Temporal and Spatial Migration and Distribution of Atlantic Salmon, *Salmo salar* L., in the Northeast Atlantic Ocean

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It has been suggested that the decline of Atlantic salmon in recent years has been caused by increased marine mortality. Many factors may affect salmon survival in the sea, although they are poorly understood (Fig. 1). In the Northeast Atlantic survival of salmon and sea surface temperatures have been shown to be correlated, suggesting that marine climate (directly or indirectly) is a key factor, particularly at the post-smolt stage (Friedland et al. 1998). There is limited information on the distribution and migration of Atlantic salmon at sea in space and time (e.g. Hansen and Quinn 1998), and until recently this was based solely on records from commercial fisheries. Understanding fluctuations in marine mortality of salmon is highly dependent on knowledge of the distribution and migration of salmon in space and time.

This paper summarises the conclusions from a recent study on the distribution and migration of post-smolts in the Norwegian Sea and from a salmon tagging program conducted at the Faroe Islands. Furthermore, we discuss the future possibilities to fill gaps in our knowledge by using information from archival tags attached to salmon.

Atlantic salmon smolts leave fresh water and the post-smolts migrate to the feeding areas in the ocean during late spring and summer (e.g. Thorpe 1988; Mills 1989). The duration of estuarine residence seems to be relatively brief. Further evidence, albeit indirect, of rapid migration comes from the fact that very few post-smolts are recorded in fjords and coastal waters during summer and autumn, although they are already present in oceanic areas in the Northeast Atlantic (Holm et al. 2000; Holst et al. 2000).

A number of post-smolts have been caught in oceanic areas of the Northeast Atlantic in recent years during pelagic trawl surveys in the Norwegian Sea in July and August (Holst et al. 1993; Holm et al. 2000; Fig. 2), and north of Scotland in May and June (Shelton et al. 1997). Based on the distribution of catches north of Scotland, the fish appear to move north-wards with the shelf edge current (Shelton et al. 1997). Further north, in the Norwegian Sea, post-smolts were caught beyond 70°N in July. Analysis of growth and smolt age distribution strongly suggested that most of the post-smolts originated from rivers in southern Europe (Holst et al. 1996).

When Atlantic salmon have reached catchable size, their marine distribution is easier to document. Many countries have had major tagging programs on smolts and adults, and some of these fish have been recaptured in the high seas fisheries. It is difficult to assess the true distribution of salmon at sea, as tag recoveries depend on the distribution of fishing effort. The absence of fishing pressure in an area does not demonstrate the absence of salmon, although it may be assumed that there is at least some general correspondence between the distribution of fish and fishermen.

Fig. 1. Factors influencing salmon at sea.

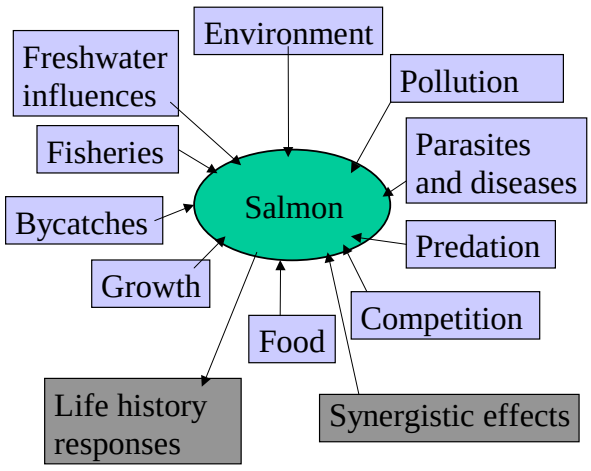

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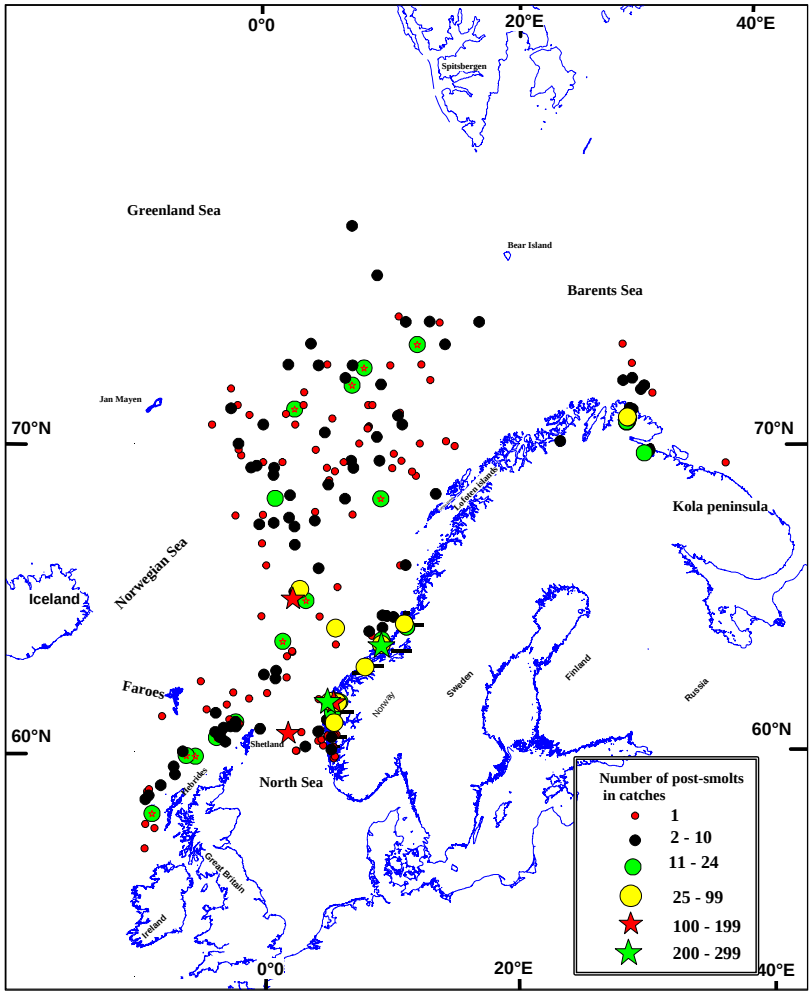
Fig. 2. Distribution of post-smolt catches in the Nordic Seas in 1990–2000. The size and colour of the symbols indicate the number of post-smolts in the catch (Holm et al. 2000).



