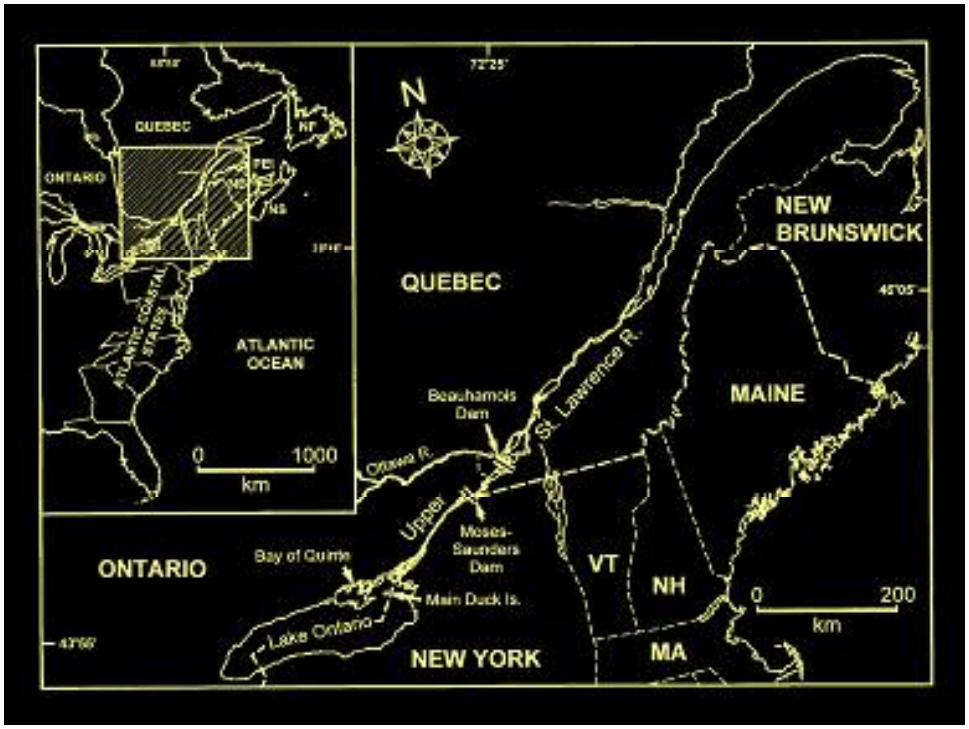
Size of Juvenile American Eels Ascending the Upper St. Lawrence River — Trends and Declining Recruitment

Lucian A. Marcogliese
30 Salem Road
R.R. 1, Ameliasburgh, Ontario K0K 1A0
marcogliese@sympatico.ca

and

John M. Casselman
Ontario Ministry of Natural Resources
Applied Research and Development Branch
Glenora Fisheries Station
R.R. 4, Picton, Ontario K0K 2T0
john.casselman@mnr.gov.on.ca



