Not to be cited without
permission of the authors[1]

Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 92/5

Ne pas citer sans
autorisation des auteurs[1]

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 92/5

Interannual variation in fecundity of Atlantic salmon from Conne River, Newfoundland

by

J. B. Dempson and M. F. O'Connell
Science Branch
Department of Fisheries and Oceans
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

[1] This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research Documents are produced in the official language in which they are provided to the Secretariat by the author.

[1] Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Abstract

Interannual variation in fecundity of Conne River Atlantic salmon was examined from samples collected over five years (N = 468). Results are discussed in relation to: 1) variability in estimates of annual egg deposition, and 2) impact on subsequent estimates of egg to smolt survival rates. Relative fecundity (number of eggs per kilogram) varied from a low of 1545 in 1990 to 2367 in 1987. Mean relative fecundity over all years was 2160. Atresia of approximately 25% was recorded in one year. Adopting relative fecundity values could revise estimates of egg deposition, for small salmon only, upwards by about 26% However, these revised values would also influence estimates of egg to smolt survival. Target egg requirements would also change dramatically should these survival rates be incorporated into a standard habitat based model as has been proposed for other Newfoundland rivers.

Résumé

Des échantillons prélevés pendant cinq ans (N = 468) dans la rivière Conne ont servi à étudier les variations de la fécondité du saumon d'une année à l'autre. On examine ici les résultats en fonction des éléments suivants : 1) la variabilité des estimations de la ponte annuelle; 2) ses répercussions sur les estimations subséquentes des taux de survie jusqu'au stade de saumoneau. La fécondité relative (nombre d'oeufs par kilogramme) se situait entre un seuil de 1 545 oeufs en 1990 et 2 367 oeufs en 1987. La fécondité moyenne relative pendant la période considérée s'établissait à 2 160 oeufs. On a enregistré un taux d'atrésie d'environ 25 % en un an. En adoptant des valeurs de fécondité relative, on pourrait majorer d'environ 26 % les estimations de ponte, cela dans le cas du petit saumon uniquement. Toutefois, ces valeurs révisées influeraient également sur les estimations des taux de survie jusqu'au stade de saumoneau. La ponte cible se trouverait profondément modifiée si l'on incorporait ces taux de survie au modèle uniforme fondé sur l'habitat que l'on se propose d'appliquer aux autres rivières de Terre-Neuve.

Introduction

Conne River, SFA 11 (Fig. 1) flows into Bay D'Espoir on the south coast of insular Newfoundland. It is a sixth-order river with a drainage area of 602 km^2 and a total length of 193 km. Since 1986, a fish counting fence has been operated to enumerate the upstream migrating population of Atlantic salmon. Mark-recapture studies were initiated in 1987 to survey the number of migrating smolts (Dempson and Stansbury 1991). Both of these operations have been continued through 1991 and the most recent assessment of the status of the stock is provided in Dempson (1990).

In the annual assessment of the Conne River stock, estimates are derived of potential egg deposition resulting from spawning escapement. Egg deposition is evaluated relative to a target egg requirement which, for Conne River, was set at 7.8 million eggs (Dempson 1988). Variability associated with estimates of egg deposition can occur from three sources; 1) error in the estimate of spawning escapement, 2) error in biological characteristics, for example the percentage, and mean weight of female salmon, and 3) error in fecundity.

This paper examines the interannual variation in fecundity of Conne River salmon from ovaries collected over five years. Error associated with estimates of spawning escapement and in biological characteristics are not addressed. Results of the fecundity study are discussed in relation to: 1) variability in estimates of annual egg deposition, and 2) impact on subsequent estimates of egg to smolt survival rates.

1. Fecundity

Fecundity was determined from ovaries collected in the recreational fishery generally in June and early July from 1986-88, and 1990-91 (Table 1). Ovaries were stored in Gilson's fluid until ovarian tissue had broken down following which time the eggs were transferred to 10% formalin. Eggs, which were in the early stages of development, were counted directly. Fecundity was recorded as total fecundity (total eggs per fish and relative fecundity (eggs per kilogram) (Randall 1989). Fecundity-length relationships were calculated using a natural log transformation (Healey and Heard 1984). Biological characteristics of female salmon sampled from Conne River from 1986-90 indicated a mean length and weight of 50.7 cm and 1.427 kg, respectively (N = 968). Seventy-eight percent of the total number of fish sampled for sex (N = 1219) were females.

