that are owned and operated by New Brunswick Power (NBP). Fisheries and Oceans Canada (DFO) and NBP have an agreement to record and count (or estimate) all fish captured and passed upriver of the Beechwood Dam, while DFO Science monitors and records all fish captured at a trap operated within the pool and weir fishway at the Tobique Narrows Dam. Annual data sets for Beechwood and Tobique Narrows dams are presented for the various fish species captured over a 30-year period from 1990-2019.

## **RÉSUMÉ**

Beaumaster, R., Chateauvert, A., Anderson, L., Linnansaari, T., and Jones, R.A. 2020. Counts of fish captured from upstream fish passage facilities at Beechwood and Tobique dams, New Brunswick, 1990-2019. *Can. Data Rep. Fish. Aquat. Sci.* 1328: iii + 23 p.

Le présent rapport résume les captures de poissons en montaison réalisées aux barrages Beechwood et de Tobique Narrows, qui sont situés sur le fleuve Saint-Jean (Wolastoq), au Nouveau-Brunswick (Canada). Les deux barrages sont associés à des centrales hydroélectriques qui sont détenues et exploitées par la Société d'Énergie du Nouveau-Brunswick (Énergie NB). Pêches et Océans Canada (MPO) et Énergie NB ont conclu une entente visant à consigner et à compter (ou à estimer) tous les poissons qui sont capturés au barrage Beechwood et qui migrent en amont de celui-ci, tandis que les Sciences du MPO suivent et consignent tous les poissons capturés dans un piège installé dans la passe migratoire en gradins du barrage de Tobique Narrows. Le rapport présente les ensembles de données annuelles concernant les diverses espèces de poissons capturées aux barrages Beechwood et de Tobique Narrows pendant une période de 30 ans, soit de 1990 à 2019.

## **BACKGROUND**

The Saint John River is approximately 673 km long and located in the provinces of New Brunswick and Quebec as well as the U.S. state of Maine (Figure 1). The river drains an area of approximately 55,000 square kilometres, of which slightly more than half is located in New Brunswick (Marshall et al. 2014). The river flow in New Brunswick is regulated by hydro electric power dams located at Mactaquac, Beechwood, Tobique Narrows and Grand Falls (Figure 1).

Annual upstream fish migrations in the Saint John River are monitored at the Beechwood and Tobique Narrow dams. Both dams have hydroelectric generating stations that are owned and operated by New Brunswick Power (NBP). Fisheries and Oceans Canada (DFO) and NBP have an agreement to record and count (or estimate) all fish captured and passed upriver of the Beechwood Dam, while DFO monitors and records all fish captured at a trap within the pool and weir fishway at the Tobique Narrows Dam.

The history of the dams, their location, size, and power generation are described in Chateauvert et al. (2018). Construction of the Beechwood Dam began in 1955 and the dam started generating power in 1957. The dam is 18 meters high and has a hydraulic head of 21.5 meters and a power generating capacity of 113 megawatts. Its upstream reservoir has a relatively small capacity (Ingram 1981). The Tobique Narrows Dam is situated upstream of the Beechwood Dam on the Tobique River (Figure 1). Construction began in 1950 and the dam started generating power in 1953. The dam is 6 m high and has a capacity of 20 megawatts (Francis 1984).

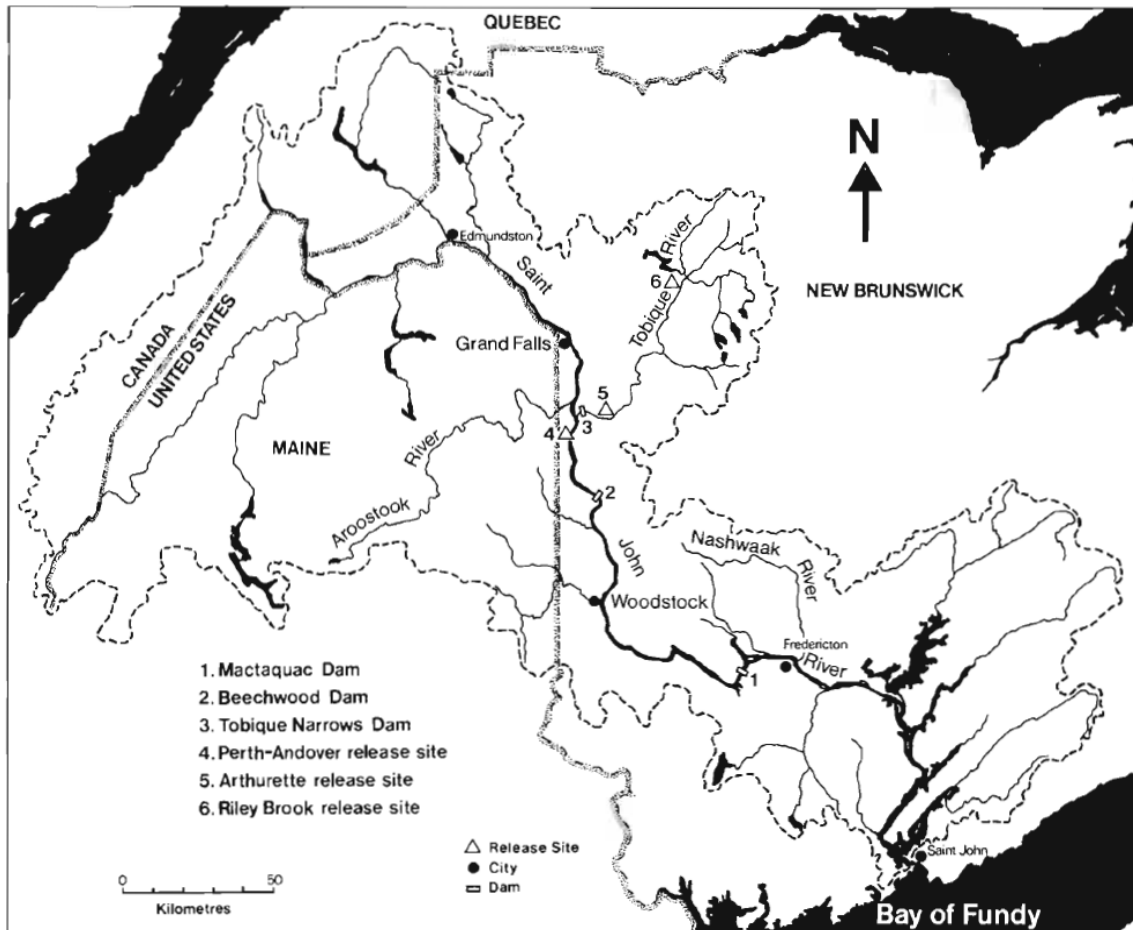


Figure 1. Major power dams and adult salmon release sites on the Saint John River System, New Brunswick (Figure taken from Ingram and Ensor 1990).

## METHODS

The Beechwood Dam has a fish elevator that helps migrating fish circumvent the height of the dam (Figure 2), and the hoist is normally lifted four times a day around 08:30, 10:30, 13:30, and 16:30 hours. When the fish runs are very active, evening lifts are sometimes necessary, however, in the late fall when runs are nearly finished, only two lifts a day (08:30 and 16:30) are required. The skip hoist is designed to work with an operator (or attendant) at the controls to automatically lift and dump fish directly into the reservoir; as a result of monitoring requirements for various fisheries, fish counts and observations are recorded prior to releasing the fish into the reservoir. Here, an attendant records each fish species (Appendix 1), checks for marked or tagged fish (particularly salmon), and carries out any necessary sampling. The floor of the fish trap is divided lengthwise into four smaller parallel compartments to make it easier for the attendant to carry out the necessary recording. Sea-run adult salmon are categorized into grilse (or small salmon; generally < 63cm) and salmon (or large salmon; generally  $\geq 63$ cm), based on visual observation from the upper deck (see Appendix 2 for distinguishing features of each category). The fishway operates annually from June 1<sup>st</sup> - November 15<sup>th</sup>, however, these dates fluctuate slightly from year to year.