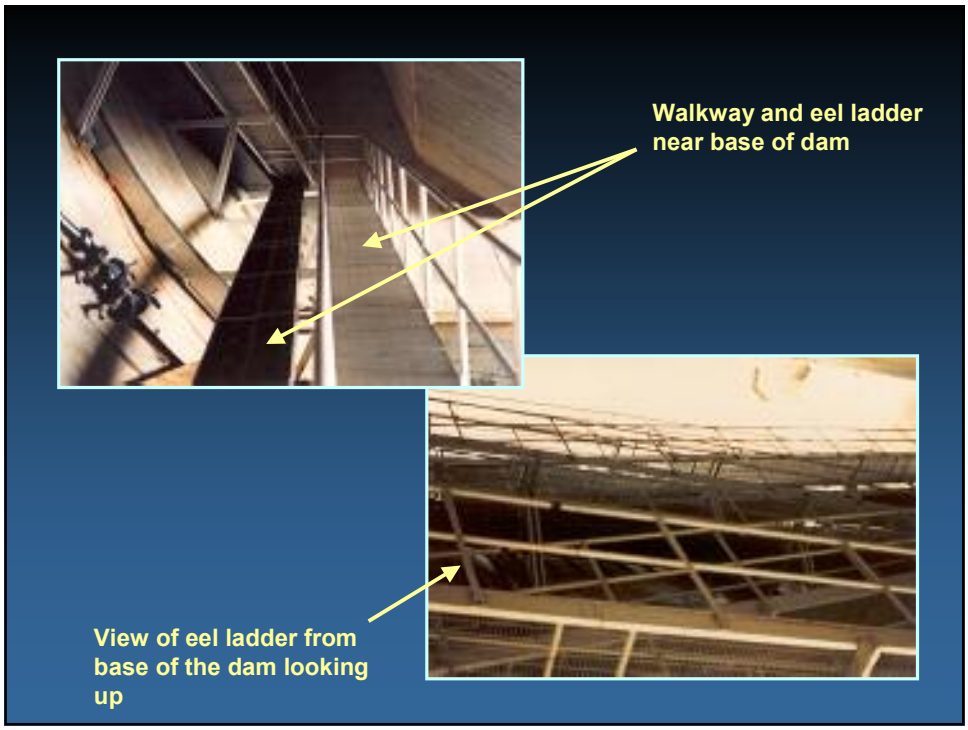
Background

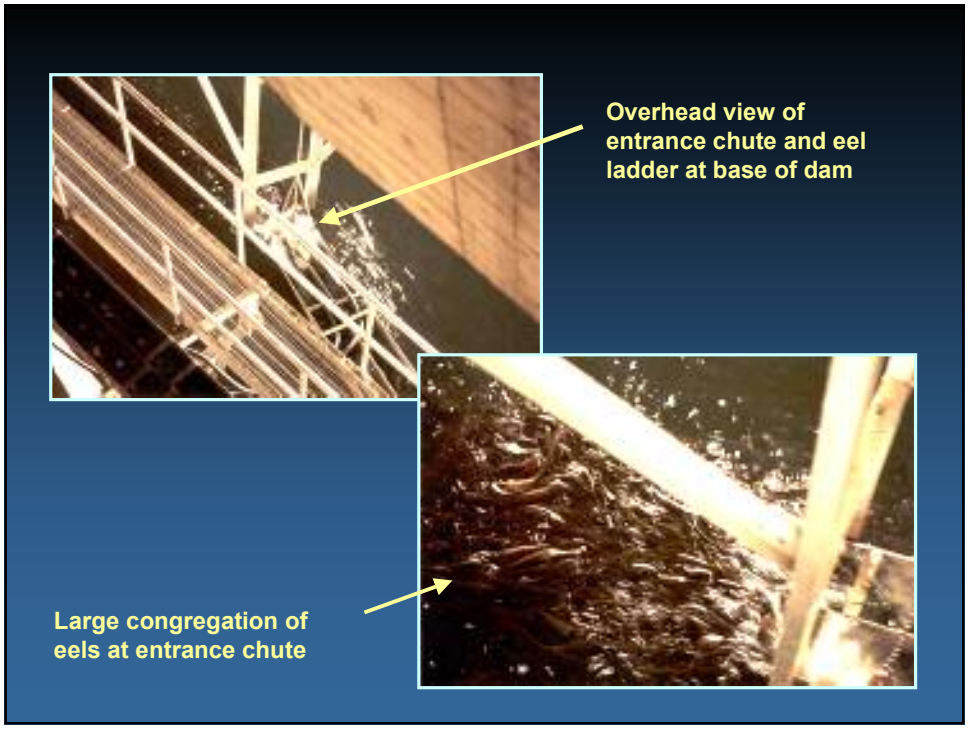
1. From 1954 to 1958, the Moses - Saunders Hydro-Electric Generating Station, Cornwall, Ontario, and the St. Lawrence River Seaway was constructed