1.1 Interannual variation in fecundity

Table 1 summarizes length, weight and fecundity statistics for the five years. In total, 468 specimens were available. Relative fecundity ranged from 1545 eggs per kilogram in 1990 to 2367 in 1987. The mean relative fecundity over all years was 2160. Coefficient of variation for total fecundity was 26.6%. By comparison, information is provided for 30 salmon collected in October of 1987. Total fecundity is 25% less than the estimate derived earlier in the year (26% if total is derived from regression equation) while relative fecundity is 17% less (26% if derived from regression using overall mean weight). In comparison with the overall mean, total fecundity of the ripe fish was 21% lower and the relative fecundity 12% less. Unfortunately similar data relating to possible atresia from other years were not available.

Regressions of fecundity on length were all significant (Table 2). However, variation in length explained only 5 to 27% of the variation in fecundity. In most years, for any given fork length, fecundity could be highly variable (Fig. 2). In the regression for all years combined, only 6% of the variation was accounted for (Table 2, Fig. 3). For ripe fish collected in 1987, length explained almost 50% of the variation in fecundity.

2. Variability in estimates of annual egg deposition

In the most recent assessment of the Conne River salmon stock, estimates of egg deposition were obtained using the fecundity relationship established in 1987 for ripe fish. If the above average relative fecundity had been used (2160), estimated egg deposition would be different (Table 3). Egg deposition (ED) was recalculated as:

$$ED = S \times PF \times RF \times MW$$

where,

S = number of spawners
PF = proportion of females
RF = relative fecundity
MW = mean weight of females

Revised estimates of egg deposition for small salmon only, are on average 25% (range from 12.4 - 31.0%) greater than that previously determined. Undoubtedly a different perception on the status of the Conne River stock could be obtained, particularly in recent years when escapements have been low.

The above values assume, however, there is no atresia; an assumption that is not entirely without foundation for salmonids (Vladykov 1956; Bagenal 1978; Prouzet et al. 1984) and a common phenomenon in many fish (Guraya 1986). Kjesbu et al. (1991) recently reported actual fecundity can be 20-80% less than potential fecundity in cod depending on the nutritional status of the fish, and Randall (1989) concluded that fecundity estimates for Miramichi and Restigouche River salmon are probably overestimated. As pointed out earlier, possible atresia of about 25% was recorded for Conne River in 1987. Prouzet et al. (1984) reported atresia of up to 30% in Atlantic salmon while Vladykov (1956), in a study on fecundity of brook trout, concluded that an egg reduction of 39-44% due to atresia can be safely considered. However, O'Connell (Science Branch, St. John's, Newfoundland, unpublished data) has evidence to suggest that in some years atresia in salmon may be small or nonexistent.

3. Estimates of egg to smolt survival

Recently, a standard methodology using theoretical smolt production parameter values was applied to derive target spawning requirements for various insular Newfoundland rivers (O'Connell et al. 1991). This approach has not as yet been applied to Conne River, as additional information was also incorporated into the derivation of the current target spawning requirement.

O'Connell et al. (1991) summarized a number of cautions regarding the use of the theoretical smolt production method to derive target spawning requirements. These included the use of fixed parameters such as 3 smolt/unit of fluvial habitat and 7 smolt/hectare of lacustrine habitat and fixed egg to smolt survival rates. Nevertheless, if this methodology were applied to Conne River, the above information on variability in annual fecundity could conceivably alter the target number of eggs and adults required for this river or for that matter any other river.

Preliminary data from Conne River, using fecundity estimates derived from ripe fish, suggests egg to smolt survival for two smolt classes from eggs deposited in 1986 and 1987 will likely be less than 0.7% from a composite of stream and pond habitat; considerably less than the values used in the derivation of theoretical smolt production (1.25% and 1.9%). A value of less than 1% can also be derived from Northeast Brook Trepassey (M. F. O'Connell, personal communication). Choosing an alternative value for fecundity to, say, the mean relative fecundity shown in Table 1 (2160), would decrease the egg to smolt survival estimates at Conne River by about 28%, reducing the survival rate to less than 0.5%. It is noted that any adverse impacts resulting from the drought conditions experienced in 1987 and subsequently influencing fish survival would be incorporated in these initial egg to smolt survival estimates. Substantial changes in egg to smolt survival would also impact on changing the river specific target spawning requirements.

