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The incidence of escaped farmed Atlantic salmon, *Salmo salar* L., in the Faroese fishery and estimates of catches of wild salmon

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Abstract

The proportion of Atlantic salmon escaped from fish farms in the Faroes salmon fishery was estimated using scale analysis. Samples were obtained of fish landed in the commercial fishery, from 1980/81 to 1990/91, and from 1991/92 to 1995/96 from research catches. The material collected were in some years limited to only a part of the fishing season. The estimated proportion of farmed salmon in the fishery was relatively low from 1980/1981 to 1986/1987, but increased considerably thereafter, and reached a peak in the 1989/1990 fishing season, when more than 40% of the catch was estimated to be of farmed origin. Later, the proportion declined, and in recent fishing seasons the proportions of farmed salmon were estimated to be around 20%. These estimates were used to split the Faroese catch into a wild and farmed component. It is suggested that if farmed components in salmon catches were not accounted for, this will overestimate catches of wild salmon, and thus complicate assessments of fisheries and stocks of wild salmon.

Introduction

In recent years salmon farming has expanded considerably. In 1995, 413,200 tonnes were produced in the north Atlantic, with Norway and Scotland accounting for the majority of the production (Anon. 1996). In comparison, the total nominal landings of salmon in commercial fisheries in the north Atlantic in 1996 was 3,343 tonnes (Anon. 1996). This catch figure includes a relatively small proportion of salmon released as smolts for ranching, or for stock enhancement, and a proportion of fish farm escapees.

Evidence from the Norwegian fish farming industry indicates that losses from the cages can occur at any time after the fish are placed in the sea and at all life stages. The escaped fish are caught in fisheries, and when sexually mature, they enter freshwater to spawn (e.g. Hansen et al. 1987; Gausen and Moen 1991; Lura and Sægrov 1991; Webb et al. 1991).

The spread of fish farm escapees into all areas of the north Atlantic where wild salmon are also found, poses several possible problems. First, interbreeding of farmed and wild salmon has been suggested to pose negative effects on wild stocks (e.g. Hindar et al. 1991). Second, the transmission of parasites and diseases from farmed to wild stocks may cause problems (e.g. Håstein & Lindstad 1991). Thirdly, catch records from fisheries comprising both wild and farm

escapes will complicate the assessment of stock status of wild fish. It is therefore of great importance to identify the proportion of farmed fish and adjust catch records accordingly.

Tagged farmed salmon released directly into Norwegian coastal waters, were recaptured in the high seas fishery at Faroes (Hansen et al. 1987), and in a recent paper Hansen et al. (1993) demonstrated that large numbers of escaped farmed Atlantic salmon were present in oceanic waters in the north east Atlantic ocean and accounted for a significant part of the commercial salmon catch at Faroes.

Since 1980/81 fishing season the long-line fishery for salmon within the Faroese 200 mile EEZ has been systematically sampled. Because analysis of scale patterns can be used as a tool for identification of farmed salmon (Lund & Hansen 1991), we used this method to develop estimates of time series of the proportion of farmed salmon in this fishery, and subsequently produced estimates of number of farmed and wild salmon caught.

Material and methods

As a part of the continued biological sampling programme of Atlantic salmon in the long-line fishery within the Faroese EEZ, fish were examined in order to estimate the occurrence of farmed salmon in the fishery.