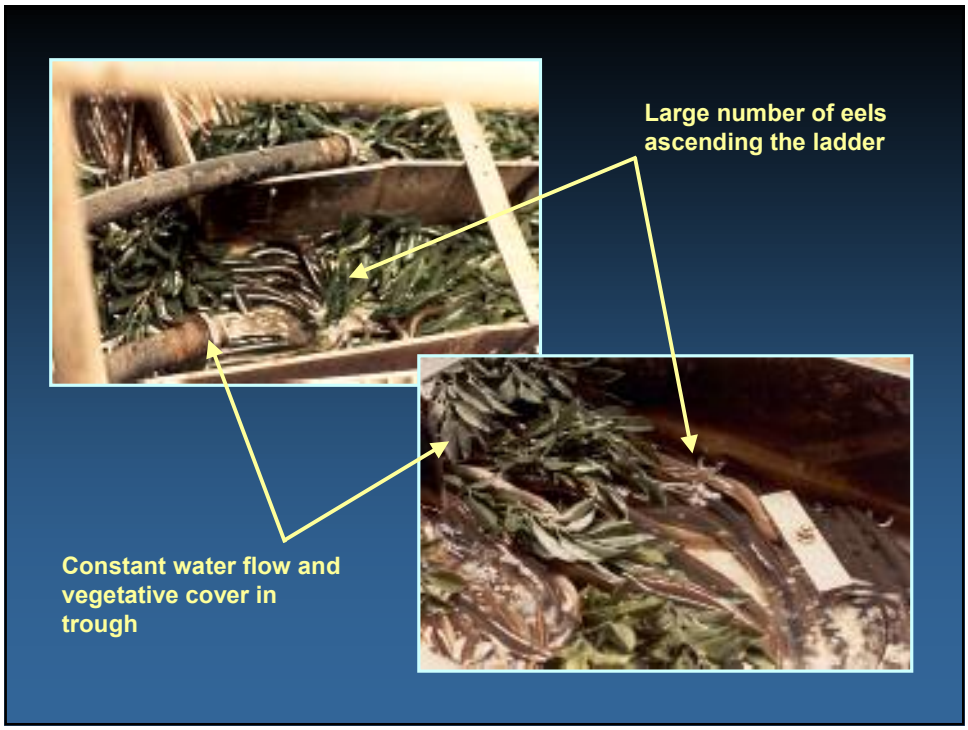
2. Construction of the Generating Station and Seaway did not completely block eel migration to Lake Ontario, but it was thought to reduce their numbers

3. In 1974, an experimental eel ladder was installed to facilitate upstream eel migration to Lake Ontario, and to help alleviate problems associated with eels clogging pump intakes as thousands of eels were seen congregating at the base of the dam each year

4. The ladder was constructed at Ice Sluice # 1, the northern most Ice Sluice off the Ontario shoreline. Location of the ladder was selected for two reasons, (1) Ice-sluice # 1 was not being used, and (2) large numbers of eels were congregating at #1 ice-sluice because there was less current, which made upstream migration easier, and it acted as a resting area







5. In 1982 and 1983, number of eels ascending the ladder to Lake Ontario was at its peak, with greater than 1,000,000 eels ascending annually

6. In 1996, we standardized annual eel ladder passage to the 31 day peak migration period. For 1982 and 1983, mean passage was 27,489 and 26,103 eels daily

7. From 1995 to 1997, and 1998 to 2002, mean daily number of eels ascending the ladder during the 31 day peak migration period was fewer than 1,000, and fewer than 100 respectively

8. Throughout the years, we see less variability in the size of eels ascending the ladder than there use to be

Objectives

1. Examine the size of eels ascending the ladder from 1975 to 2002

2. Compare the size of eels between those ascending the ladder during annual passage with those ascending during the 31 day peak migration period

