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REPORT OF THE WORKSHOP ON THE DEVELOPMENT AND USE OF HISTORICAL SALMON TAGGING INFORMATION FROM OCEANIC AREAS (WKDUHSTI)

19–22 FEBRUARY 2007

ST. JOHN'S, CANADA

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Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The Workshop established by ICES on the Development and Use of Historical Salmon Tagging Information from Oceanic Areas has been held and the present report provides the following:

- A list of literature of published information on oceanic research on salmon with main emphasis on oceanic tag recoveries.
- Data on tag recoveries including recoveries in oceanic areas from smolt tagging in home waters, and recoveries in oceanic areas as well as in home waters of salmon tagged at sea. There is still large numbers of material available, but they have to be standardised and converted to same format.
- A standard format for recording tag recoveries was agreed, and an EXCEL file with the appropriate form has been developed.
- Using GIS as a tool the first examples of geographical distribution of recaptured salmon originating from different areas were provided demonstrating the potential for the use of this tool. Apparently there is great potential to analyse standardised datasets, but it remains to develop detailed statistical methods and models to analyse the material and test appropriate hypotheses.
- A number of hypotheses that might be testable on oceanic migration and distribution of salmon using the tagging and recapture material were discussed and developed.

1 Introduction

Atlantic salmon (*Salmo salar* L.) are distributed widely in the North Atlantic Ocean (Figure 1) and have been harvested for many years in freshwater, fjords and coastal areas as well as at the feeding areas on the high seas. While the life history of salmon is complex, in general terms, smolts leave the rivers in the spring, earlier in the south than in the north and quite quickly move from coastal waters to the open sea. Salmon spend normally one to three years, occasionally up to five years feeding in the open ocean, before returning “home” to their natal river to spawn (Mills, 1989).

The number of wild salmon has periodically declined throughout their native range due to loss in habitat productivity development, over fishing, episodic outbreaks of disease; historical management initiatives such as habitat protection and restoration, harvest restrictions and fish health actions have mitigated some declines. However, for at least two decades declines have continued and mitigation options are limited (e.g. Parrish *et al.*, 1998), which has led to the call for more research to assess the reasons for this recent decline. The status of the salmon populations in both North America and Europe show a clear geographical pattern, with most populations in the southern areas in severe condition; in the north the populations are generally stable while at intermediate latitudes, populations are declining (e.g. Parrish et al. 1998; ICES 2002). While many of the problems could be attributed to the construction of dams, pollution (including acid rain), and total dewatering of streams, along with overfishing, and recently, changing ocean conditions, and intensive aquaculture, many declines cannot be fully explained.

When coastal fisheries developed more than 100 years ago in both North America and Europe (May and Lear 1971) some information became available on salmon in the local environment, but distribution and migration of salmon in oceanic areas was a “black box” until oceanic fisheries developed in the 1960s at West Greenland and later in the northern Norwegian Sea. Research on material sampled from these fisheries was undertaken (e.g. Parrish and Horsted, 1980; Hansen and Pethon, 1985, Reddin et al., 1988; Jacobsen, 2000), and new knowledge was gained. However, these investigations did not address the distribution and ecology of fish outside the fishing seasons and areas.

With increasing salmon farming activity in recent years, the abundance of escapees from the farms has become relatively high in some areas. 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 the commercial catches at the Faroes are of farmed origin (Hansen et al. 1999). In North America, escapes from Maine, USA, New Brunswick and Newfoundland are also known to occur although the fish do not seem to range as widely in the ocean as they do on the eastern side of the Atlantic and especially at Greenland (Hansen et al., 1997).

It is well known that there are large variations in survival of salmon among different smolt year classes (Porter and Ritter, 1984; Friedland et al., 1998). Although there is a lack of direct evidence, it has been suggested that the heaviest mortality of salmon in the sea may take place during the first months after smolts leave freshwater (Doubleday *et al.*, 1979; Ritter, 1989). It is expected that many factors affect smolt survival and therefore the return of adult salmon, however these factors are poorly documented (Dempson et al. 1998). Research on this subject has been strongly recommended by a number of organisations, but it was only recently that there were systematic efforts to sample salmon and especially post-smolts at sea (Lear, 1976; Reddin, 1985; Reddin and Short, 1991; Holst *et al.*, 1993; Shelton *et al.*, 1997; Holm *et al.*, 2000). Results from these studies together with the development of new techniques to analyse life history signals from scales, bones and tissue of salmon (e.g Friedland et al., 1993) have improved our understanding of the biology of salmon post-smolts, but there are still major knowledge gaps. As part of the process of learning more about salmon at sea, NASCO's International Research Board has proposed a program of research called SALSEA, a part of which is the examination of historical tagging data to map salmon distribution in the ocean.

