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**Status of Atlantic Salmon (*Salmo salar* L.) in Gander River,  
Notre Dame Bay (SFA 4), Newfoundland, 1989-1991**

by

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### Abstract

The status of Atlantic salmon in Gander River in 1989-91 was determined using complete counts obtained from a counting fence located on the main stem just above head of tide, recreational fishery data, and biological characteristic data. The percentage of target spawning requirement achieved ranged from 33% (1991) to 36% (1990). There is evidence to suggest that declining catch per unit of effort in the recreational fishery in Gander River during 1979-89 was due in part to an increase in exploitation in the commercial fishery in the Gander Bay area. Low escapements since 1989 could also have been due to possible juvenile mortality resulting from unusually low flows in Gander River in 1987 and 1988 and to decreased marine survival.

### Résumé

On a déterminé l'état des stocks de saumon de l'Atlantique de la rivière Gander de 1989 à 1991 en se fondant sur des dénombrements complets effectués à une barrière de dénombrement du bras principal de la rivière, en amont de la limite des eaux de marée, sur les résultats de la pêche sportive et sur des caractéristiques biologiques. Pendant cette période, on a atteint de 33 % (1991) à 36 % (1990) des besoins-cibles de reproducteurs. Selon certaines indications, la baisse des prises par unité d'effort dans la pêche sportive pratiquée dans la rivière Gander de 1979 à 1989 est due en partie à une intensification de la pêche commerciale dans la région de la baie de Gander. Par ailleurs, les faibles échappées que l'on connaît depuis 1989 pourraient être causées par la mortalité de juvéniles attribuable au débit exceptionnellement bas des eaux de la rivière Gander en 1987 et en 1988, ainsi qu'à une baisse de la survie en mer.

## Introduction

The Gander River, with a drainage area of 6,398 km<sup>2</sup> (Porter et al. 1974), is the third largest in insular Newfoundland. The river is located in Salmon Fishing Area (SFA) 4 (Notre Dame Bay) (Fig. 1). On average, for the period 1984-89, Gander River accounted for 25% of the total recreational catch of Atlantic salmon for SFA 4 and 10% of the total catch for the insular Newfoundland portion of the Newfoundland Region. In addition to being one of the most important Atlantic salmon angling rivers in insular Newfoundland, the river has historically supported a relatively large angler guiding and outfitting industry.

In recent years there has been a general concern that the Gander River is underproducing. In 1989, the Department of Fisheries and Oceans in cooperation with the Gander Rod and Gun Club and the Gander Bay/Hamilton Sound Development Association, initiated a 3-year study to determine the status of the Gander River Atlantic salmon population.

In this paper, counts of Atlantic salmon obtained from a counting fence are used in conjunction with recreational fishery data and biological characteristic data to calculate spawning escapement and egg deposition. Status of stock in 1989-91 is evaluated against a target spawning requirement (calculated in terms of fluvial and lacustrine habitats) derived for Gander River.

## Methods

### RECREATIONAL AND COMMERCIAL FISHERY DATA

Catch and effort data from the recreational fishery in Gander River were collected by Department of Fisheries and Oceans (DFO) Officers and processed by DFO Science Branch personnel. Commercial fishery data for communities in the Gander Bay area (Fig. 2) were compiled by Fisheries Statistics and Systems Branch of DFO. Procedures for the collection and compilation of both recreational and commercial data are described by Ash and O'Connell (1987).

### BIOLOGICAL CHARACTERISTIC DATA

Biological characteristic information on adult Atlantic salmon in Gander River was obtained by sampling recreational catches (Table 1). For fish < 63 cm in length (grilse), mean values for all years combined were used in the calculation of egg deposition. For fish  $\geq$  63 cm in length (large salmon), mean values for all available data for Gander River and Terra Nova River combined were used (Table 1).

Fecundity was determined from ovaries collected in the recreational fishery. Ovaries were stored in Gilson's fluid until ovarian tissue had broken down after which time eggs were transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. The relative fecundity value used to calculate egg deposition for both grilse and large salmon was 1,665 eggs/kg and represented all data combined for the years 1984-87 (N = 173).

## ESCAPEMENT AND EGG DEPOSITION

Escapement and egg deposition were calculated for grilse and large salmon separately. Total egg deposition was obtained by summing depositions for grilse and large salmon.

### Total River Escapement

Total river escapement (TRE) was calculated as follows:

$$(1) \quad \text{TRE} = \text{RC}_b + C$$

where,

$\text{RC}_b$  = recreational catch below counting fence  
 $C$  = count of fish at counting fence

### Spawning Escapement

Spawning escapement (SE) was calculated as follows:

$$(2) \quad \text{SE} = \text{FR} - \text{RC}_a$$

where,

FR = fish released from counting fence  
 $\text{RC}_a$  = recreational catch above counting fence

### Egg deposition

Egg deposition (ED) was calculated as follows:

$$(3) \quad \text{ED} = \text{SE} \times \text{PF} \times \text{RF} \times \text{MW}$$

where,

SE = number of spawners  
 PF = proportion of females  
 RF = relative fecundity (No. eggs/kg)  
 MW = mean weight of females

The phenomenon of atresia has been reported to occur in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet et al. 1984). Recently there is evidence to show that it can occur to varying degrees in insular Newfoundland (O'Connell and Dempson, unpublished data). Since the egg deposition calculations above were based on eggs in early stages of development, they should be regarded as potential egg depositions.

## TARGET SPAWNING REQUIREMENT

The target spawning requirement for Gander River was developed by O'Connell and Dempson (1991). The egg deposition requirement for classical

fluvial parr rearing habitat (Elson 1957) was 240 eggs/unit (a unit = 100 m<sup>2</sup>) (Elson 1975); the requirement for lacustrine habitat was 368 eggs/ha (O'Connell et al. 1991). It should be noted that Gander Lake was not included in the calculation of the egg deposition requirement.

Accessible rearing habitat and target spawning requirement in terms of eggs and adults calculated for Gander River (O'Connell and Dempson 1991) were as follows:

	<u>Lacustrine</u>	<u>Fluvial</u>	<u>Total</u>
Accessible habitat	21,488 ha	159,560 units	-
Eggs (No. x 10 <sup>6</sup> )	7.917	38.294	46.211
Grilse (No.)	3,739	18,089	21,828

The target spawning requirement was calculated in terms of grilse only. Egg deposition from large salmon was considered as a buffer to the estimate of spawning requirement.

#### SPAWNING ESCAPEMENTS AND PROPORTIONS OF TARGET SPAWNING REQUIREMENT ACHIEVED PRIOR TO 1989

Each year for the period 1989-91, an exploitation rate ( $\mu$ ) was determined for Gander River according to the formula,

$$(4) \quad \mu = \frac{TRC}{RC_b + C}$$

where,

TRC = total recreational catch

Total river escapement was then determined as follows:

$$(5) \quad TRE = \frac{TRC}{\mu}$$

Spawning escapement was calculated according to the formula,

$$(6) \quad SE = TRE - TRC$$

Using the above expressions, spawning escapements were simulated and expressed as a proportion of the target number of grilse required. Exploitation rates were drawn randomly from a uniform distribution between 0.149 and 0.175 and applied to angling catches between 1979 and 1988. Angling catches were varied by a factor of 20%. Simulations were run 1,000 times in order to generate a frequency distribution of the proportion of target achieved during 1979-88.

