ATLANTIC SALMON: Planning for the Future

Edited by DEREK MILLS AND DAVID PIGGINS

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Chapter Ten

THE ATLANTIC SALMON IN THE RIVERS OF SPAIN WITH PARTICULAR REFERENCE TO CANTABRIA

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10.1 INTRODUCTION

Historical Perspective

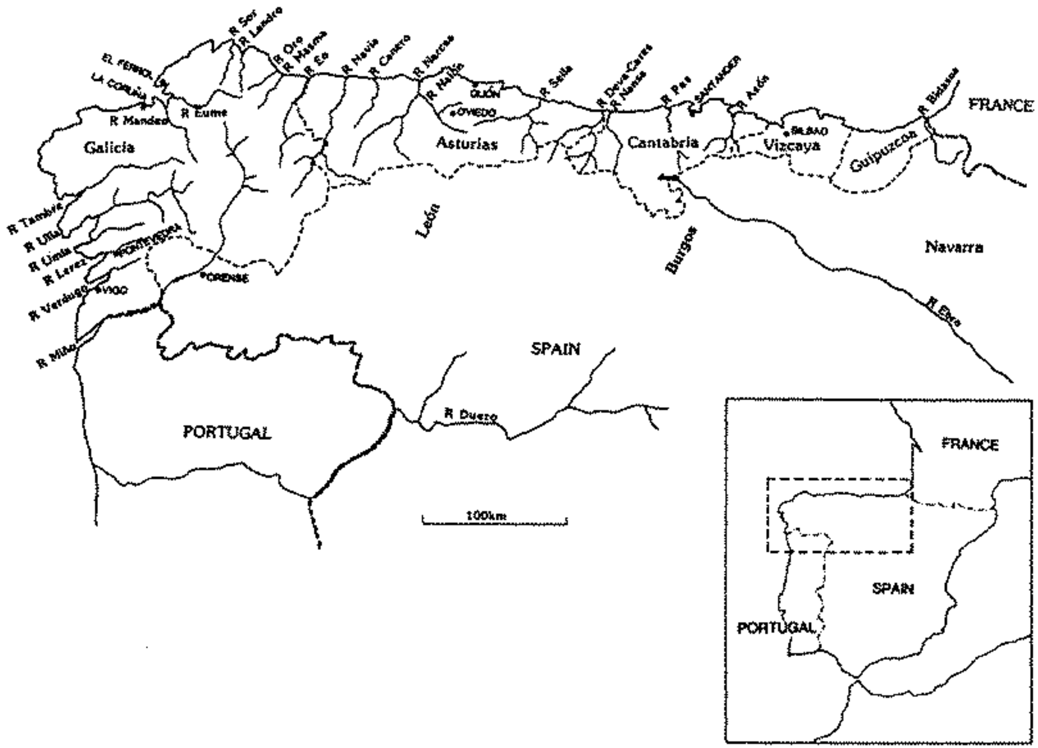
In the Iberian peninsula, comprising Spain and Portugal, salmon are only found in rivers of the north and northwest provinces entering the Cantabrian Sea and the North Atlantic. They are absent from rivers flowing into the Mediterranean sea (Figure 10.1).

Perhaps the first written mention of Atlantic salmon (*Salmo salar*, L.) in Spain appears in several writings in the seventh century (Jusué Mendicouague, 1953). Later, in the eleventh century, contracts dealing with the fishing rights for salmon became commonplace (Camino, 1940). Salmon harvesting at that time was the patrimony and privilege of feudal landowners, abbeys and noblemen who owned large estates. Entire beats of the rivers and estuaries were crossed by a series of double stockades or *postas* which effectively trapped upstream migrants. The remains of these *postas* may still be seen in some rivers.

Salmon catches during these times must have been similar to those elsewhere in Europe. In 1258 the Spanish King Alfonso el Sabio (Alfonso the Wise) established what must have been the first attempt to regulate this fishery by introducing close seasons (Netboy, 1974). A royal decree in 1435 by King Juan II stipulated large fines for poachers caught poisoning the waters, suggesting that by the fifteenth century pressures on the fishery were rapidly mounting. Salmon harvesting in this century was, in fact, cause for much litigation between noblemen (Escagedo, 1927).

By the end of the sixteenth century specific gear regulations were being introduced, thereby protecting the smolt runs and the spawning of adults. The administration of the fisheries was handed over to the various provinces and boroughs, which were now free to implement their own netting regulations.

Figure 10.1: Major salmon rivers of Spain



Salmon catches were still very large in these northern rivers. The historian Sanchez Reguart in his 'Diccionario Histórico' published in 1791-1795 estimated that 2,000 salmon were caught daily in the Principality of Asturias alone. The total Spanish salmon catch in the seventeenth and eighteenth centuries is said to have been between 8,000 and 10,000 fish per day which, according to Netboy (1974), must have amounted to 600,000-900,000 salmon annually, if daily catches are projected over a three month fishing season. Catches derived from historical accounts, however, should always be treated with some reservation although catches of similar magnitude have been reported elsewhere for other European and North American rivers (Dunfield, 1985).

By the end of the eighteenth century the monopoly on salmon stockades, traps and nets was finally lifted in most regions following a royal decree by King Carlos IV. Additional regulations stipulated that mill dams and lades be kept open at all times to ensure the spawning of adults.

In the nineteenth century many small hydro-electric stations were being built adding to the already considerable number of weirs, mill dams, and private water constructions obstructing the passage of ascending adults. Fish ladders were either absent or notably inefficient despite the regulations laid down previously. The once-flourishing salmon fishery was never to recover, not through a lack of protective laws but due to the inability of government to enforce them. In 1920-30 Spanish rivers were yielding a fraction of their historical catches, despite progressive action by government to control overexploitation.

The first salmon hatcheries were being built at this time to restock the rivers and some scientific studies were undertaken by a group of enthusiasts, notably the Marquis of Marzales who made contact with Calderwood and Hutton in Britain and Roule in France. The existence of male precocious parr in the Spanish rivers was well known at this time and there must have been some knowledge of the age and length composition of the salmon populations (Camino, 1940). Salmon fishing was managed independently by two government ministries, one regulating the estuaries, the other regulating the rivers. As in France, divided administration did little to preserve the salmon stocks (Netboy, 1968).

Netting in the estuaries started in mid-February, often for the entire week and operated day and night. Salmon catches in this period amounted to some 4,000 fish per year in the province of Santander and slightly more in Galicia and Asturias. Total salmon catches probably amounted to some 20,000 fish per year (Camino, 1940; MacCrimmon and Gots, 1979). These quite high catch levels, however, may have resulted from increasingly more effective fishing effort rather than from improvements in abundance.

According to Camino (1940) who refers to a survey carried out by W.M. Gallichan (1904) of most salmon rivers in Spain at the turn of the century, the best ones were capable of producing between 50,000 and 90,000 salmon per year. Industrial pollution was still virtually unknown, productivity was high and there were extensive excellent spawning grounds in most rivers.

As a result of the growing concern among anglers and administrators alike, a royal decree in 1927 introduced some limitations on the operation of netting stations, explicitly forbidding the netting of salmon from 0600 hrs on Friday to 0600 hrs on Monday. Banning of all salmon netting (coastal, estuarine and riverine), however, had to wait another 16 years when the catches reached their lowest levels ever, following the Spanish Civil War (Netboy, 1980).

Salmon populations suffered badly during the civil war (1936-1939) when they provided relatively easy food for the population. Fishing regulations could no longer be implemented and there was little or no control resulting in the looting of rivers by a variety of means including the use of explosives, bleach and other poisons, and all kinds of nets.

Reasons for the steady decline were found in the gross overexploitation and poaching of the rivers, the lack of bailiffs and realistic fines, the pollution of some rivers (Miera, Bidasoa, Besaya), and the existence of countless obstructions to the movement of ascending adults (Camino, 1940).

In February 1942 the Government finally banned all salmon netting stations and in this way dedicated the fishery entirely to anglers.

