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**A review of Atlantic salmon  
enhancement activities on the Terra  
Nova River (SFA 5), Newfoundland**

**Examen des activités de mise en  
valeur du saumon atlantique dans la  
rivière Terra Nova (SPS 5), à  
Terre-Neuve**

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## **Abstract**

The development of the Terra Nova River stock of Atlantic salmon, through enhancement activities, is documented from 1954 to 2001. Counts of salmon up to 2001 are presented for the two fishways constructed in the mid 1950's. Stocking activities subsequent to the provision of fish passage around Mollyguajeck Falls in 1985 are documented. A brief discussion of the success of Atlantic salmon in colonising newly opened habitat is compared for three methodologies: (i) straying of adults (ii) adult transfers and (iii) fry stocking. The data suggest that the greatest stock growth appears to be in the part of the watershed presently undergoing fry stocking.

## **Résumé**

Dans ce document, nous recensons les activités de mise en valeur du stock de saumon atlantique de la rivière Terra Nova réalisées de 1954 à 2001. Nous présentons les dénombrements de saumons effectués jusqu'en 2001 aux deux passes migratoires construites dans les années 1950, ainsi que les travaux d'ensemencement réalisés après la construction en 1985 d'une passe permettant au poisson de contourner les chutes Mollyguajeck. Nous comparons le succès de colonisation de nouveaux habitats par le saumon atlantique à partir de trois méthodes, soit (i) l'égarement d'adultes, (ii) le transfert d'adultes et (iii) l'ensemencement d'alevins. Les données semblent indiquer que le stock présente une plus forte croissance dans la partie du bassin versant où des alevins sont actuellement ensemencés.

## Introduction

The Terra Nova River, on the north-east coast of Newfoundland, is the largest river in Salmon Fishing Area (SFA) 5 (Figure 1) and has been the site of stream remedial work (enhancement) to provide fish passage for Atlantic salmon. Two fishways were constructed and stream remedial work completed on Mollyguaheck Falls: i) Lower fishway at kilometre 11.4 constructed in 1954 eased fish passage as this obstruction was not complete, ii) Upper fishway at kilometre 22.4 was constructed in 1952 to provide fish passage around a complete obstruction, and iii) a series of pools were blasted around Mollyguaheck Falls in 1985 to provide fish passage around this complete natural obstruction (Fig. 2).

Additional colonisation activities conducted in this watershed, included the transfer of adult Atlantic salmon and egg incubation/fry stocking to the areas above Mollyguaheck Falls since 1985 (see Table 1 for detail).

This manuscript reviews the Atlantic salmon enhancement activities within the Terra Nova watershed.

## Materials and Methods

### Watershed Designations

For purposes of discussion in this document the areas of the watershed referred to as lower, middle and upper refer to the following areas (see Figure 2); lower – the area between the lower and upper fishway, middle – the area between the upper fishway and Mollyguaheck Falls and upper – the area upstream of Mollyguaheck Falls.

### Adult Transfers

Atlantic salmon adult transfers were conducted from 1985-1989. Adult salmon collected at the upper fishway throughout the salmon run were held onsite and transferred to the area above Mollyguaheck Falls in late September early October each year (see Table 1). The fish were sexed prior to transfer with a resultant sex ratio of 2.8 to 1.0 in favour of females. Fish were transferred utilising a helicopter and a modified fire bucket to areas above Mollyguaheck Falls with adequate staging areas and suitable spawning habitat. Fish that were transferred did not have their downstream movements impeded.

### Fry Stocking

Fry stocking occurred from 1994-2002. Broodstock for fry stocking were collected at the upper Terra Nova fishway. Fry that were stocked were produced in recirculation

incubators supplied with water from surface wells on the bank Terra Nova Lake. Fry were stocked at the swimup stage using helicopters with a similar distribution system to that used on the Exploits River (Bourgeois and Murray, 1995). Fry were stocked at a density of 75 fry/100m<sup>2</sup> for the areas stocked above Mollyguaieck Lake.