## Results

### Recreational Fishery

The recreational catch in 1991 (Table 2, Fig. 3) was similar to 1990 (+ 2%) but was 59% below the 1979-83 mean and 49% below the 1984-89 mean. The 1984-89 mean corresponds to years under major management changes introduced in 1984 (see O'Connell et al. 1990). The 1989, 1990, and 1991 catches were similar and were approximately 20% below that of 1987 in which year drought conditions resulted in the closure of the major tributaries entering Gander Lake to angling from July 14 to September 7 (end of the angling season). In 1990 and 1991, out of the total catch of grilse presented in Table 2, an estimated 220 and 300 respectively were caught below the counting fence. Negligible catch occurred below the fence in 1989.

Effort in 1991 (Table 2, Fig. 3) decreased from 1990 (-18%), the 1974-83 mean (-20%), and the 1984-89 mean (-30%); catch per unit of effort increased over 1990 (20%) but decreased from the 1974-83 (-53%) and 1984-89 (-26%) means.

### Counts at Counting Fence and Fishway

Counts obtained from the counting fence on the main stem of the Gander River for 1989-91 were as follows:

<u>Year</u>	<u>Grilse</u>	<u>Large salmon</u>	<u>% Large</u>
1989	7,743	473	5.5
1990	7,520	508	6.3
1991	6,445	670	9.4

The lowest count of grilse and the highest count of large salmon occurred in 1991. The proportion of large salmon in 1991 was higher than in 1989 and 1990 which in turn were similar.

Counts of grilse and large salmon at the fishway located in Salmon Brook tributary for the period 1979-91 are shown in Table 3. Counts in each size category in 1991 were the lowest on record.

### Total Escapement and Spawning Escapement

Total escapement, spawning escapement, and egg deposition for grilse (G) and large salmon (LS) for Gander River in 1989-91 were as follows:

<u>Year</u>	<u>Total escapement</u>		<u>Spawning escapement</u>		<u>Egg deposition (No. x 10<sup>6</sup>)</u>		<u>Proportion of target</u>
	<u>G</u>	<u>LS</u>	<u>G</u>	<u>LS</u>	<u>G</u>	<u>LS</u>	
1989	7,743	473	6,570	473	13.909	2.363	0.35
1990	7,740	508	6,585	508	13.940	2.538	0.36
1991	6,745	670	5,565	670	11.781	3.347	0.33

The percentage of target spawning requirement achieved was lowest in 1991.

#### Proportion of Target Achieved During 1979-88

The results of simulations to estimate the proportion of target spawning requirement achieved during the ten year period, 1979-88, are shown in Fig. 4. It is estimated that in that time period, on average, 60-65% of target requirement was met.

#### Trends in the Gander River Recreational Fishery and the Gander Bay Commercial Fishery

Since 1979, there has been a steady decline in catch per unit effort (CPUE) in the recreational fishery in Gander River (Fig. 3). For the years 1979-89, the trend was significant ( $\log_e Y = 1283.4 - 169.2 \log_e X$ ;  $r^2 = 0.67$ ;  $df = 8$ ;  $P = 0.0036$ ). The years 1987, 1990, and 1991 were atypical and were omitted from the regression. In 1987, portions of the river were closed to angling due to drought conditions. In 1990 and 1991, the commercial fishery in SFA 4 was controlled by quota. In 1990, the quota was taken on July 25 while in 1991, the fishery was in effect until the usual closure date of October 15. In 1991 however, severe ice conditions that persisted until early July delayed the start of the commercial fishery by several weeks. During 1979-89, there was also a significant decline in recreational catch of grilse ( $\log_e Y = 1127.1 - 147.2 \log_e X$ ;  $r^2 = 0.39$ ;  $df = 8$ ;  $P = 0.0528$ ) (Fig. 3); there was no apparent trend for effort expenditure ( $r^2 = 0.0003$ ;  $df = 8$ ;  $P = 0.9641$ ). The regression of catch on effort was not significant ( $r^2 = 0.33$ ;  $df = 8$ ;  $P = 0.0815$ ).

Coincident with the decline in grilse catch and CPUE in Gander River, the commercial catch (by number) of small salmon in the Gander Bay area during the period 1979-89 (Fig. 5) showed a significant increase ( $\log_e Y = 263.8 \log_e X - 1994.2$ ;  $r^2 = 0.63$ ;  $df = 9$ ;  $P = 0.0033$ ). The regression of CPUE in the Gander River recreational fishery on the commercial catch of small salmon in the Gander Bay area (Fig. 6) for the period 1979-89 was negative and significant ( $Y = 43.4018 X^{-0.5467}$ ;  $r^2 = 0.85$ ;  $df = 8$ ;  $P = 0.0001$ ). The regression (Fig. 7) was also significant with the years 1974-78 added ( $Y = 0.553 - 0.0000248 X$ ;  $r^2 = 0.70$ ;  $df = 13$ ;  $P = 0.0001$ ).

#### **Discussion**

The fact that recreational catch declined significantly, effort expenditure did not change appreciably, and the relationship between catch and effort was not significant, suggests that the decline in CPUE in Gander River resulted from decreasing escapements. The negative relationship between CPUE in Gander River and the commercial catch of small salmon in the Gander Bay area suggests there was a decrease in escapements during 1979-89 due, in part, to increased exploitation in the commercial fishery in the Gander Bay area.

Beginning in the early 1980's and ending in 1990, many fishermen in Gander Bay fished gillnets with a stretched mesh size of 4.5 inches as opposed to a previously used mesh size of 5 inches. It is possible that the reduction in mesh size contributed to increased commercial exploitation. Low escapements

since 1989 could also have been partially due to unusually low river flows in 1987 and 1988 (Figs. 8 and 9) which might have increased juvenile mortality. An apparent general decrease in survival at sea since 1989 (O'Connell et al. 1990, 1991) might have contributed to low escapements to Gander River as well.

As mentioned earlier, in 1990 the commercial fishery in SFA 4 closed on July 25 when the quota was taken. Also beginning in 1990, caution notices were moved farther out in Gander Bay than in previous years. In spite of such restrictions, the total escapement to Gander River in 1990 remained similar to that of 1989. This suggests that had the restrictions in the commercial fishery not been in place, escapement in 1990 might have been lower than in 1989. The severe ice conditions in 1991 delayed the start of the commercial fishery in Gander Bay. Also the timing of entry of salmon into Gander River was later in 1991 than in 1989 and 1990 (Fig. 10). The commercial fishery in Gander Bay lasted the entire season in 1991 and the catch was the lowest since 1979. This plus the fact that the river escapement in 1991 was the lowest of the three year assessment period indicates that abundance in 1991 was the lowest of the three years.

Using exploitation rates calculated for Gander River ranging from 0.149 to 0.175, the results of simulations suggest that 60-65% of target spawning requirement was achieved during the ten year period prior to 1989. In order to have had achieved target spawning requirement in that time period, exploitation rates would have had to vary between 0.08 and 0.15. In order for the level of target achieved to have been similar to those observed for 1989-91, exploitation rates would have had to vary from 0.20 to 0.35. Since actual exploitation rates showed little variation over the three year period, it is reasonable to assume that they could be characteristic of Gander River and applicable to years prior to 1989.