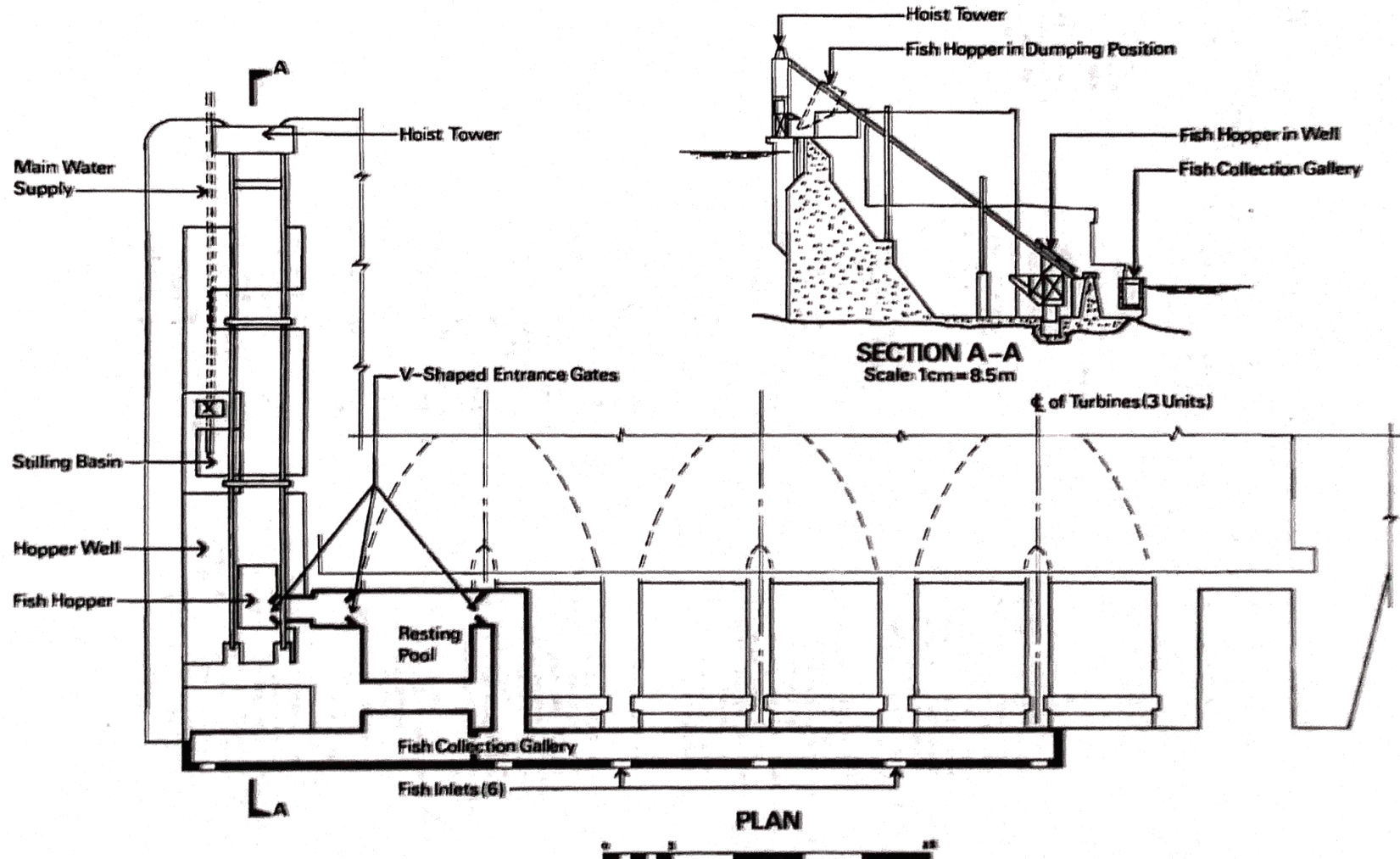


Figure 2. Site plan of the Beechwood Hydro Dam and upstream fish passage facilities, showing fish collection gallery, resting pool and fish hopper (Figure from Ingram 1981).



A fish ladder at the Tobique Narrows Dam allows migrating fish to circumvent the head of the dam (Figure 3). The fishway passage facilities consist of a collection gallery at the base of the dam and a pool and weir fishway extending to the reservoir above the dam (Figure 3). Within the ladder is a series of partitions, or baffles, to break the force of the water flow and assist fish in their ascent. The fishway has four large holding, or resting, pools situated in each of the four turns. A metal counting trap is located in the top resting pool below the fishway exit, which is fished by elevating the entire unit with a manual winch, supported above the trapping area. The trap is fished daily, according to the intensity of the run. After each check and count, the fish are released directly into the upstream area of the resting pool so that they can continue their migration through the remaining portion of the fishway and into the headpond. The fishway operates annually from approximately June 15<sup>th</sup> until November 15<sup>th</sup>, with slight yearly fluctuations.

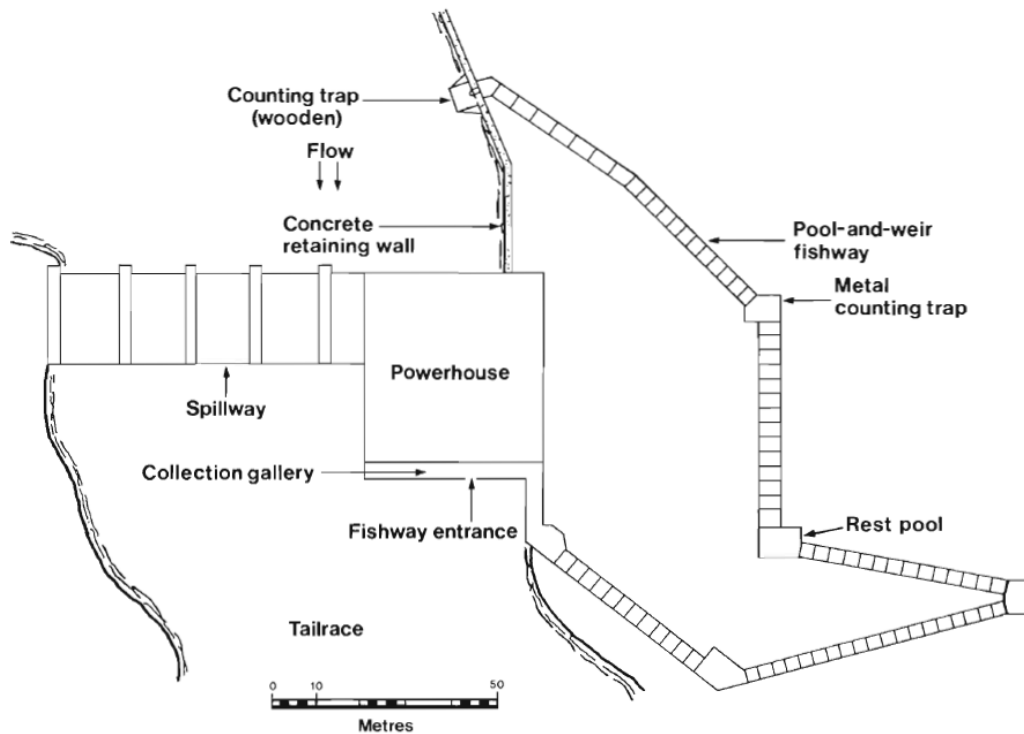


Figure 3. Site plan of the Tobique Narrows Hydro Dam and pool and weir fishway, showing fishway entrance, collection gallery, resting pools and counting trap locations (Figure taken from Francis 1984).

## DATA

The annual counts for fish captured at the upstream fish passage facilities at the Beechwood Dam are summarized from 1990-2019 (Table 1). Catches prior to 1990 have been previously published (Smith 1979, Ingram 1981, Ingram 1987). When possible, fish were identified by species (Appendix 1) and by life stage for Atlantic salmon (Appendix 2) by the NBP fish lift operators. The start and end dates for the operation of the upstream fish passage facility has varied over the 30-year time-series (Table 2). Dates or time periods when the fish lift was not operated due to high water in the tailrace, or for mechanical repairs, has not been recorded in Table 2. Sea-run adult salmon counts have been divided into salmon and grilse based on visual observations by the fish lift operators. It is important to point out that captive-reared salmon (Jones et al. 2004) may have been released at Woodstock, downstream of the Beechwood Dam, between 2003 -2019, and that NBP attendants would not be able to distinguish these from the returning sea-run salmon. The annual counts since 1990 are presented in Figure 4. The 30 year time-series of annual catches for American eel (Figure 5), (unspecified) Bass (Figure 6), Landlocked salmon (Figure 7), Suckers (Figure 8), Whitefish (Figure 9), *Alosa* species (Figure 10), *Esox* species (Figure 11), Perch (Figure 12), and Trout (Figure 13) are also presented. Note that the Y axis values for these figures vary among species. Handling of individual fish was generally not done, and therefore, some catches were not distinguished to the species category; i.e. suckers, perch, gaspereau, whitefish, bass and trout (Table 1).

Table 1: Annual counts for fish (by species and life stage) captured at the upstream fish passage facilities at the Beechwood Dam from 1990-2019. All numbers in shaded grey cells should be considered minimum numbers captured for that specific year. Captive-reared salmon may have been released at Woodstock, downstream of the Beechwood Dam, between 2003 -2019, which cannot be distinguished from the sea-run returns by NBP attendants. Two fish captured and recorded as lake trout in 2003 were moved into "Trout (unspecified)" category.

Y E A R	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	T O T A L
Grilse	1700	1111	2273	801	477	615	1267	641	1610	882	603	427	509	231	693	304	657	535	712	170	436	460	77	210	61	279	242	153	216	275	18627				
Salmon	530	442	488	416	224	201	425	175	143	381	89	174	70	47	220	70	81	133	209	62	64	328	51	70	28	70	97	77	45	11	5421				
Captive Reared	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Landlock Salmon	202	8	26	57	41	7	35	93	47	45	10	0	0	0	0	0	0	0	0	0	3	4	5	0	0	0	0	0	0	0	3	0	586		
Parr or Pre-smolt	0	0	0	17	7	0	0	2	15	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43	
American Eel	461	0	8	59	44	35	17	8	19	8	0	1	1	3	3	0	0	1	0	0	0	3	4	0	4	2	1	0	1	0	683				
Bass (unspecified)	36	1	5	4	0	91	16	38	12	66	7	111	75	39	26	7	18	25	63	0	35	59	30	12	2	67	33	8	259	145	1290				
Brook Trout	0	1	0	0	0	10	2	25	0	0	0	17	6	4	8	0	6	18	25	0	0	2	1	1	1	17	2	1	16	3	166				
Brown Bullhead	43	0	4	15	11	0	29	111	76	913	16	131	10	115	77	32	26	15	33	104	2	2	10	14	3	26	0	4	1	0	1823				
Brown Trout	1	1	12	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	2	0	0	2	0	0	0	28	0	50				
Burbot	0	0	0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	9				
Chain Pickerel	4	0	4	6	3	2	5	8	0	3	0	0	0	1	3	0	0	0	3	1	0	9	0	0	0	0	1	0	0	0	53				
Creek Chub	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	13				
Gaspereau	1	0	1	1	0	10	5	33	20	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	191	19	309			
Muskellunge	0	0	2	2	3	0	2	6	1	0	0	0	1	0	0	1	15	1	0	1	3	15	15	18	18	17	9	14	36	19	199				
Perch (unspecified)	204	30	80	203	523	305	714	673	723	253	72	341	73	87	51	20	52	73	212	0	26	30	0	0	2	9	21	20	0	0	4797				
Rainbow Trout	2	0	1	1	0	1	3	3	1	11	0	0	1	0	0	1	0	0	0	4	0	0	7	3	0	2	1	0	11	2	55				
American Shad	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1			
Smallmouth Bass	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	3	0	0	0	0	0	0	0	0	0	10			
Striped Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1			
Sucker	2	0	4	10	27	2	4	3	117	4	0	32	0	0	1	0	0	0	0	8	4	17	5	0	0	0	0	0	70	4	314				
Sunfish	1	0	1	0	5	7	4	4	0	2	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	27			
Trout (unspecified)	46	6	7	30	21	41	99	84	56	30	3	10	2	7	62	3	1	0	8	0	5	10	15	3	0	0	0	1	0	0	550				
White Perch	9	2	1	35	0	13	41	4	45	3	0	22	56	0	150	0	0	4	0	24	0	1	0	0	0	0	0	0	3	0	413				
Whitefish	0	0	0	1	0	5	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9			
Yellow Perch	12	0	1	28	0	10	5	50	30	80	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	140	52	414				