### Management Measures

Management restrictions implemented in 1992 that impacted marine exploitation of salmon are as follows:

1. Moratorium on commercial salmon fishing along the coast of insular Newfoundland.
2. Moratorium on the cod fishery in areas 2J, 3K and 3L implemented on July 15, 1992. In 1998 a limited inshore index cod fishery was permitted in Sept. – Oct. and in 1999 a limited 9,000 t (total allowable catch) fishery was permitted. In 2000 a TAC of 7,000 t was established with season dates of June 26 to July 29 and Sept. 11 to Nov. 30. In 2001 there was a 5,600-t quota for the index fishery with sentinel surveys in this area.
3. Closure of the Labrador commercial Atlantic salmon fishery in 1998.

For the recreational fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each SFA. The quota was assigned for each SFA as a whole and not administered on a river by river basis.

Recreational fishery quotas were eliminated in 1994, the season catch for salmon was lowered from eight to six small salmon. For 1995-97 the season retention was 6 small salmon (3 prior to July 31 and 3 after) with hook and release after.

Since 1998 the Terra Nova River has been under special management restrictions as follows:

1998: Only catch-and-release angling was permitted on the entire river from June 20 to July 10. From July 11 to Sept. 7, only catch-and-release angling was permitted in the following areas: from 25 metres below to 25 metres above the Old Mill Bench; from 800 metres below Grand Falls upstream to second Steady; from 25 metres below Upper Fishway downstream to 800 metres below Upper Fishway; all tributaries above Terra Nova Lake dam. An area from 25 metres above the Upper Fishway to 25 metres below the Upper fishway remained closed to all angling for the season. From July 11 to Sept. 7, all areas not closed or restricted to catch-and-release angling opened for catch-and-retain angling.

1999-2001: Catch-and-retain areas of the river were rated Class III (i.e. season and daily retention limit of two fish and a daily hook-and-release limit of four fish). The section of river from a point 25 metres below the Upper Fishway up to Terra Nova Lake dam was closed to all angling for the season. The following sections were rated Class IV (i.e.

catch-and-release angling only with a limit of four fish per day): Morine's Pool, from a point 25 metres below The Bench up to a point 100 metres above The Bench. The section of river from a point 25 metres above Island Pool, up to a point 25 metres below Briffett's/Second Steady. The section of river from a point 25 metres below the Upper Fishway, downstream to a point 800 metres below the Upper Fishway. All of the watershed above Terra Nova Lake dam, including the main stem of the river.

### Recreational catches

Catch and effort data from the recreational fishery on the Terra Nova River were collected by: i) DFO enforcement staff river monitors and ii) Since 1994 angling statistics are those from the License Stub (see Table 2).

### Salmon Count Data

Atlantic salmon have been counted at the lower and upper fishways since 1956 and 1955 respectively. Partial counts were obtained at Mollyguaieck Falls in 1985-86 and complete counts in 1992 and 2001 (see Table 4).

### Habitat Calculations

The juvenile rearing habitat for the Terra Nova River is detailed in Table 3.

### Conservation Target

O'Connell and Dempson (1991) calculate the conservation spawning requirement as 14,235,104 eggs (Table 3). It is estimated that 8,937 small salmon could provide the egg deposition.

### Fecundity

During 1995-97 a total of 90 salmon were examined for fecundity at spawning time yielding the following relationship  $Y = 117.24X - 3880$  where  $X$  = length of female fish and  $Y$  = Number of eggs. The equation is solved to determine the mean number of eggs per female salmon on the Terra Nova River.

## **Results**

### Lower Terra Nova River

Enhancement activities commenced on the lower Terra Nova watershed with the completion of the lower fishway, which was a partial obstruction to fish migration, in 1955. Adult salmon immediately used the new fishway.