3. Examine the relationship between number and size of eels ascending the ladder

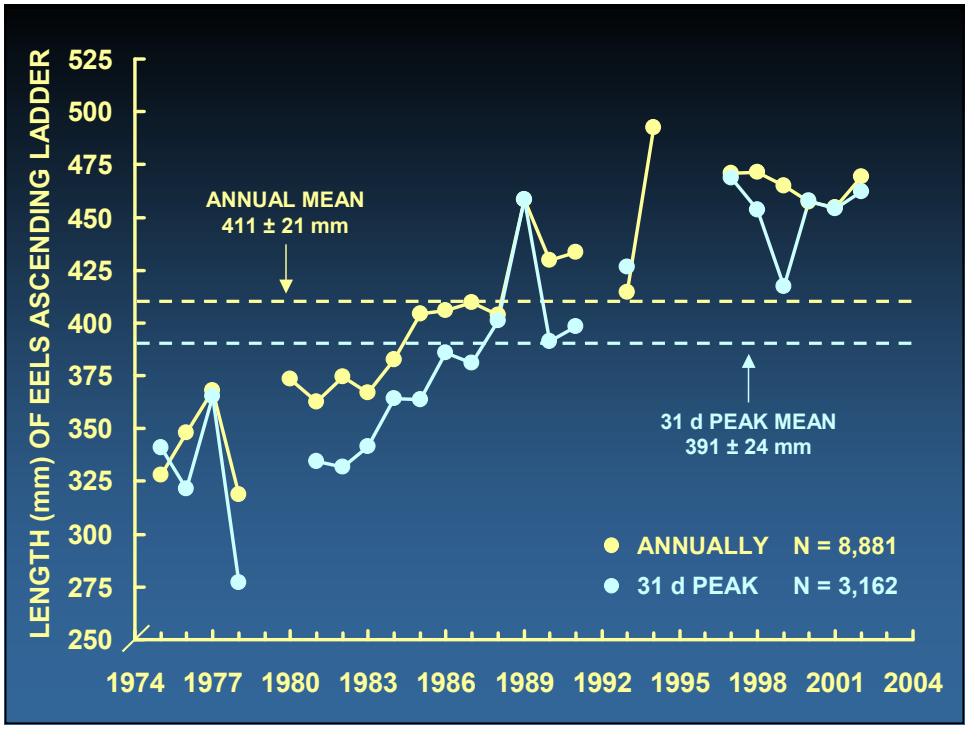
4. To provide better precision and understanding of the eel ladder and recruitment dynamics and failure

Overall mean size (mm) of American eels ascending the ladder by decade. ANOVA and LSD statistical tests.

Size	Decade	*N*	Mean	C.I.	CV	*P* (≤ 0.05)
length (mm)	1970	3,930	341[1]	2.7	25.6	
	1980	3,291	380[2]	2.8	21.3	
	1990	1,019	457[3]	4.8	17.0	
	2000	641	460[3]	5.9	16.4	<0.0001
weight (g)	1970	3,930	59.8[1]	1.5	81.1	
	1980	3,291	84.4[2]	2.2	76.3	
	1990	1,019	138.0[3]	4.9	58.2	
	2000	430	142.9[3]	7.2	52.9	< 0.0001

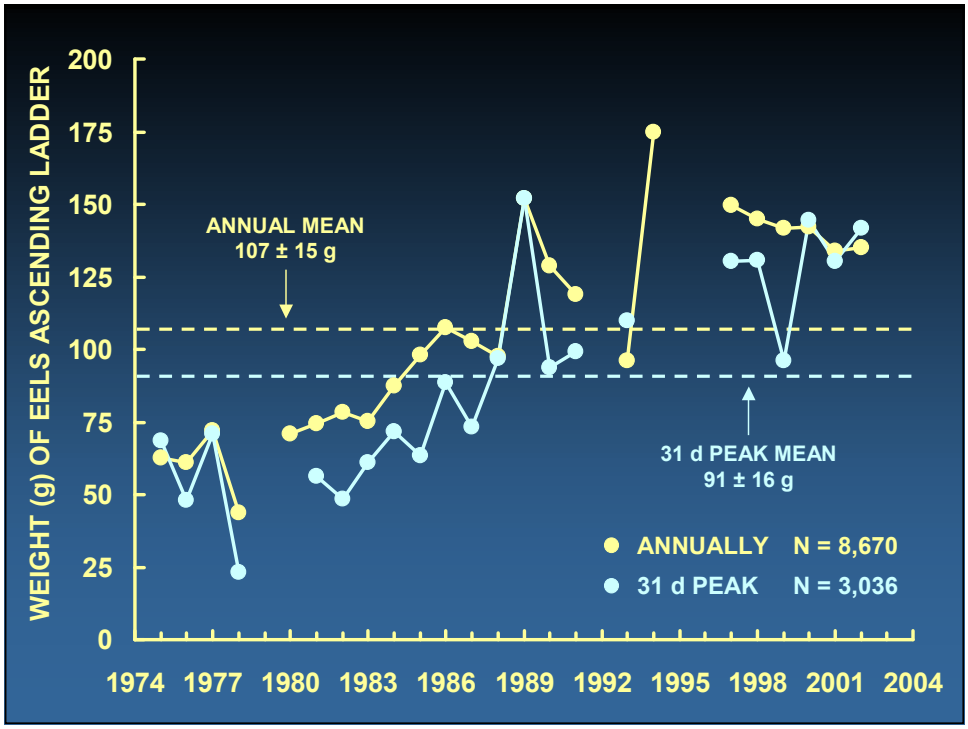
Size (mm) of American eels ascending the ladder during 31 day peak migration period, by decade. ANOVA and LSD statistical tests.