Results of the above analyses highlight the importance of obtaining annual information on fecundity. In particular, additional information on the extent of atresia is required as in many cases, fecundity estimates are derived from fish collected early in the summer.

References

Bagenal, T. B. 1978. Aspects of fish fecundity, p. 75-101. In S. D. Gerking [ed.] Ecology of freshwater fish production. Blackwell Scientific Publications, London, U.K.

Dempson, J. B. 1988. Status of the Atlantic salmon, Salmo salar, population of Conne River, Newfoundland, 1988. CAFSAC Res. Doc. 88/70. 18 p.

Dempson, J. B. 1990. Assessment of the Atlantic salmon population of Conne River, Newfoundland, in 1990. CAFSAC Res. Doc. 90/83. 33 p.

Dempson, J. B. and D. S. Stansbury. 1991. Using partial counting fences and a two-sample stratified design for mark-recapture estimation of an Atlantic salmon smolt population. North Am. J. Fish. Mgmt. 11: 27-37.

Guraya, S. S. 1986. The cell and molecular biology of fish oogenesis. Monographs in Developmental Biology [ed. H. W. Sauer]. Karger, Basel.

Healey, M. C., and W. R. Heard. 1984. Inter- and intra-population variation in the fecundity of chinook salmon (Oncorhynchus tshawytscha) and its relevance to life history theory. Can. J. Fish. Aquat. Sci. 41: 476-483.

Kjesbu, O. S., J. Klungsoyr, H. Kryvi, P. R. Witthames, and M. Greer Walker. 1991. Fecundity, atresia, and eggs size of captive Atlantic cod (*Gadus morhua*) in relation to proximate body composition. Can. J. Fish. Aquat. Sci. 48: 2333-2343.

O'Connell, M. F., J. B. Dempson, and R. J. Gibson. 1991. Atlantic salmon (*Salmo salar* L.) smolt production parameter values for fluvial and lacustrine habitats in insular Newfoundland. CAFSAC Res. Doc. 91/19. 11 p.

Prouzet, P., P. Y. Le Bail, and M. Heydorff. 1984. Sex ratio and potential fecundity of Atlantic salmon (*Salmo salar* L.) caught by anglers on the Elorn River (Northern Brittany, France) during 1979 and 1980. Fish. Mgmt. 15: 123-130.

Randall, R. G. 1989. Effect of sea-age on the reproductive potential of Atlantic salmon (*Salmo salar*) in eastern Canada. Can. J. Fish. Aquat. Sci. 46: 2210-2218.

Vladykov, V. D. 1956. Fecundity of wild speckled trout (*Salvelinus fontinalis*) in Quebec lakes. J. Fish. Res. Board Can. 13: 799-841.

Table 1. Mean fork length (mm), whole weight (kg), total fecundity, and relative fecundity (eggs per kilogram) of Atlantic salmon from Conne River, Newfoundland.

Year	N	Fork length		Whole Weight		Total Fecundity		Relative Fecundity
		Mean	Range	Mean	Range	Mean	Range	
1986	102	509	450-560	1.48	1.0-2.9	3494	1450-5590	2367
1987	166	510	420-576	1.42	1.0-2.6	3244	1287-5476	2289
1988	85	502	460-600	1.35	1.0-2.2	3196	2111-5054	2366
1990	93	511	460-570	1.45	1.1-2.0	2245	703-3544	1545
1991	22	517	470-552	1.37	1.0-1.6	2885	595-5010	2102
TOTAL	468	509	420-600	1.42	1.0-2.9	3075	595-5590	2160
1987 (ripe)	30	507	460-560	1.28	1.0-1.7	2430	1796-3454	1906

Table 2. Regression coefficients for the regression of $\log_e$ fecundity on $\log_e$ fork length for Atlantic salmon from Conne River, Newfoundland.