### Middle Terra Nova River

Construction of the upper fishway in 1952 removed a complete obstruction to fish passage on the Terra Nova watershed. There was no stocking program associated with the fishway construction, the colonisation of the area above the fishway was left to natural straying of adults from the area below the fishway. Adult salmon immediately used the newly opened habitat. The area above the upper fishway to the falls at Mollyguaieck Falls requires approximately 3,000 small salmon to achieve conservation egg deposition. This being the case the enhancement of the Terra Nova watershed is a successful venture in that the area above the upper fishway presently has approximately 1600 spawners. Table 4 provides the count of salmon for the lower and upper fishways.

In viewing the colonisation of the area above the upper fishway, the proportion of salmon counted at the lower fishway that are subsequently enumerated at the upper fishway appears to have stabilised after several generations. Figure 3 displays the growth of the stock, based on a five-year generation, above the upper fishway, based on returns to the fishway. As expected growth of the stock from the first generation of spawners increased by approximately 250% and then slowed in future generations of returns. The returns up to and including 1999 are the result of natural spawning.

While the total population is increasing to the watershed, the area above the upper fishway is not colonising the newly opened habitat at the same rate as in other watersheds that have undergone colonisation stocking (Mullins et. al. 2003). A rather simple explanation for this slow colonization rate may be that no stocking was conducted in the newly opened habitat above the upper fishway and is a testament to the slow rate of colonization through straying as opposed to fry or adult stocking; however given the number of spawners utilising this newly opened habitat greater stock growth would be expected.

Prior to the realization of any returns from any fry stocking (2000) above the upper fishway there were nine generations of natural spawners (Table 1) to the area above the upper fishway, which based on experiences with colonisation activities on the Exploits and Torrent rivers, should have been enough time for this portion of the watershed to approach conservation egg deposition (Mullins et. al. 2003). At best the area has received approximately 50% of the required conservation egg deposition. This section of the watershed is expected to achieve over half of its freshwater smolt production from lacustrine habitat (see Table 3) assuming the production of 3 smolts per unit of fluvial habitat and 7 smolts per hectare of lacustrine habitat. Smolt production from lacustrine habitat requires that spawning habitat exist within close proximity of standing water habitat that is utilised by juvenile salmon (O'Connell and Dempson, 1991). The latter may explain the poor stock growth in the Terra Nova watershed. The Torrent and Exploits rivers, where adult transfers/straying were highly successful both derive over fifty percent of their production from fluvial habitat (Bourgeois et.al.2001, Mullins et.al.)

The returns from the 1985-89 spawners were low in most areas of the province especially for the 1990-91 years however, there were only partial counts at the upper fishway for

these two years hence they are not included in the 1990-94 mean. During the 1993-96 time frame the recreation catch more than doubled the previous angling take which led to new management measures that reduced the retained catch. The decrease in the stock growth during the 1990-94 returns can be simply accounted for by an increase in the recreational fishery (the retained catch doubled from approximately 500 to 1,000 fish of which on average 60% would have been destined for the area above the upper fishway).

The following text table details the time frames when increased salmon production were expected to be observed from stocking activities within the upper Terra Nova watershed.

Activity	Year 1 <sup>st</sup> returns expected	
1. Adult transfer 1985-1989 (average of 282 adults)	1990	
2. Fry stocking 1988-90 ( average of 2,133 fry)	1993	
3. Fry stocking 1994-1995 ( average of 56,527 fry)	1999	
4. Fry stocking 1996-present ( average of 399,349 fry)	2001	

Returns or increased production from the four activities are difficult to quantify due to level of stocking activities or unrelated events that have led to increased escapement. Expected/anticipated increases in production from the adult transfer are complicated to document for the following reasons; i) the 1990 and 1991 escapements to most of the island are the lowest on record ii) the 1990 and 1991 counts to the upper fishway are only partial counts and iii) closure of the commercial salmon fishery in 1992.