Management and data collection until 1944 had been dealt with by the Forestry Districts with a lack of resources and limited manpower. Data from this period are very unreliable and hard to find except for the accounts provided by Marzales and a handful of other enthusiasts (Gallichan, 1904; Camino, 1940).

Official salmon statistics were collected from 1949 onwards by the present system of logging each fish caught. All legally caught salmon are given a circular tag and issued with a certificate of capture or guia. This includes data on the weight, fork length, girth, lure or bait employed, name and address of the fisherman, site of capture, and sometimes sex of fish based on external characters (Garcia de Leániz, Hawkins, Hay and Martinez, 1987).

In the early 1960's coinciding with the boom in the Spanish tourist industry, a National Association of Bailiffs was created within the Civil Service resulting in the acquisition of much better fishery statistics. The previous Service became the National Service for Freshwater Fisheries and Game (1960-1972) and considerable funds were invested in the creation of fish ladders, bridges, fishing chalets, and facilities for the stripping and maintenance of broodstock and the hatching of salmon ova.

It was in this period that the division of the salmon beats into restricted areas (cotos) and free zones (zonas libres) was introduced and some entire rivers were designated National Salmon Reserves like the rivers Narcea and Cares in Asturias, Deva in Cantabria and Eo in Galicia. However, this was also a time for the construction of artificial reservoirs, large hydro-electric stations and major projects to regulate the flow of rivers all of which subjected the rivers to still more stress. At present, over 70 per cent of the salmon catches are taken from restricted beats or cotos.

Salmon management was transferred in 1972 to the Institute for the Conservation of Wildlife (ICONA) which continued operating until 1984, when the administration of the fishery was handed over to the regional governments and the various Services of Mountains, Game and Wildlife were created.

Today the Spanish salmon rivers are administered independently by the five northern regional governments of País Vasco (province of Guipuzcoa), Navarra, Cantabria, Asturias, and Galicia. Fishing regulations are basically similar and have been summarised elsewhere (Garcia de Leániz et al., 1987).

10.2 THE SALMON RIVERS

Although the number of salmon rivers in Spain was considerable at one time and included some long ones like the river Duero (Netboy, 1968), salmon are now found only in about 20 rivers (Figure 10.1) of which only six, the river Sella, Cares and Narcea in Asturias and Pas, Asón and Deva in Cantabria, account for over 70 per cent of the total rod and line catch (Table 10.1)

Most of these salmon rivers are short, usually less than 50 km, and have small catchment areas. They are spate rivers, quick to rise and fall and prone to droughts during the summer months when flow rates can decline dramatically.

Much of the land in these northern provinces is over 500 m high with peaks up to 2,500 m. Gradients can be quite steep and run-off and erosion pose important problems in periods of heavy rain, particularly in areas where deforestation has taken place. The pH of these rivers is generally not far from neutral becoming slightly alkaline during the summer. Serious industrial pollution is generally not a problem and the best salmon rivers tend to score high in water quality assessments.

Water temperatures differ markedly from those in more northern latitudes and only fall below 7°C for one or two months during the year. The growing season for juvenile salmon (number of days in which water temperature is above or equal to 7°C; Symons, 1979) is considerable and averages over 330 days per

Table 10.1: Spanish salmon statistics 1949-1985

showing numbers of salmon caught by rod and line by river and district

	Galicia									Asturias					Cantabria				Navarra
	Eo	Landro	Lerez	Mandeo	Masma	Miño	Sor	Tambre	Ulla	Canero	Cares	Narcea	Navia	Sella	Asón	Deva	Nansa	Pas	Bidasoa
1949	187	1	2	0	1	0	1	10	51	0	600	666	200	715	200	101	48	10	29
1950	220	1	2	2	2	0	1	15	60	0	711	750	288	822	320	112	60	15	30
1951	221	2	2	1	5	0	2	19	78	0	815	782	300	900	558	210	78	22	35
1952	242	3	3	1	7	0	1	23	100	0	900	800	321	915	621	298	90	29	38
1953	258	4	3	1	9	0	1	30	128	0	965	810	360	1,052	798	320	95	32	40
1954	544	5	22	20	39	0	31	31	443	0	1,478	788	576	2,871	1,321	298	146	69	224
1955	465	3	15	58	34	0	27	164	339	0	1,376	622	725	1,068	702	61	88	39	45
1956	433	3	10	30	39	0	21	138	367	0	1,701	1,108	1,169	1,236	1,008	291	60	110	111
1957	191	3	14	10	23	0	28	177	281	0	855	630	811	978	801	147	51	127	75
1958	191	1	16	16	24	0	15	109	152	0	842	353	755	992	732	140	28	82	65
1959	312	0	21	8	37	0	58	109	96	20	1,335	1,298	701	2,781	1,541	361	129	136	94
1960	390	0	26	5	16	0	13	90	99	0	1,066	785	374	1,381	917	154	51	109	180
1961	56	3	6	2	30	5	21	17	115	7	677	389	280	984	552	55	44	79	96
1962	185	0	16	1	39	1	38	64	140	37	623	592	175	1,151	559	158	68	135	87
1963	361	4	19	3	51	4	29	90	269	28	677	555	276	1,705	476	189	30	111	61
1964	285	6	84	3	82	4	38	89	261	29	1,683	564	359	1,027	741	292	25	79	226
1965	375	1	116	2	77	14	11	45	295	115	1,365	860	787	1,534	1,106	289	49	166	158
1966	348	14	23	8	69	30	46	58	97	76	1,063	1,197	764	1,162	1,343	255	36	305	324
1967	703	17	30	2	105	39	19	24	357	104	1,119	1,928	387	1,194	773	281	18	226	146
1968	366	10	65	15	82	45	18	11	160	70	1,114	860	189	2,078	747	285	47	294	110
1969	409	15	79	15	82	48	42	155	435	195	1,871	1,349	286	2,041	881	742	55	466	135

Table 10.1 (Cont'd)

	Galicia									Asturias					Cantabria				Navarra
	Eo	Landro	Lerez	Mandeo	Masma	Miño	Sor	Tambre	Ulla	Canero	Cares	Narcea	Navia	Sella	Asón	Deva	Nansa	Pas	Bidasoa
1970	505	8	158	3	96	108	46	31	510	209	1,071	1,195	137	1,853	781	334	36	619	74
1971	233	1	54	3	11	61	7	7	74	93	461	279	18	567	422	133	16	211	47
1972	174	2	84	7	66	113	11	39	291	185	1,366	626	10	2,230	603	278	75	699	155
1973	166	7	33	5	18	52	1	7	197	100	781	424	2	1,176	461	166	37	420	108
1974	144	7	94	3	34	181	6	0	112	104	670	183	0	443	250	136	45	301	31
1975	619	6	78	0	122	301	0	4	189	206	463	818	0	630	192	275	74	522	102
1976	622	5	81	2	127	296	6	0	263	260	321	916	2	306	38	121	16	132	91
1977	316	14	23	0	44	74	3	2	88	194	646	455	6	486	113	152	42	473	81
1978	753	12	52	2	44	329	3	0	296	553	1,000	687	22	676	58	308	53	604	41
1979	514	10	3	6	54	30	0	2	24	593	831	793	6	1,211	52	405	52	404	37
1980	1,222	32	39	12	70	142	0	3	543	741	922	1,975	18	1,196	182	467	41	568	30
1981	835	7	16	15	27	113	0	14	256	541	682	756	10	678	54	94	65	214	17
1982	187	2	3	0	19	43	0	0	104	291	233	198	9	382	3	69	30	185	0
1983	489	10	0	0	12	36	0	0	104	336	632	851	19	823	70	143	41	428	35
1984	343	15	11	10	35	106	6	1	180	161	348	956	38	551	94	103	25	186	16
1985	389	12	3	11	41	63	2	2	175	166	312	201	10	384	262	57	27	150	8

year or 90 per cent of the time, compared to 18-41 per cent in some rivers in Norway (Jensen and Johnsen, 1986) and around 50 per cent for some Scottish rivers.

