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Stock characteristics of Atlantic salmon *(Salmo salar)* in France: a review

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Abstract

The general characteristics of the main salmon (*Salmo salar* L.) stocks in the Massif armoricain (Brittany and Lower Normandy), in the Loire-Allier and in the Adour-Gaves-Nive have been summarized. Due to the poor quality of the previous fishing statistics, there is no clear picture of the historical evolution of the salmon stock. However, a dramatic decrease in the endemic range of Atlantic salmon in France can be shown since the mid-18th century and more particularly during the last 50 years. The lack of precise informations describing the size of the catches and the levels of exploitation at sea and in the estuaries make it impossible to estimate the impact that exploitation has led on the evolution of salmon stocks. The mean age of salmon in freshwater ranges from 1 to 1.5 years. The Loire-Allier basin is characterized by a relatively high proportion of large salmon (3 fish) in the rod catches. Fish native to Brittany and Lower-Normandy (Massif armoricain) have lower growth rates than those from the Loire-Allier and Adour-Gaves-Nive Basins. A greater proportion of the early grilse stocks (migration May-July) are males than compared with fish running later. The sex ratio of the multi-sea-winter salmon is biased towards females.

Keywords : Atlantic salmon, *Salmo salar*, catch records, stocks, France.

Synthèse concernant les caractéristiques des stocks de saumon atlantique (Salmo salar) *en France.*

Résumé

Cette analyse des principaux travaux effectués en France sur le saumon atlantique (*Salmo salar*) précise les caractéristiques des stocks des trois principaux bassins versants: Massif Armoricain (Bretagne et Basse-Normandie), Loire-Allier, Adour-Gaves-Nive. On constate une réduction importante des aires de colonisation du saumon atlantique en France depuis le milieu du XVIIIe siècle et surtout depuis le début du XXe due principalement à l'édification de barrages et à la dégradation générale du milieu. Cependant, compte tenu du peu de qualité des données antérieures, il est difficile d'avoir une idée précise sur l'évolution à long terme des captures ainsi que sur l'impact de l'exploitation sur la diminution des stocks. La durée moyenne de vie en rivière du saumon atlantique est comprise entre 1 et 1,5 hivers. Le bassin Loire-Allier se distingue par une forte proportion de saumons de trois hivers de mer dans les captures. Les saumons du Massif Armoricain sont de taille et de poids plus réduits que ceux des bassins Loire-Allier ou Adour-Gaves-Nive à même durée de vie en mer. Chez les «grilses» précoces (remontée mai-juillet), on note une majorité de mâles ou tout au moins une proportion de mâles plus importante que chez les grilses tardifs (remontée automnale). En ce qui concerne les saumons de plusieurs hivers, le sex-ratio est très nettement en faveur des femelles.

Mots-clés : Saumon Atlantique, *Salmo salar*, captures, stocks, France.

INTRODUCTION

Over the last 15 years the many studies that have been conducted at the various French research institutions (IFREMER, INRA, CEMAGREF) (1) and by the management organization (CSP) (1) increased our knowledge of the characteristics of the salmon stocks particularly the exploited component. However as they have only dealt with the qualitative aspects, very few quantitative data are available, particularly the catch records describing marine and estuarine fisheries. The absence of reliable information is a characteristic of migratory fish stocks. Even if available, catch records are based on the statements of anglers and fishermen and are not confirmed by any survey. Therefore, they are frequently incomplete and biased so that the result of any analysis can lead to decisions being taken contrary to the socio-economic interest. It has been impossible to accurately estimate former abundance, because reliable catch records based on direct counts such as those found for some "Baro" fisheries (*fig.* 1 *a*) in the 19th and 20th centuries are absent. Nevertheless, in some rivers like the Adour, it is thought that, in the late 1800s and early 1900s production, irrespective of the fishing gear used, ranged between 50 and 100 t.

Salmon has disappeared from almost all the once productive large French rivers including the Garonne, Meuse, Moselle, Seine, Loire and Dordogne, mainly because of the presence of dams and the envrionmental degradation of coastal waters. Spawning is now limited to some 25 streams of the Massif Armoricain and the rivers Allier, Gave d'Oloron, Nive and Nivelle (*fig.* 1 *b*).

VARIATIONS IN CATCHES

In saltwater, data from Marine Fishery Records indicate a sharp decline in estuarine catches after the Second World War (*fig.* 2). In 1896-1938 the average annual catch was 69 t while in 1945-1986, it dropped to 10.2 t (85%, Anon., 1988). In addition, previous catches varied widely (× 5) between year. This decrease was almost certainly due to a change in data collection after the war rather than a real decrease in catch.