Size	Decade	*N*	Mean	C.I.	CV	*P* (🔔 0.05)
length (mm)	1970	1,512	330[1]	4.2	25.1	
	1980	1,162	356[2]	4.2	20.6	
	1990	167	417[3]	10.6	16.6	
	2000	321	458[4]	8.4	16.7	<0.0001
weight (g)	1970	1,512	56.4[1]	2.3	79.6	
	1980	1,162	67.9[2]	2.7	69.6	
	1990	167	104.2[3]	7.9	49.7	
	2000	195	141.8[4]	10.3	51.2	< 0.0001



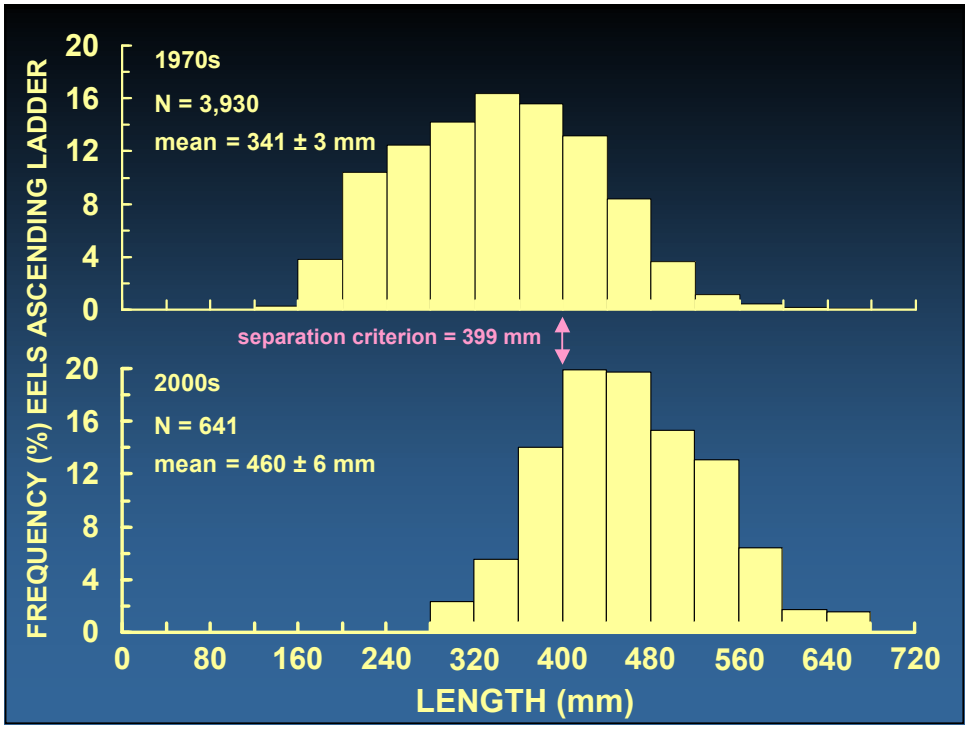
Mean length (mm) of eels ascending the ladder annually compared to the 31 day peak migration period. Two sample t-test.

Year	N	Length (mm) Annual	Peak	P (≤ 0.05)	Year	N	Length (mm) Annual	Peak	P (≤ 0.05)
1975	926	330	341	0.0086	1989	35		458	
1976	1,202	348	322	0.0000	1990	134	430	391	0.0085
1977	863	368	366	0.7186	1991	71	434	398	0.0288
1978	939	319	277	0.0000	1992				
1979					1993	77	414	427	0.3934
1980	138	374			1994	65	493		
1981	1,209	363	335	0.0000	1995				
1982	375	375	332	0.0000	1996				
1983	350	367	342	0.0010	1997	67	471	469	0.9652
1984	250	383	364	0.0143	1998	109	472	454	0.2845
1985	350	404	364	0.0000	1999	496	465	417	0.0000
1986	275	406	386	0.0344	2000	437	457	458	0.9253
1987	225	410	381	0.0082	2001	52	455	454	0.9794
1988	84	404	401	0.7342	2002	152	469	462	0.5315



Mean weight (g) of eels ascending the ladder annually compared to the 31 day peak migration period. Two sample t-test.