The 1988 - 1990 and 1994 – 1995 fry stockings are too insignificant to provide a measurable increase in production.

The last activity, i.e. reasonable level of fry stocking, only yielded its first returns in 2001. It will be 2002 before the two major smolt ages will be realized i.e. three and four year old smolt.

Figures 3 and 4 shows the ratio of fish that used both fishways. Prior to 1990 (the first expected returns from the adult transfer) approximately 60% of the fish that used the lower fishway also used the upper fishway; after 1990 this figure changed to 66%. This change in the ratio could be due to an increase in production not a change due to the moratorium.

### Upper Terra Nova River

Fish passage to this section of the watershed was completed in 1985. Since construction of the fishway, partial counts of salmon have been obtained in only four years Table 4. In 2001 a partial count of spawners (329 spawners) was obtained at Mollyguaieck Falls on the upper Terra Nova River. This count, when adjusted for the broodstock removed at the



upper fishway suggests that 436 adult salmon were destined for the area above Mollyguaheck Falls. No adjustment was made for fish removed by the recreational fishery.

### Discussion

Figure 4 shows the continuous growth in terms of spawners for the lower and middle Terra Nova River. The growth while very slow (approximately 40 years) has seen the population increase from 74 (initial 5-year mean in 1959) to over 1600 spawners. If the population had doubled every 5 years (for every spawner you would get two returns) it would take little more than 20 years for the population to achieve its present size. On the Great Rattling Brook and the Torrent River, two watersheds where an adult transfer was conducted with the opening of habitat, both watersheds were achieving conservation egg deposition within 20 years.

A comparison of the mean number of spawners, for the various sections of the Terra Nova watershed, in 1995 and 1996 to the number of spawners observed in 2001 yielded the following results.

Section of watershed	Returns per spawner
Lower	0.7
Middle	1.1
Upper	1.6

This data suggests that based on the single count at Mollyguaheck Falls in 2001 that stock growth in the Terra Nova watershed is the highest for the upper Terra Nova watershed where fry stocking is being conducted.

The moratorium on commercial salmon fishing in 1992 led to increased escapement to the Terra Nova River through the fact that no fish were removed through the commercial fishery. Comparison of the ratio of fish enumerated at the lower and upper fishways allows for a comparison of the stock growth at these fishways irrespective of the moratorium.

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Table 1. Stocking activities conducted within the middle and upper Terra Nova watershed.

Year	Adults Transferred		Fry Stocked (location)
	Small	Large	
1985	123	0	
1986	341	33	
1987	193	7	
1988	374	25	2,640 (middle)
1989	312	4	0
1990			3,760 (middle)
1991			0
1992			0
1993			0
1994			47,847 (upper)
1995			65,208 (upper)
1996			375,954 (upper)
1997			488,487 (upper)
1998			439,615 (upper)
1999			434,576 (upper)
2000			423,975 (upper)
2001			233,487 (upper)

Adults transfers were to the upper watershed

Table 2. Recreational Atlantic salmon fishery statistics for the Terra Nova River 1974 - present.