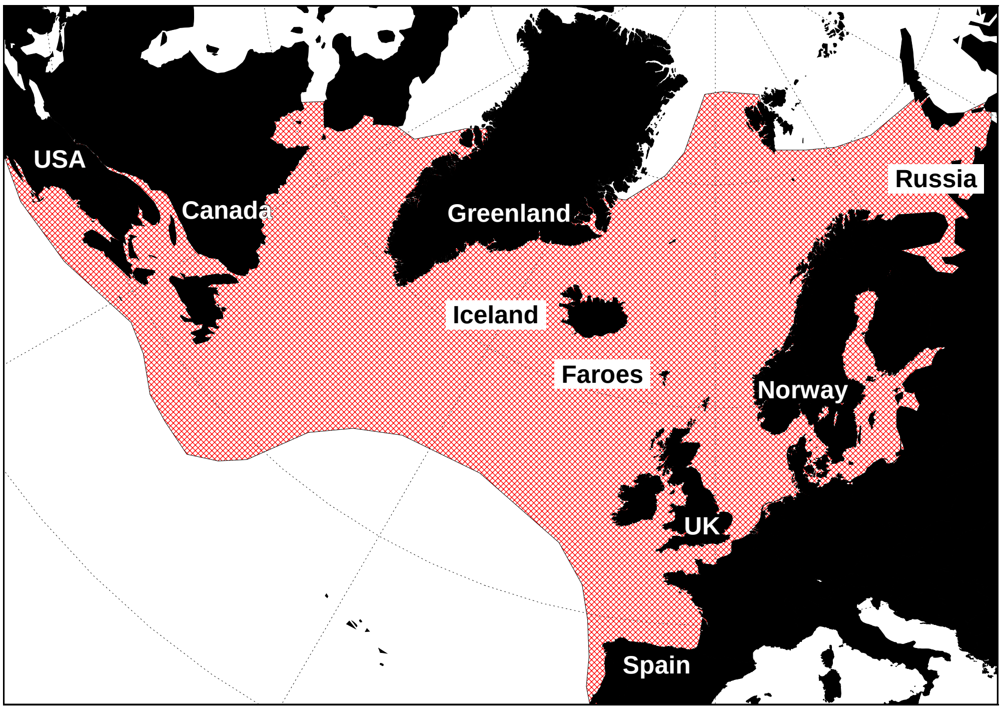

Fig. 1. Geographical distribution of Atlantic salmon in the north Atlantic.

1.1 Main tasks

At the 2006 Science Conference, ICES made a resolution (C. Res. 2006/2/DFC02) that the Workshop on the Development and Use of Historical Salmon Tagging Information from oceanic areas (WKDUHSTI) (Chair Lars Petter Hansen, Norway) will meet in St. John's, Canada 19-22 February.

The terms of reference given by ICES were as follows:

a) collate published information on oceanic tag recoveries of salmon (including the grey literature);

b) present and evaluate data (quantity and quality) available from different countries;

c) compile an inventory of available databases, and evaluation of metadata for geo-referencing;

d) develop a spatial framework for analysis of tag recovery data;

e) examine how the material can be used to develop and test hypotheses on oceanic migration and distribution of North Atlantic salmon.

The Workshop consisted of 13 participants, and the full address list of the participants is provided in Annex 1. The workshop considered 7 working documents which are listed in Annex 2, and information was also submitted from USA, Faroes and Russia who were not present at the meeting.