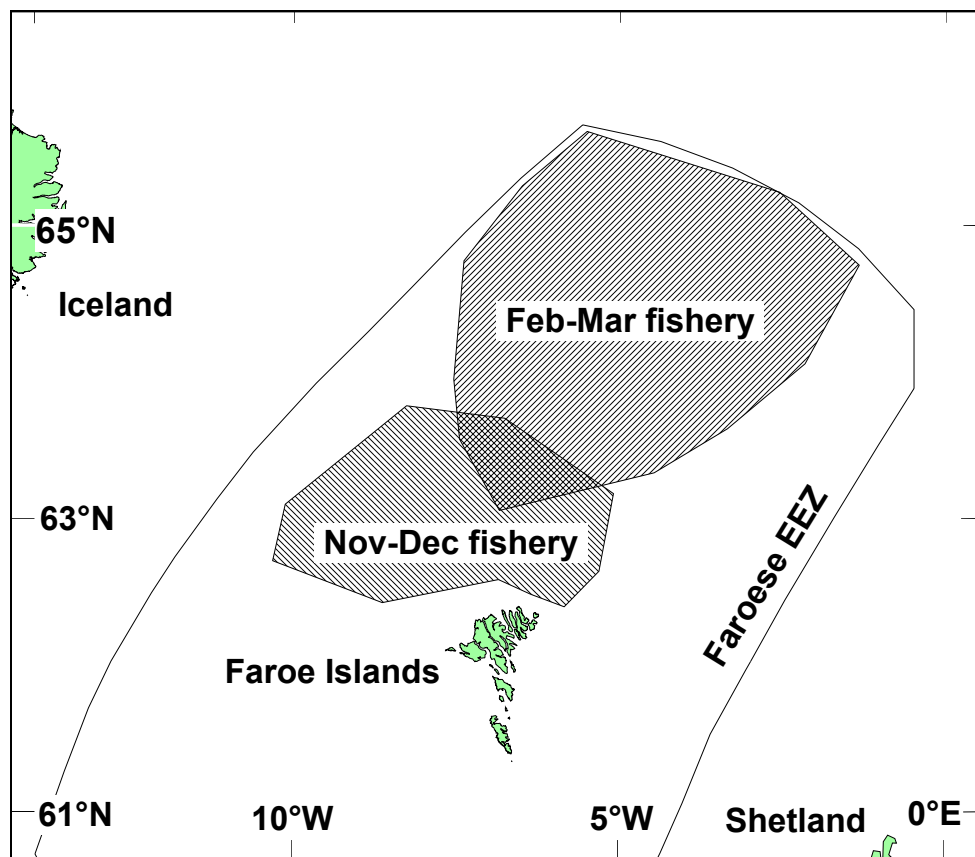


Figure 1. The area sampled. The autumn fishery is located closer to the Faroe islands and more westerly than the winter fishery.

Table 1. The material used for estimation of the proportion of farmed salmon in the Faroes fisheries since 1980, and estimates of the proportion of farmed fish in the samples. Indet.= number of fish not possible to classify.

Season	Time	Year	Wild	Reared	Indet.	Total	% reared
1980/81	January	1981	153	4	1	158	3
	Mars	1981	124	3	5	132	2
1980/81	January-Mars		277	7	6	290	2
1981/82	January	1982	74	3	1	78	4
	February	1982	70	0	0	70	0
	Mars	1982	44	1	1	46	2
	April	1982	22	0	0	22	0
1981/82	January-April		210	4	2	216	2
1982/83	February	1983	48	1	1	50	2
	March	1983	63	2	1	66	3
	April	1983	63	0	5	68	0
1982/83	February-April		174	3	7	184	2
1983/84	January	1984	147	4	5	156	3
	February	1984	52	5	2	59	8
1983/84	January-February		199	9	7	215	4
1984/85	January	1985	71	8	1	80	10
	February	1985	47	4	1	52	8
	Mars	1985	90	6	3	99	6
	April	1985	35	2	2	39	5
1984/85	January-April		243	20	7	270	7
1985/86	January	1986	52	2	3	57	4
	February	1986	53	4	3	60	7
	April	1986	75	2	1	78	3
1985/86	January-April		180	8	7	195	4
1986/87	March	1987	134	4	2	140	3
	April	1987	66	2	1	69	3
1986/87	March-April		200	6	3	209	3
1987/88	January	1988	45	3	2	50	6
	February	1988	73	10	0	83	12
	April	1988	82	4	1	87	5
1987/88	January-April		200	17	3	220	8
1988/89	November	1988	75	23	2	100	23
	January	1989	91	20	8	119	17
	April	1989	83	12	6	101	12
1988/89	November-April		249	55	16	320	17
1989/90	January	1990	106	87	13	206	42
	February	1990	36	32	5	73	44
1989/90	January-February		142	119	18	279	43
1990/91	December		49	42	8	99	42
1991/92	November	1991	71	47	4	122	39
	December	1991	117	69	10	196	35
	February	1992	10	102	6	208	49
	March	1992	87	40	2	129	31
1991/92	April	1992	133	56	9	198	28
	December-April		508	314	31	853	37
1992/93	November	1992	11	8	6	25	32
	December	1992	54	18	22	94	19
	March	1993	125	61	14	200	31
1992/93	November-March		190	87	42	319	27
1993/94	November	1993	132	58	10	200	29
	December	1993	124	65	9	198	33
	January	1994	15	5	5	25	20
	February	1994	112	27	10	149	18
	March	1994	153	50	13	216	23
1993/94	November-April		536	205	47	788	26
1994/95	November	1994	120	34	2	156	22
	February	1995	83	22	1	106	21
	March	1995	88	16	7	111	14
1994/95	November-March		291	72	10	373	19
1995/96	December		195	64	11	270	24