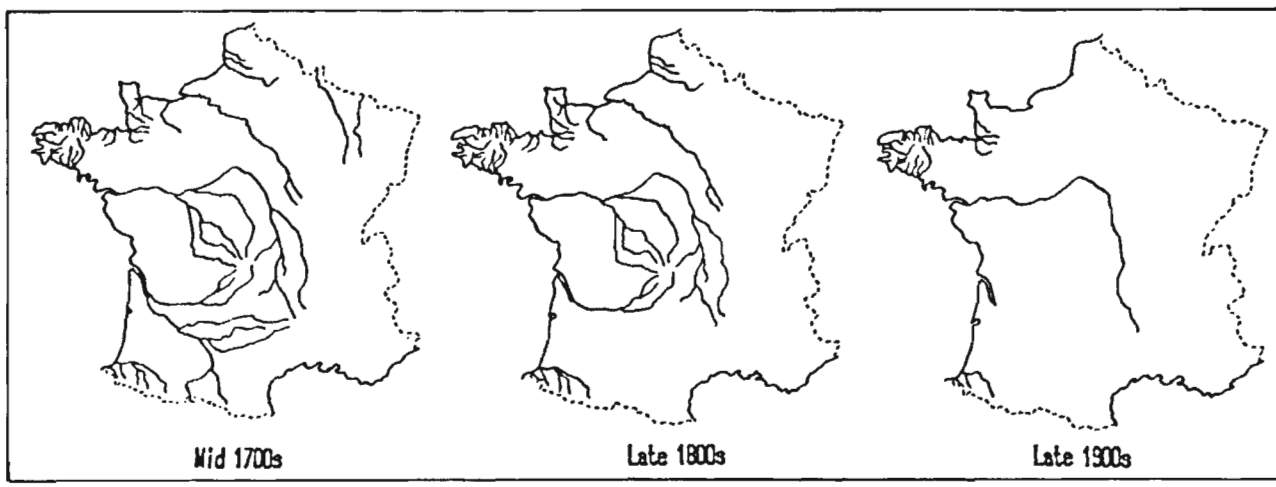

Figure 1 *a*. – The decline in the number of salmon rivers in France since the 1700s (after Thibault, 1987).

In freshwater, in the late 1800s and early 1900s with the exception of the Baro fisheries little long term catch data are available. However, rod catches are available for the last 20 years for all French rivers (Anon., 1988). Even though some caution must be exercised when analysing. These mean catches were the highest in the Massif Armoricain (*fig.* 3). Rod-and-line catches do not reflect the variations in the total stock mainly because grilse are only available late in the fishing season. However, increasing length of the fishing season in the Massif armoricain in 1986 by shifting the closing date from mid-June to mid-

(1) IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer).
INRA (Institut National pour la Recherche Agronomique).
CEMAGREF (Centre de Machinisme Agricole du Génie Rural et des Eaux et Forêts).
CSP (Conseil Supérieur de la Pêche).

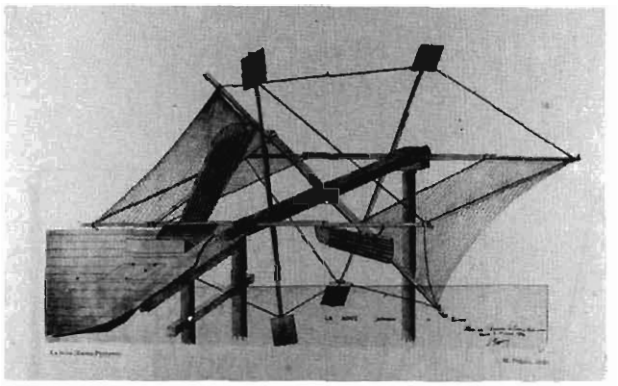

Figure 1 *b*. – "Baro" fishery after de Drouin de Bouville (1900) *in*: "Pêche fluviale en France".

Pêche dite « de Baro » d'après de Drouin de Bouville (1900) *extrait de l'ouvrage « Pêche fluviale en France »*.

as follows:

– cold temperate climate with monthly mean temperatures in summer and winter ranging between 16 and 18°C and 3 and 6°C respectively;

– the specific module (rate of flow per unit of area) increases from the east to the west and in Lower Normandy it is always higher than 8 l/s/km^2;

– the 25 salmon rivers are relatively short (50-150 km);

– there are numerous obstacles to upstream migration but as there are generally relatively low, fish ladders can be fairly easily installed.

Fry and parr

Juvenile densities vary but between rivers and types of habitat within rivers. Fish aged 0+ year are more abundant in the rapid streams and shallower areas of rivers than fish aged 1+ years. In the Elorn, juvenile density ranges between 3 and 28/100 m^2 and in the Scorff, Baglinière and Champigneulle (*loc. cit.*) recorded the densities of 0+ and 1+ fish ranging

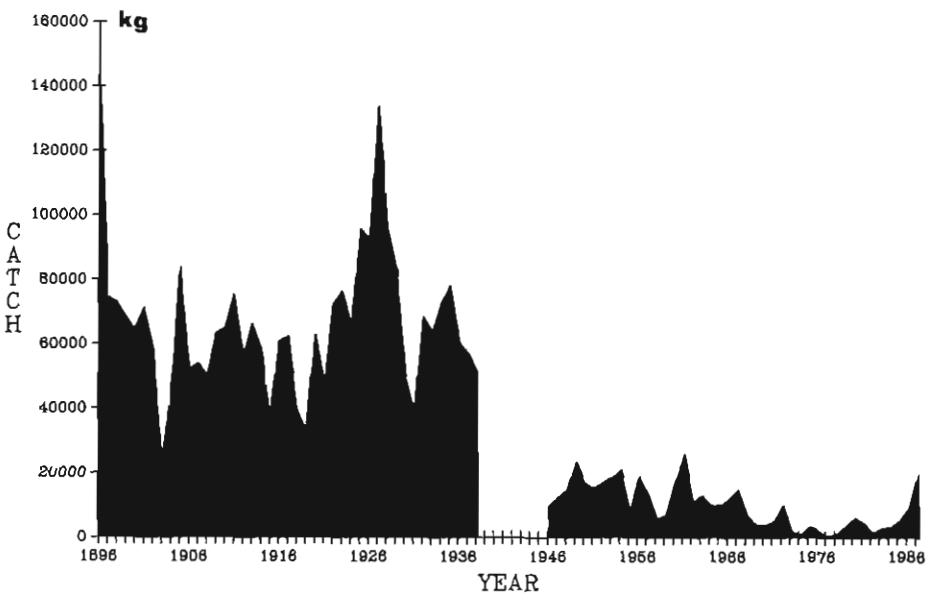

Figure 2. – Commercial catches (kg) in the French estuaries since 1896 (Anon., 1988).