Year	N	Intercept	Slope	SE Slope	r^2	F	P
1986	102	-4.202	1.981	0.393	0.20	25.4	0.0001
1987	166	1.122	1.113	0.386	0.05	8.3	0.0045
1988	85	-3.604	1.875	0.337	0.27	31.0	0.0001
1990	93	-9.576	2.768	0.643	0.17	18.5	0.0001
1991	22	-38.170	7.363	2.904	0.24	6.4	0.0197
TOTAL	468	-2.369	1.663	0.295	0.06	31.7	0.0001
1987 (ripe)	30	-1.617	2.394	0.472	0.48	25.7	0.0001

Table 3. Comparison of original and revised egg deposition estimates (in millions) for small salmon from Conne River, Newfoundland if the mean relative fecundity values were applied. Mean relative fecundity of 2160 eggs/kg was used for this example.

Year	Escapement (small)	Mean		Percent female	Egg deposition	
		Length	Weight		Original	Revised
1986	5428	50.6	1.450	76	9.86	12.92
1987	7823	50.8	1.469	78	14.65	19.36
1988	5567	50.6	1.356	80	10.65	13.04
1989	3609	51.0	1.398	79	6.95	8.61
1990	3765	51.2	1.460	81	7.50	9.62
1991	2062	51.8	1.363	70	3.678	4.25

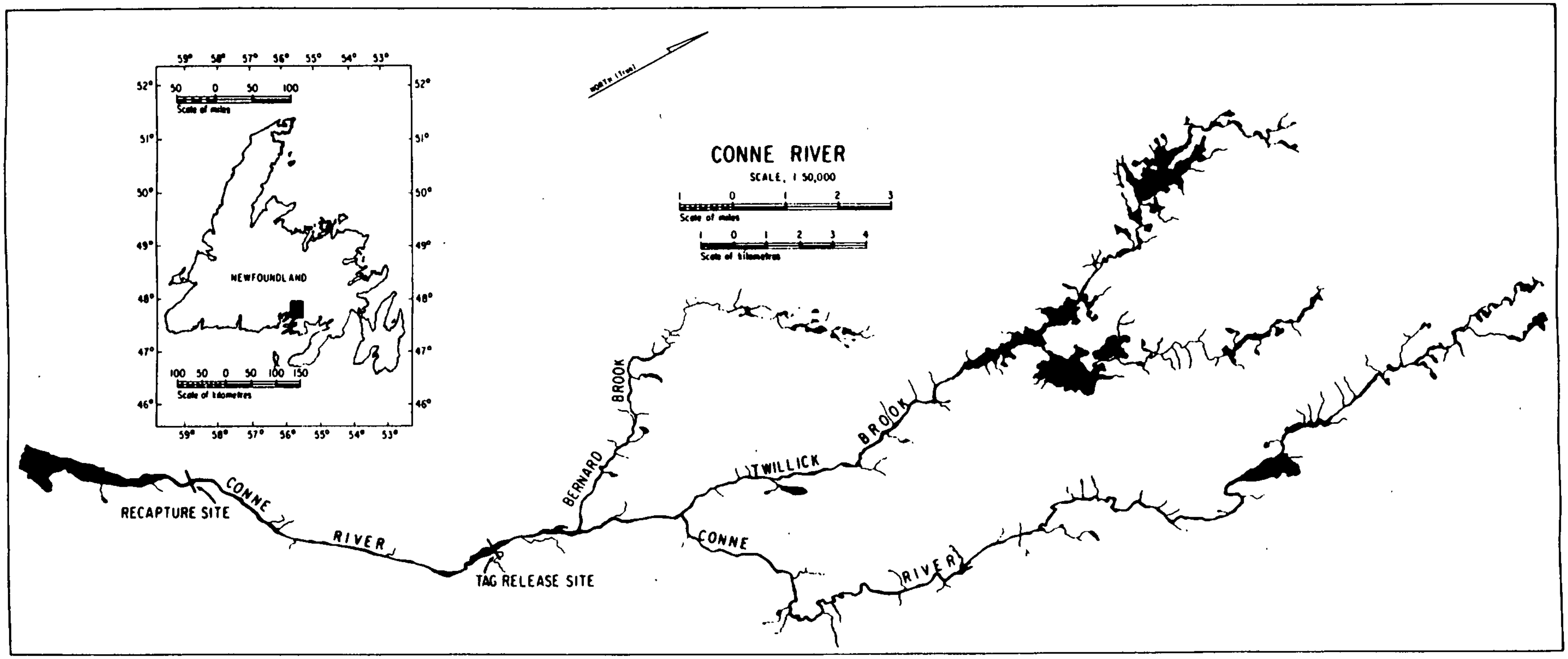

Fig. 1. Conne River, Newfoundland, SFA 11.