1.2 Participants

Lars P. Hansen (Chair)	Norway
Peter G. Amiro	Canada
Vegar Bakkestuen	Norway
J. Brian Dempson	Canada
Mark Fowler	Canada
Terry Nicholls	Canada
Niall O Maoileidigh	Ireland
Sumarlidi Oskarsson	Iceland
Stig Pedersen	Denmark
Dave Reddin	Canada
Ian Russell	UK (England & Wales)
Gordon W. Smith	UK (Scotland)
Fred Whoriskey	Canada

1.3 Background

Several initiatives have been undertaken by NASCO and ICES to improve the knowledge of distribution and migration of salmon at sea, which in turn may help to understand mortality of salmon at sea. In home waters large tagging programs of salmon smolts have been conducted with large numbers of tag recaptured in oceanic fisheries. There have also been tagging programs at sea, both at Greenland and in the Norwegian Sea. Results from these studies have only been reported as single experiments and not been analysed as a whole. As a first step this Workshop has started this process by developing a list of relevant literature, giving an overview of data available from the different countries with a form for developing an inventory. The literature list is presented in Annex 3 and includes papers quoted in the report. Furthermore, the Workshop developed a framework to use GIS as a tool to analyse the data and proposed how the material can be analysed.

1.4 Summary of literature

Northwest Atlantic

The following is a description of the known distribution of salmon within the Northwest Atlantic. This material has been published (Reddin, 2006) and is available through the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat - Research Document series: www.dfo-mpo.gc.ca/csas/csas/Publications/Pub_Index_e.htm.

Postsmolts were defined by Allan and Ritter (1977) as the juvenile stage in the ocean from the onset of the smoltification process to the end of the first winter at sea. The first directed capture of postsmolts at sea in the northwest Atlantic Ocean other than incidental captures in coastal areas (Caron, 1983; Meister 1984; Dutil and Coutu, 1988) was reported by Reddin and Short (1991). It was shown that postsmolts were distributed over much of the Labrador Sea in the autumn of all study years viz. 1987-89 and 1991. More recently, research vessels have caught postsmolts in the Labrador Sea in 1998, 2001 and 2005. Reddin and Short (1991) concluded that postsmolts are found annually in the Labrador Sea. Postsmolts at the time of the surveys were more abundant between 56° and 58° N than in other locations. In comparison to adult distribution in autumn, postsmolts were found over a smaller area. Montevecchi et al. (1988) and Montevecchi et al. (2002) reported gannets feeding on postsmolts in the vicinity of the Funk Island, Newfoundland in early to mid-summer. More recently acoustic curtains placed across the Strait of Belle Isle are showing postsmolts migrating through the area in early July.

Reddin and Short (1991) have concluded, based on river ages of postsmolts and Carlin tagged postsmolts caught during their study, that postsmolts in the Labrador Sea originated from rivers over much of the geographical range of salmon in North America. Based on high catch rates of one-sea-winter (1SW) salmon in the Labrador Sea in spring and because water temperatures suitable for salmon occur there over the winter, Reddin (1985, 1988) concluded as did Ritter (1989) that some postsmolts likely overwinter in the southern Labrador Sea and Grand Banks areas. However, the corroborative evidence from directed research or indirectly by commercial vessels fishing during the winter is lacking. Also, Dutil and Coutu (1988) observed postsmolts that were caught as bycatches in herring gear in the northern Gulf of St. Lawrence late in summer. It is not known if all of these postsmolts would have left the Gulf later in that year or if some would have overwinter. Ritter (1989) concluded that postsmolts from inner Bay of Fundy rivers, first reported by Jessop (1976) because of a lack of tag recoveries from outside the immediate area, also overwintered in the Bay of Fundy and surrounding area.