July has not yet increased in catches even though large upstream migrations of grilse were observed in some rivers (Elorn) late in the fishing season.

ENVIRONMENTAL AND SALMON STOCK CHARACTERISTICS

Brittany and Lower Normandy (*fig.* 4)

These characteristics have been previously described by Fontenelle *et al.* (1980) and can be summarized

between 0.3 and 10.2/100 m^2 and, between 0.04 and 7.4/100 m^2 respectively during the period 1976-1980. The length of juveniles varies widely. In the Scorff, for example between 1973 and 1983, the mean length of the 0+ and 1+ salmon ranged between 87 and 100 mm and, between 134 and 154 mm respectively (Baglinière *et al.*, 1987). Fluctuations in growth are dependent on both the temperature and the flow rate (Fasencieux, 1984).

The mean lengths of the 0+ and 1+ salmon removed in September 1984 from different areas in the tributaries and in the main stream of the Elorn ranged

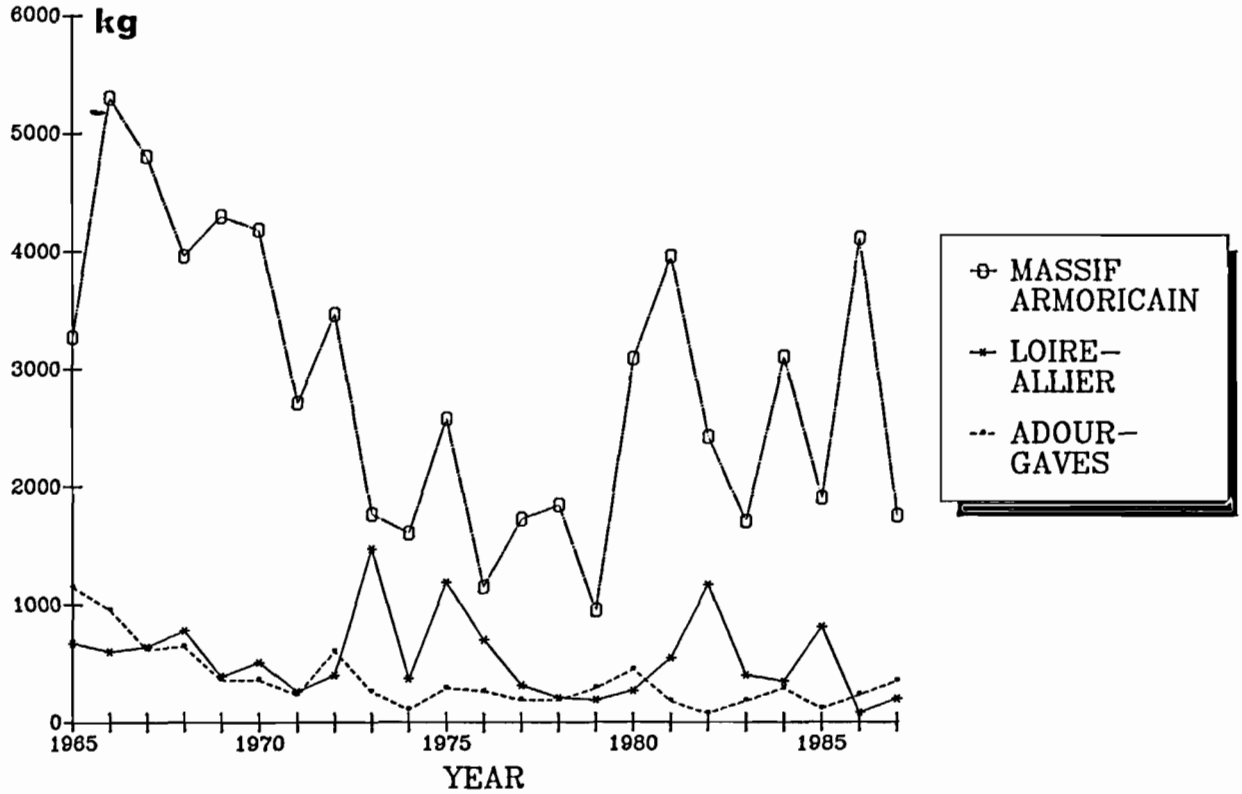

Figure 3. – Rod catches in the main salmon regions in France since 1965.

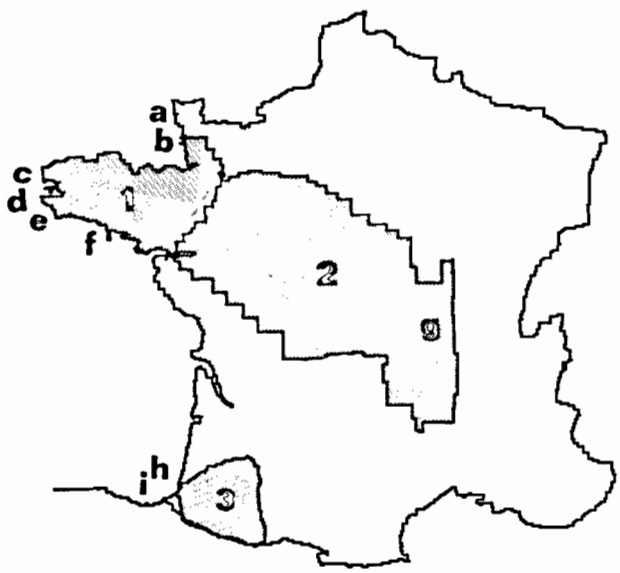

Figure 4. – Location of the main salmon basins. 1: Massif Armoricain; 2: Loire-Allier; 3: Adour-Gaves-Nive. The mean river age of salmon from different rivers (after Prévost 1987). a: Sée River 1.2; b: Selune 1.1; c: Elorn 1.5; d: Aulne 1.5; e: Ellé 1.4; f: Scorff River 1.3; g: Allier 1.3; h: Gaves 1.2; i: Nive 1.1.

between 80.5 and 118.4 mm and between 136 and 172 mm respectively. This rapid growth, especially of males, favours early sexual maturity. Although, 0+ males fish are sometimes found to be mature (Prouzet, 1981 *b;* Baglinière and Maisse, 1985), early maturity is much less frequent among females (Prouzet, 1981 *a*, Baglinière *et al.*, 1987).