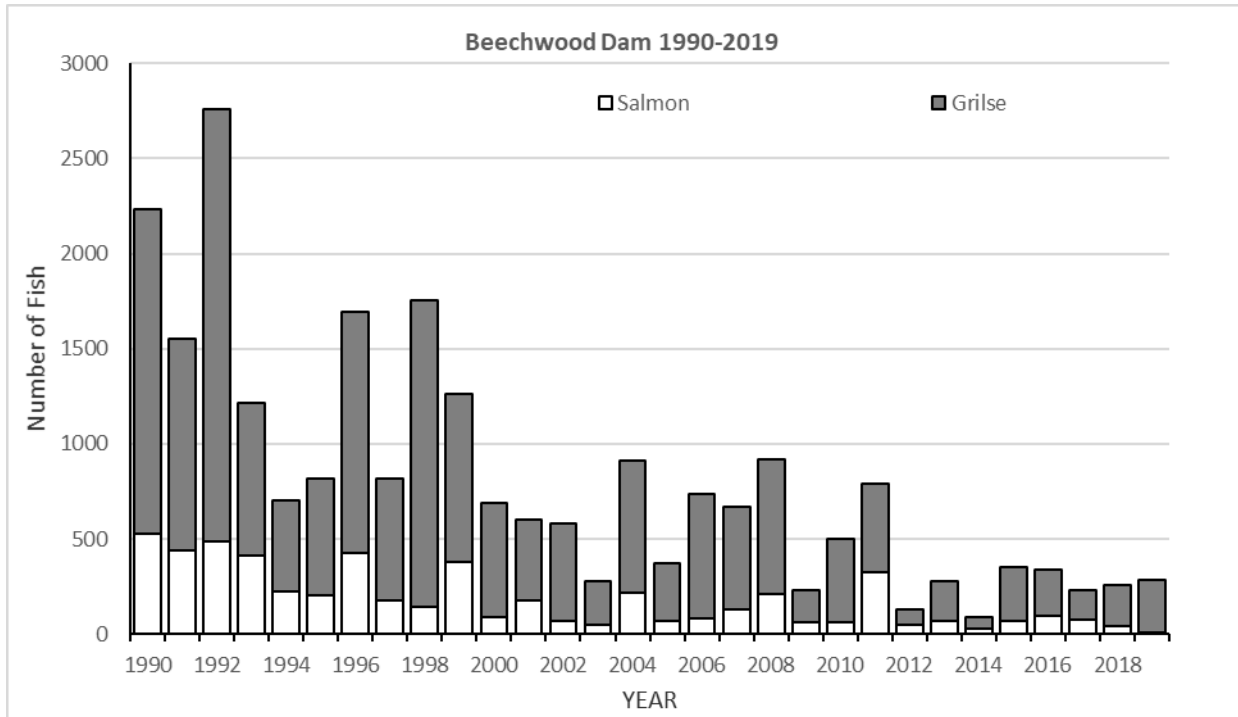


Figure 4. Annual Salmon and Grilse counts at Beechwood Dam from 1990-2019. Numbers may include captive reared salmon released in Woodstock.

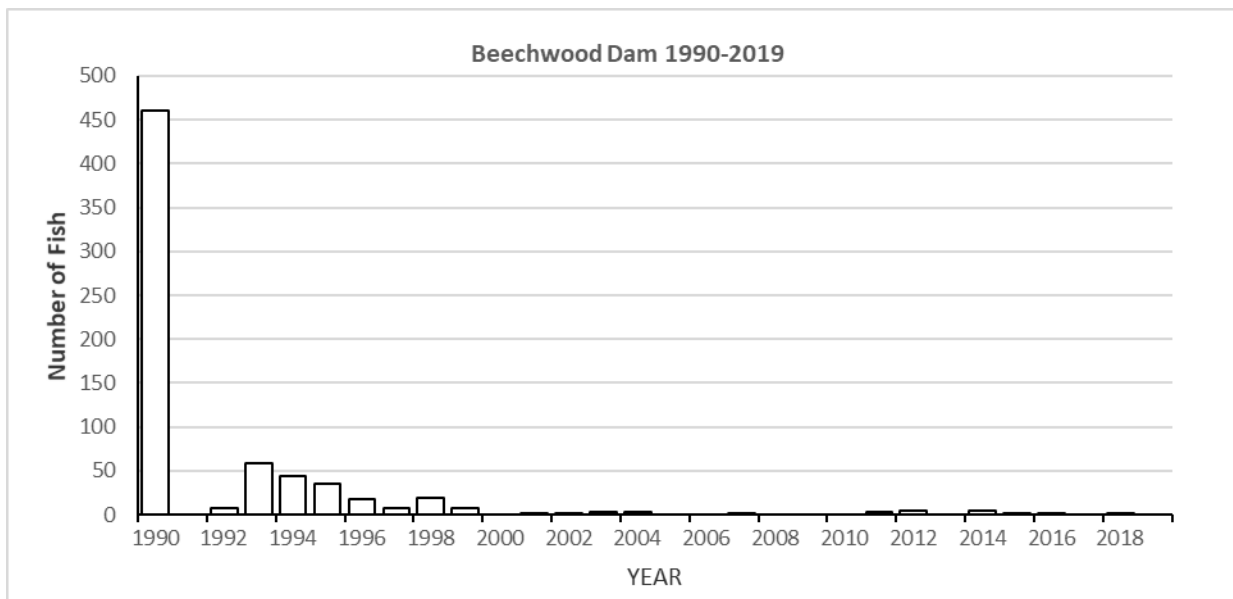


Figure 5. Annual counts of American Eel at Beechwood Dam from 1990-2019.

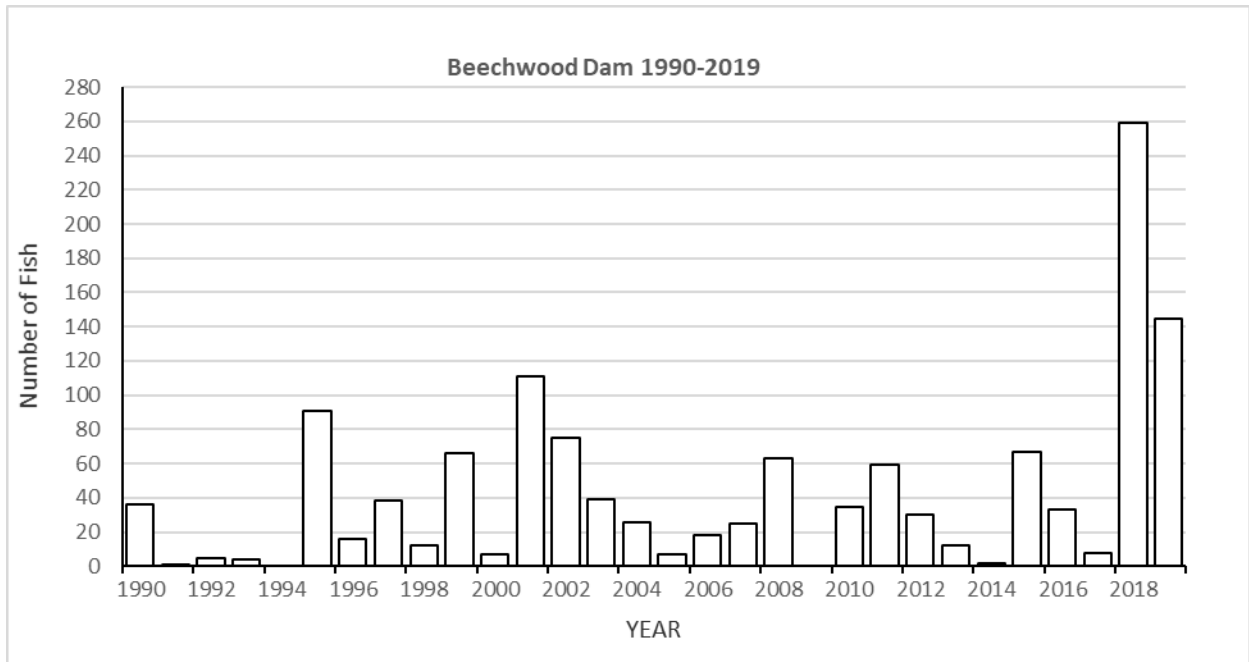


Figure 6. Annual counts of Bass (unspecified) at Beechwood Dam from 1990-2019.