The movement of postsmolts into the Labrador Sea from their rivers of origin in eastern North America has been discussed by Belding and Prefontaine (1938), Belding (1939), Caron (1983), Meister (1984), Dutil and Coutu (1988); Reddin and Short (1991), Montevecchi et al. (1988) and Ritter (1989) who postulated from tag recaptures that postsmolts from rivers in Maine, the Bay of Fundy, the Atlantic coast of Nova Scotia, and some rivers in Newfoundland and Labrador migrate off eastern Newfoundland, arriving near the Funk Islands (southern Labrador Sea) in late July-early August. Caron (1983) and Dutil and Coutu (1988) concluded that salmon of some Gulf of St. Lawrence stocks exit the Gulf through the Strait of Belle Isle, and that at least some postsmolts remained in the Gulf of St. Lawrence until late autumn (Dutil and Coutu 1988). Dutil and Coutu (1988) suggested that the timing of the movement of postsmolts out of the Gulf of St. Lawrence may be related to environmental factors, especially sea temperature, and the presence/absence of prey. Friedland et al. (1999) suggested that the Gulf of St. Lawrence acted variously in some years as a nursery area but that the presence of overwintering salmon was unlikely due to cold water. Caron (1983) showed that the northerly Gulf of St. Lawrence stocks left the Gulf through the Strait while a portion of the southwesterly salmon stocks used the Cabot Strait to the south of Newfoundland. Irrespective of which strait they left the Gulf of St. Lawrence, salmon arrive in the Labrador Sea to northern Grand Banks area sometime in early summer to fall.

Postsmolt salmon are found in the Labrador Sea within four months or less of leaving their home rivers suggesting that this area is important nursery habitat during their early marine life. The available evidence from tag recaptures and river age distributions (*see text table in Biological characteristics section*) shows that postsmolts from many stocks can be found mixed in the Labrador Sea (Møller Jensen and Lear 1980; Meister 1984; and Montevecchi et al. 1988; Reddin and Short 1991), including salmon of North American and European origin (Lear and Sandeman 1980). Food resources and environmental conditions in the Labrador Sea during the winter months may influence postsmolt survival and growth as suggested by Reddin (1988). Scarnecchia (1983, 1984) showed that for Icelandic stocks, sea temperatures in the early months that salmon are at sea positively correlate with the number returning one and two years later; as well as with their age at maturity. Trophic interactions (predator-prey) between postsmolts and seabirds (Montevecchi et al. 2002) indicate that, as well as a significant source of mortality in freshwater, avian predators may also cause significant mortality of postsmolts at sea. Avian predators can capture postsmolts at sea suggesting that postsmolts spend at least some of their time in the upper part of the water column. Montevecchi et al. (2002) showed that gannets shifted diet to other species including salmon postsmolts when capelin were in reduced abundance. If postsmolts destined to return at different sea ages are distributed at different locations at sea and are differentially affected by shifts in trophic dynamics and annual variations in environment then annual variability in the ratio of 1SW to multi-sea winter (MSW) of salmon returns to home rivers may be independent of genetics or physiology (Saunders et al. 1983; Scarnecchia 1984; Martin and Mitchell (1985); Meerburg 1987). While Jonnson and Jonnson (2004a) showed the marine environmental conditions as measured by the NAOJ influenced the age of maturity of some European stocks this is not always the observed pattern.

The size of the population of postsmolts in the Labrador Sea is also of interest. Reddin and Short (1991) could not directly estimate the population size but noted that the mean catch rate for postsmolts in the Labrador Sea in the fall of 1988 was about 50% of the average catch rate at Greenland, suggesting that the population in the Labrador Sea is quite large, especially considering the large area involved.

Templeman (1967, 1968), May (1973) and Lear (1976) reported that salmon were found in the spring in surface waters of the Northwest Atlantic from the southern edge of the Grand Bank to slightly south of Cape Farewell, Greenland. As May (1973) observed, the most westward positions where salmon were caught, closely follow the edge of the Arctic pack ice in spring. Reddin and Shearer (1987) and Reddin (1988) reported that salmon were usually found at sea in relatively cool water between 3°C and 8°C, indicating that they may be actively selecting water of this temperature. There are two locations where salmon have been found in abundance during spring. One location lies about 300 miles east of the Strait of Belle Isle. The other lies slightly to the east of the 200 m isobath (depth contour) along the eastern edge of the Grand Bank.

Reddin (1985) presented some evidence based on smolt ages suggesting that salmon stocks in the Labrador Sea may be different from those along the eastern edge of the Grand Bank. The lower smolt ages of salmon caught to the east of the Grand Bank suggested that these stocks there were more southerly in origin than those in the Labrador Sea where smolt ages were higher. It is also known that stocks from Europe also occur in the Labrador Sea and Irminger

Sea areas (Møller Jensen and Lear 1980; Reddin et al. 1984; Reddin and Lear 1990) and a clinal longitudinal distribution with continent of origin has been noted by several authors extending out into the Labrador Sea from the Greenland coast (Møller Jensen and Lear 1980; Lear and Sandeman 1980). Thus, the salmon population in the Labrador Sea consists of more North American salmon further to the west.