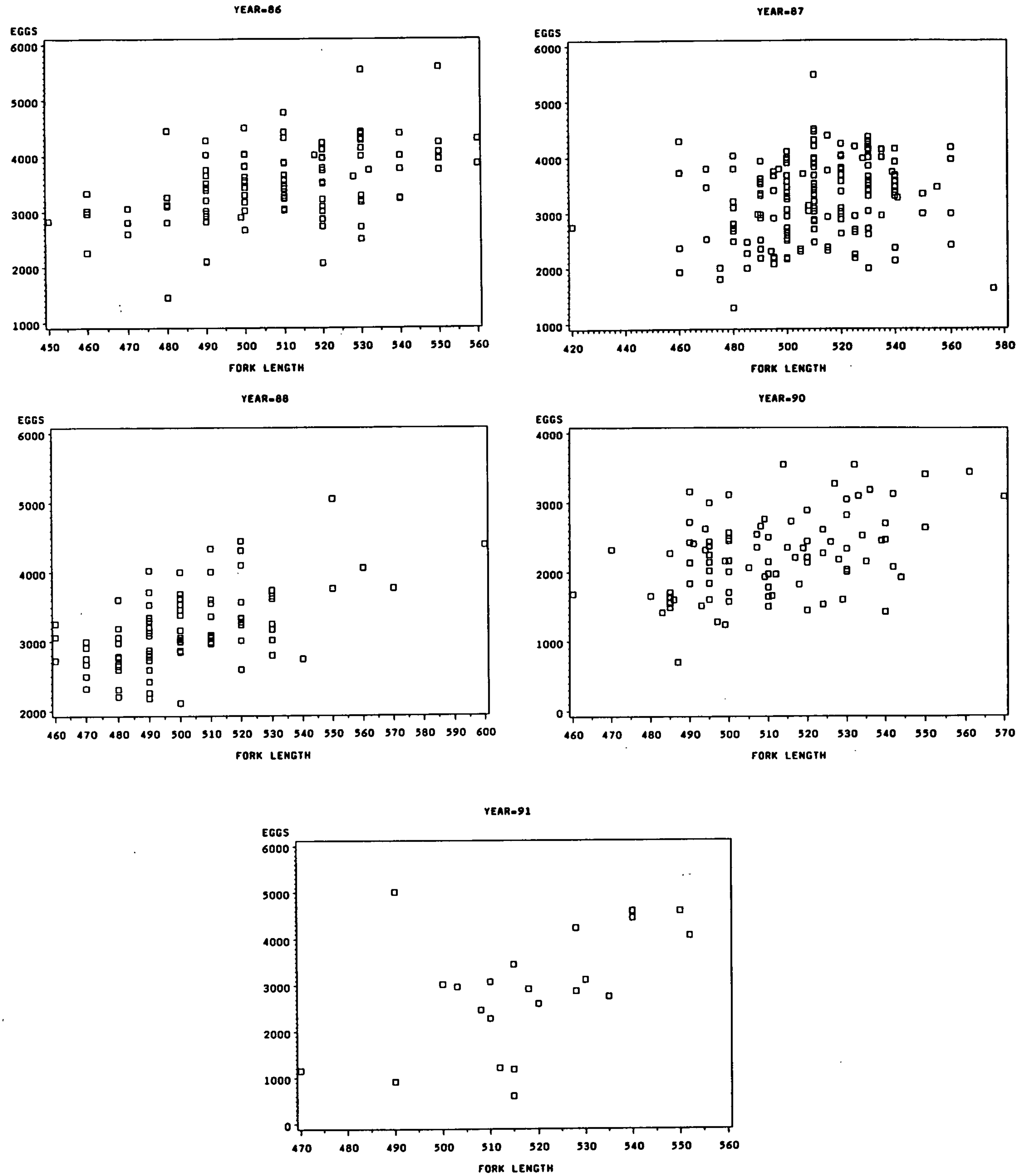

Fig. 2. Scatter plot of the number of eggs on fork length for Atlantic salmon from Conne River, 1986-88, and 1990-91.