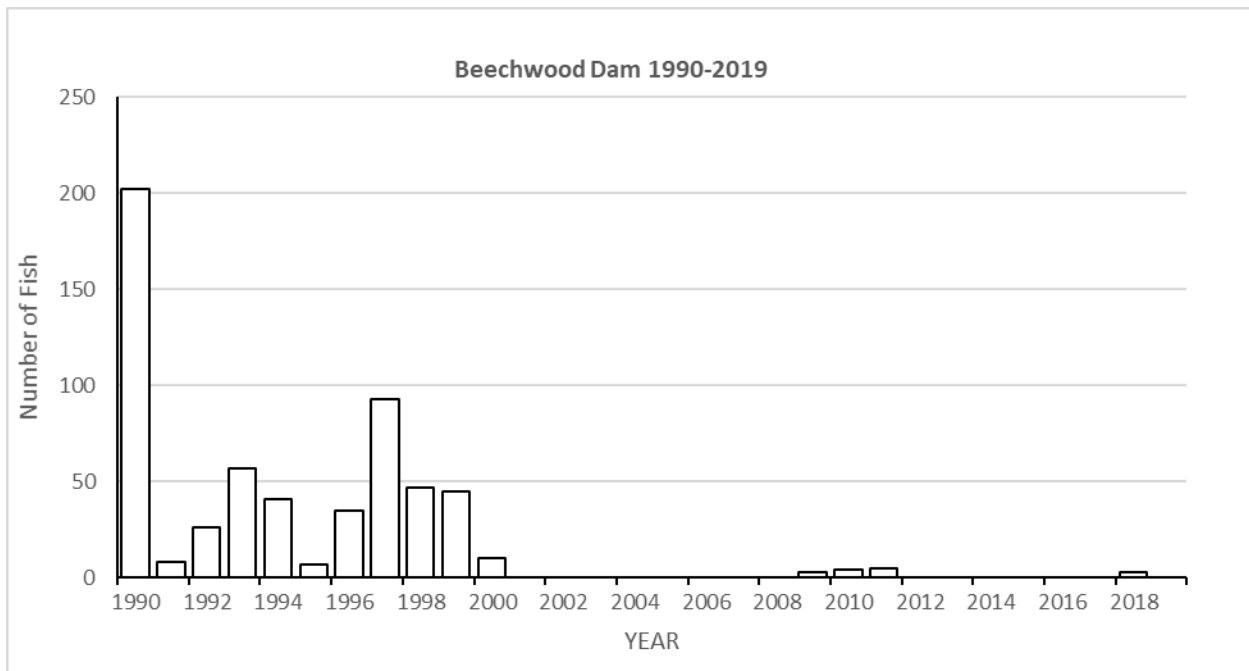


Figure 7. Annual counts of Landlock Salmon at Beechwood Dam from 1990-2019.

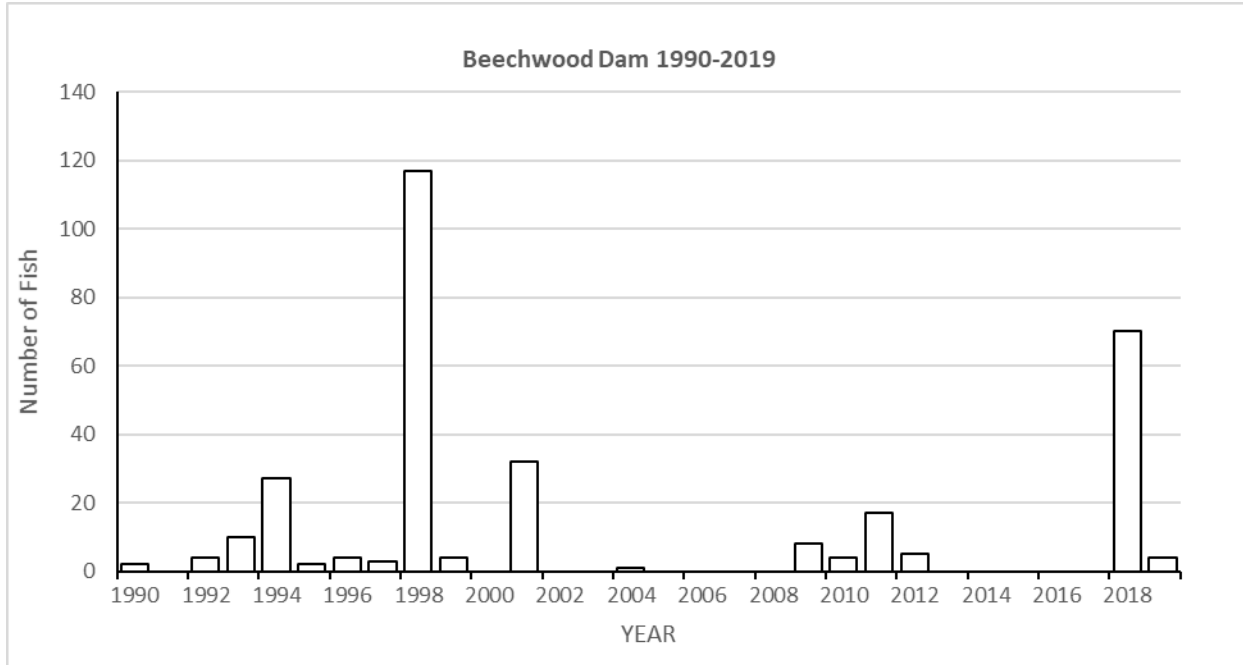


Figure 8. Annual counts of Suckers (Longnose & White Sucker combined) at Beechwood Dam from 1990-2019.

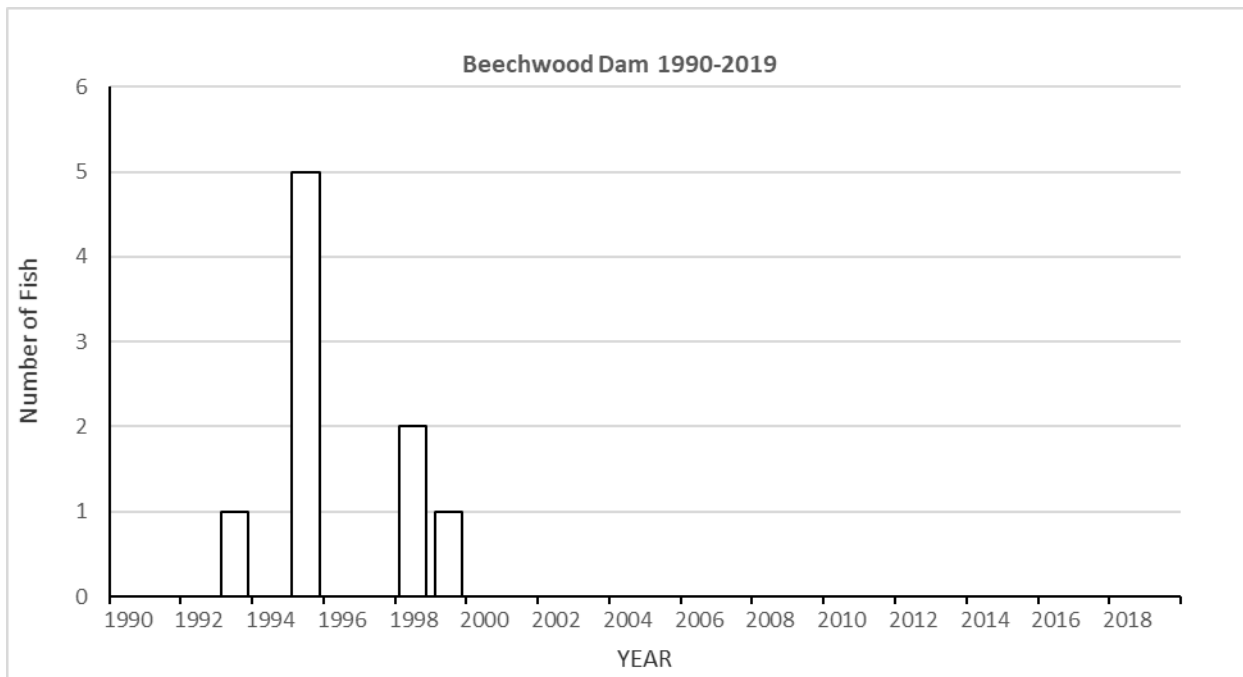


Figure 9. Annual counts of Whitefish at Beechwood Dam from 1990-2019.

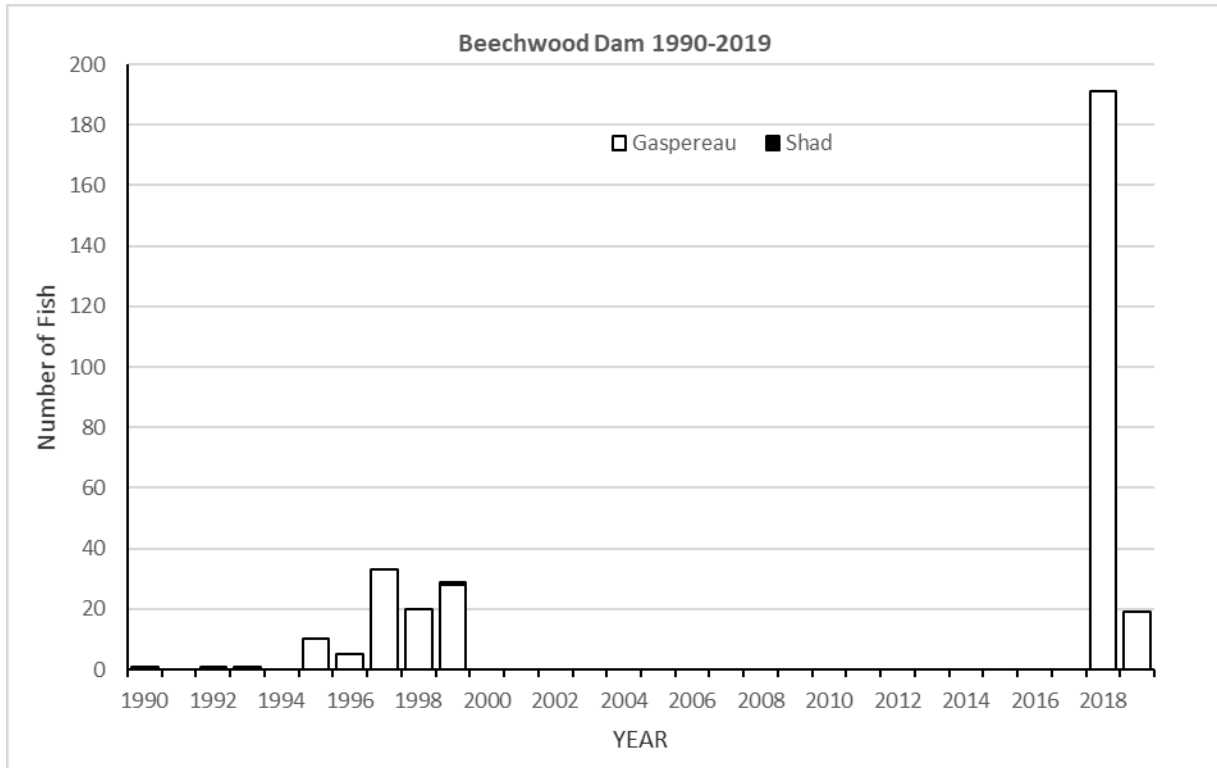


Figure 10. Annual counts of Gaspereau (Alewife and Blueback Herring combined) and American Shad at Beechwood Dam from 1990-2019.