In the Northeast Atlantic, salmon are found in large areas in the Norwegian Sea. In the 1970s there was an important commercial long-line fishery in the Norwegian Sea in February–May. Recoveries of fish in this fishery that had been tagged as smolts, and recaptures in coastal and freshwater fisheries of salmon tagged in the Norwegian Sea, suggested that Norwegian salmon were most abundant, although fish from the United Kingdom, Sweden and Russia were also present. Most of the fish tagged in the Norwegian Sea were recaptured in homewaters in the same year they were tagged, suggesting that they were maturing (Rosseland 1971). Towards the end of the 1970s, fishing for salmon in the Northern Norwegian Sea was banned, and fishing was limited to the area within the Faroese Exclusive Economic Zone (EEZ).

The abundance of salmon within the Faroese EEZ has been assessed from sampling of the fishery for a number of years. Jákupsstovu (1988) reported on a tagging program at sea from 1969–1976 in which 1,946 salmon caught on long-lines were tagged and released. The fish were tagged in more southerly parts of the Faroese EEZ, and 1SW fish were probably highly over-represented. In total, 90 fish were recovered: 33 in Scotland; 31 in Norway; 15 in Ireland; 8 in other European countries; and 3 at West Greenland. The majority of the tags were reported in homewaters in the same year as tagging occurred. However, it is interesting to note that some fish in the Faroese area may have been on their way westwards, as they were reported from the fishery at West Greenland later that year.

In the Norwegian Sea large numbers of escaped farmed salmon are present, and it has been estimated that up to 40% of the salmon in commercial catches at the Faroes are of farmed origin (Hansen et al. 1999). Some years ago a tagging program was carried out in the major fishing grounds north of the Faroes. From November–March in the 1992/93, 1993/94 and 1994/95 fishing seasons, 5,456 salmon (3,811 wild and 1,637 farmed) were caught by long-line, tagged and released (Hansen and Jacobsen 2000). In total, 106 fish (87 wild and 19 farmed) were recaptured. Wild salmon of Norwegian origin were most abundant in the area but Scottish and Russian salmon were also common. Some additional recaptures were reported from Ireland, Iceland, Spain, Sweden, Denmark, England, and even Canada (Table 1; Hansen and Jacobsen 2000), strongly suggesting that salmon originating from most areas of the distribution range are present at some life stage in this area, but in variable proportions at different times (Jacobsen et al. 2001). Of the escaped farmed salmon, 18 were recaptured in Norway and one at the west coast of Sweden.

At the NINA research station at Ims, in southwest Norway, 75 kelts were tagged with Kiwi temperature loggers and released back into the river (Hansen and Friedland unpublished data). After a journey lasting about 9 months, three fish returned to the river to spawn for a second time and were caught in a trap at the mouth of the river. The temperature was recorded every hour and showed a potential for determining the exact timing of sea entry, timing of the onset of the homing migration, migratory speed on the return migration, and timing of river entry. Further development and the use of archival tags on Atlantic salmon will improve the knowledge of the salmon's life history significantly and thus enhance assessments and salmon management.

Table 1. Number of wild salmon tagged at Faroes during the 1992/1993, 1993/1994 and 1994/1995 fishing seasons and subsequently captured in different countries. From Hansen and Jacobsen (2000).

Country	Tagged 1992/1993		Tagged 1993/1994		Tagged 1994/1995		Total	
	Rec.93	Rec.94	Rec.94	Rec.95	Rec.95	Rec.96	No	%
Norway	22	3	2		17	3	47	54.0
Scotland	8		1		3		12	13.8
Ireland	3		2		4		9	10.3
Sweden	2	1			1		4	4.6
Russia	1	1	3		1		6	6.9
Canada	1				3		4	4.6
Denmark	2						2	2.3
England	1						1	1.1
Iceland	1						1	1.1
Spain	1						1	1.1
Total	42	5	8	0	29	3	87	99.8

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