The presence of immature salmon of sea age 1 in the Labrador Sea-west Greenland area that will not mature until the year following as 2SW salmon has been documented by Idler et al. (1981). There were no non-maturing salmon found along the south and west coasts of Newfoundland suggesting that the Labrador Sea (Idler et al. 1981) is an area of overwintering for non-maturing 1SW salmon originating along the entire coast of North America. In late summer and autumn, non-maturing 1SW salmon are found inshore along the northeast Newfoundland and Labrador coasts, at West Greenland, in the Labrador Sea and in the Irminger Sea including the east Greenland coast (Idler et al. 1981).

Specifically, salmon are concentrated along the West Greenland coast from the inner coastal fjords to between 45 and 60 km offshore. These are potential multi-sea winter salmon that in their 2nd summer at sea have not started to mature and will spend another winter at sea before returning to their home river. Relatively good catches have occurred, as well, in the Labrador Sea north of 55°N. Salmon also have been caught by research vessels in the Irminger Sea and in commercial nets in east Greenland but catch rates were not nearly as high as at Greenland or in the Labrador Sea (Møller Jensen and Lear 1980). No sets have been made in summer/autumn in the Grand Bank area and undoubtedly there are other locations that are currently outside the survey area where salmon can be found in abundance, viz. the Gulf of St. Lawrence.

Few sets have been made for salmon during the winter months and these were all to the east of the Grand Bank of Newfoundland in 1985. The zero to low catch rates in the area of the Grand Bank suggest that they were located elsewhere at this time. These results suggest, since salmon were found in the Labrador Sea in the fall and then in the following spring, that adult salmon of North American origin may overwinter there.

Reddin and Shearer (1987) discussed regional variations in abundance in the Northwest Atlantic by summarizing standardized catch rates from research surveys and commercial fishing. Mean catch rates in the Greenland fishery were highest, those in the Labrador Sea and east of the Grand Bank were 55% less than those at Greenland, and catch rates on the Grand Bank and Irminger Sea were about 75% lower than those in the Labrador Sea and east of the Grand Bank (Table 1). Therefore, salmon were found concentrated in abundance in the spring off the eastern slope of the Grand Bank and less abundantly in the southern Labrador Sea and over the Grand Bank. During summer to early fall, salmon were concentrated in the West Greenland area and less abundantly in the northern Labrador Sea and Irminger Sea.

The exception to the above distributions seems to be for salmon from the inner Bay of Fundy as few are caught outside of the bay itself Jessop (1976). Ritter (1989) concluded that inner Bay of Fundy salmon remain as adults in the Bay of Fundy and surrounding areas. Another specialized area is the Ungava Bay where salmon from local rivers are known to over-winter (Power et al. 1987). Thus, there are three possible overwintering (nursery) areas for Canadian salmon in the northwest Atlantic.

Table 1. Average catch rate (numbers per 100 nets) of salmon from research and commercial fishing with surface gillnets in various regions of the North Atlantic , 1969-91.
~ indicates catch rate from commercial fishery
* indicates data for post smolts only ** indicates data for Adults
note: 1 net = 33 meters