Spanish salmon rivers can also be narrow and deep, their bottom profile being v-shaped in those that run from the higher mountains through narrow gorges of bed-rock. The numerous deep pools formed between waterfalls may offer ideal habitats for resident trout but there may be a shortage of salmon fry habitat in some areas.

Some spawning ground has been lost through water schemes and power plants; in the salmon rivers of Asturias almost 30 per cent of the total river length has been lost in just 36 years (see Chapter 11). There are, however, numerous small streams and tributaries which could be colonised by salmon if fish passes were created or repaired.

10.3 THE SALMON STOCKS

The Spanish rod and line salmon catches, 1949-1985

Figure 10.2 shows the Spanish rod and line catch for the period 1949-1985, with the contribution to the total catch by the three major salmon regions of Asturias (60.2 per cent), Cantabria (20.6 per cent) and Galicia (15.6 per cent). Navarra has been excluded as its only salmon river, the Bidasoa, provides less than 2 per cent of the total catch (Table 10.1).

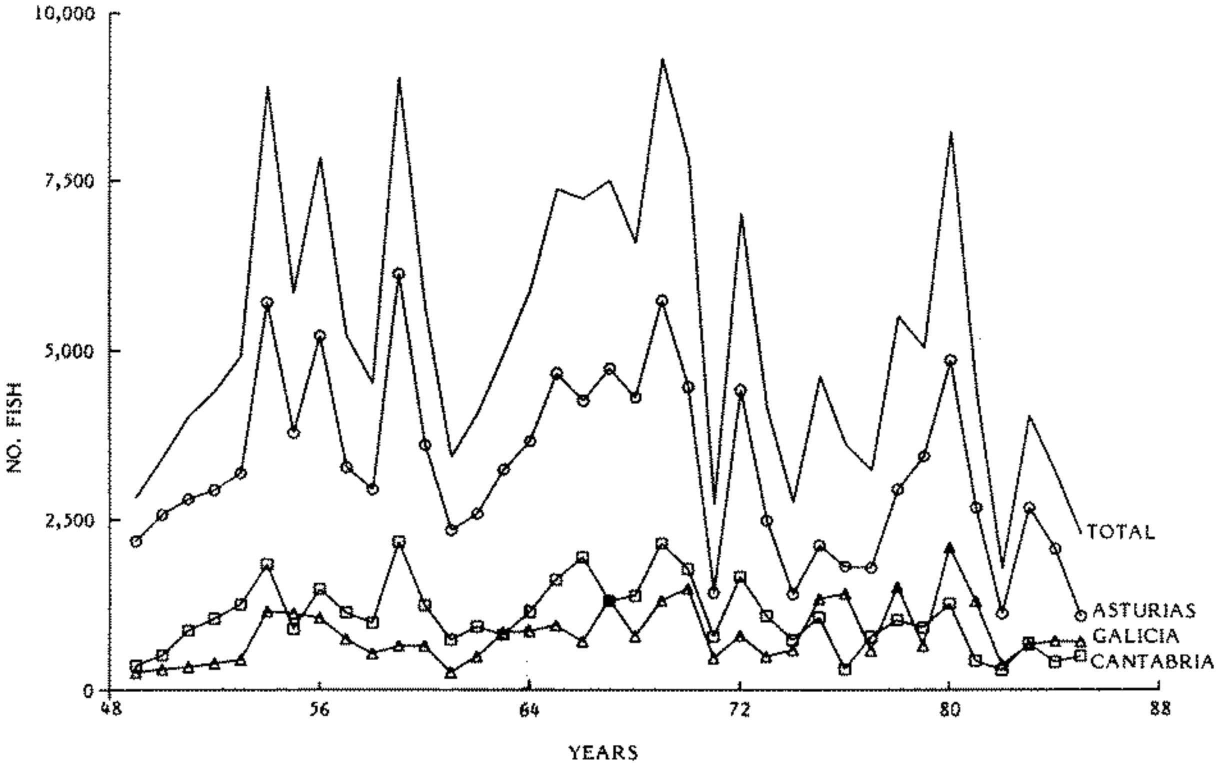
A series of marked peaks and troughs in the total catch are evident every 10-11 years, beginning in 1949, but it is probably unwise to draw far-reaching conclusions about the reasons for these variations without data on salmon abundance.

In general, Spanish salmon catch statistics may reflect mean salmon abundance in particular periods (Miranda, personal communication) but great care must be exercised when looking at individual rivers, as fishing effort is largely unknown and dependent on highly seasonal factors - weather, holidays, etc. The construction of dams and water abstraction schemes exerts effects upon the catches, and the incidence of poaching is variable and dependent on river topography, weather conditions and vigilance by bailiffs.

The abrupt decline in salmon catches in 1971 (Figure 10.2) is thought to be related to the first high incidence of infectious disease in Spain, when hundreds of fish were found dead along the banks of most salmon rivers. Important losses of adult salmon at around this time were also reported in the British Isles and in France (Mills, 1971; Prouzet, 1984).

Ulcerative dermal necrosis (UDN) was held responsible for the deaths but no proper diagnosis has been carried out to date in Spain although plans were recently made in the region of

Figure 10.2: Spanish rod and line salmon catches, 1949-1985, showing contribution by the three major regions of Asturias, Cantabria and Galicia



Cantabria to send samples abroad. Patches of skin fungus had been analysed and both Saprolegnia, a fungus, and Aeromonas spp., a bacterial disease, were identified, both these conditions being associated with the syndrome of UDN (Roberts and Shepherd, 1986). Losses were particularly high in the river Sella in Asturias and the rivers Pas and Asón in Cantabria but a pronounced drop in the salmon catches is also apparent elsewhere (Table 10.1, Figure 10.2). In recent times the numbers of diseased fish is thought to have decreased considerably. Strict comparisons are impossible as there are no overall counts of dead salmon and estimates largely come from the information provided by the bailiffs.

Declines in salmon catches in particular rivers can sometimes be related to the construction of dams and to sources of industrial pollution. Salmon were caught in the river Canero (also called Esva) in Galicia, for example, only after a dam had been damaged by a series of heavy spates in the late 1960s. Salmon disappeared completely in the rivers Miera and Besaya in Cantabria as a result of industrial pollution at the turn of the century. Declines in captures in the rivers Navia, Ulla, Nansa and Miño can also be related to hydro-electric projects (MacCrimmon and Gots, 1979; Garcia de Leániz et al., 1987), (Table 10.1). Although opposition to major water schemes, which alter the flow and topography of the rivers, is certainly growing (Martinez-Conde, 1984), the general interest in the welfare of the salmon is understandably slight and usually subordinated to the pace of industrial progress.

Total salmon catches in the period 1949-1985 averaged 5,224 salmon per year which, compared with over 20,000 fish caught annually in the decade 1920-1930 (Camino, 1940), represents a fourfold decrease over 25 years. Comparisons of yearly catches between the three major salmon regions of Asturias, Cantabria and Galicia yield various degrees of correlation. Salmon catches in Asturias are highly correlated with those in Cantabria ($r=0.88$, $p < 0.001$) while comparisons between both Asturias and Galicia and between Cantabria and Galicia show a poor degree of correlation ($r=0.44$, $p < 0.01$ and $r=0.31$, NS, respectively). Correlation of yearly catches between regions, therefore, seems to depend largely on geographical proximity with rivers in Asturias and Cantabria yielding closely related captures (Figure 10.2).

Spanish salmon catches show no clear correlation with total Scottish catches. It must be stressed that grilse are largely under-represented in the catch sample from these rivers, so changes in abundance of this age class will have little or no effect on the reported captures.

Spawning and time of entry to freshwater

There are no fish counters or fences in Spanish rivers nor are there reliable ways of counting adults ascending salmon rivers outside the fishing season. Both spawning time and time of entry into freshwater must come from historical accounts and information provided by the bailiffs. In places where broodstock are caught and held for stripping, some information on the time of entry is available.

Salmon enter Spanish rivers throughout the year (Camino, 1940; Notario, 1971) although the majority of them are probably spring fish entering the rivers in March-July with peaks in catches generally occurring in May and June. Fish are known to enter the rivers during the winter (Camino, 1940; Notario, 1971) and are called 'invernizos' (meaning from the winter). These are usually large multi-sea-winter fish which are still represented in the rod and line catch in March, at the beginning of the fishing season.