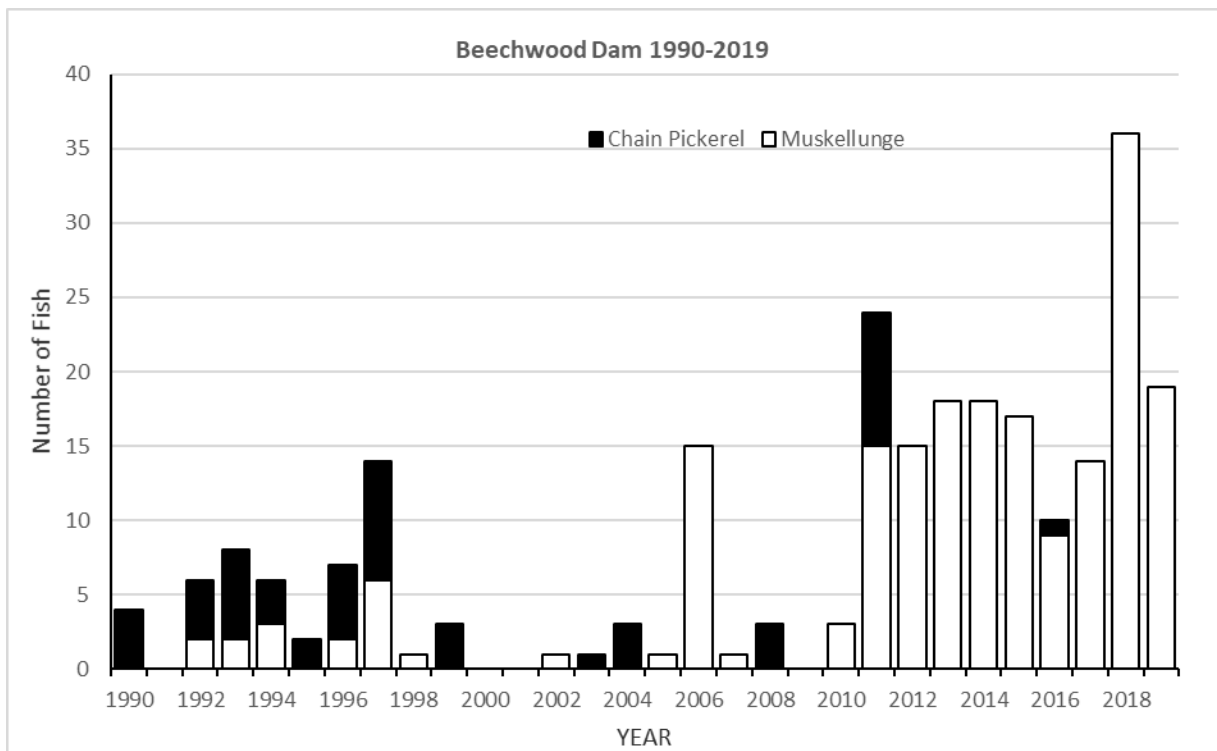


Figure 11. Annual counts of Muskellunge and Chain Pickerel at Beechwood Dam from 1990-2019.



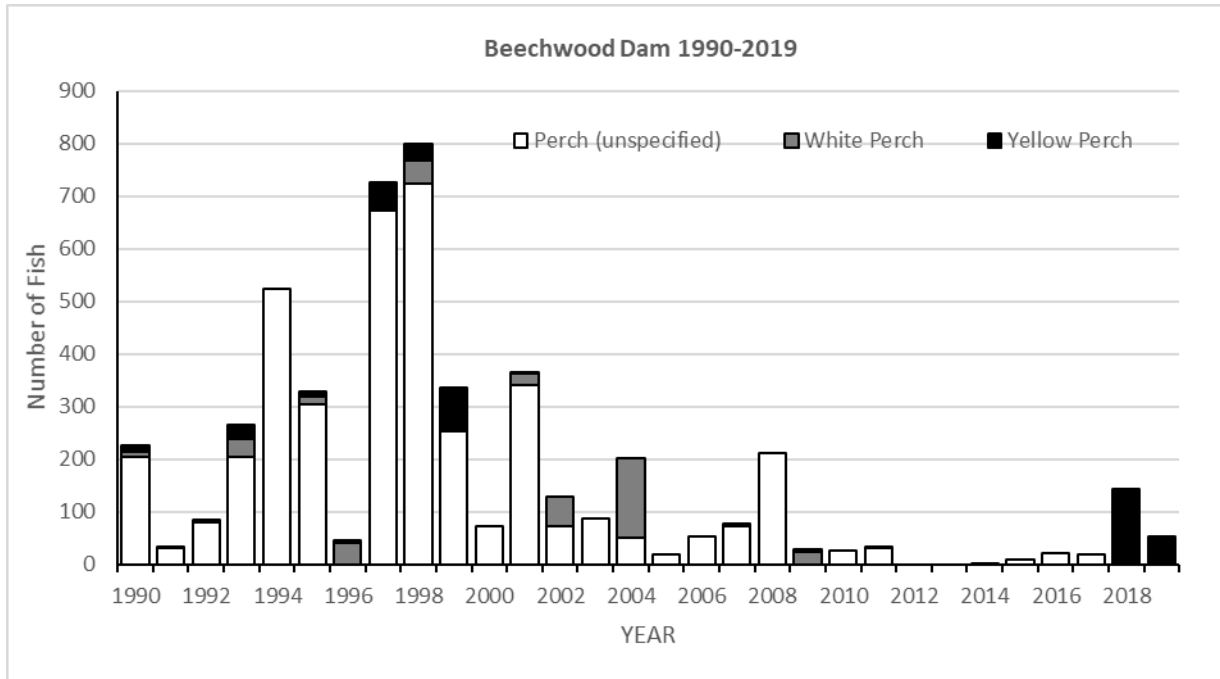


Figure 12. Annual counts of Perch (unspecified), White Perch, and Yellow Perch at Beechwood Dam from 1990-2019.

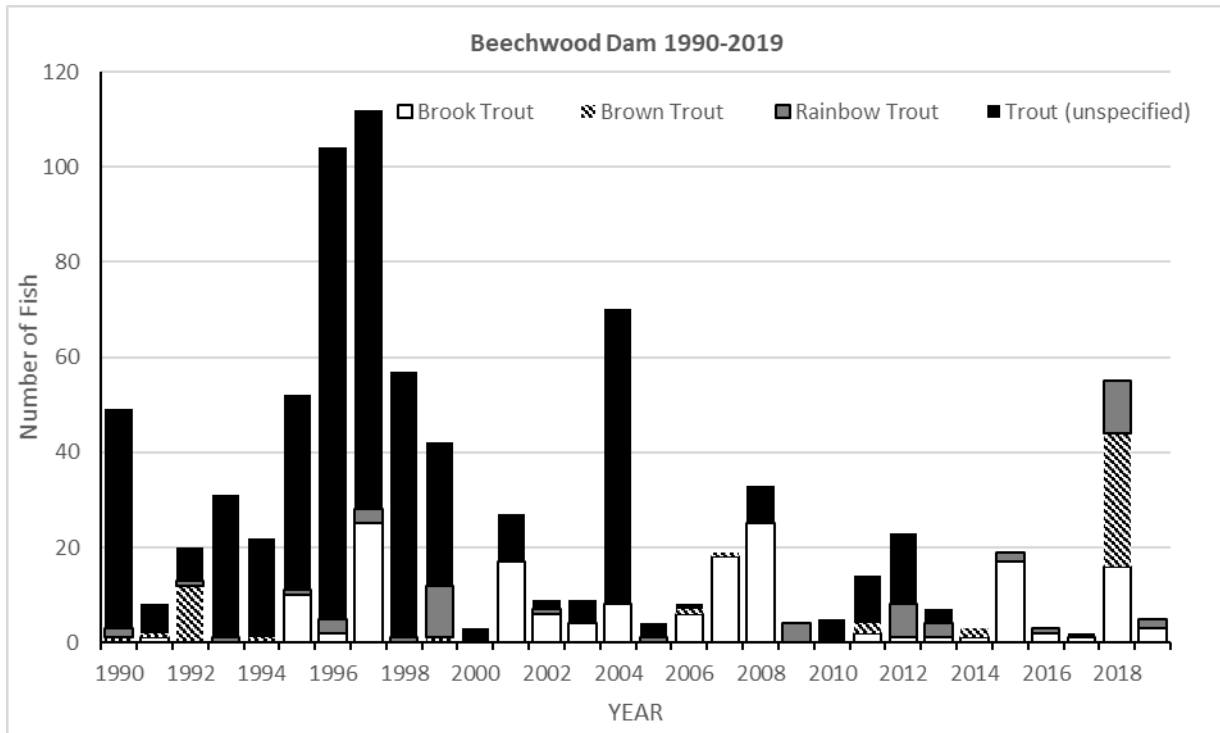


Figure 13. Annual counts of Trout (unspecified), Brook Trout, Brown Trout, and Rainbow Trout at Beechwood Dam from 1990-2019.