Smolts

Smolts generally migrate in April but the migration period may extend into May. Their mean lengths vary between years (Baglinière, 1976; Prouzet, unpubl. data). Variation in the length and weight of smolts from the Ellé and Elorn are summarized in *table* 1. Two age groups (1+ and 2+ years) are generally present and the proportion of each age group within a population varies between years (Baglinière, 1976).

Adults (sampling during the fishing season)

The characteristics of fish caught during the fishing season, have been described by many authors such as Prouzet (1979), Fontenelle *et al.* (1980), Baglinière and Porcher (1980), Prouzet and Jézèquel (1983), Prouzet (1984), Baglinière *et al.* (1987).

– River age (*fig.* 4).

Salmon generally spend from 1 to 2 years (more rarely 3) in freshwater before migrating to the sea as

Table 1. – Mean length and weight of smolts sampled in the Ellé and Elorn rivers (Brittany) from Baglinière, 1976 and Prouzet (unpubl. data).

River	Characteristics	Age (years)		Observations
		1+	2+	
Ellé	Fork length (cm)	15.4 to 16.5	19.1 to 20.0	Variations in characteristics between 3 years of sampling (9060 measured 655 weighed)
	Weight (g)	30.5 to 39.7	58 to 62.4	
Elorn	Fork length (cm)	14.9 s.d. = 1.9	18.00 s.d. = 1.75	Sample of 216 smolts measured in a counting trap during the migration period (early April-late May)
	Weight (g)	33.3	57.3	
		(weight-length relationship $W = 0.014\ L_F^{2.879}$)		

s.d. = standard deviation.

smolts (Fontenelle *et al.*, 1980, Baglinière *et al.*, 1987). In France, the mean age of smolts ranges between 1 and 1.44 years depending on the geographical location of the rivers (1.44 years in Northern Brittany, 1.37 years in Southern Brittany and 1.16 years in Lower Normandy: Baglinière *et al.*, 1987). Nevertheless the mean age of smolts varies widely between years (Prouzet, 1983; Prouzet and Jézèquel, 1983 and unpubl. data). The annual variation in the mean age of smolts from the Elorn in 1971-1983 is shown in *figure 5*.

Figure 5. – The mean river age (number of winters) of salmon caught in the Elorn river by year of production.

– Sea age.

An analysis of a sample of 3845 salmon collected during the fishing season showed that 95.1% were spring salmon and that the majority (84.6%) were small spring fish (2SW fish) (Baglinière *et al.*, 1987). The proportion of grilse in the sample (2.5%) was small because they migrate into freshwater towards the end of the fishing season (late May-early June) and the catchability of grilse by rod and line based on observations made in the Elorn river in 1987 is less than that for salmon (the exploitation rates of salmon and grilse on the Elorn were 30% and less than 5% respectively; Anon., 1988).

– Sex-ratio.

The sex-ratio was determined either by serodiagnosis (Prouzet *et al.*, 1984, Prouzet and Jézèquel, 1983) or on external characteristics (Maisse and Baglinière, 1986).

Most 2SW salmon were females (74%) (Baglinière *et al.*, 1987).

The sex-ratios of the various age groups of salmon caught in the Elorn in 1979-1987 varied (*table* 2) while males were dominant (59%) in the early grilse

Table 2. – Variation in sex ratio according to the sea age groups of salmon sampled in the Elorn river from 1979 to 1987 (March to July).

Sea age groups	Number of females	Number of males	Percentage of females	Sex-ratio
1 SW (sea winter)	40	58	40.8	1.45 M/1 F
2 SW	681	163	80.7	0.24 M/1 F
3 SW	10	3	76.9	0.30 M/1 F
Previous spawner	8	1	88.9	0.13 M/1 F

SW: Sea winter.

migrating upstream late in the fishing season. Spring salmon were predominantly (80.5%) female and this value remained relatively constant throughout the season.

– Length and weight.

Baglinière *et al.* (1987) recorded; variations between rivers in the length and weight of 2 and 3 SW salmon; significant differences between years have also been observed in the fork length and the weight of 2 SW salmon in the Elorn (figure 6*a* and *b*) and seasonal differences in other rivers in Brittany.

– Fecundity.

The potential fecundity of spring salmon decreased during the period between entry into freshwater and spawning as the mean number of oocytes decreased from 2358 to 1457 oocytes/kg of fresh body weight (Prouzet *et al.*, 1984). Prouzet and Gaignon (1985) estimated the mean relative fecundity of grilse at 1719 oocytes/kg of body weight. The same authors noticed a wide variation (ranging between 436 and 3022 oocytes/kg of fresh body weight) between individuals and that the mean relative fecundity of spring salmon was lower than that of grilse (1457 compared with 1719 oocytes/kg of fresh body weight).