Spring fish are sometimes named according to their month of entry and are generally 2-sea-winter fish in the rivers of Cantabria and probably elsewhere. The average size of fish entering in June and July is normally smaller. By the end of the fishing season, and occasionally earlier, catches tend to drop considerably and small numbers of grilse (55-65 cm) may be represented in varying numbers depending on the year.

When netting was still permitted in Spanish rivers prior to 1942, the smallest fish were normally caught in August and the largest in March and April (Camino, 1940). Although the mean weight of salmon does not seem to have changed substantially and is still about 5 kg in the rivers of Cantabria (Table 10.2), large fish (sometimes reaching up to 18 kg; Camino, 1940; MacCrimmon and Gots, 1979) were often caught at the beginning of the netting season in mid February.

Spawning takes place usually from December to February but it can extend over November to March (Camino, 1940). Differences in water temperature exist between rivers due to snow melt and underground springs so there is some variation in the time of hatching of salmon ova which in Spanish rivers is probably between 35 and 45 days based on a development rate of 410-450 degree days observed in a French river of similar temperatures (Prouzet and Gaignon, 1982). Although the construction of dams and small weirs without appropriate fish ladders has greatly reduced the available area for spawning in some rivers, there are still extensive areas in the upper reaches which could be used for the stocking of eggs and fry in large numbers.

Table 10.2: Wet weight (kg) of salmon caught in four different rivers Mean ± 95% CL, sample size in parentheses

	River			
Year	Pas	Deva	Asón	Nansa
1983	5.24±0.14 (428)	5.04±0.32 (143)	4.56±0.23 (70)	4.92±0.33 (41)
1984	5.33±0.20 (186)	4.99±0.23 (103)	4.97±0.27 (95)	5.29±0.74 (25)
1985	5.12±0.22 (150)	4.66±0.36 (57)	4.62±0.11 (262)	5.75±0.70 (27)
1986	4.71±0.16 (250)	5.00±0.21 (93)	5.33±0.25 (146)	4.57±0.53 (49)
N	1,014	396	573	142

<u>Differences in the length of adults returning to different rivers</u>

Mean fork lengths in the period 1983-86 for each of the Cantabrian rivers (Pas, Asón, Deva and Nansa) were analysed for significance by ANOVA tables with unequal sample size (Zar, 1984).

Differences in mean length between rivers were found to be statistically significant (Table 10.3), indicating that the sample

Table 10.3: Yearly differences in mean fork length (cm) between rivers. Mean ± 95% CL, sample size in parentheses

	River					F
Year	Pas	Deva	Asón	Nansa	N	Value
1983	83.44±0.59 (428)	80.84±0.70 (143)	78.30±1.09 (70)	79.46±1.62 (41)	682	23.62*
1984	83.64±0.94 (186)	80.33±1.01 (103)	80.80±1.26 (95)	81.92±3.20 (25)	409	8.04*
1985	83.40±1.02 (148)	80.24±1.84 (57)	79.37±0.54 (260)	83.52±3.13 (27)	492	18.71*
1986	78.96±0.94 (249)	81.55±0.92 (93)	80.51±1.21 (146)	74.74±2.93 (47)	535	10.40*
N	1,011	396	571	140	2118	
F value	28.91*	1.23 (NS)	3.91**	8.44*		

Table 10.3 (Cont'd)

* $p < 0.001$
** $p < 0.01$

catches from these rivers did not belong to the same population. Inspection of the means in fork length and length frequency distributions (Figures 10.3 and 10.4) showed that salmon from the river Pas normally have a greater fork length and heavier weight due to the higher incidence of early run fish, except in 1986 when some numbers of grilse entered this river in June.

Means of fork length for each river were also found to differ significantly from year to year except in the river Deva (Table 10.3). Yearly variations in mean fork length can usually be attributed to the varying contribution of grilse and small two sea-winter salmon to the sample catch.

Although early run fish can sometimes be sexed based on external characters (Shearer, 1972), some bailiffs tend to overestimate the number of males based on the protrusion at the tip of the lower jaw, frequently mistaken for an incipient kype. Sex ratios will not, therefore, be given.

Seasonal changes in the length of returning fish

Table 10.4 shows the seasonal differences in mean fork length in the four major salmon rivers of the region of Cantabria. Data from different rivers were not pooled as significant differences between rivers were found to exist. In all four rivers, mean fork length decreased significantly with season ($p < 0.001$) although individual monthly differences were not always significant.

Inspection of the monthly length frequency distributions for each river reveals the successive removal of larger fish and the entry of smaller individuals as the season progresses. Peak catches occur mostly in May and June except in the river Pas where they occur in April and May. No significant correlation was found between size of monthly catches and monthly total rainfall for this period although peak catches tended to occur after periods of some rain.

Small fish (possibly grilse) are largely absent from the rod-and-line catch (Figures 10.3 and 10.4) except in the Pas and to a lesser extent in the Nansa where they were present in some numbers at the end of the fishing season in 1986.

Figure 10.3: Length frequency distribution of rod-and-line catch, rivers Pas and Ason, 1983-1986

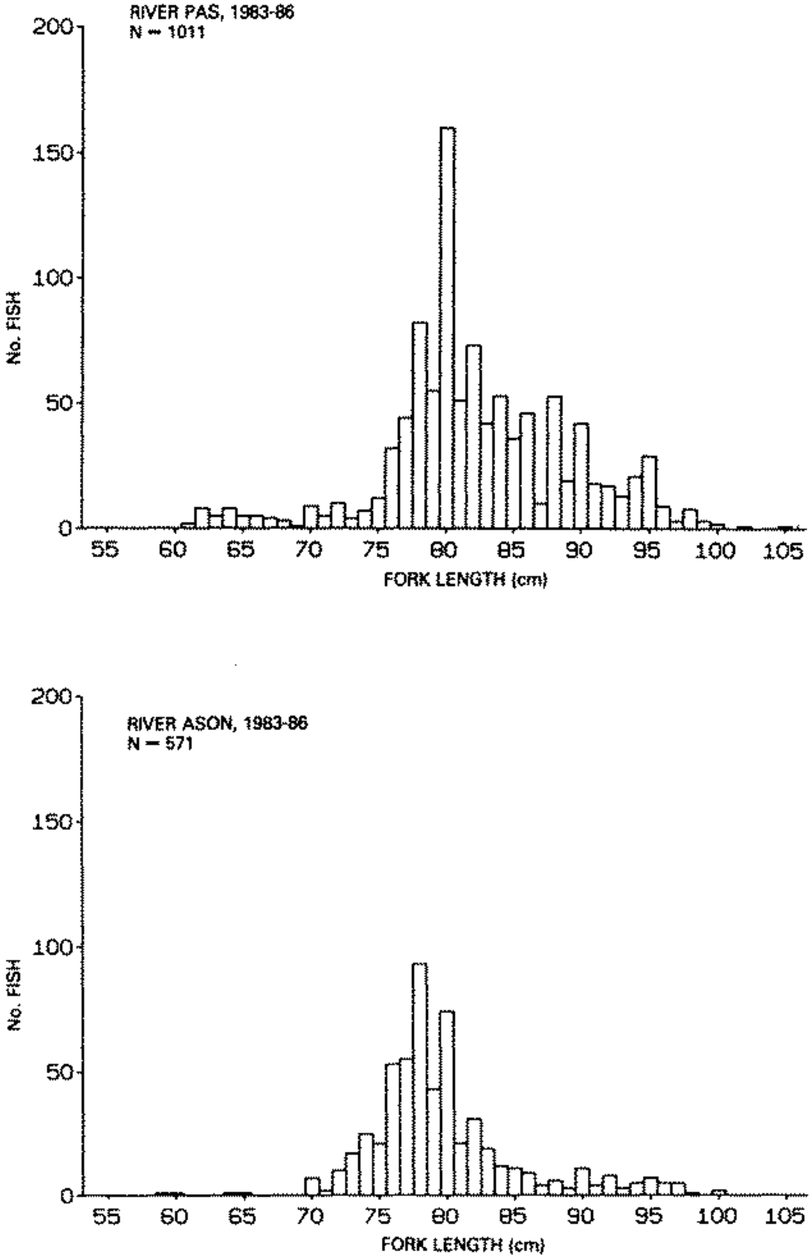
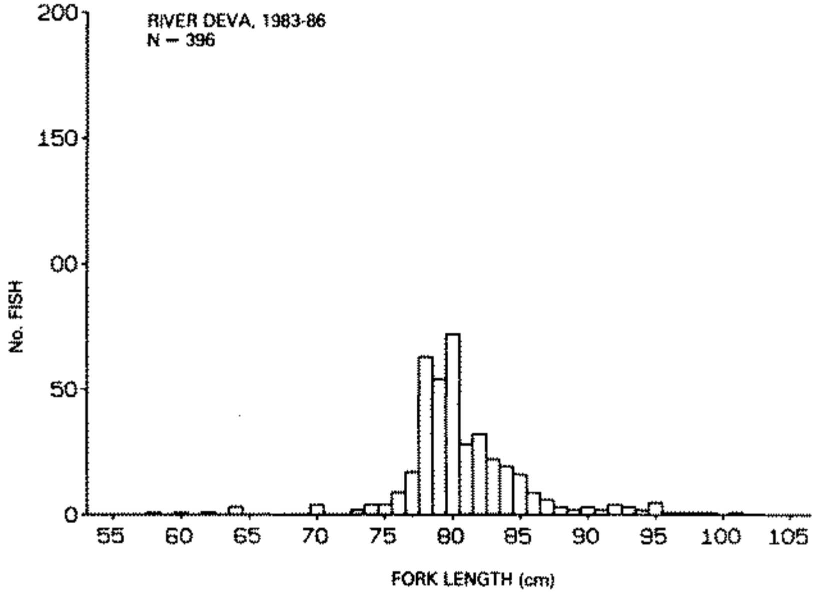