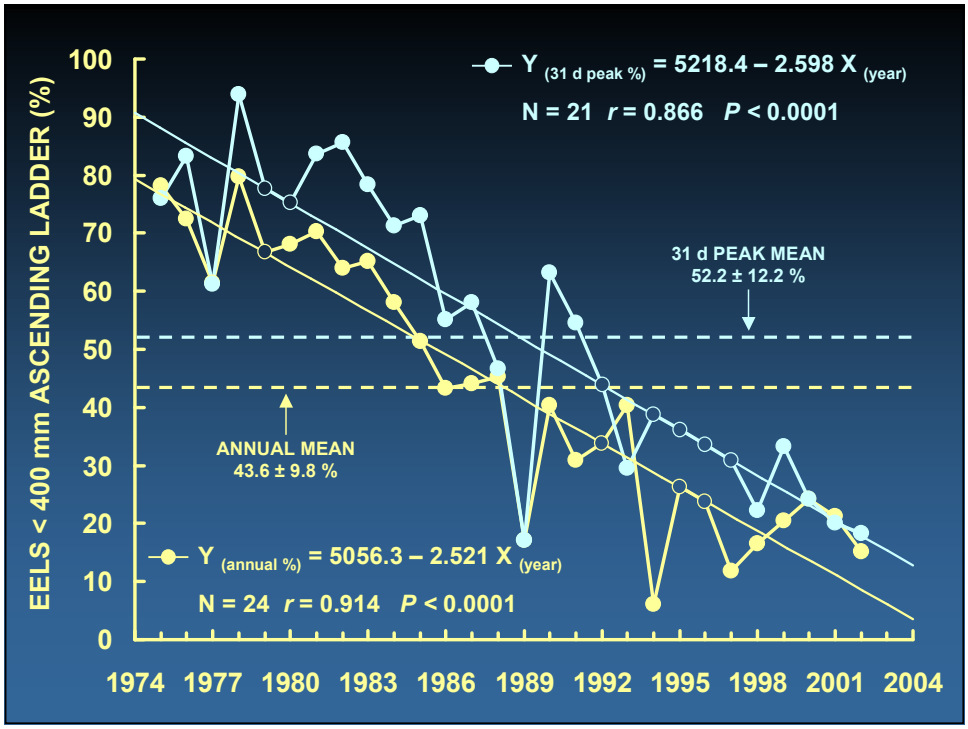
		Weight (g)			continued		Weight (g)		
Year	*N*	Annual	Peak	*P* (≤ 0.05)	Year	*N*	Annual	Peak	*P* (≤ 0.05)
1975	926	63	69	0.0267	1989	35		152	
1976	1,202	61	48	0.0000	1990	134	129	94	0.0034
1977	863	72	71	0.7128	1991	71	119	99	0.1040
1978	939	44	23	0.0000	1992				
1979					1993	77	96	110	0.1703
1980	138	60			1994	65	175		
1981	1,209	74	56	0.0000	1995				
1982	375	78	48	0.0000	1996				
1983	350	75	61	0.0073	1997	67	150	131	0.7673
1984	250	88	72	0.0017	1998	109	145	131	0.4063
1985	350	98	64	0.0000	1999	496	142	96	0.0000
1986	275	108	89	0.0201	2000	226	142	144	0.7799
1987	225	103	73	0.0001	2001	52	134	130	0.8327
1988	84	98	97	0.9297	2002	152	148	142	0.6211