Sampling during the close season, by different methods (collection of dead fish, electrofishing, trapping) outside the fishing season identified the existence of a late run of grilse in the rivers of the Massif armoricain and that these fish were on an average longer than the early grilse. However, these observations should be treated with some caution due to the heterogeneity of the sampling methods (Prouzet and Gaignon, 1985, Baglinière *et al.*, 1987).

The Loire-Allier (*fig.* 4)

The studies of Bousquet (1979) and Cuinat (1987) have described the main characteristics of the Loire-Allier Basin as follows:

– the Loire is the longest (1000 km) river in France with a drainage area of 117480 km^2;

– the salmon producting areas are located in its main tributary, the Allier, which joins the Loire 536 km upstream from its mouth. The Allier is 404 km long and its flow rate is 156 m^3/s;

– the climate is continental, which explains the large variation (between 0.5°C in winter and 29°C in summer) in the water temperature.

Compared with the rivers of Brittany where salmon have a relatively short distance (5-150 km) to travel to their spawning areas, in the Allier river adults have to migrate 700-800 km and overcome at least a dozen obstacles of varying difficulty depending on water temperature and flow before reaching suitable spawning areas.

Fry and parr

The production of parr (0+ and 1+ fish) is very variable (from a few to one hundred/100 m^2) both between areas and between years (Cuinat, 1980; 1987). Their growth is rapid and their mean length on an average at the end of the first and second summer is 11 and 18 cm respectively (Bousquet, 1979, Cuinat, 1980).

Smolts

The dowstream migration of smolts normally peaks between mid-March and mid-April (Bousquet, 1979). They reach the Loire in Saint-Laurent-des-Eaux which is 450 km from the farthest upstream spawning areas between early April and early May. The downtream migration rate ranges between 10 and 30 km/day, the journey to the sea takes between 1-3 months (Cuinat, 1987). As the result of their rapid growth, they smoltify after 1 winter (89%) and 2 winters (10%) in the river and their mean size is 17 cm and 20.5 cm respectively (Bousquet, 1979).

Adults

As sport fishing is the main fishery, most fish sampled were caught by anglers. Grilse which migrated upstream late in the fishing season were not sampled. Thus, their absence from the sample does not mean that there are no grilse in this river. In fact, 15% of the total catch taken by nets in the Loire in 1988 were less than 70 cm long indicating that grilse are present in the river (Anon., 1989).

As a result of the rapid growth in freshwater, the mean river ages of the fish sampled were 1.3 (Prévost, 1987). Rod catches mainly consisting of 3 SW salmon is particular in France to the Loire-Allier watershed (*fig.* 7).

Table 3 summarizes the length and weight by sea age of the fish sampled and *figure* 8 illustrates the large size of 3 SW salmon from the Loire-Allier compared with those collected in the short rivers of