Figure 10.4: Length frequency distribution of rod-and-line catch, rivers Deva and Nansa, 1983-1986



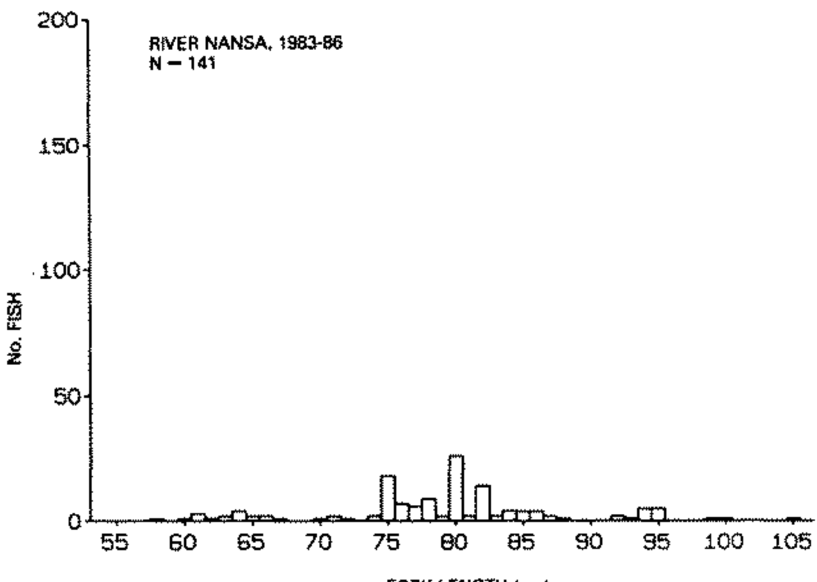


Table 10.4: Monthly differences in mean fork length (cm) 1983-1986 pooled data. Mean ± 95% CL, sample size in parentheses

	River			
Month	Pas	Deva	Asón	Nansa
March	87.50±1.14 (153)	86.93±4.06 (15)	85.31±2.24 (38)	90.17±6.06 (12)
April	82.27±0.64 (284)	83.10±1.51 (60)	81.18±1.09 (148)	82.27±2.63 (30)
May	82.20±0.59 (350)	80.98±0.55 (187)	78.60±0.57 (257)	80.33±1.69 (36)
June	79.04±1.15 (205)	78.98±0.78 (122)	78.85±0.79 (124)	74.69±2.05 (62)
July	81.74±2.38 (19)	76.92±4.94 (12)	78.00±2.24 (4)	-
n	1,011	396	571	140
F value	37.83*	17.02*	16.62*	18.82*

* $p < 0.001$

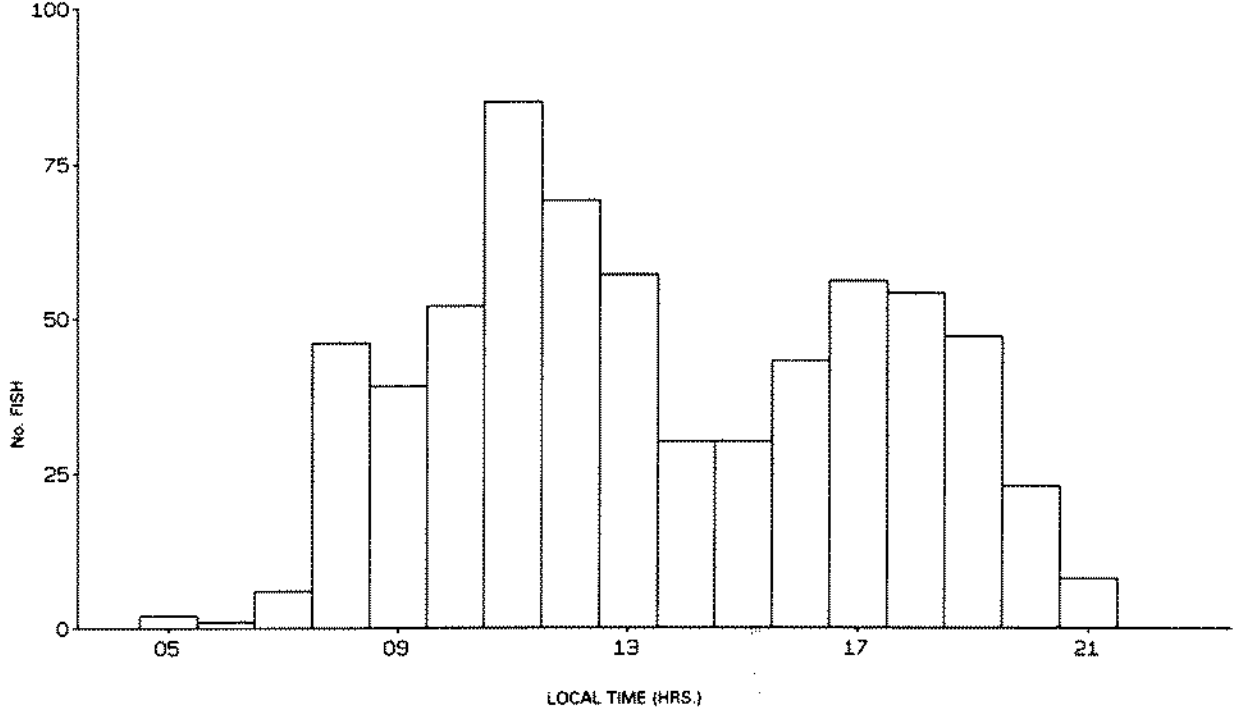
Distribution of salmon catches throughout the day

In Spain salmon may be caught from one hour before sunrise to one hour after sunset in accordance with the fishing regulations (Garcia de Leániz et al., 1987). There is little information on the daily activity rhythms of wild salmon although continuous tracking studies of adult fish in some Scottish rivers seem to suggest that peaks in activity occur around sunrise and sunset with lows around noon (Hawkins and Smith, 1986).