Cautions associated with the parameter values used to calculate the target spawning requirement have been discussed previously by O'Connell et al. (1991) and O'Connell and Dempson (1991) and will not be dealt with here in detail. Recent research findings pertaining to the egg-to-smolt parameter however warrant mention. This parameter is very sensitive to change in terms of impact on calculations of egg deposition requirement using the model presented in O'Connell and Dempson (1991). There is reason to believe that egg-to-smolt survival could be substantially lower than used in the model. However, further substantiation is required. The use of a lower value would increase the target spawning requirement accordingly.

For Gander River, the calculation of target spawning requirement assumes that the locations of spawning substrate and nursery areas are such that under natural mechanisms of distribution, juveniles will have access to all the specified fluvial and lacustrine rearing habitat. Currently investigations are ongoing to determine if logging operations, both past and present, have negatively affected productive capacity of habitat. The egg deposition requirement value presented above therefore is an interim value which could be subject to change pending the outcome of the habitat assessment.



### Acknowledgments

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**Table 1.** Biological characteristic data for female grilse (data for years 1975-87 combined) from Gander River and for female large salmon from Gander River and Terra Nova River (separately and combined).

Year	Length of females				Weight of females (kg)				River age				Sex ratio	
	N	$\bar{X}$	SD	Range	N	$\bar{X}$	SD	Range	N	$\bar{X}$	SD	Range	N	% Female
<b>Grilse</b>														
Gander River	928	52.2	38.6	39.0-62.1	941	1.63	0.37	0.68-3.68	944	3.74	0.57	3.00-6.00	1,217	78
<b>Large Salmon</b>														
Gander River	8	69.2	80.6	63.0-82.6	8	3.66	1.81	2.38-7.71	8	3.50	0.53	3.00-4.00	10	80
Terra Nova River	6	68.3	38.4	63.0-73.5	6	3.08	0.60	2.27-3.70	6	4.00	0.63	3.00-5.00	6	100
Gander and Terra Nova rivers combined	14	68.8	63.9	63.0-82.6	14	3.41	1.41	2.27-7.71	14	3.71	0.61	3.00-5.00	16	88

Table 2. Recreational catch of grilse as well as effort and catch per unit of effort (CPUE) for Gander River, Notre Dame Bay (SFA 4), Newfoundland, 1974-91.

Year	Catch (No.)		Effort (rod days)	CPUE
	Grilse	Large Salmon		
1974	2,270	19	5,153	0.44
1975	2,976	38	6,670	0.45
1976	2,374	132	6,633	0.38
1977	2,269	927	6,939	0.46
1978	3,332	389	8,322	0.45
1979	4,199	318	7,217	0.63
1980	2,664	268	6,384	0.46
1981	4,578	249	10,643	0.45
1982	2,176	205	8,026	0.30
1983	2,033	239	6,934	0.33
1984	2,028	13	7,590	0.27
1985	3,358	*	10,207	0.33
1986	2,361	*	9,740	0.24
1987**	1,444	*	6,384	0.23
1988	2,686	*	7,943	0.34
1989	1,173	*	6,290	0.19
1990	1,155	*	7,118	0.16
1991	1,180	*	5,853	0.20
1974-83				
Mean	2,887.1	278.4	7,292.1	0.43
SD	888.0	(255.8)	1,464.7	0.03
N	10	10	10	10
1984-89				
Mean	2,321.2		8,354.0	0.27
SD	808.4		1,609.9	0.03
N	5		5	5

\*Retention of large salmon prohibited.

\*\*Not included in mean.

Table 3. Counts of Atlantic salmon at Salmon Brook fishway, 1979-91.

Year	Grilse	Large salmon
1979	404 <sup>1</sup>	6 <sup>1</sup>
1980	997	15
1981	2,459	33
1982	1,425	18
1983	978	12
1984	1,081	38
1985	1,663	26
1986	1,064	12
1987	493 <sup>1</sup>	9 <sup>1</sup>
1988	1,562	24
1989	596	24
1990	328 <sup>1</sup>	7 <sup>1</sup>
1991	245	2

<sup>1</sup>Partial count: not included in mean.

1979-83

Mean	1,464.7	19.5
SD	694.2	9.3
N	4	4

1984-89

Mean	1,193.2	24.8
SD	430.9	9.2
N	5	5

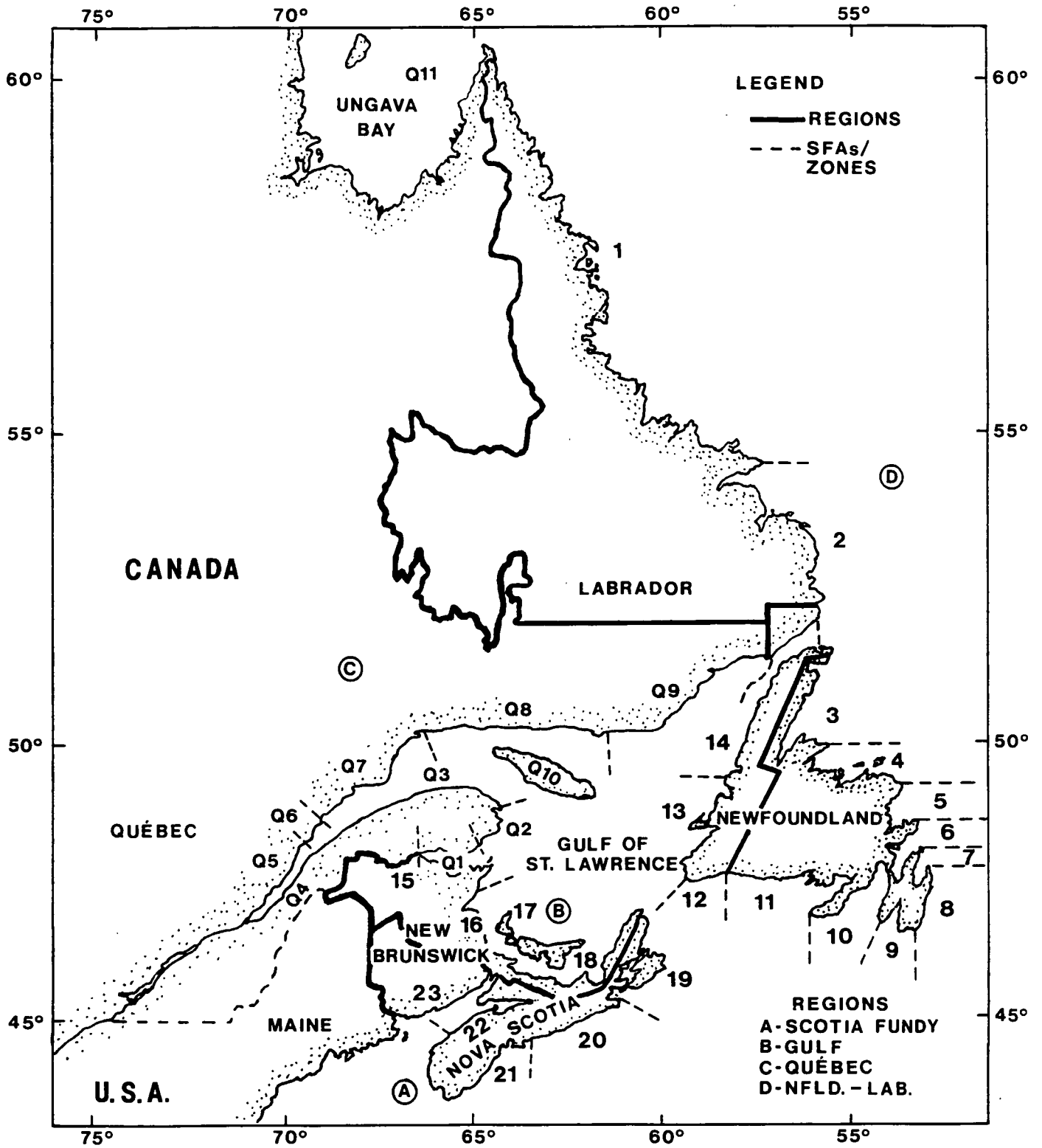


Fig. 1. Map of Atlantic Provinces of Canada showing Salmon Fishing Areas (SFAs) 1-23, Salmon Management Zones of Quebec (Qs) 1-11, and regional boundaries. The Newfoundland Region is comprised of SFAs 1-11.