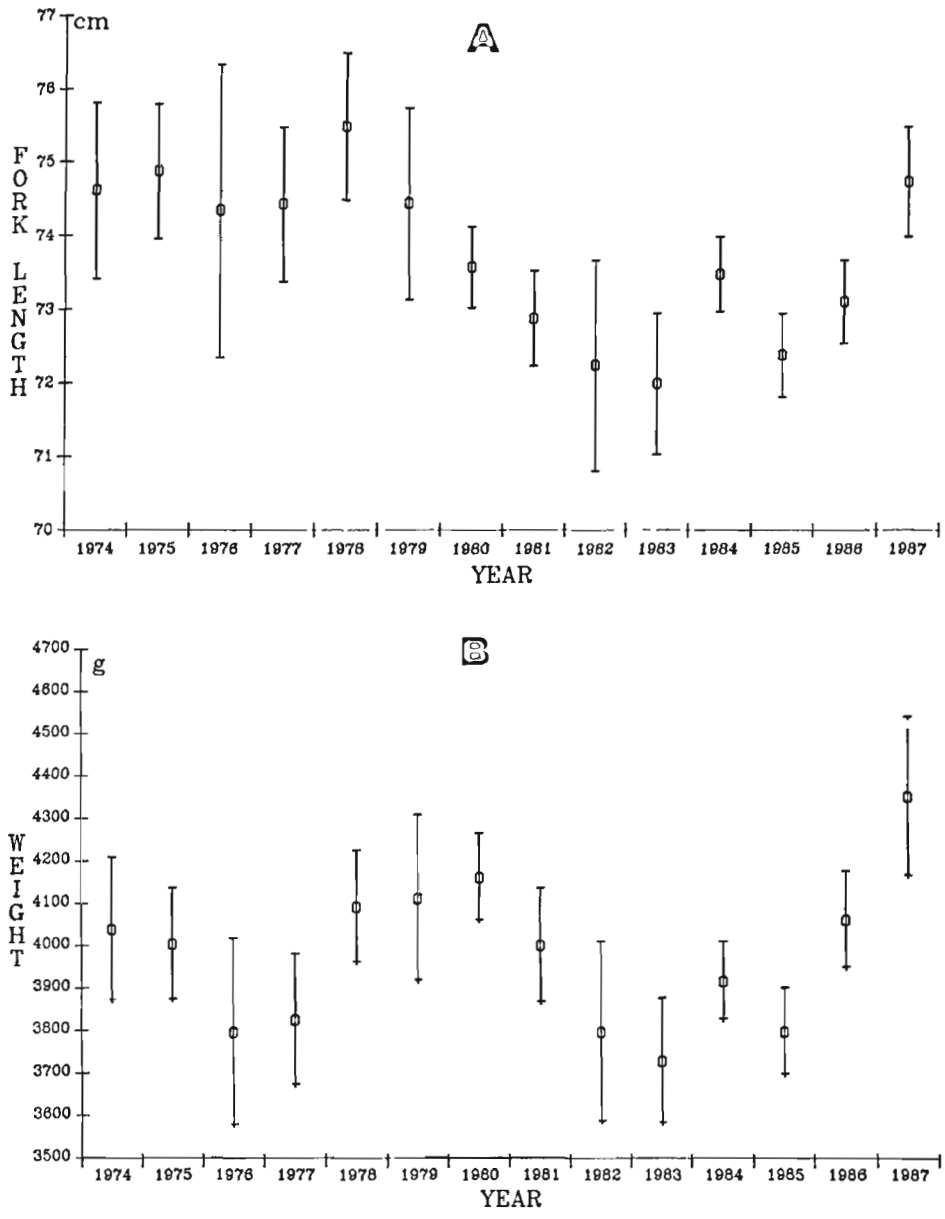

Figure 6. – A. Mean fork length of 2 sea winter salmon caught in the Elorn river during the fishing season. B. Mean weight of 2 sea water salmon caught in the Elorn river during the fishing season.

the Massif Armoricain (Bretagne Sud; Bretagne Nord, Basse Normandie).

The Adour-Gaves-Nive Basin (*fig.* 4)

The Adour basin is one of the largest watersheds with a total drainage area of 16 000 km^2 and a length of 310 km on the Atlantic coast. Both the size of the fisheries (rods and nets) and the catch of between 1 000 and 6 000 fish recorded each year since 1985 are the largest in this area. The three main tributaries are the Nive (drainage area 1 000 km^2 and 75 km long), the Gave de Pau (drainage area 2 600 km^2 and 134 km long) and the Gave d'Oloron (drainage area 2 700 km^2 and 175 km long). At present, salmon producting areas are located in the Gave d'Oloron, the Nive and their tributaries. Although these rivers are all obstructed by many dams, none are a major obstruction. However, together with the deterioration in the habitat, they were the major cause of eradication of salmon in the Gave de Pau.

The climate is temperate and oceanic and due to the vicinity of the mountain range the rainfall is above average. The latter influences the rate of flow of the

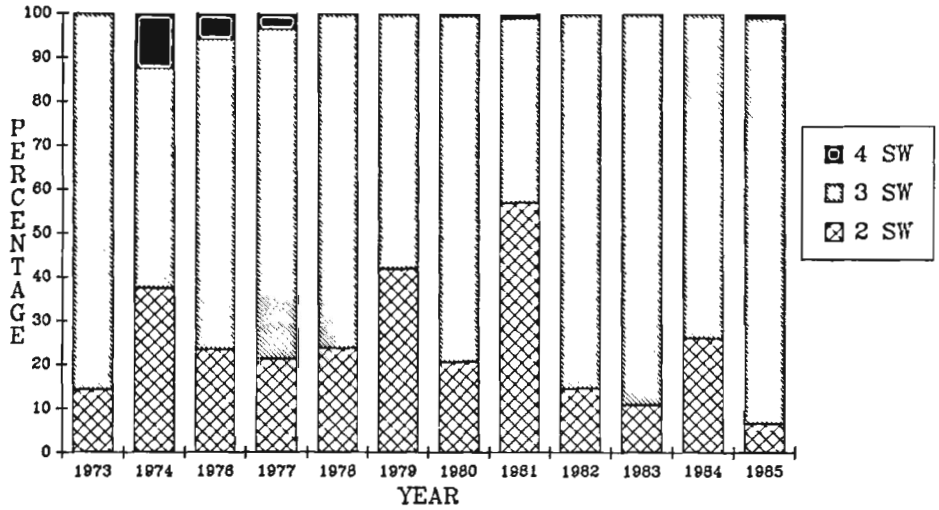

Figure 7. – The different sea age groups of salmon caught off the Loire-Allier basin, expressed as percentages (data from Cuinat, 1987).

Table 3. – Weight and length characteristics of the different types of salmon caught by the rod and line fishery in the Loire-Allier axis in 1988 (Anon. 1989) (s.d. standard deviation).

	Sample size	Mean size (mm)	Mean weight (g)
Grilse	1	650	2500
2 Sea winter salmon	60	809 s.d. = 52	4645
3 Sea winter salmon	192	965 s.d. = 45	7728

Gaves which is of the nival type with a maximum flow rate (about 350 m^3/s) during the snowmelt in May. Water temperature varies between 5 and 20°C.

Fry and parr

Because of the physical and chemical characteristics of the water (high temperature and alkalinity), growth rates are high. The mean lengths of the 0+, 1+ and 2+ parr sampled in the late summer by Bousquet and Marty (1987) were 11 to 12, 16 to 18 and 22 to 24 cm, respectively. The same authors also recorded