Adult salmon normally cease to feed when they enter freshwater (Jones, 1959). Anglers, however, catch these fish with both artificial lures and live bait and, at least for juvenile salmon, angling success with equal fishing effort can provide reliable estimates of activity levels (Gibson, 1973). Changes in the numbers of fish caught at different times of the day, therefore, may depend on both the activity levels of the fish and the degree of fishing effort. Detailed records exist in Cantabria since 1983 on the time of capture of all fish during the fishing season though estimates of fishing effort are not available.

Only three anglers have the right to fish the restricted beats and it is likely that fishing effort at these sites will be unevenly distributed throughout the day. Fishing in the free

Figure 10.5: Distribution of salmon rod-and-line catches in the free zones throughout the day. Pooled data, rivers Pas, Asón, Deva and Nansa 1983-1986



zones, on the other hand, is done on a half an hour basis if there is more than one angler seeking the same beat at the same time. Fishing effort in these zones may be more uniformly distributed, especially when competition exists between anglers. The rivers in Cantabria, like most salmon rivers in Spain, are short and salmon are mostly caught in a limited number of well-known pools which are clearly signposted and mapped (Garcia de Leániz et al., 1987).

Figure 10.5 shows the number of fish caught in the free zones at each time during the day. A bimodal distribution with modes at 1100 h and 1800 h and lows at 1400 h and 1500 h can be observed. The catch distribution remains the same (clock time) before and after the introduction of Spanish summer time, starting in late March every year. The distribution of catches is thus likely to be independent of the behaviour of salmon and probably results from a non-uniform distribution of fishing effort. Fishing pressure in the free zones cannot reach extreme values as very few fish are caught between 1400 h and 1500 h (the local lunchtime) and only one fish may be caught per fisherman per day. This observation is at variance with the assertions of Netboy (1974) that professional anglers fish continuously '...from dawn to dusk ...every day of the week'.

Lures and baits

Salmon in Spain are caught by a variety of lures and baits, including worms (usually Lumbricus terrestris, the earthworm), cooked or uncooked prawns, mixed worm and prawn, freshly killed minnows (Phoxinus), wet and dry flies, and spoons and devons. Anglers in Cantabria, and probably elsewhere, normally carry a number of different baits and lures and may switch from one to another depending on the conditions.

The number of fish caught by each bait or lure in the Cantabrian rod-and-line fishery for 1983-1986 is shown in Table 10.5. The majority of the catch is taken by prawns (40 per cent), mixed prawns and worm (21.6 per cent), spoons (14.7 per cent) and worms (11.1 per cent).

Table 10.5 also shows the mean fork length of salmon caught by the different lures and baits. Overall variations in the mean fork length of fish caught by each bait are not significant in the rivers Nansa and Asón but are statistically different ($p < 0.05$) in the rivers Pas and Deva.

The Turkey test for multiple comparisons with unequal sample size (Zar, 1984) was employed to identify significant pairwise comparisons in these two rivers (Table 10.6). The mean fork length of all the fish caught by worms during the season is significantly larger than those caught by prawns in both the Pas and the Deva ($p < 0.01$ and $p < 0.05$ respectively). Other pairwise

Table 10.5: Differences in mean fork length of salmon caught by various baits and lures. Pooled data 1983-1986. Mean ± 95% CL, sample size in parentheses

	Pas	Deva	Asón	Nansa	n	%
Worm	84.39±1.23 (105)	82.67±2.04 (52)	78.78±1.12 (73)	-	230	11.1
Mixed	82.64±0.82 (226)	80.81±0.54 (182)	79.35±3.25 (17)	81.61±3.05 (23)	448	21.6
Spoon	82.43±1.78 (76)	81.44±5.41 (9)	80.30±0.87 (182)	81.05±3.53 (38)	305	14.7
Devon	87.67±16.17 (3)	80.50±2.49 (12)	75.0[a] (1)	-	16	0.8
Minnow	82.17±1.46 (81)	-	79.90±1.95 (40)	-	121	5.8
Fly	81.58±1.42 (85)	80.60±1.72 (10)	81.08±2.74 (24)	76.86±9.33 (7)	126	6.0
Prawn	81.73±0.70 (418)	79.93±0.98 (128)	79.49±0.74 (216)	77.51±1.77 (70)	832	40.0
N	994	393	552	138	2,077	100
F value	2.64**	2.29*	1.12 (NS)	2.29 (NS)		

Note: a, excluded from calculations.

* p<0.05
** p<0.01

Table 10.6: Tukey test for multiple comparisons showing q values. All other comparisons not significant

	River	
Comparison	Pas	Deva
Worm vs Prawn	4.99**	4.73*

comparisons are not different.

Comparisons of mean fork lengths of salmon caught by mixed bait (only one fish was caught by worm) and those caught by prawns in the river Nansa were also significantly different (t = 2.33, $p<0.05$).

Differences in the mean fork length of fish caught by various baits and lures may result from one or both of the following factors: (a) differences in lure selectivity, and (b) seasonal trends in the use of particular baits.

It is clear from Table 10.7 that catch by bait is highly dependent on season in all four rivers ($p < 0.001$). Salmon are caught with worms largely at the start of the fishing season (March) and with prawns mostly at the end (June, July). Since larger fish appear in the catch before smaller fish irrespective of the bait being employed (Table 10.4), a spurious correlation may occur between bait or lure and fish size.

Table 10.7: Contingency tables for hypotheses testing. 1983-1986 pooled data. Ho= bait/lure used is independent of month

River	Contingency table	n	d.f.	Chi square
Pas	6 x 5	998	20	88.7***
Asón	6 x 4	554	15	67.2***
Deva	3 x 5	363	8	32.0***
Nansa	3 x 4	130	6	32.6***

*** $p < 0.001$

Reject Ho for all rivers.

The seasonal use of baits and lures (worm first, prawn later) may be related to a variety of factors including water flow conditions, temperature, angler's choice, and availability and cost of live bait. Whether the effectiveness of different baits bears any relation to the behaviour and size of the fish at the beginning and end of the fishing season (e.g. large multi-sea-winter salmon vs. small 1-2 sea-winter fish) can only be ascertained by controlled field experiments and fishing effort data.

<u>Age structure</u>

Table 10.8 shows the age at smolting of adult salmon caught by rod and line in the Asón in April-June 1986. Age data from a limited number of smolts caught by electrofishing in April 1986 is also shown for comparison.

Although the combined sample size (n=113) is very small, the results indicate that most of the smolts in the Asón (94.7 per

Table 10.8: Age at smolting from adult rod and line catch data and smolt sampling (in brackets). R. Asón, April-June 1986, n=95 (18)

Smolt age	n	%
S1	35(11)	40.7
S2	54(7)	54.0
S3	6(0)	5.3

cent) emigrate to sea after one or two years of residence in freshwater.

These results are similar to those found in rivers of Asturias where most smolts are S1 (55-85 per cent) or S2 (15-45 per cent) (Martin Ventura personal communication). In the river Elorn in France, the proportion of smolts migrating after one and two years of residence in freshwater is 47 and 53 per cent respectively (Prouzet and Gaignon, 1985). In the river Eo in Galicia most smolts are S1, in the Pas in Cantabria they are S2 (Camino, 1940; Netboy, 1968). The smolt run takes place from March to May although in some rivers, like the Pas, it may extend to June.

Most of the scales examined did not show the clear freshwater winter bands normally found in salmon from more northern latitudes suggesting that growth in these rivers is almost continuous. In fact, the scale growth patterns observed are similar to those often seen in hatchery reared fish (Anon, 1984a).