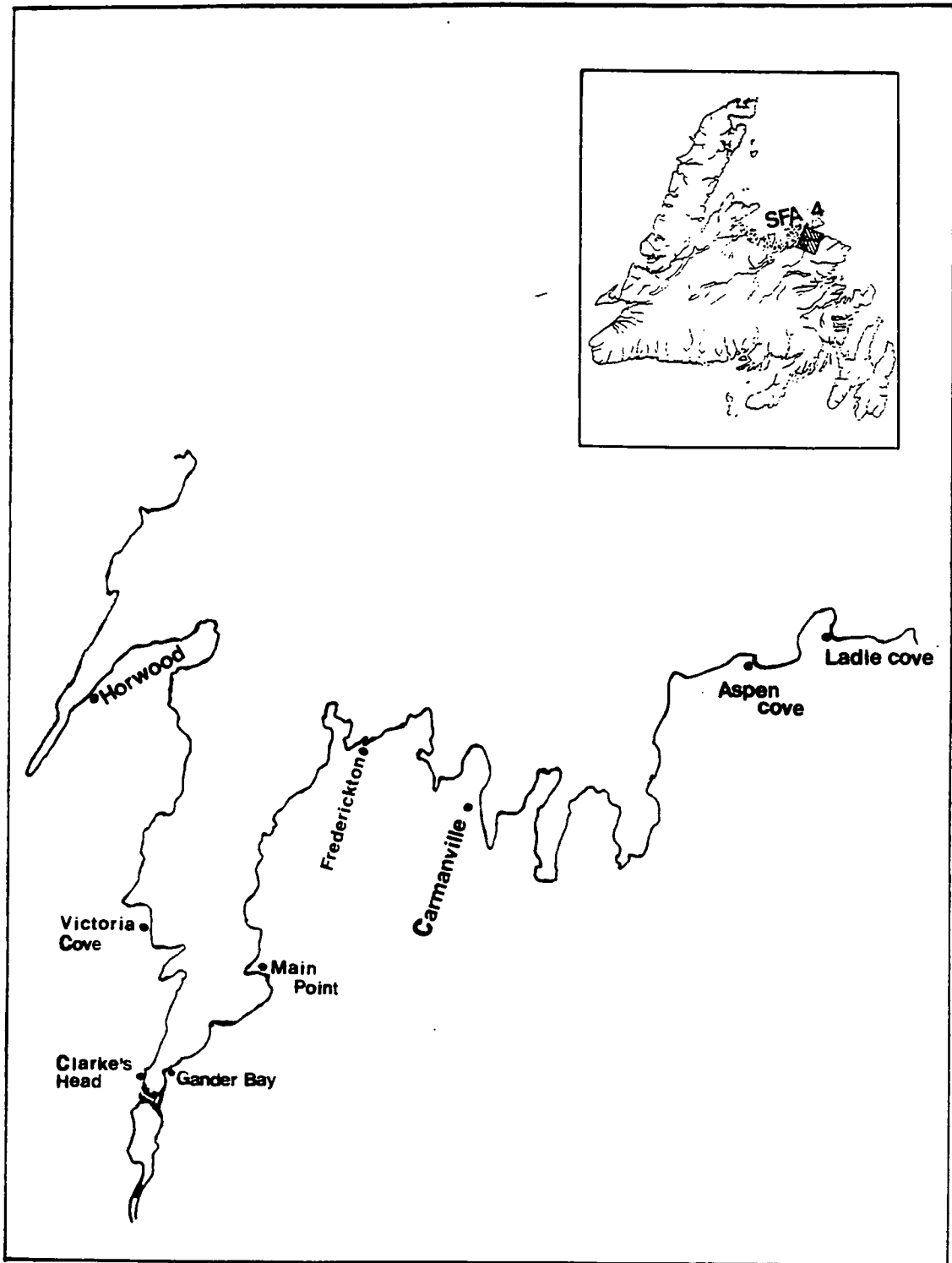


Fig. 2. Map of fishing communities in the Gander Bay area of Notre Dame Bay (SFA 4).