The material analysed was collected from the 1980/81 fishing season onwards to the 1995/96 fishing season, and was sampled mainly from the areas north of the Faroes (Figure 1). In

November-December sampling was carried out farther south and closer to the Faroes than in January-April. From the 1980/81 fishing season to the end of 1990 sampling was carried out from commercial salmon catches, whereas from 1991 to 1995 sampling was carried out from a research fishery operated by only one vessel. During the whole period scale samples were collected randomly from the catch, and the fish were measured (fork length) and weighted to the nearest 0.1 kg.

Identification of farmed fish was carried out by scale analysis (Lund et al. 1989; Lund and Hansen 1991). This method has been developed by analysis of scales from Norwegian salmon of known origin, and the characters used were smolt size, transition zone from freshwater to saltwater, the position of sea winter bands, the number of summer checks and the proportion of replacement scales at the marine stage. To be classified as reared, at least two out of the six characters examined must indicate that the fish were of reared origin. This method has been shown to give good separation between farmed and wild salmon, but fish escaped at smolt stage or released as smolts for ranching or enhancement are difficult to detect accurately, and the proportion of those are thus underestimated (Lund and Hansen 1991). Table 1 shows the number of scale samples collected and estimates of the proportion of farmed salmon on a monthly basis.

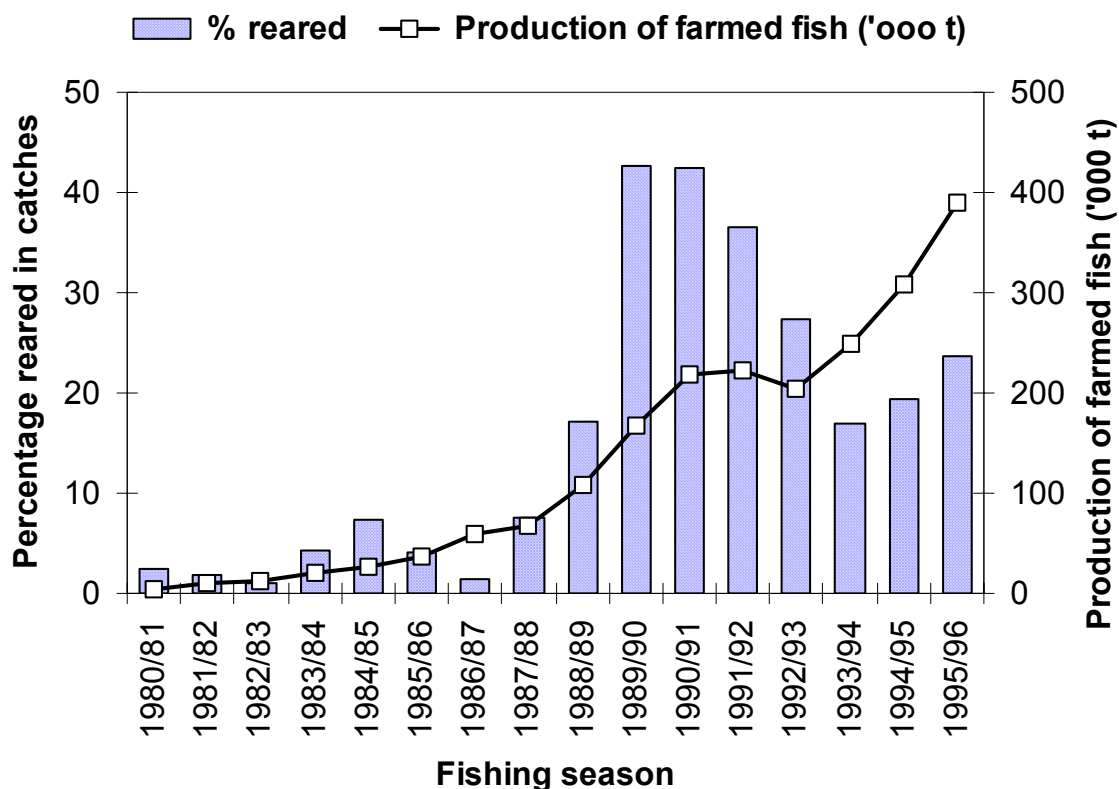


Figure 2. Distribution of farmed salmon in samples collected in Faroese waters from the 1980/81 fishing season, and total production of farmed salmon in the northeast Atlantic.

Sampling was not carried out all months throughout the fishing seasons, in 11 out of 16 seasons only one part of the season was sampled, and in two of those sampling was carried out only in one month. Monthly variations within fishing seasons in the proportion of farmed fish

were examined using χ^2 tests. The only significant differences occurred in the fishing season 1991/1992, whereas the 13 other fishing seasons when data from two or more months were available no significant differences were detected. To split the total catch of salmon at Faroes by season into wild and farmed components, it was therefore found appropriate to use the mean estimated proportions by season of fish from these two groups in the calculations.

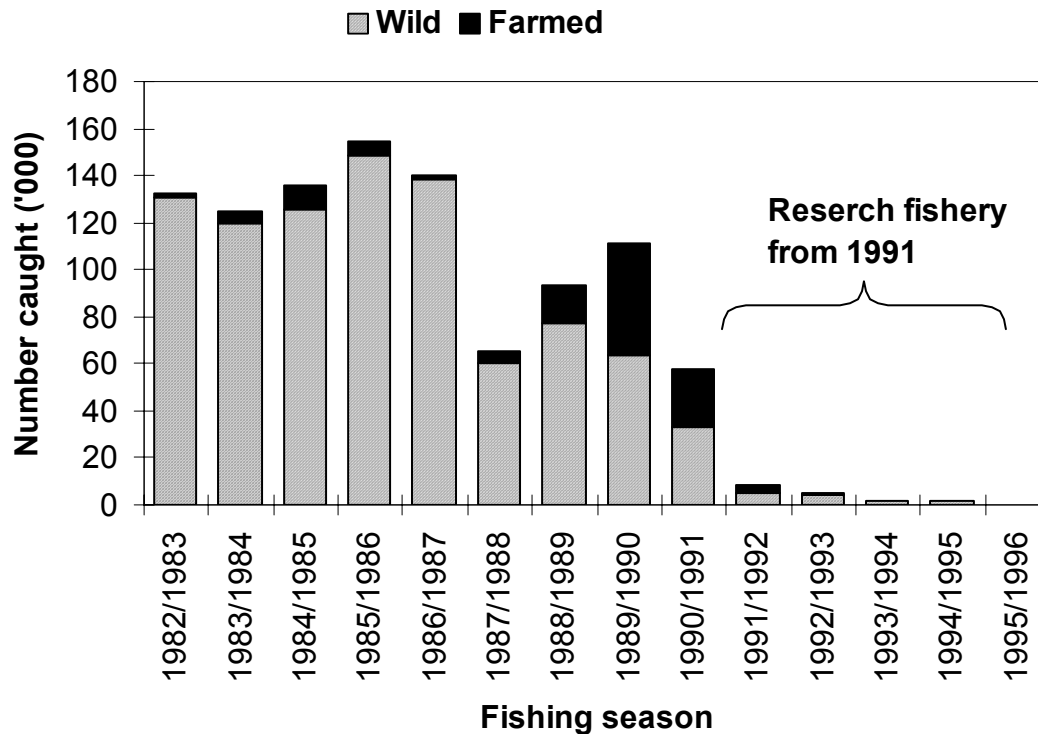


Figure 3. Estimated catches of wild and farmed Atlantic salmon in Faroese waters from the 1982/83 fishing season.