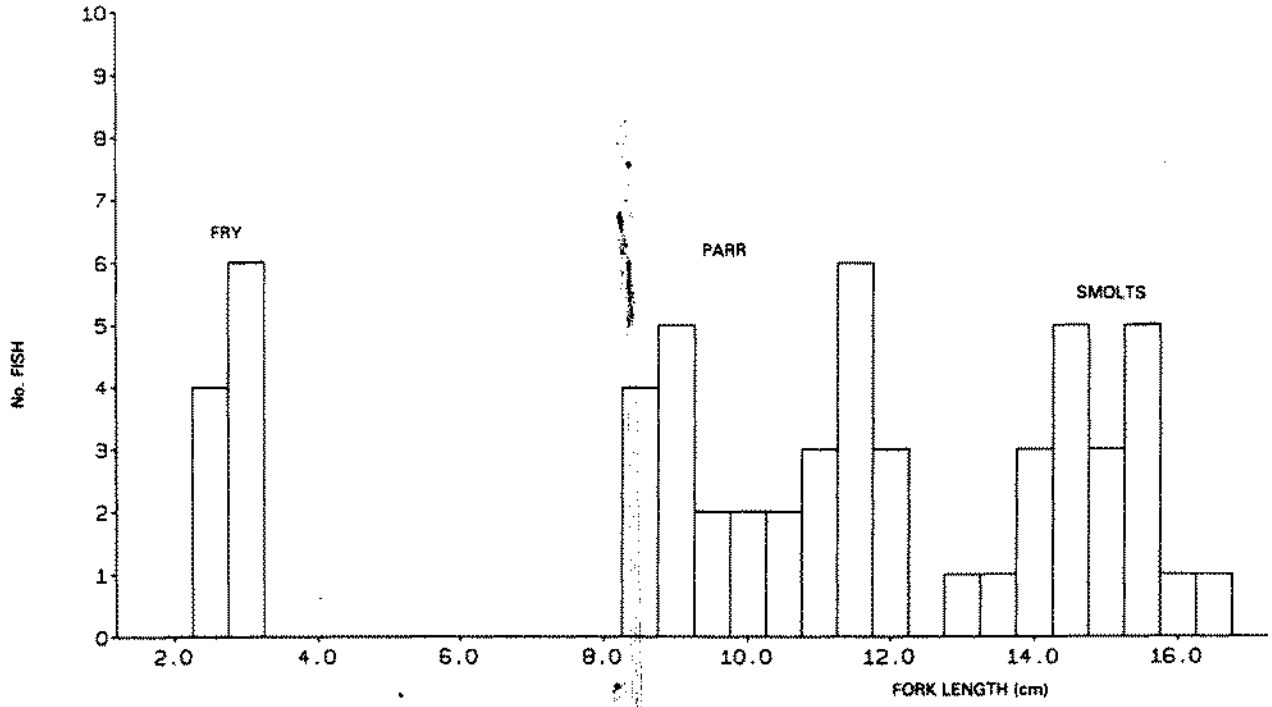
Spanish smolts are large, normally averaging 15-17 cm in fork length (Camino, 1940). Larger smolts, sometimes reaching 20-25 cm, are occasionally reported by bailiffs.

Qualitative estimates of bottom fauna were carried out in the rivers Asón and Pas during April 1986. Large numbers of insects including mayflies (predominantly Ephemerella, Ecdyonurus, Rhithrogena and Baetis), and flies were found along with some freshwater snails and Echinogammarus, an amphipod normally associated with productive warm habitats. Productivity in these rivers is known to be quite high (Camino, 1940), although detailed data are not available.

Water temperatures are not available for all rivers, but these tend to vary from 6-10 °C in winter to 15-21°C during the summer (Anon, 1984b). These temperatures lie within the optimum range for both egg fertilisation and incubation and juvenile salmon growth (MacCrimmon and Gots, 1979).

Mature male parr occur in many of the rivers of Northern Europe and North America. Some of the juveniles caught in the

Figure 10.6: Length frequency distribution of juveniles caught by electrofishing, river Asón, April 1986



Asón in April 1986 (Figure 10.6) were also mature males. Mature female parr, on the other hand, are extremely rare among anadromous salmon (Mills, 1971), probably due to the difficulty of attaining enough weight in freshwater to produce a sufficiently large number of eggs.

The existence of mature female parr has been reported by some bailiffs in Spain but it has not been properly documented and there are no published accounts. Recently, a large mature female parr measuring 22.5 cm and weighing 150 g was caught in the river Elorn in France; this fish produced 256 viable ova which could be made to hatch (Prouzet, 1981).

The majority of the adult scales examined in the Asón in 1986 were from 2SW fish (86 per cent), although 3SW (13 per cent) and 4SW salmon (1 per cent) were also present (Table 10.9).

Table 10.9: Sea age of rod and line sample catch. River Asón, April-June 1986 (n=97)

Sea age	n	%
2 SW	83	85.6
3 SW	13	13.4
4 SW	1	1.0
Prev. spawners	2	2.1

Most salmon from rivers in Galicia and Asturias are also 2SW fish (Netboy, 1968; Martin Ventura, Chapter 11) but grilse are represented in some numbers (5-15 per cent). The absence of 1SW in the scales examined probably results from the small sample size and the early closing of the fishing season this year. Grilse averaging 2.2 kg in weight enter the river Elorn in France from May to January (Prouzet and Gaignon, 1985).

A relatively high proportion of the adult scales examined from the river Asón (19 per cent) showed a large degree of erosion, this being particularly noticeable from fish caught in June (50 per cent), when rainfall and flow rates normally drop considerably (Table 10.10). This may indicate that salmon could be held in the lower beats of the river during the dry periods before being able to move upstream in the wetter months.

There is very little information concerning the migration of Spanish salmon as no tagging programmes have been carried out in recent years (Miranda, personal communication). An adult salmon tagged on September 1969 in Disko Bay off west Greenland, however, was subsequently recaptured in October 1970

Table 10.10: Mean air temperatures and total rainfall in the city of Santander, province of Cantabria. Standard deviations in parentheses

			Mean air temperature (°C)			
Period	March	April	May	June	July	August
1983-86	10.4(0.7)	12.3(1.9)	13.6(1.0)	17.3(0.7)	20.0(0.9)	19.7(0.1)
1926-86	11.2	12.1	14.1	16.9	19.0	19.4
			Total rainfall (mm)			
Period	March	April	May	June	July	August
1983-86	122.2(49.2)	103.0(40.8)	119.8(98.2)	38.3(12.9)	50.4(35.9)	121.7(140.6)
1926-86	88.1	95.1	92.6	65.7	56.5	82.5

in the Asón (Netboy, 1974). An additional tagged fish from the same station was caught in the Sella in May 1972, suggesting that Spanish salmon may reach the same distant feeding grounds as fish from some British, Irish and French rivers. The great majority of recaptures of wild smolts tagged prior to 1972 in French rivers was found in Greenland (Swain, 1980), again suggesting that salmon from southern Europe may share the same feeding grounds as those from northern Europe.

Stocking effort

Stocking of salmon eyed ova and fry into Spanish rivers was already being carried out at the turn of the century (Camino, 1940; MacCrimmon and Gots, 1979) although more systematic stocking started only in 1949.

Total stocking effort in recent times is estimated as 200,000-300,000 eyed ova and between 90,000 and 120,000 fry (4-5 cm) annually, coming partially from the stripping of native broodstock and from the purchase of salmon ova from Scotland, Iceland and Scandinavian countries (Miranda, personal communication).

In the region of Cantabria detailed records exist of all the stocking programmes since 1972. Average annual stocking of eyed ova and fry is 180,000 and 9,500 respectively. Eyed ova are all imported from Scotland and Iceland and planted in Vibert boxes between January and March. Stocking densities tend to be very high and planting sites are not always the most appropriate probably resulting in higher than normal mortalities.

Fish were released only in the rivers Asón and Pas in the early 1970s. Planted fish ranged from 6 to 10 cm in fork length and came from local hatcheries or, in the Pas, from the rescue of parr (10 cm) caught in isolated pools during particularly dry summers.

Hatchery-reared fry have been planted out normally in November while rescued parr were transferred from the dry zones in July and August.

Other fish planted in the salmon rivers of this province include large numbers of brown trout (Salmo trutta) of local and foreign origin. Rainbow trout (Salmo gairdneri) have been introduced to the river Deva. Black bass (Micropterus) has also been introduced in a large artificial reservoir draining into the Mediterranean.