Table 3 summarizes the annual counts for fish captured in the counting trap within the pool and weir fishway at the Tobique Narrows Dam from 1990-2019. Catches prior to 1990 have been previously published (Smith 1979, Francis 1984). The fishway was seasonally operated from 1984 to 1988 but was not monitored. When possible, fish were identified by species (Appendix 1) and by life stage for Atlantic Salmon (Appendix 2) by Fisheries and Oceans Canada (DFO) and Tobique First Nation Science staff. DFO Science and Tobique First Nation have partnered together to monitor the fish counts at the fishway since the early 1990's as a collaborative project through the Aboriginal Fisheries Strategy program. The start and end dates for operation of the trap and monitoring of the fishway have differed over the 30 year time-series (Table 4) depending on available human resources. Dates or time periods when the fishway was not operational due to mechanical repairs are not documented in Table 4. In 2009, the fishway was not operated due to a non-fisheries related dispute between Tobique First Nation and NB Power. In most cases, data collected on sea-run adult salmon captured in the trap has been reported as either Salmon and Grilse based on actual measurements and/or visual observations by Science staff. In most years, adult salmon were also categorized into wild-, hatchery- or captive reared-origin based on fin clips and/or fin erosion. The annual adult salmon counts since 1990 are presented in Figure 14. The 30 year time-series of annual catches for American Eel (Figure 15), (unspecified) Bass (Figure 16), Landlock salmon (Figure 17), Suckers (Figure 18), and Trout (Figure 19) are also presented.

Table 3: Annual counts for fish (by species and life stage) captured at the upstream fish passage facilities at the Tobique Narrows Dam from 1990-2019. Fishway was operated but not monitored for the 2009 season.

Y E A R	1 9 9 0	1 9 9 1	1 9 9 2	1 9 9 3	1 9 9 4	1 9 9 5	1 9 9 6	1 9 9 7	1 9 9 8	1 9 9 9	2 0 0 0	2 0 0 1	2 0 0 2	2 0 0 3	2 0 0 4	2 0 0 5	2 0 0 6	2 0 0 7	2 0 0 8	2 0 0 9	2 0 1 0	2 0 1 1	2 0 1 2	2 0 1 3	2 0 1 4	2 0 1 5	2 0 1 6	2 0 1 7	2 0 1 8	2 0 1 9	T O T A L
Grilse	677	538	940	279	263	547	288	148	480	176	403	232	290	103	170	296	478	254	389	n/a	209	340	28	123	41	189	128	114	129	259	8511
Salmon	117	120	198	186	77	90	131	38	30	102	48	109	19	31	48	135	67	47	59	n/a	33	160	43	23	18	25	48	59	27	77	2165
Captive Reared	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	25	71	n/a	29	6	65	36	6	4	5	0	67	27	345
Landlock Salmon	1	0	0	0	0	1	0	0	0	2	4	5	1	0	0	3	1	2	0	n/a	0	1	3	5	1	0	2	0	0	0	32
Parr or Pre-smolt	31	5	0	0	0	0	19	24	89	16	23	18	9	51	63	4	0	9	0	n/a	11	2	0	2	0	0	1	0	0	0	377
American Eel	23	1	0	0	0	0	0	0	4	0	1	2	1	0	0	0	1	0	0	n/a	0	0	0	0	0	0	0	0	0	0	33
Bass (unspecified)	10	5	10	9	3	0	0	0	1	7	5	8	0	1	1	9	0	1	0	n/a	0	0	2	0	0	0	0	0	31	0	103
Brook Trout	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	1	n/a	0	0	2	0	0	0	0	0	5	0	16
Brown Bullhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	n/a	0	0	0	0	0	0	0	0	0	0	2
Brown Trout	1	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	n/a	0	0	0	0	0	0	0	0	0	0	7
Burbot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Creek Chub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Gaspereau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Perch (unspecified)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	1
Rainbow Trout	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	n/a	0	0	0	0	0	0	0	0	0	2	5
American Shad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	n/a	1	0	0	0	0	0	0	2	0	0	0	8
Striped Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0	0
Sucker	36	2	0	187	0	0	7	0	1	0	21	33	1	0	18	1	0	0	1	n/a	163	2	75	4	8	0	18	0	2	4	584
Sunfish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0	0
Trout (unspecified)	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	4
White Perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Whitefish	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0
Yellow Perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	n/a	0	0	0	0	0	0	0	0	0	0	0

Table 4: Annual operational dates of the trap in the fishway at Tobique Narrows Dam from 1990 to 2019. It was closed for the 2009 season.

YEAR/ MONTH	Tobique Operational Dates					
	June	July	August	September	October	November
1990						
1991						
1992						
1993						
1994						
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
2003						
2004						
2005						
2006						
2007						
2008						
2009						
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2011						
2012						
2013						
2014						
2015						
2016						
2017						
2018						
2019						
	June	July	August	September	October	November

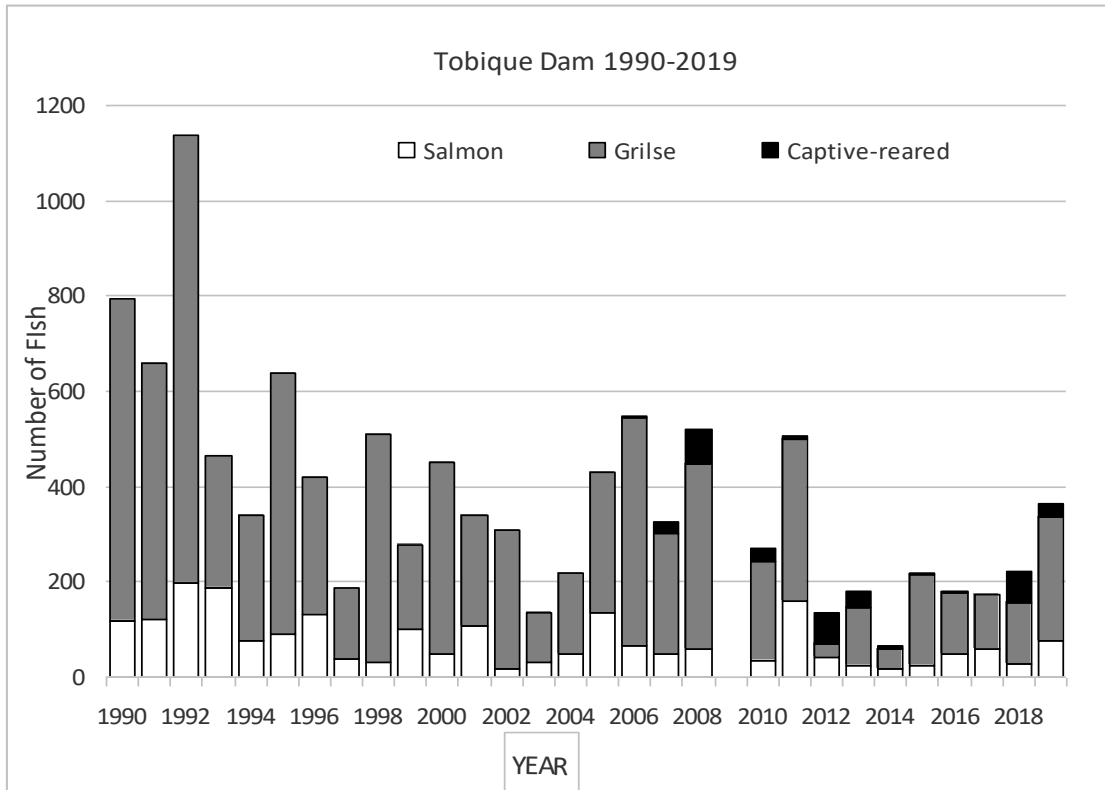


Figure 14. Annual counts of captive-reared salmon, sea-run Grilse, and Salmon at Tobique Narrows Dam from 1990-2019.

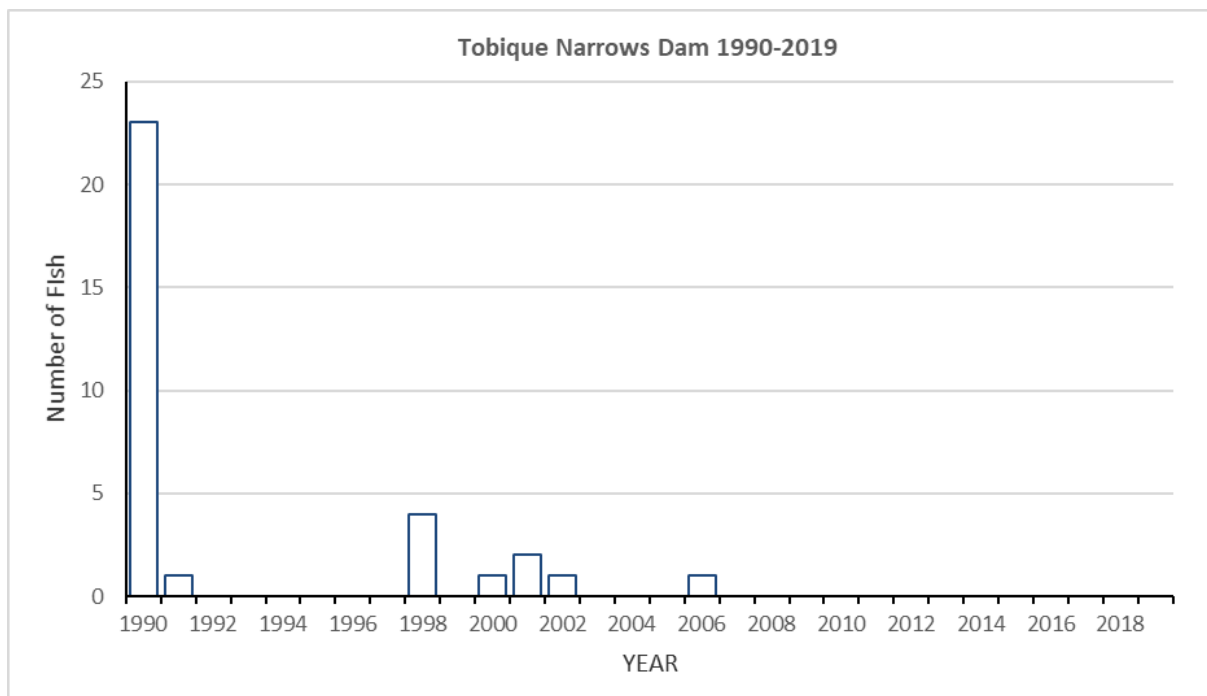


Figure 15. Annual counts of American Eel at Tobique Narrows Dam from 1990-2019.