Year	Month	West Greenland	Irminger Sea	Labrador Sea	Grand Banks	East of Gr. Banks	Northeast Shelf
		a,b,c	*a*	*c*	*b,c*	*b,c*	*c*
1969	Sep-Oct	26.4		30.6			
1970	Apr			5.1			6.6
	Sep-Oct	10.4		10.5			
1971	May			9.7	4.2		13.9
	Sep	21.1		14.2			
1972	Apr			5.6		4.8	
	Aug-Sep	11.3		39.2			
	Aug-Oct	42.0 ~	0.7 ~				
1973	Jun				6.9		
	Aug	41.0 ~	5.7				
1974	Jul	44.0 ~	8.5				
	Aug	72.0 ~	2.1				
1975	Aug	111.0 ~	11.9				
1977	Oct			26.1			0.0
1978	Aug	116.0		67.5			
1979	May				1.0		
	Aug-Sep	21.8		6.4			
1980	May-Jun				10.0	20.8	11.3
	Aug-Sep	35.1					
1982	Aug-Sep	48.5					
1985	Feb					1.2	
	Nov-Dec				0.8		
1986	Oct-Nov			4.0	2.0		
1987	Sep-Oct**			17.7	0.0		0.4
	Sep-Oct*			3.1			0.0
1988	Sep-Oct**			16.4			0.3
	Sep-Oct*			25.5			7.3
1989	Sep-Oct*	10.9		13.1			
	Sep-Oct*	0.0		38.9			
1991	Oct**			10.6	0.0		0.0
	Oct*			16.6	4.0		4.3
Mean		40.8	5.8	19.0	3.2	8.9	4.4
SD		34.8	4.6	16.1	3.4		5.2

a From Moller and Lear (1980)
b From Reddin (1986)
c DFO database

Northeast Atlantic

Atlantic salmon smolts leave fresh water and migrate to the feeding areas in the ocean during late spring and summer (e.g. Thorpe 1988; Mills 1989). Most of the data available suggest that post-smolts move relatively quickly into the ocean, after a period of more passive movements with tidal currents. Further evidence 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 east Atlantic (Holm *et al.*, 2000) and west Atlantic (Reddin and Short, 1991) at this time of the year. However, Dutil and Coutu (1988) caught many post-smolts in a nearshore zone of the northern Gulf of St. Lawrence, suggesting that this trait may vary among populations or areas.

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 (Holm *et al.*, 2000), and north of Scotland in May and June (Holm *et al.*, 1996; Holst *et al.*, 1996; Shelton *et al.*, 1997). Based on the distribution of catches north of Scotland, the fish appeared to move northwards with the shelf edge current (Shelton *et al.*, 1997). Farther 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). This was supported by the recapture of a salmon that had been tagged in April 1995 in southern England, and recovered about 2000 km farther north three months later, demonstrating the capacity for rapid travel by post-smolts.

There is evidence that the marine distribution of Atlantic salmon is dependent on temperature (Reddin and Shearer, 1987), but whether distribution of food is an important factor is still an open question. The biomass of Atlantic salmon in the ocean relative to other pelagic oceanic fish species is extremely small, and salmon during its marine phase is thought to be an opportunistic pelagic predator, supporting rapid growth rate by exploiting a wide range of invertebrates and fish prey. The wide variety of food in different areas and periods suggests that salmon abundance is unlikely to be very sensitive to annual changes in the availability of any particular prey (Jacobsen and Hansen, 2001).

When Atlantic salmon have reached catchable size, their marine distribution,which reflects the fisheries, 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 know the true distribution of salmon at sea, as recoveries depend on the distribution of the fishery and fishing effort. In the East Atlantic, salmon are found over large areas in the Norwegian Sea.

Smolt tagging programmes in many countries and adult tagging experiments at sea during since 1960s have provided information on the composition of country of origin of salmon in the North Atlantic. The general pattern is that salmon from the Northwest Atlantic are mainly confined to the western area, while salmon from the Northeast Atlantic are found both in the eastern and western part of the Atlantic.

The tagging program that took place at west Greenland during the period 1965-1972 (**Figure 2**) showed that Canada accounted for most of the North American component and UK (mainly Scotland) and the southern European regions accounted for most of the European fish (e.g. Parrish and Horsted 1980). There were also recoveries of adult salmon in France and Spain. From 1969 to 1997, the proportion of European salmon relative to north American salmon has varied between 25 and 66% with a general decrease in the European fish in recent years (Reddin and Friedland 1999).

In the 1960s and 70s, there was an important commercial long-line fishery far north 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 were recaptured in homewaters the same year as 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 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 longlines were tagged and released. The fish were tagged in more southerly areas of the Faroes, and 1SW fish were probably highly overrepresented. 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 great majority of the tags were reported in homewaters in the same year as they were tagged. However, it is interesting to note that some fish in the area may have been on their way westwards, as they were reported from the fishery at West Greenland later that year.