Commercial rearing in Spain of both Atlantic and Pacific salmon (mostly Oncorhynchus kisutch, Coho salmon) has increased in recent years but the market is still dominated by the production of rainbow trout at a level of 17,000 metric tons per year (Miranda, personal communication).

The effect of stocking programmes upon the subsequent recruitment of adults is often subject to debate. When the fish being stocked, either from eyed eggs or fry, are not the same as the native population, problems may arise. The introduced fish may not have the most appropriate characteristics and, ideally, some form of marking should be employed to assess the specific contribution of these individuals to the total catch. When this is not possible, recruitment models may be needed to estimate the effect of stocking.

Variable numbers of salmon ova and fry have been planted irregularly in the river Asón since 1973. A simple model to examine the effects of stocking has been constructed based on the following assumptions:

(1) The survival rates from planted eyed ova and fry to smolt are constant from year to year. These survival rates were estimated as 0.05 and 0.2 respectively which are slightly more conservative than those reported by Symons (1979) for low survival conditions.

(2) Five per cent of the smolts from stocked ova leaving the streams return as adults and 25 per cent of these returning adults are taken by the rod and line fishery operating from March to June-July every year.

(3) The contribution of each age class to the total catch is constant for the period studied (1976-1986) and may be summarised as follows:

Total age	Percentage contribution
3 years	33
4 years	50
5 years	15
6 years	2

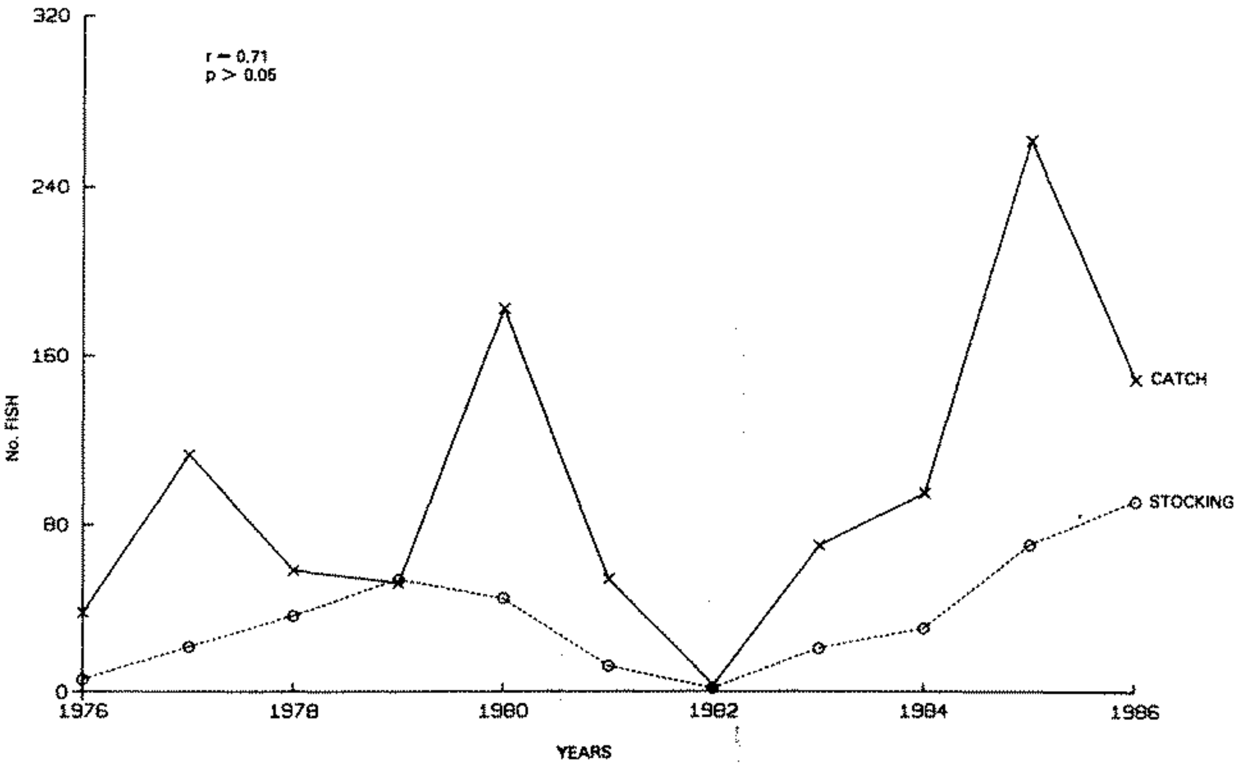
These are total age estimates obtained from adult age data in 1986.

(4) The contribution to the fishery of second generation adults resulting from the stocking of fish is negligible for this short period.

A null hypothesis formulated as Ho = salmon catches in the period 1976 to 1986, bear no relation to stocking effort in previous years as defined above. Actual values of survival rates and recruitment are irrelevant to the model provided they hold more or less constant for this period. Small violations of the assumptions can also be tolerated.

Figure 10.7 shows the relation between the estimated recruitment from stocking and the actual salmon catch for the period 1976-1986. The correlation coefficient is 0.71 ($p < 0.05$) for a sample size of 11 years. A simple linear regression indicated that half the variance in salmon catches in this period

Figure 10.7: Relation between rod and line catches and estimated recruitment from stocking programmes in the river Asón, 1976-1986



could be explained by the estimated effect of stocking in previous years. Factors of greater importance in controlling yearly catches of salmon in these rivers possibly include the relative strength of different year classes, the variation in catchability coefficients and fishing pressure and the fluctuations in natural populations.

Rivers like the Pas with relatively larger catches are likely to be less affected by similar or lower levels of stocking, but since no age data exist for these rivers no attempts were made to investigate the possible effect of stocking programmes.

CONCLUSIONS

(1) Yearly variations in catches for all salmon rivers in Spain from 1949 to 1985 show no discernible trend. Particular declines in catches in some rivers can be correlated with the construction of impassable dams, the occurrence of diseases (possibly UDN) and the growth of industrial pollution. The resources allocated to salmon data collection have varied greatly and many other factors including the incidence of poaching may affect the catches.

(2) In all four Cantabrian rivers (Pas, Asón, Deva and Nansa) mean fork length of fish caught by rod and line decreased significantly from March to July in the period 1983-1986. Age data from the river Asón suggests that this is due to the early entry of large multi-sea-winter fish and the late addition to the catch of increasingly smaller salmon, mostly 2SW fish. Grilse (1SW) are seldom represented in the total catch perhaps because their time of entry normally lies outside the fishing season.

(3) Statistically significant variations in mean fork length occurred from year to year in all but the river Deva. These differences result mostly from the varying contribution to the catch of small (70-77 cm) 2SW individuals. No significant correlation exists between either air temperature or total rainfall and monthly catches for the period 1983-1986.

(4) Significant yearly differences in mean fork length and length frequency distributions exist between the four rivers studied, salmon caught in the Pas being generally larger and heavier except for 1986, where a sizeable proportion of grilse (60-68 cm) entered this river in May-June.

(5) Although significant differences in mean fork length were found between fish caught by a variety of baits (notably worm vs. prawn), the use of different baits is highly seasonal, some baits and lures being used mostly at the start of the fishing season, others almost exclusively at the end. Seasonal trends in bait choice probably depend on many factors which may or may not bear any relation to lure selectivity and salmon behaviour.

(6) Salmon in the four rivers studied may be caught from one hour before sunrise to one hour after sunset in accordance with the fishing regulations. Catch peaks, however, occur at mid morning and mid afternoon with lows around local lunchtime for both restricted beats (with a limit of three anglers per day) and free zones (one angler per beat on a half an hour basis). It is tentatively concluded that fishing effort at different times of the day in these rivers is unevenly distributed and far from the level expected to result from intense competition between anglers in the free zones (legal saturation level).

(7) At least for one river, the river Asón, it can be shown that stocking effort bears a direct relation to salmon recruitment for the last ten years. In fact, half the variation in yearly catches for this period can be explained by stocking alone. Stocking in these rivers, however, is done with limited resources and this is more likely to have an effect only in rivers yielding moderate to low catches.

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