Year	Effort Rod Days	Small (<63 cm)				Large (>=63 cm)				Total (Small + Large)			
			Ret.	Rel.	Tot.		Ret.	Rel.	Tot.		Ret.	Rel.	Tot.
1974	2098		243	.	243		5	.	5		248	.	248
1975	1723		506	.	506		2	.	2		508	.	508
1976	1236		424	.	424		7	.	7		431	.	431
1977	1956		850	.	850		13	.	13		863	.	863
1978	1608		628	.	628		6	.	6		634	.	634
1979	910		537	.	537		15	.	15		552	.	552
1980	872		512	.	512		22	.	22		534	.	534
1981	1303		739	.	739		33	.	33		772	.	772
1982	1174		465	.	465		24	.	24		489	.	489
1983	2157		486	.	486		43	.	43		529	.	529
1984	2042		636	.	636		0	.	0		636	.	636
1985	1810		751	.	751		.	.	0		751	.	751
1986	1485		620	.	620		.	.	0		620	.	620
1987	1764		546	.	546		.	.	0		546	.	546
1988	1613		682	.	682		.	.	0		682	.	682
1989	1946		357	.	357		.	.	0		357	.	357
1990	2165		624	.	624		.	.	0		624	.	624
1991	1701		448	.	448		.	.	0		448	.	448
1992	2488		409	141	550		.	0	0		409	141	550
1993	3925		484	569	1053		.	62	62		484	631	1115
1994	5853		822	178	1000		.	44	44		822	222	1044
1995	6042		696	132	828		.	72	72		696	204	900
1996	5933		896	260	1156		.	113	113		896	373	1269
1997			296	148	444		.	10	10		296	158	454
1998			146	379	525		.	32	32		146	411	557
1999			103	162	265		.	12	12		103	174	277
2000			92	268	360		.	7	7		92	275	367
							.						

Table 3. Habitat inventory data and conservation egg deposition requirement for Terra Nova River upstream of the Lower Fishway.

Area (% of egg deposition)	Fluvial (100m <sup>2</sup> )	Lacustrine (Ha.)	Egg Requirement
Total Watershed(above lower fishway)	32,659	17,383	14,235,104
Lower to Upper Fishway (7%)	3,990	0	957,600
Upper Fishway to Mollyguaieck Falls (33%)	10,509	5,790	4,652,880
Above Mollyguaieck Falls (60%)	18,160	11,593	8,624,624

Table 4. Counts of Atlantic salmon at fishways on the Terra Nova River.

Year	Lower Fishway			Upper Fishway			Mollyquaieck Falls		
	Small	Large	Total	Small	Large	Total	Small	Large	Total
1955				53	24	77			
1956	558	36	594	32	44	76			
1957	141	41	182	21	1	22			
1958	677	195	872	10	0	10			
1959	394	67	461	120	20	140			
1960	490	217	707	86	0	86			
1961	318	99	417	74	1	75			
1962	496	275	771	284	4	288			
1963	551	320	871	372	35	407			
1964	419	297	716	246	18	264			
1965	474	254	728	334	51	385			
1966	368	220	588	134	2	136			
1967	613	359	972	373	42	415			
1968	715	374	1089	409	28	437			
1969	658	393	1051	463	136	599			
1970	754	470	1224	563	170	733			
1971	580	277	857	316	121	437			
1972	609	348	957	330	202	532			
1973	455	299	754	340	222	562			
1974				162	121	283			
1975				778	52	830			
1976				335	37	372			
1977				371	262	633			
1978	810	20	830	436	89	525			
1979	569	170	739	455	30	485			
1980	843	39	882	420	17	437			
1981	1115	90	1205	619	28	647			
1982	963	19	982	625	8	633			
1983	1210	57	1267	853	76	929			
1984	1233	107	1340	904	98	1002			
1985	1557	112	1669	960	60	1020	6		(6)
1986	1051	140	1191	726	58	784	1		1
1987	974	56	1030	570	38	608			
1988	1737	206	1943	795	45	840			
1989	1138	142	1280	668	51	719			
1990	1149	144	1293	(410)	(34)	0			
1991	873	114	987	(311)	(26)	0			
1992	1443	270	1713	886	224	1110	98	10	(108)
1993	(2713)	(470)	3183	962	173	1135			
1994	1571	242	1813	1179	172	1351			
1995	2258	634	2892	1298	260	1558			
1996	2005	464	2469	1285	185	1470			
1997	1577	527	2104	979	173	1152			
1998	1780	390	2170	1332	143	1475			
1999	1836	343	2179	1198	76	1274			
2000				833	90	923			
2001	2151	330	2481	1512	181	1693	292	37	(329)

Numbers in parentheses indicate partial counts.