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 longline within the Faroese EEZ, tagged and released back into the ocean (Hansen and Jacobsen 2000). In total, 106 fish (87 wild and 19 farmed) were recaptured as adult fish. Analyses of the recovery information showed that wild salmon of Norwegian origin were most abundant, but Scottish and Russian salmon were also common. Some fish originating from Ireland, Iceland, Spain, Sweden, Denmark, England, and even Canada were also present (Hansen and Jacobsen 2000). Results from this experiment suggest that salmon originating from large areas of the salmon's distribution range are present at some life stage in this area, but in variable proportions at different times. Of the escaped farmed salmon 18 were recaptured in Norway and one at the west coast of Sweden.

For the management of salmon stocks, it is of great importance to identify precisely the country of origin of the stocks fished on the high seas, and to obtain knowledge of their temporal and spatial population structure. With such knowledge the fishery could target the effort towards less threatened stock complexes in the sea, by e.g. temporal and spatial restrictions in the fishery.

Escaped farmed salmon have been observed in wide areas of the north Atlantic (e.g. Hutchinson 1997), as well as in the high seas salmon fisheries in the Norwegian Sea (Hansen *et al.*, 1999). Several detrimental effects on wild stocks have been suggested from the escapees, of which interbreeding and transmissions of parasites and diseases in coastal areas were considered the most severe (e.g. Hutchinson, 1997). Of the harmful parasites in the sea, particularly sea lice (*Lepeophtheirus salmonis*) have caused great controversy, especially in the coastal areas of the significant fish farming production countries such as Norway, Scotland and Ireland, where large runs of wild salmon also occur.

Intercontinental migrations of salmon in the North Atlantic

Reddin et al. (1984) first provided information on the migration of salmon from Europe to North America and the reverse which they labelled as intercontinental migrations. While overall numbers were rather low, based on the number of tag recaptures, there being only less then twelve from either side of the Atlantic, it did provide evidence of salmon straying on the outside of their migration pathways. Recently, there has been further documented evidence of Miramichi River salmon present in the fishery at Faroes from salmon tagged at Faroes (Hansen and Jacobsen 2003). Hansen and Jacobsen (2003) did a simulation based on tag returns which showed that Canadian origin salmon in the Faroes area were 6% of the overall population in the area. Tucker et al. (1999) showed based on Cesium-137 (^{137}Cs) levels in salmon returning to the St. Marguerite River in Quebec and from patterns of ^{137}Cs in the ocean, that 43% of grilse and MSW salmon sampled had levels consistent with their spent time in the Faroes/Norwegian Sea area.

The high values of Tucker et al. (1999) are in sharp contrast to what is generally believed to be the case that inter-continental migrations are rather low. Overall, the number of tags recaptured in the northeast Atlantic from North America has been low compared to the 1000s tagged. In addition, based on scale characters and database from the discriminant analysis used for the West Greenland fishery (Reddin and Friedland 1998), Reddin (1987) concluded the number of North American salmon in the Faroes area was very low. The results of Tucker et al. (1999) were especially surprising in that grilse showed high levels of ^{137}Cs which would require the fish to travel across the Atlantic and return in some 12 to 14 months. The intercontinental migrations reported by Reddin et al. (1984) and Hansen and Jacobsen (2003) were putative based on the MSW salmon capture date which was later confirmed by scale analysis. Resolution of this apparent contradiction could be done by DNA analysis of scale material collected during studies on Faroese long-line and Irish Sea fisheries.