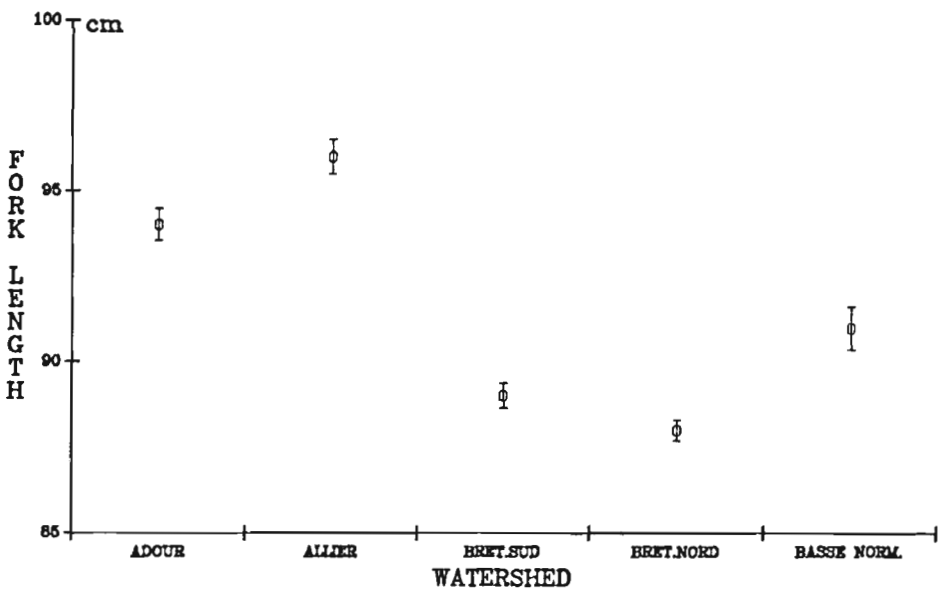

Figure 8. – The mean lengths of 3 sea winter salmon caught off the three main salmon Basins (after Prévost 1987). Bret. Sud: Southern Brittany; Bret. Nord: Northern Brittany; Basse Norm.: Lower Normandy.

extremely low densities ranging in the nursery areas from 100 up to a maximum of 1 000 fish/ha.

Smolts

The smolts in the basin of the Gave d'Oloron and in the Nive have been studied by Bousquet (1979 and 1983) and Vibert (1950). In both rivers, most smolts were 1+ years old and more recent data from the Nive have confirmed that most of the smolts migrate after spending one winter in freshwater (*table* 4).

The majority of salmon had spent one winter in freshwater before migrating to the sea. During the last few years, this proportion has increased (higher than 90%) and as a result the mean river age has declined (*fig.* 9). The cause of this change has not yet been elucidated.

The difference between the results of these studies is significant, but may only be due to different sampling procedures (*table* 5). Those obtained by IFREMER, using a stratified sampling design, indicate a much

Table 4. – Characteristics of smolts sampled in the Adour basin, from Bousquet et Marty (1987).

Adour basin	Distribution of age classes (%) (Mean fork length in cm)			Period of observation
	1+	2+	3+	
Gaves	57.5 (15.6 cm)	42.3 (16.9 cm)	0.2 (20.4 cm)	(1946-1948)
Gave d'Oloron	67.4 (19.4 cm)	25.1 (21.5 cm)	7.5 (23.2 cm)	13 March to 18 April (1969)
	80 (17.7 cm)	12 (21.5 cm)	8 (22.4 cm)	3 April to 22 April (1970)
	43.2 (19.7 cm)	45 (20.8 cm)	11.8 (23.6 cm)	20 March to 20 April (1971)
	55.2 (21.3 cm)	38 (23.1 cm)	6.8 (26.0 cm)	10 April to 20 April (1972)
	67.9 (19.3 cm)	27.1 (21.0 cm)	5 (22.6 cm)	5 April to 25 April (1973)
	69 (18.5 cm)	28 (21.5 cm)	3 (23.1 cm)	20 March to 5 May (1978)
Nive	95.7 (19.6 cm)	4.3 (24.2 cm)		26 March to 28 April (1980)
	98.3 (18.3 cm)	1.7 (22.7 cm)		30 March to 15 May (1981)
	94.3 (17.6 cm)	5.7 (22.1 cm)		16 March to 27 May (1982)

In both rivers the dowstream migration takes place between late March and early May. Although Bousquet and Marty (1987) reported that the period of migration has not changed, they have suggested not only that the proportion of 1 year old smolts has increased but also that the average length and weight have increased by 20 and 40% respectively compared with the corresponding values recorded by Vibert (1950) between 1942 and 1948.

Adults

Various studies have been undertaken, first by Vibert (1950) over the period 1942-1948, then by the CSP between 1979 and 1981 and more recently by IFREMER from 1985.

higher proportion of grilse in the catches taken in the estuary when compared with those reported by Vibert (1950), Bousquet and Marty (1987), Anon, (1988). The data analysed by these authors mainly came either from samples collected in the salmon smoked plants of the Pays-Basque which preferentially use large individuals (Vibert, 1950) or from the rod-and-line fishery (Bousquet and Marty, 1987) which tends not to catch grilse because of their lower catchability compared with salmon (Anon., 1988). In fact, the analysis of historical commercial catch records dating back to the late 1800s and the early 1900s has shown that in some years the proportion of grilse accounted to almost 30% of the catches (*fig.* 10).

Figure 9. – The mean river age (number of winters) of salmon caught in the Adour river.

Table 5. – Comparison between the different results concerning the distribution of age classes of salmon caught by rod and net fisheries in the Adour-Gaves Basin.

Period	1 SW (%)	2 SW (%)	3 SW (%)	4 SW (%)	Previous spawner	Authors Sources	Fishing gears
1942-1946	27	29	66.6	0.4	1.3	Vibert (1950)	Bag net
1977-1981	6	75	18.7	0.1	0.2	Bousquet et Marty (1987)	Line and drift net
1985	68.4	42.2	8.9	–	0.5	IFREMER	Drift net
1986	22.3	74.5	3.1	–	–	IFREMER	Drift net
1987	91.3	7.8	0.6	–	0.3	IFREMER	Drift net
1987	29	63	8	–	–	CSP	Rod and line

SW: Sea winter; CSP: Conseil supérieur de la pêche.