# Gander River

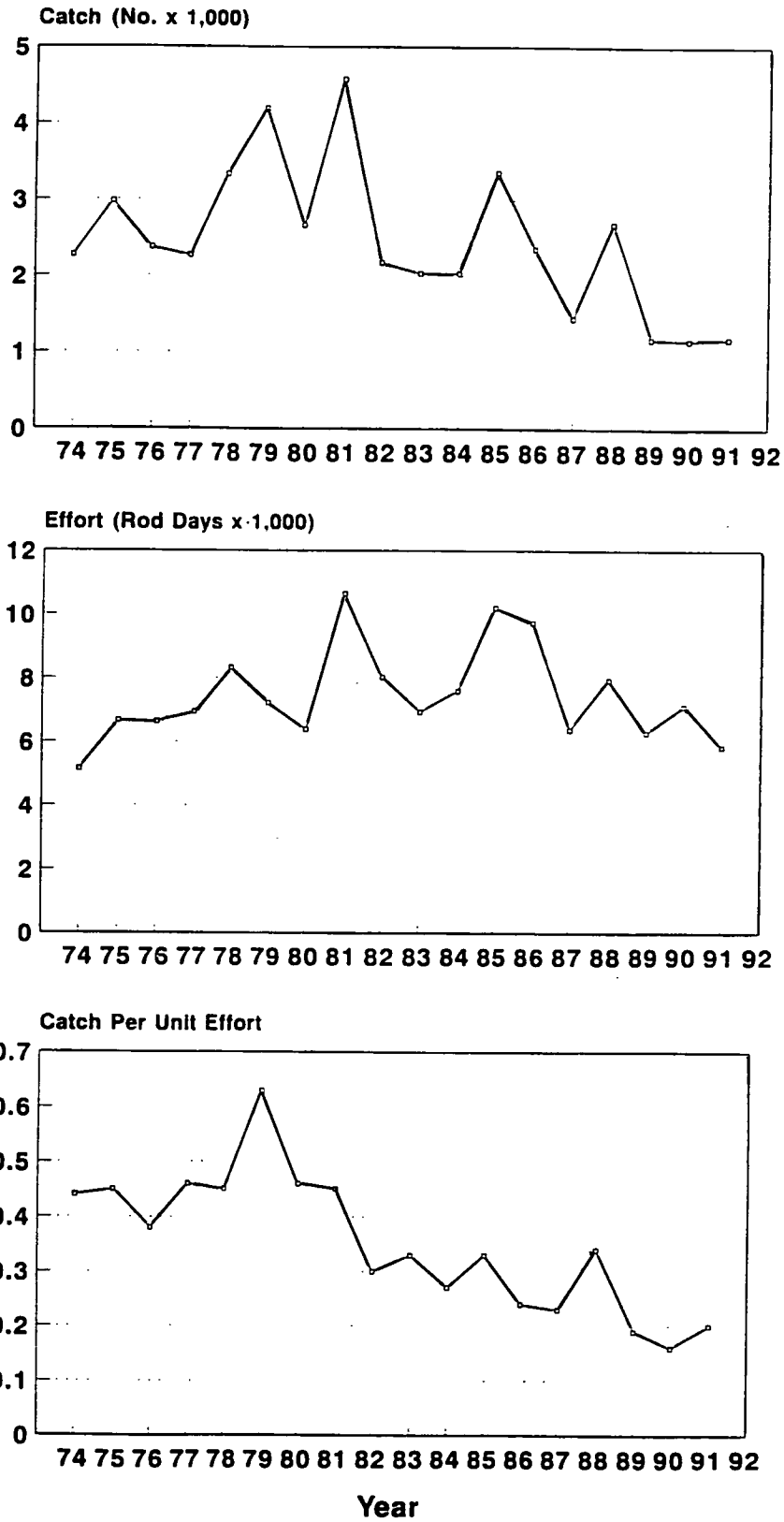


Fig. 3. Atlantic salmon recreational catch, effort, and catch per unit of effort for Gander River, 1974-91.

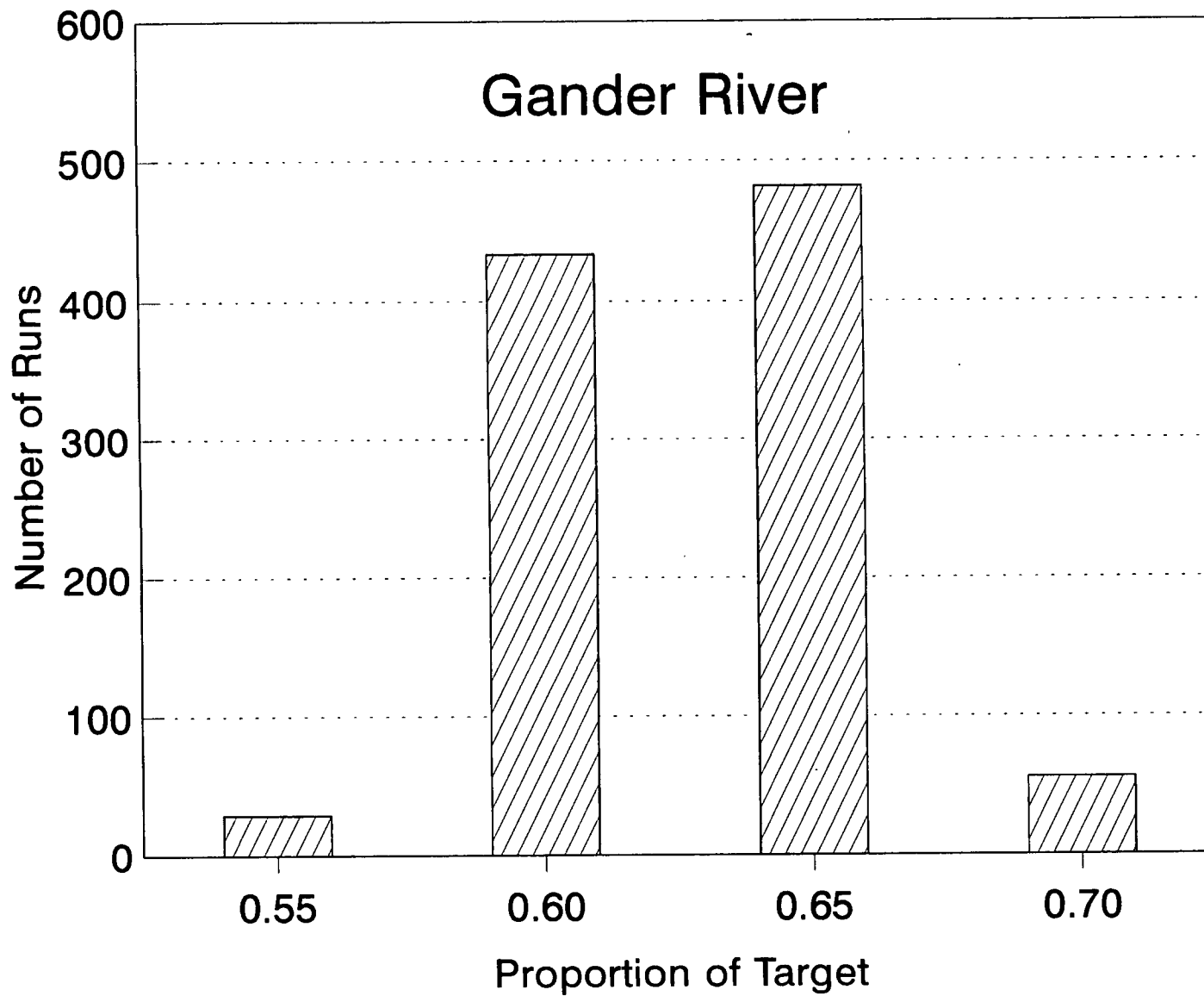


Fig. 4. Distribution of the proportion of target spawning requirement achieved in Gander River for the period 1979-88 resulting from the simulation model.