Results

The time series of the estimated proportions of farmed salmon in the Faroes fishery between the 1980/81 and the 1995/96 fishing seasons are shown in Figure 2 compared with time series of the total production of farmed salmon in the Northeast Atlantic the previous year. The proportion was relatively low from 1980/1981 to 1986/87 fishing season, and increased considerably thereafter, and reached a peak in the 1989/1990 and 1990/91 fishing seasons when more than 40% of the samples were farmed salmon. Then the proportion declined, and in the past three fishing seasons the proportion of farmed fish was estimated to be around 20%. The estimated proportion of farmed salmon in the Faroese fishery was significantly correlated with the total production of farmed salmon in the Northeast Atlantic (Spearman rank correlation analysis: $r_s = 0.81$; $p = 0.0001$).

Adjusted catches at Faroes of respectively wild and farmed salmon are shown in Figure 3. The decline in catches of wild salmon after the 1988/1989 fishing season is more pronounced when corrected for farmed salmon.

Discussion

The variation in the proportion of farmed salmon among seasons in the salmon fisheries at Faroes is relatively consistent with the increase in overall production of farmed salmon in the northeast Atlantic. The total production of farmed salmon in the Atlantic in 1995 was 413,200 tonnes (Anon. 1996). Of this, 95% were produced in Europe, and of the total production Norway and Scotland accounted for 71% and 17%. The production at Faroes was 9,000 tonnes which represents about 2% of total production in the Atlantic. Salmon escape from cages in all areas where farms are present, and it is reasonable to assume that the largest number of fish escape from Norwegian farms.

Experimental releases of tagged farmed salmon during their first year in sea cages have shown that the survival to sexual maturity is highest when the fish are released in the spring. When released in late summer and autumn, the survival of these fish is low (Hansen & Jonsson 1989). Furthermore, in most cases these fish return, in a crude sense, to the marine area from where they escaped. However, when fish escaped in March they were observed to stray to rivers far away from the site of escape, although they were not reported from other areas than Norway and the west coast of Sweden (Hansen & Jonsson 1991). The high proportion of farmed salmon observed in Norwegian home water fisheries (Lund et al. 1996), combined with the fact that Norway accounts for the major production of farmed salmon in the Atlantic, strongly suggest that most farmed salmon occurring in the Norwegian Sea are of Norwegian origin. This is supported by the fact that tagged farmed salmon released on the Norwegian coast were recaptured in the Faroese fishery (Hansen et al. 1987). However, we can not rule out that farmed fish escaping from cages in Scotland, Faroes and Ireland also contribute to the Faroese fishery.

When assessing salmon fisheries and wild salmon stocks, it is important to estimate the farmed and ranched component. A high proportion of such fish present, which are not accounted for, will overestimate the catches of wild salmon and mask the size and status of the wild stocks. If not accounted for, this could have happened in assessments of the Faroese fishery from the 1988/89 fishing season and onwards.

The methodology used in the present study tends to underestimate the proportion of reared fish, in particular those escaped at the freshwater stage, or at an early marine stage (Lund et al. 1989; Lund & Hansen 1991). On the other hand, the method will also detect a part of salmon released for ranching or as smolts in stock enhancement programmes. However, a large part of these fish carry external or internal tags, often combined with fin clips. The salmon analysed in the present material were screened for tags, and tagged fish were not included in the analysis. Furthermore, the number of hatchery reared smolts released into rivers in the northeast Atlantic is relatively small compared with the number of wild salmon present, except in Iceland where ranching has been established as an industry. However, very few fish tagged in Icelandic ranching operations have been reported from the Faroese fishery, suggesting that they exploit other feeding areas. All in all, this suggests that deliberately released salmon smolts are a small component of the salmon sampled, and that escaped farmed salmon account for the major proportion.

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