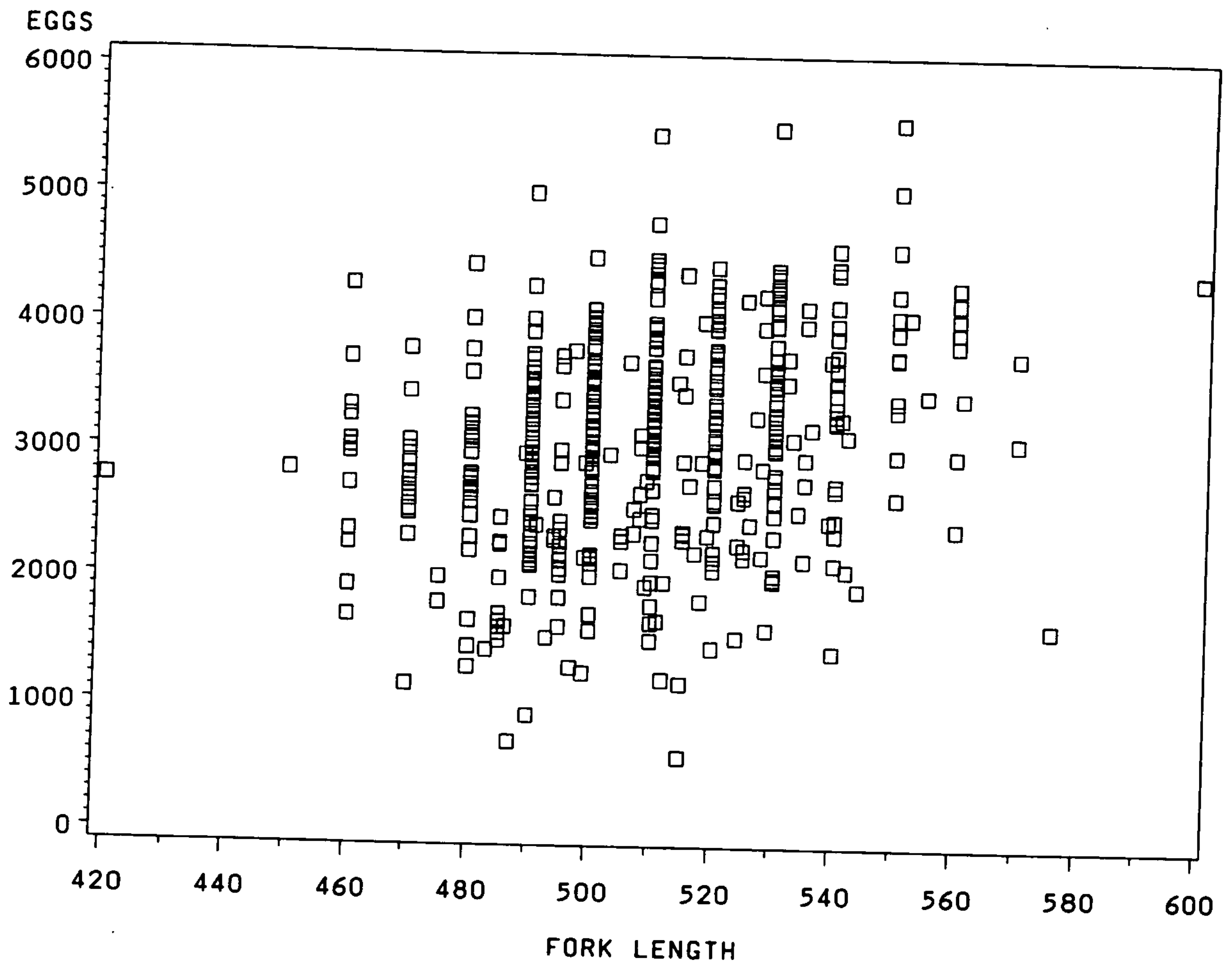

Fig. 3. Scatter plot of the number of eggs on fork length for Atlantic salmon from Conne River, Newfoundland, data combined for 1986-88, and 1990-91 (N = 468).