# Gander Bay

## Commercial Catch

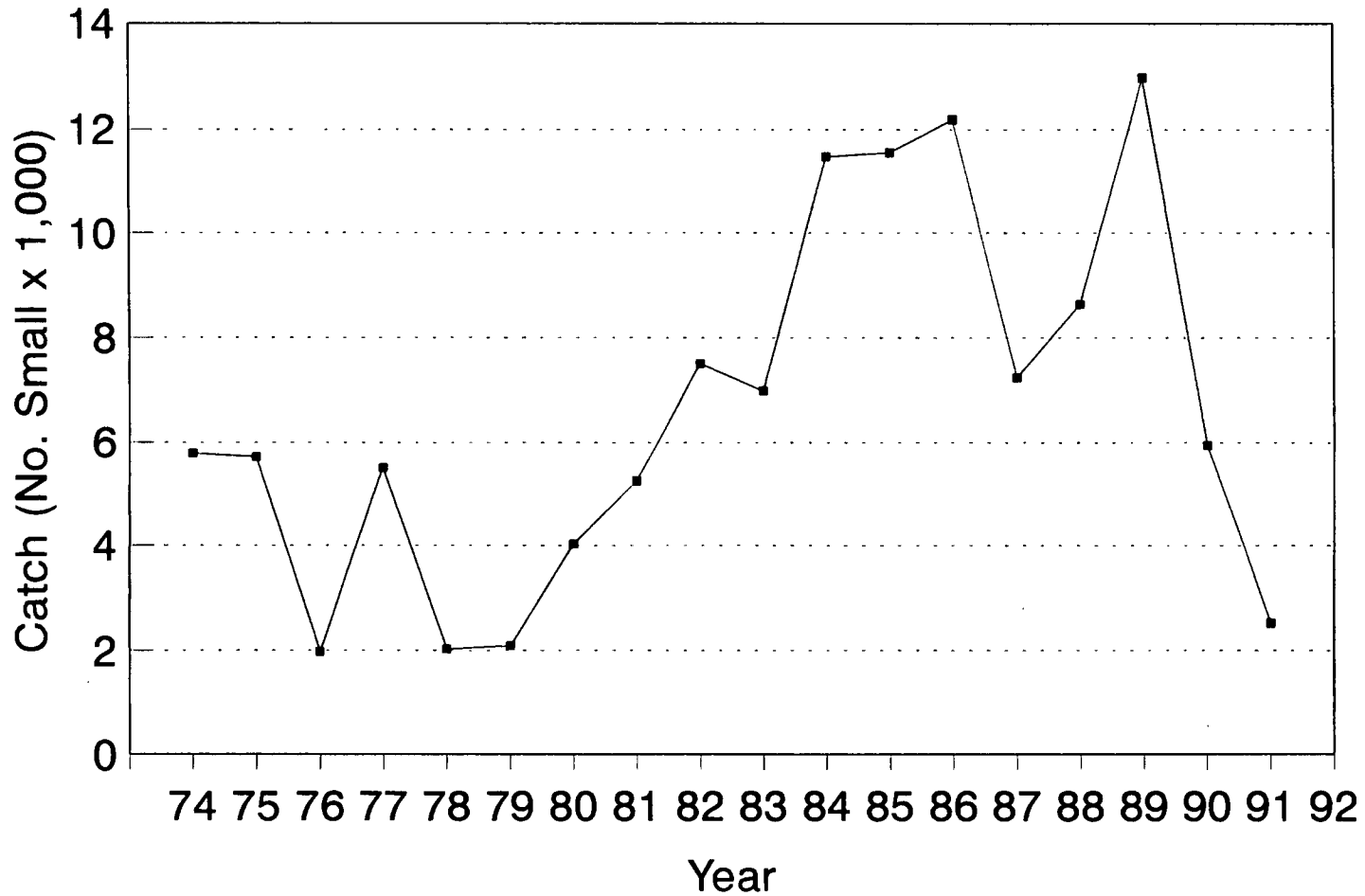


Fig. 5. Commercial catch of small salmon (by number) in Gander Bay, 1974-91.

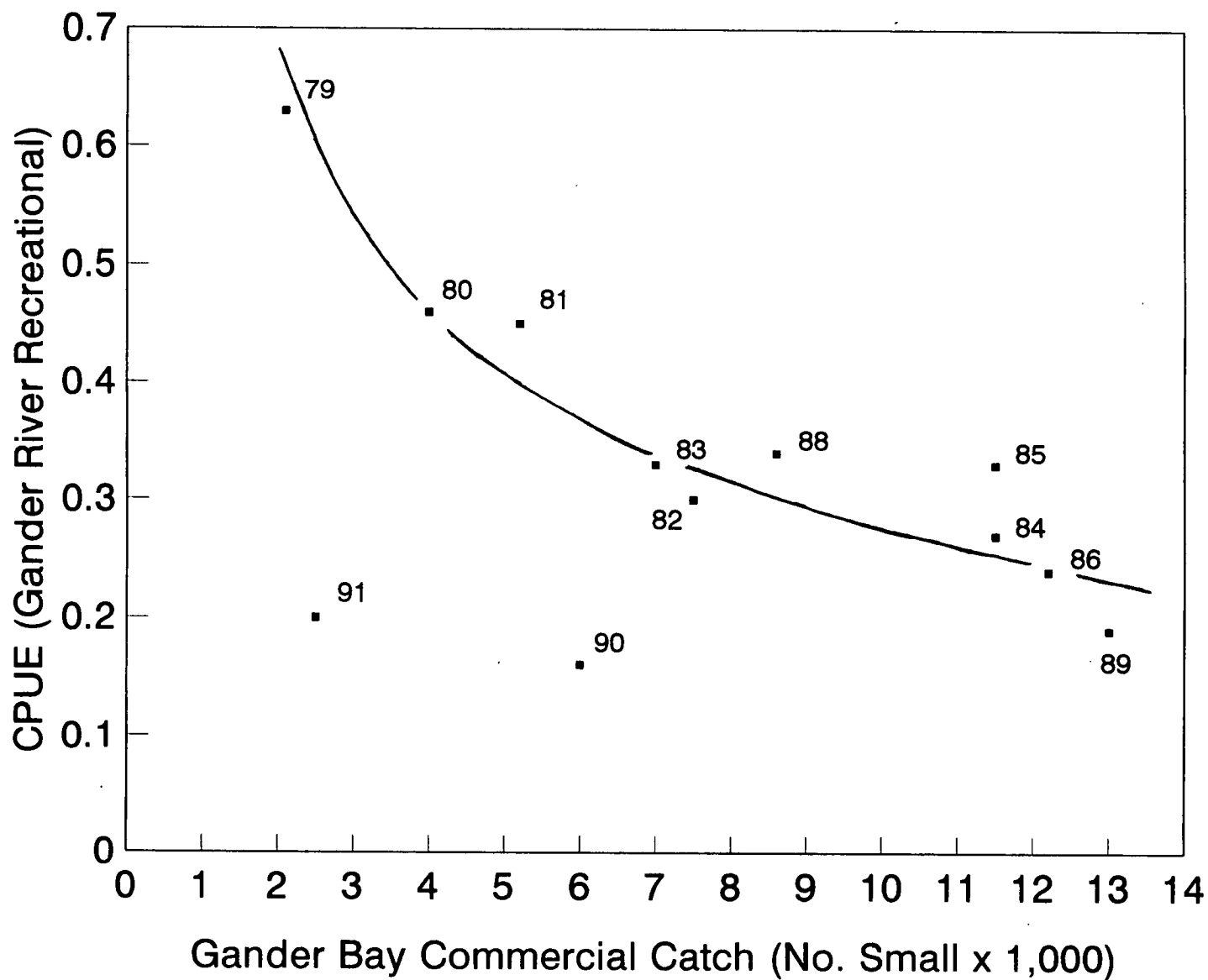


Fig. 6. Regression of Atlantic salmon recreational catch per unit of effort in Gander River on commercial catch of small salmon (by number) in Gander Bay, 1979-89. Points for 1990 and 1991 are shown for comparison purposes but not included in the regression.