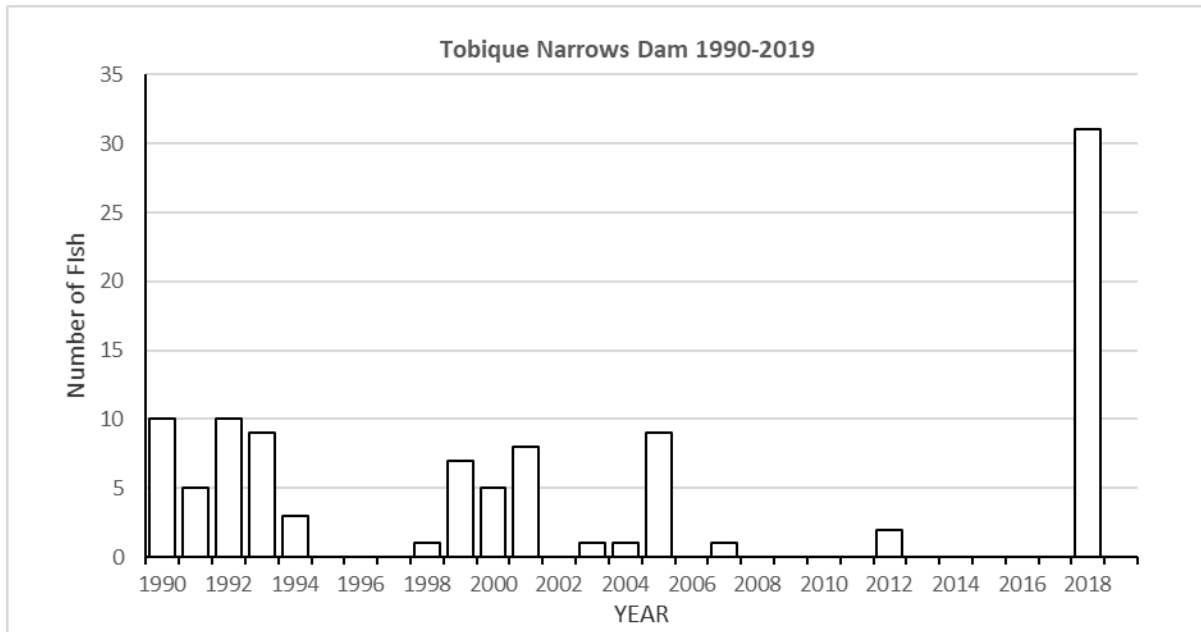


Figure 16. Annual counts of bass (unspecified) at Tobique Narrows Dam from 1990-2019.

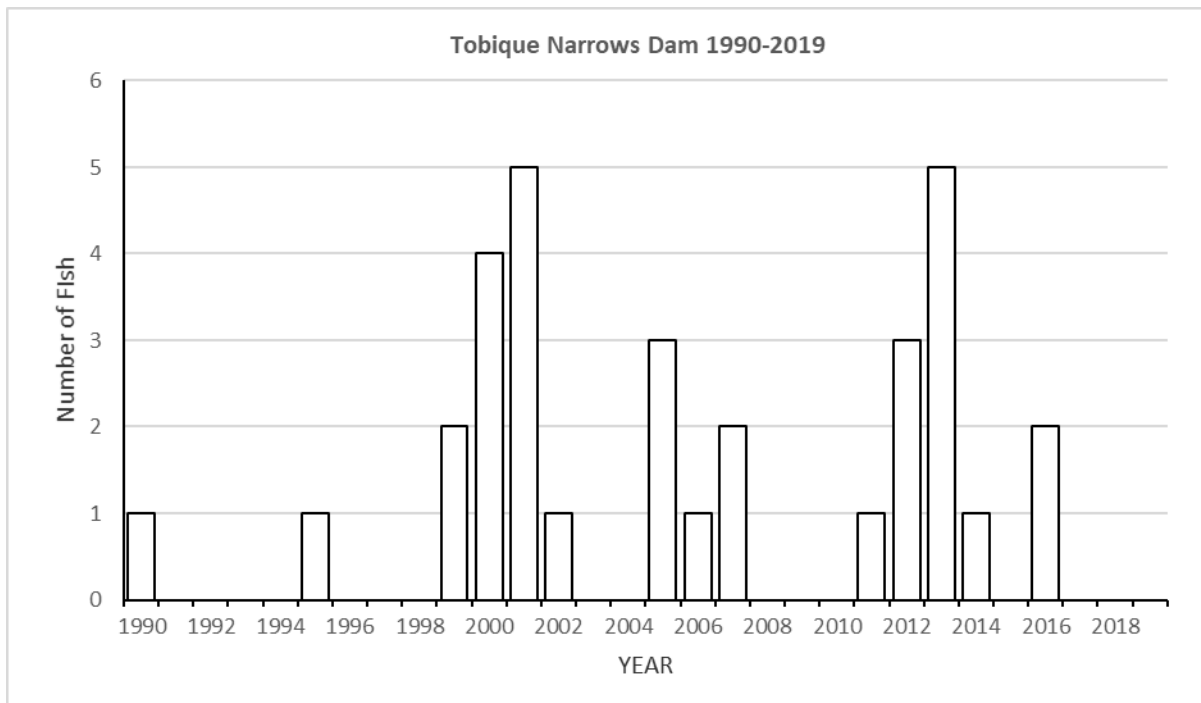


Figure 17. Annual counts of Landlock Salmon at Tobique Narrows Dam from 1990-2019.

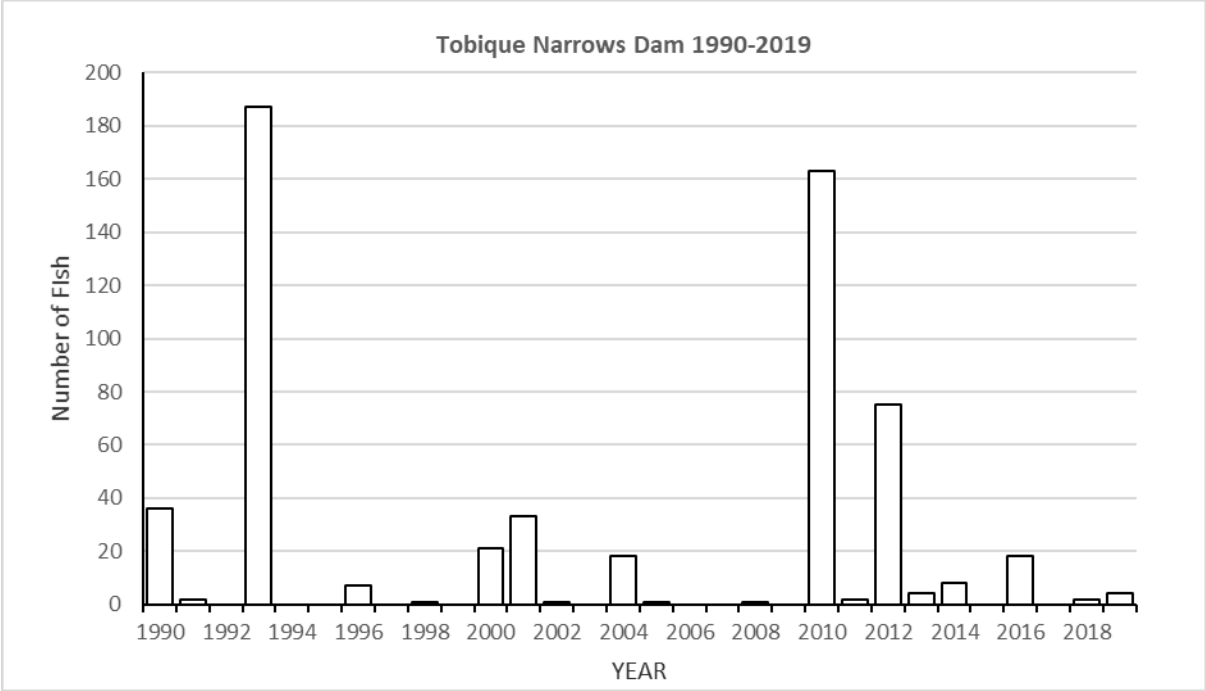


Figure 18. Annual counts of suckers (Longnose & White Sucker combined) at Tobique Narrows Dam from 1990-2019.