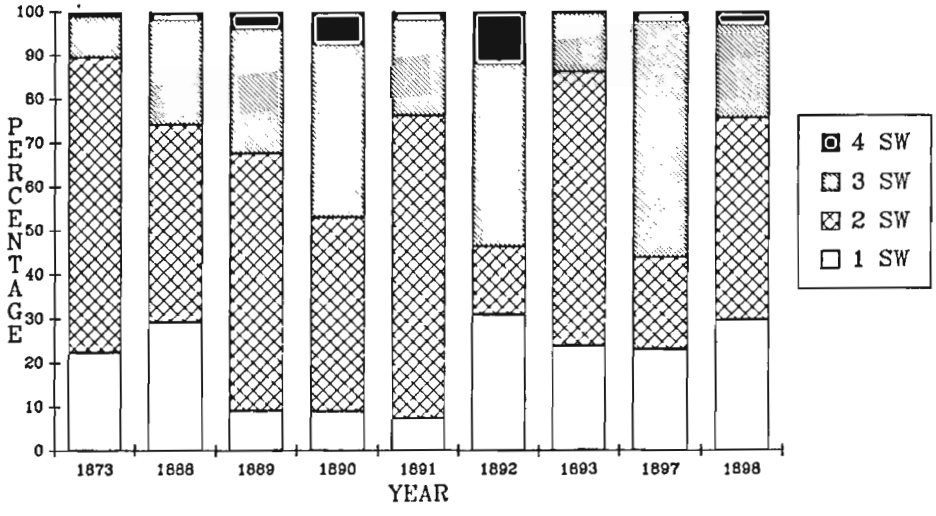

Figure 10. – Percentage distribution of the sea age groups of salmon in the commercial catch from the Gave rivers at the end of the 19th century.

An analysis of the monthly catch data indicates that, except in 1987 when the number of grilse was abnormally high, the proportion of grilse and 2SW salmon has remained about the same. However, there has been a marked decrease in the number of 3 and 4SW salmon in catches compared with that of the beginning of this century (*fig.* 10).

– Sex-ratio.

The sex of the salmon taken in the estuarian fisheries was determined by serodiagnosis. The grilse sex-ratio is either balanced or biased towards males and it varies from year to year. On the other hand, the sex ratios of the spring and summer salmon are biased towards females. In common with the grilse, the sex ratio of the large spring salmon varies from year to year (*table* 6). Any variation in the abundance of any of these sea age groups, and in the sex-ratio within a group can have a marked effect on the reproduction potential (from 1990 to 6200 oocytes per fish) of each spawning stock.

Table 6. – Variation in sex-ratio according to the sea age groups of salmon sampled in the Adour during the period 1985-1987.

Sea age groups	Number of females	Number of males	Percentage of females	Sex-ratio
1 SW	135	195	40.9	1.44 M/1 F
2 SW	256	80	76.2	0.31 M/1 F
3 SW	26	15	63.4	0.58 M/1 F

SW: Sea winter.

– Length and weight

In the Adour basin, as in the Allier river, 2 and 3 sea winter salmon are larger than in the rivers of Brittany (*table* 7). Moreover, some years there are substantial numbers of summer salmon and they are always larger and heavier than those belonging to the corresponding sea age group of salmon found in Brittany. The same holds true for the grilse migrating upstream late in the fishing season. In this area, there are no large migrations of late grilse at the end of the year and outside the fishing season similar to those observed in the small rivers of Brittany (Prouzet and Jezéquel, 1983) or in the Nivelle, a small river close to the mouth of the Adour (Dumas and Casaubon, 1987).

Table 7. – Weight and length characteristics of the different types of salmon caught by the commercial fishery in the Adour estuary during the period 1985-1987.

Type of salmon	Mean fork length ± s.d. (cm)	Mean weight ± s.d. (g)
Grilse	65.8 ± 3.8 N = 499	2991 ± 581 N = 489
Small spring salmon	78.2 ± 4.2 N = 211	5076 ± 826 N = 230
Small summer salmon	80.4 ± 4.1 N = 293	5661 ± 924 N = 230
Large spring salmon	94.5 ± 4.0 N = 42	9115 ± 1558 N = 52

N: sample size; s.d.: standard deviation.

CONCLUSION

The mean freshwater age of juvenile salmon is generally low (between 1 and 1.5 years). However, there are significant variations between years in the proportion of 1 and 2 years old smolts in the rivers of Brittany due to variations in temperature and flow rate. Variations in the mean age must be related to factors in addition to the thermal gradient associated with latitude (*fig.* 4). Summer salmon (2+SW) are almost absent in the rivers of Brittany, whereas they are abundant in some years in the rivers of the Adour basin. Three sea winter salmon were the main component in catches from the Loire-Allier area whereas they are almost absent in catches from the other rivers studied.

There are differences between rivers in the length and weight of salmon of the same sea age. Whatever their sea age, they are shorter and lighter on an average in the short rivers of Brittany than in the large rivers such as the Adour-Gaves and the Loire-Allier. Since the end of the last century, the number of 3 SW salmon in the Adour river has decreased but there is no evidence that the increase in grilse has been detrimental to the number of 2 SW salmon. The sex-ratio varies between sea age groups, generally, grilse tend to be males and multi sea winter salmon, females.

Two types of studies have been undertaken to characterize the French stock relative to the population of North Atlantic salmon. The first study attempted to discriminate salmon stocks on the basis of differences in the shape of their scales (de Pontual, 1986, de Pontual and Prouzet, 1987; 1988). Using this technique a number of similarities were found between French, Spanish and Scottish stocks. Guyomard (1987) using biochemical techniques, showed that the French stocks and more generally European Atlantic stocks exhibit a relatively high level of within-population variability (4.3%). From a genetic point of view the European stocks form a homogeneous group, quite distinct from the Canadian stock, thus indicating that the Atlantic salmon is one of the less differentiated and polymorphic species of salmonid.

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