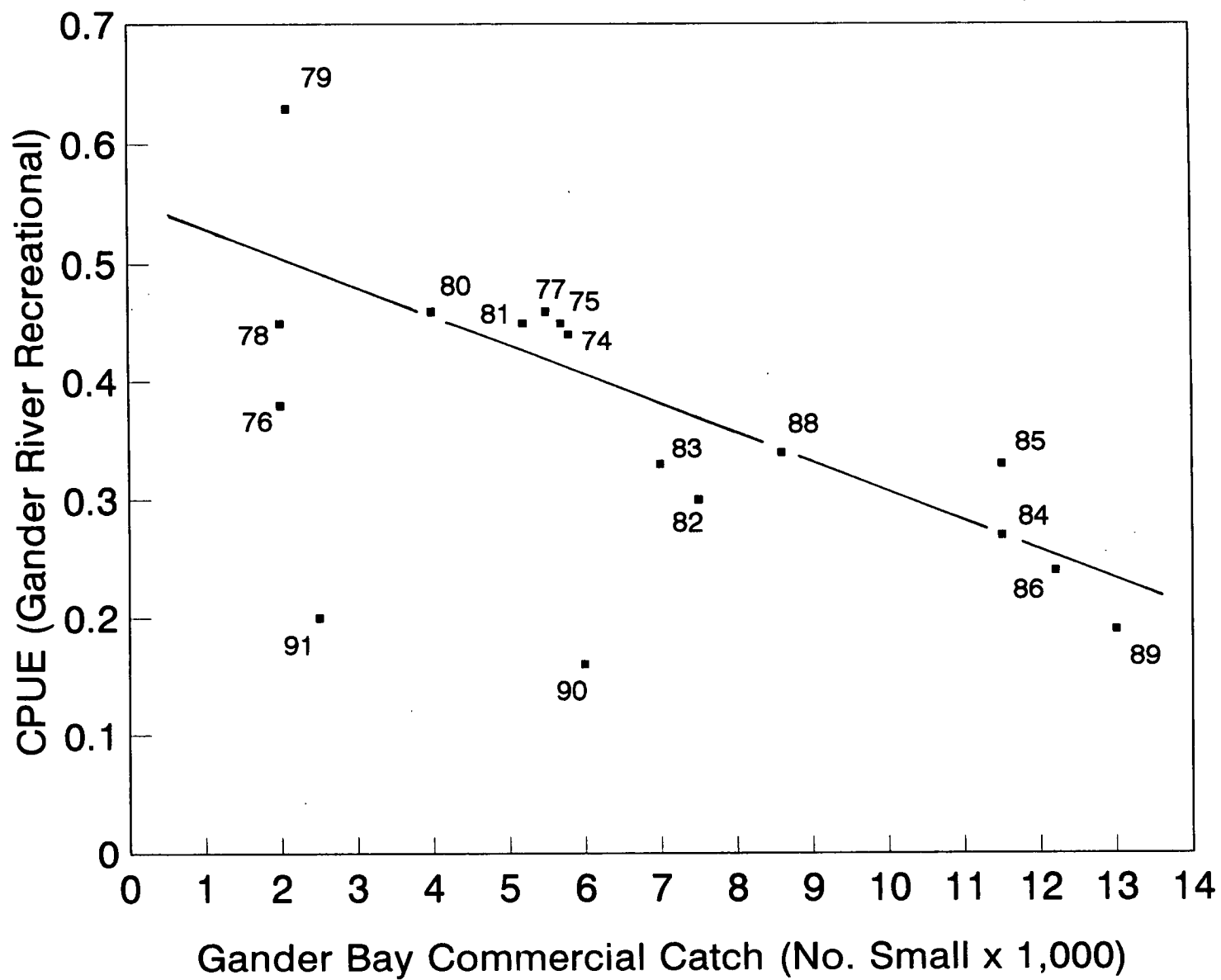


Fig. 7. Regression of Atlantic salmon recreational catch per unit of effort in Gander River on commercial catch of small salmon (by number) in Gander Bay, 1974-89. Points for 1990 and 1991 are shown for comparison purposes but not included in the regression.

## Mean Flows (Low Flow Period) June 1 to September 30

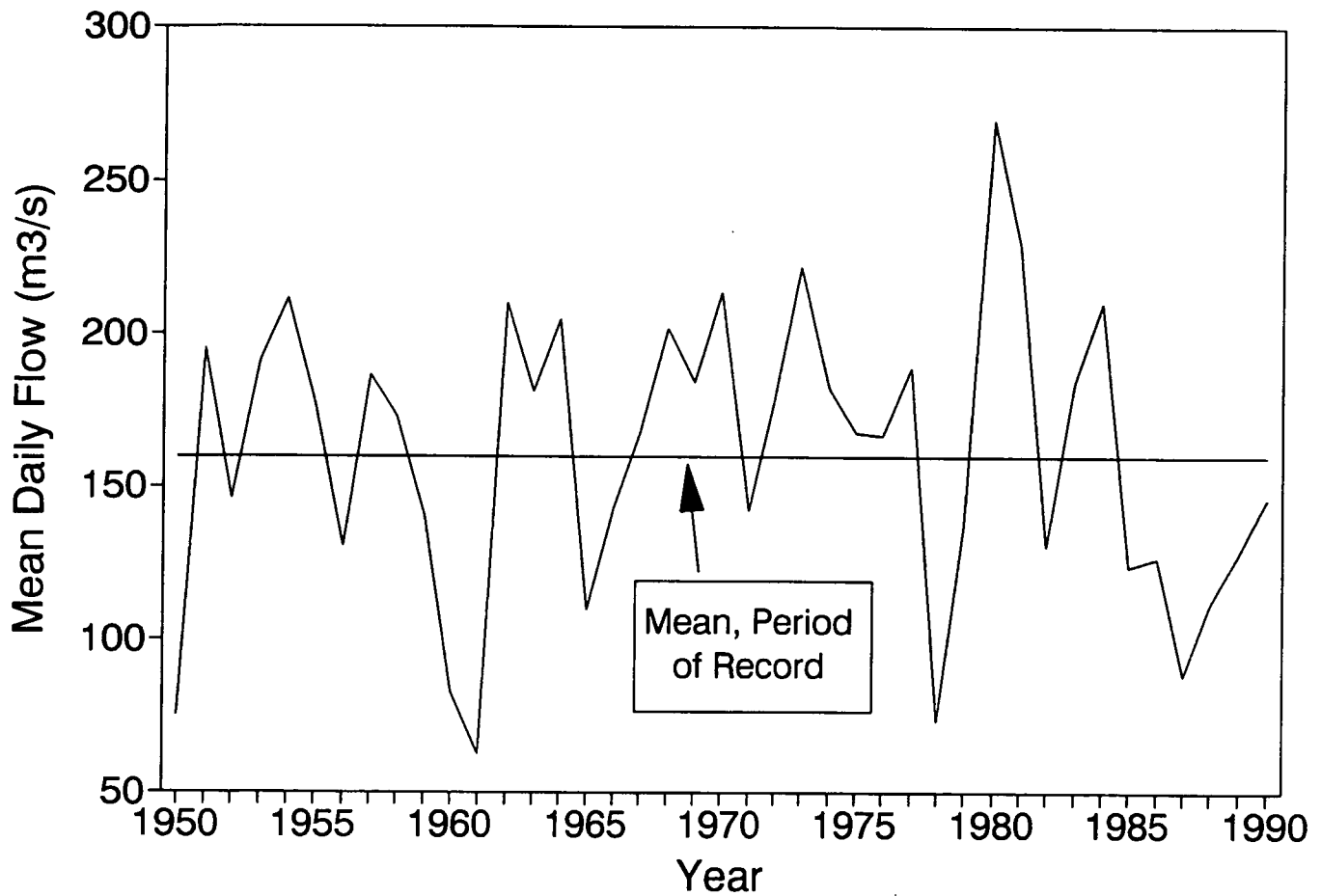


Fig. 8. Mean flows in Gander River for June - September for individual years from 1950 to 1990 and the mean of all years.