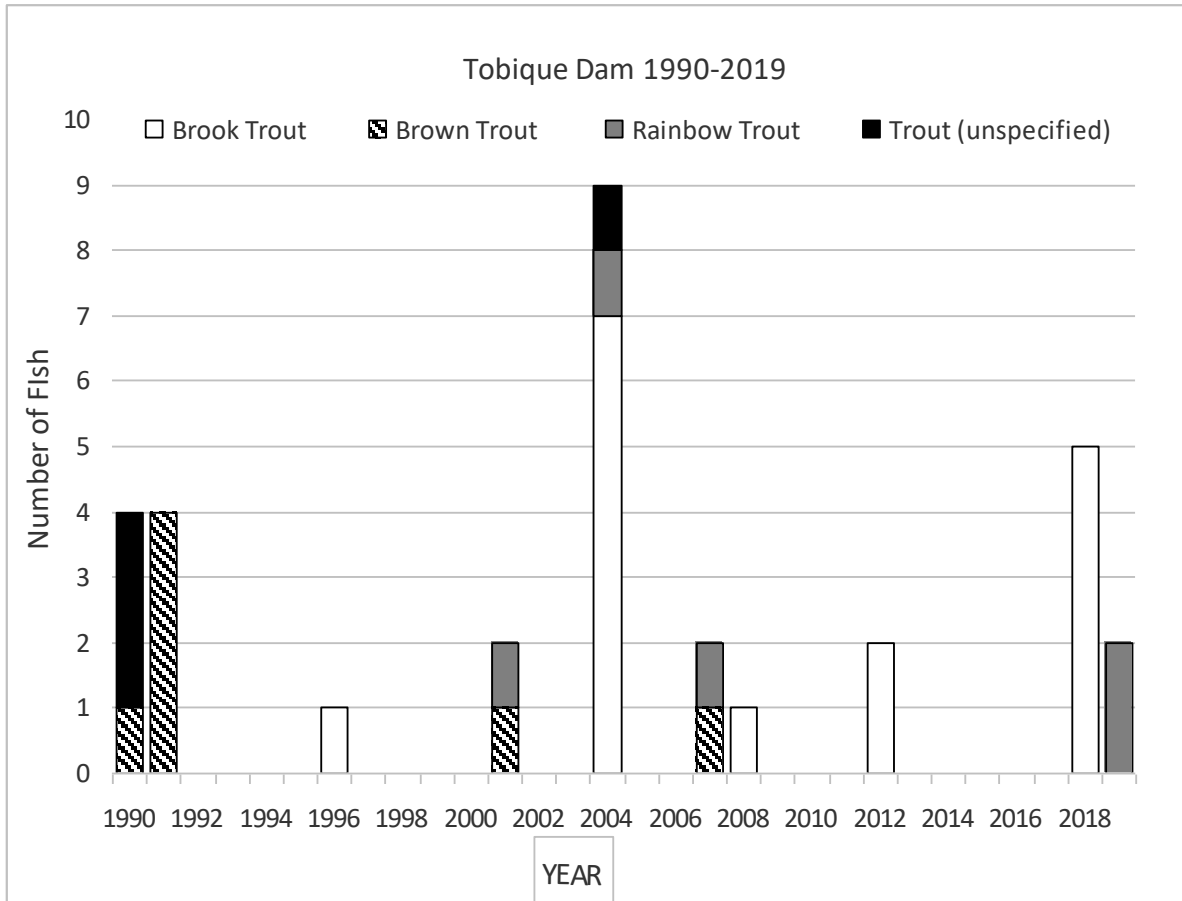


Figure 19. Annual counts of trout (unspecified), Brook Trout, Brown Trout, and Rainbow Trout at Tobique Narrows Dam from 1990-2019.

## CONCLUSIONS

This data report compiles 30 years of biological and catch information collected by staff from the Tobique First Nation, New Brunswick Power and Fisheries and Oceans Canada since 1990. This report continues the time-series of upstream fish counts at the Beechwood and Tobique Narrows dams previously published by Smith (1979), Ingram (1981, 1987) and Francis (1984) and is an example of successful collaboration between an indigenous community, federal government, industry, and academia. Staff from the Canadian Rivers Institute, University of New Brunswick assisted in compilation of the data because of their interest in fish passage at the various hydro-electric dams on the Saint John River system.

The data have been presented in a simple format to create interest in further data analyses. These could include examining run timing data in relation to tailrace discharge and nearby water temperatures. Ensuring appropriate training in fish species identification for various staff is important to ensure detailed recording of catches with only minimal additional effort.



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## APPENDICES

**Appendix 1:** List of various fish with common name and (*Scientific name*) captured at the Tobique Narrows and Beechwood dams on the Saint John River from 1990 to 2019:

Atlantic Salmon (*Salmo salar*).

American Eel (*Anquilla rostrata*)

American Shad (*Alosa sapidissima*).

Brook Trout (*Salvelinus fontinalis*)

Brown Bullhead (*Ameiurus nebulosus*)

Brown Trout (*Salmo trutta*)

Burbot (*Lota lota*)

Chain Pickerel (*Esox niger*)

Creek Chub (*Semotilus atromaculatus*)

Gaspereau includes both Alewife (*Alosa pseudoharengus*) and Blueback Herring (*Alosa aestivalis*)

Muskellunge (*Esox masquinongy*)

Rainbow Trout (*Oncorhynchus mykiss*)

Smallmouth Bass (*Micropterus dolomieu*)

Striped Bass (*Morone saxatilis*)

Suckers includes both White Sucker (*Catostomus commersonii*) and Longnose Sucker (*Catostomus catostomus*)

Redbreast Sunfish (*Lepomis auritus*)

White Perch (*Morone americana*)

Lake Whitefish (*Coregonus clupeaformis*)

Yellow Perch (*Perca flavescens*)

**Appendix 2:** The life cycle stages of Atlantic Salmon (*Salmo salar*).

Figure A1 illustrates the life cycle of salmon migrating between freshwater and marine environments.

**Egg** - develops from green egg to eyed egg stage, approx. 1 cm in diameter

**Sac-Fry/Alevin** - approx. 2-3 cm fork length; Fed-Fry-approx. 3-5 cm fork length

**Parr** - possess 9-11 vertical bands or “parr marks”, approx.. 5-9 cm fork length

**Pre-Smolt** - prior to undergoing osmoregulation and migrating to saltwater, approx..9-13 cm fork length

**Smolt** - have undergone osmoregulation and is migrating to saltwater, approx. 13-17 cm fork length

**Grilse** - less than 63 cm in fork length and are those salmon which return to spawn following a single winter at sea and also referred to as one-sea-winter (1SW) Salmon

**Salmon** - greater than or equal to 63 cm in fork length are referred to as large or multi-sea-winter (MSW) Salmon and include those fish that return following two or more winters at sea and repeat spawners

**Captive-Reared salmon** were collected from the wild as juveniles, reared at the Mactaquac Biodiversity Facility and then released to naturally spawn upriver of Mactaquac Dam (Jones et al. 2004)

**Landlock salmon** - have never gone out to sea, but have spent their entire life cycle in fresh water. To differentiate the physical characteristics of landlock salmon from wild sea-run Atlantic salmon: they are generally smaller sized at approximately 50-55 cm in length and have a lot of black spots on their lateral sides, as compared to the larger and more silvery colored wild Atlantic salmon.

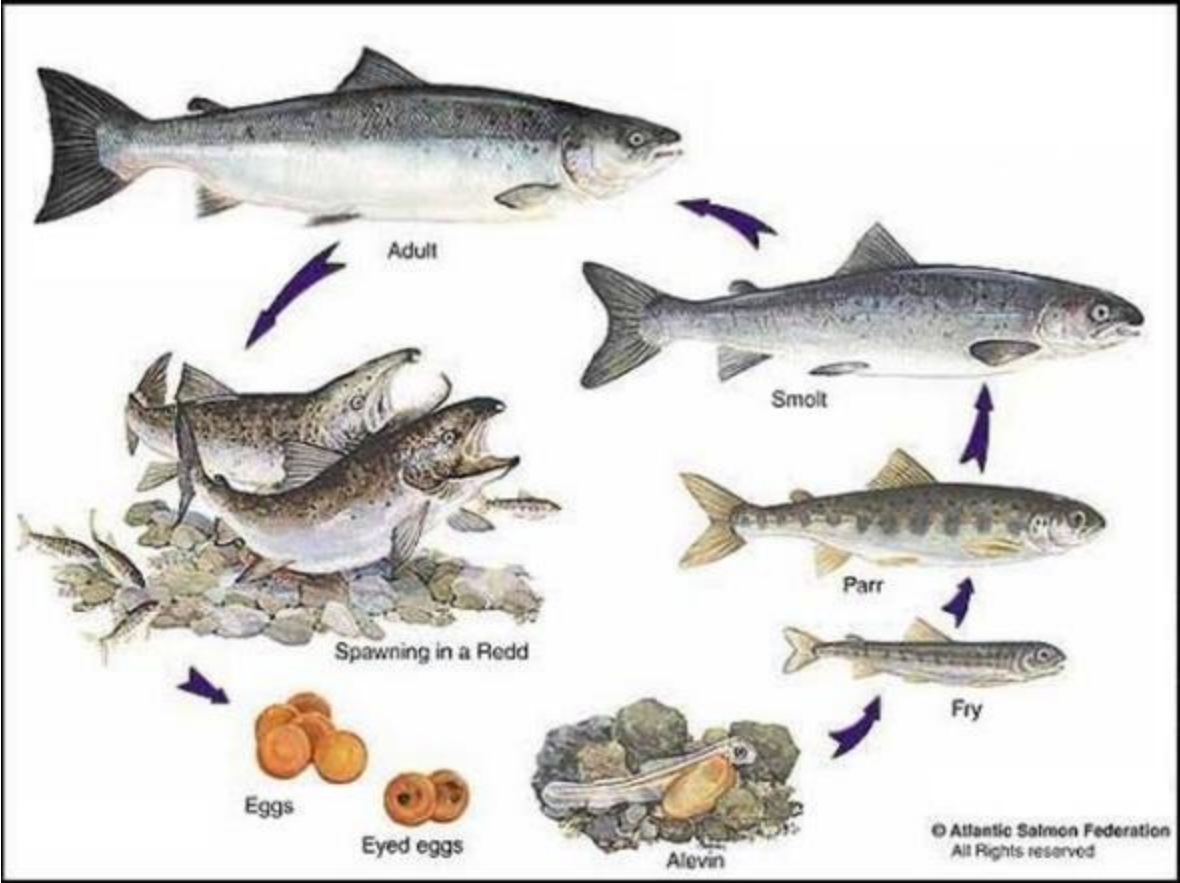


Figure A1. Atlantic Salmon lifecycle (illustration by J.O. Penanen, reprinted with permission from Atlantic Salmon Federation).