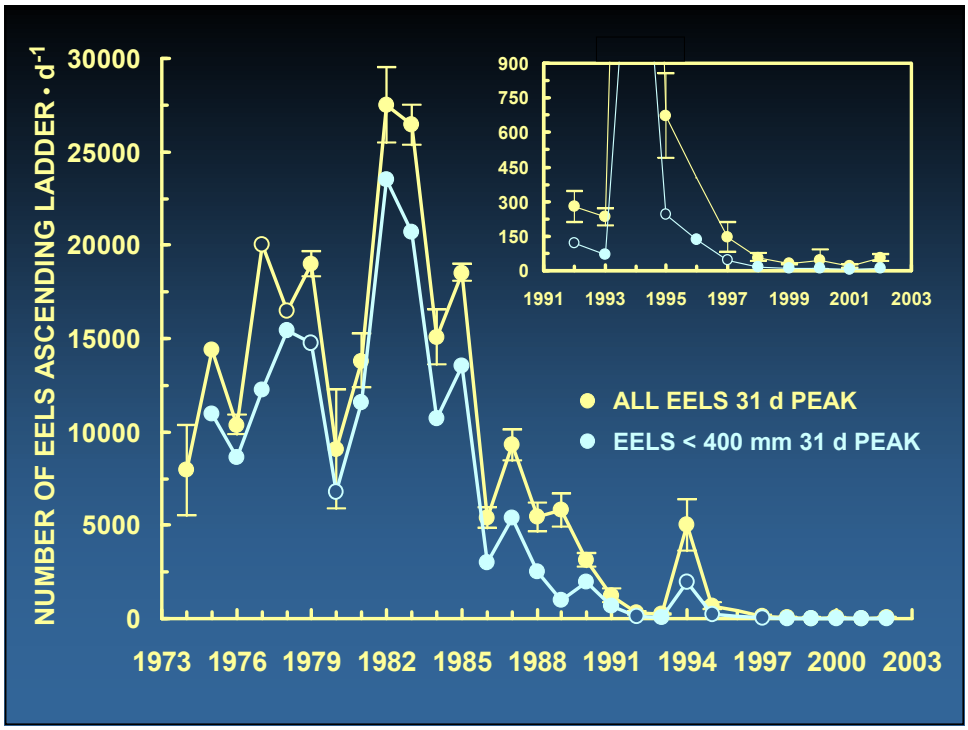


Seasonal Changes in the Size of Eels Ascending the Ladder

1. Historically, at the start of migration (usually late May to early June) larger eels ascend the ladder first, followed in July and August by very large numbers of smaller eels during the peak migration period. Often, a very small surge of eels ascends the ladder in late September and early October consisting mainly of larger eels

2. More recently, the number of small eels during peak summer migration has declined to the point where the small surge of larger eels that ascends in the fall is threatening to become the peak migration period





Relationship Between number and size of eels ascending the ladder During Peak Migration

Correlation –regression equation:

Eel length (mm) = 432.53 –4.75E –03 X (31d peak)

***N* = 22 *r* = 0.786 *P* < 0.0001**

Conclusions

1. From the 1970s to 2000s, annual mean length and weight of eels ascending the ladder during overall passage significantly increased by 35% and 139% respectively ($P < 0.0001$)

2. From the 1970s to 2000s, annual mean length and weight of eels during the 31 day peak migration period significantly increased by 39% and 151% respectively ($P < 0.0001$)

3. From 1975 to 2002, annual mean length and weight of eels ascending the ladder was significantly different than during the 31 day peak migration period (P =0.0002 and 0.0004, length and weight respectively)

4. In 1988, length of eels during peak migration surpassed a transitional size of 400 mm (401 ± 3, 96.9 ± 9.4 g) and has remained above this level since 1993

5. The proportion of small eels <400 mm ascending the ladder has declined significantly throughout the years ($P < 0.0001$)

6. From 1975 to 1983, the proportion of small eels < 400 mm accounted for 61 to 94% of all eels during peak migration. In 1986, a declining trend of small eels started (55%) and by 1988, they fell below 50% of peak passage for the first time (47%). Since 1992, small eels have accounted for less than 50% of all eels during peak migration. In 2002, they represented only 18%

7. In 1982 (86%) and 1983 (78%) respectively, 23,531 and 20,718 small eels ascended the ladder per day during peak migration

8. Most recently from 1998 to 2002, only 4 to 13 small eels ascended the ladder per day during peak migration. The index of recruitment for small eels has essentially ceased

9. This decline represents a significant and substantial loss of small recruits and is jeopardizing the Upper St. Lawrence River – Lake Ontario stock

10. We have good reason to believe the eel ladder index is reliable and functions as it did before. Large congregations of eels are no longer seen at the base of the ladder

11. We now have a good understanding of the relationship between numbers and size of eels ascending the ladder. The next step is age

12. Preliminary results indicate mean age has increased with time