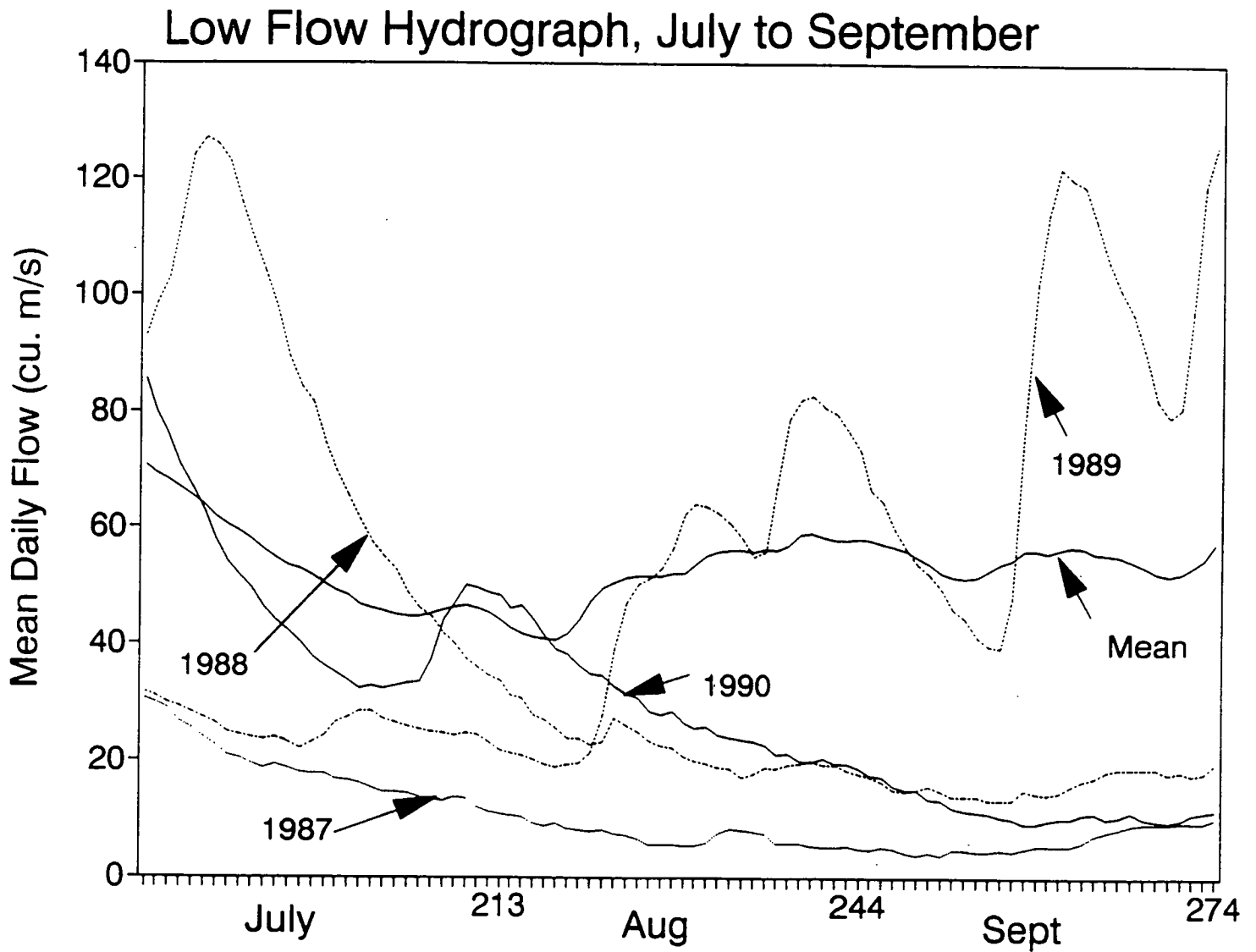


Fig. 9. Mean daily flows in Gander River for the period July - September for each individual year from 1987 to 1990 and the mean of the four years.

Year

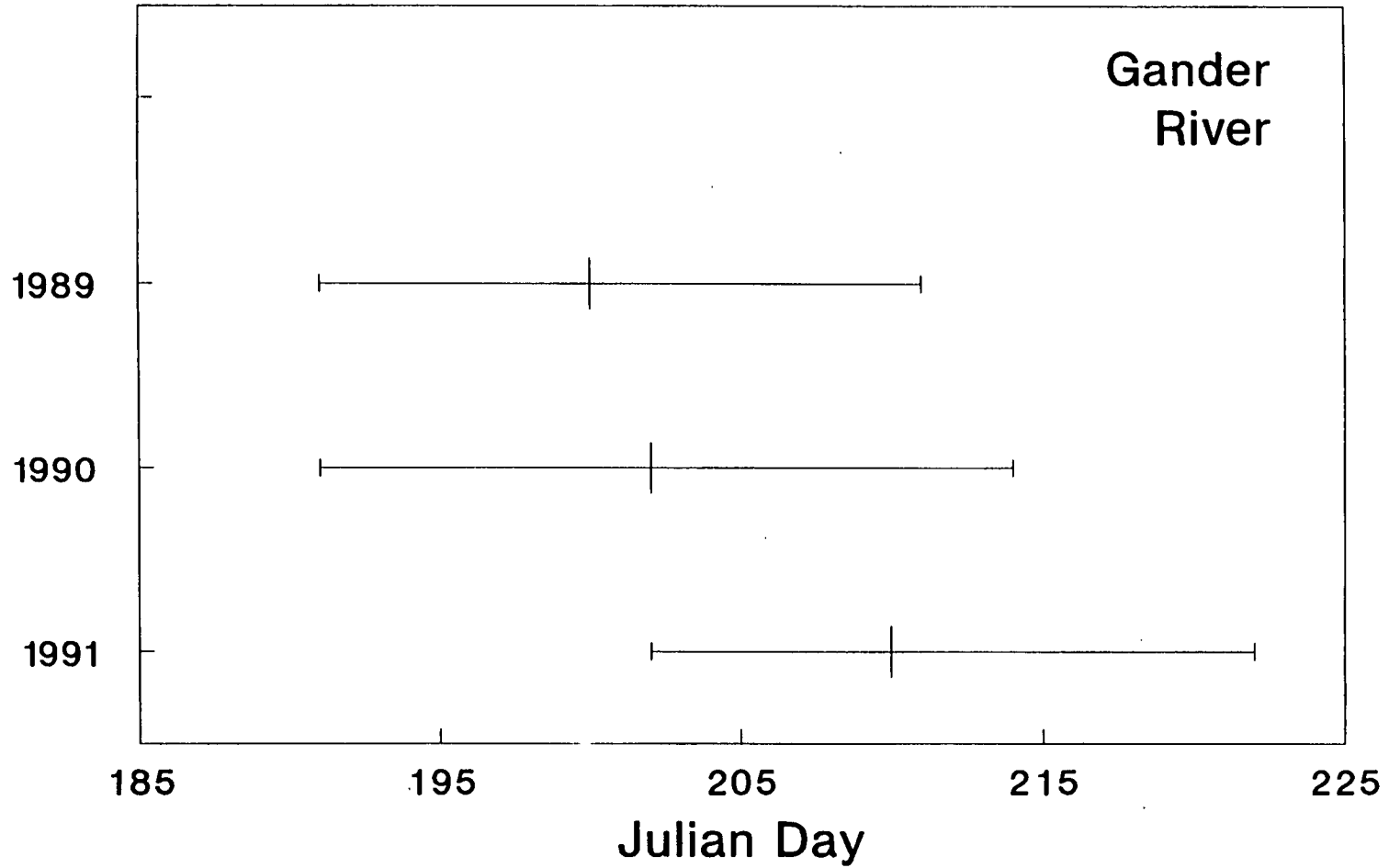


Fig. 10. Timing of the 25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> percentile of Atlantic salmon count (grilse and large salmon combined) in Gander River, 1989-91.