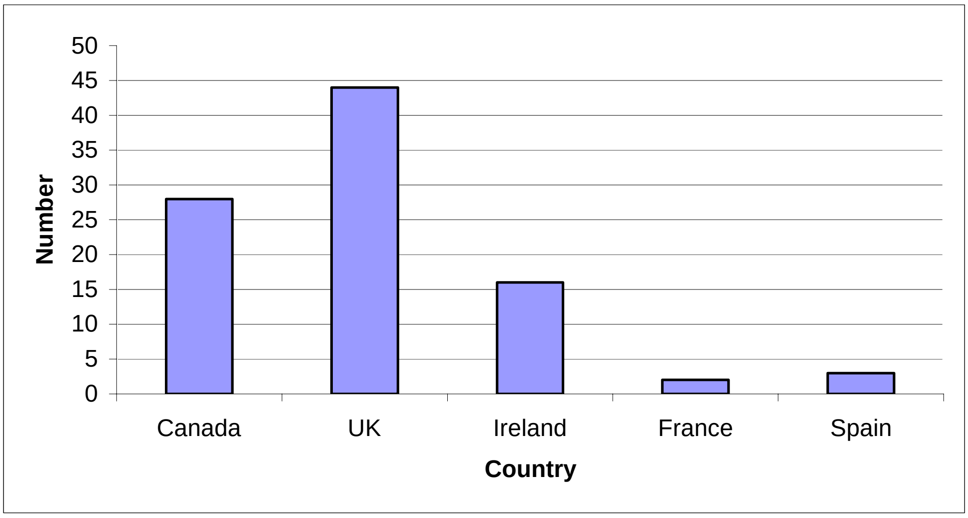

Fig. 2. Number of tag recoveries from different countries of salmon tagged at West Greenland 1965-1972 (Jensen 1980).

2 National tagging and tag recovery summaries

This chapter gives an overview of the tagging and tag recovery data that were reported to the Workshop including information received from Russia and USA who were not present at the Workshop. The details are presented in Annex 4.

2.1 Canada

Newfoundland & Labrador Region

There has been tagging within the Newfoundland and Labrador Region for many years and thus several datasets are available to the Workshop. The following data are available in electronic format:

1) Sand Hill Tagging: salmon smolts/kelts of Sand Hill River were tagged from a counting fence, 1969-73 and returns were available from various fisheries in 1969-1976 (Anderson 1985). This is the only dataset available that describes the distribution at sea of any Labrador salmon stock. In total, 1,035 recaptures of salmon at various ages are available.

2) Marine Data: the Newfoundland & Labrador Region tagged salmon at sea in coastal areas between 1940 and the early 1980s. In total, 3,495 salmon of various sea ages were tagged with Carlin tags and released back into the sea. Of these, 892 (26%) were recaptured at various locations in the sea and freshwater (Reddin & Lear 1990). Recaptures ranged from North America to Greenland to Europe (Scotland).

3) Offshore Distribution/Tagging: as initiated by Templeman (1967, 1968) distributional/tagging studies took place in 1965 in the Labrador Sea and Greenland area mainly in response to the burgeoning Greenland commercial fishery. While there have not been many recaptures from the tagging, the location of salmon caught is available for all fish and provides the best current information on distribution at sea. In total, 2,241 salmon have been caught at sea including in the Greenland and Irminger Sea areas.

Gulf Region

There are three data sets of tagging and recoveries are available of potential use in the development of a tagging and recapture database for the North Atlantic

Dataset 1 – Fisheries Research Board historical data

Fisheries & Oceans Gulf Region has a spreadsheet file of recoveries of Atlantic salmon tagged during Fisheries Research Board activities dating from 1957 to 1975. There are 17,370 records of tagging and recaptures for Atlantic salmon for these tagging years. Within the salmon records, 851 recaptures are recorded from West Greenland. Some records have partial recovery dates identified. Overall 13,378 records have complete tagging and recovery dates. Most of the tag recoveries were from smolt tagging programs followed by bright salmon with most from wild smolt and wild adult salmon tagging programs. A large percentage (72%) of the recoveries are in freshwater, primarily in the Miramichi River which was the primary location of study during those years. Useable recoveries (i.e. with complete date information) at West Greenland number 428 records. Recoveries from Labrador total 9, from Newfoundland 487 records, and from Quebec 37 (based on rough geographic groupings).

The majority of the marine recoveries were obtained from smolt tagging programs. Bright grilse and bright salmon tagging programs occurred as fish were returning to the river to spawn and the majority of the recoveries occurred in the same year and generally in the same river of tagging. Fresh water recoveries were defined as recapture locations which were specific to a river, a tributary and even a location in a river. Estuary recoveries were defined on the basis of the recapture location name. Coastal recoveries are those which were not specific to a river or a known embayment.

The area of tagging and the area of recapture fields are not coded using values which allow for easy spatial expansion or contraction. Latitude and longitude data have not been defined for the area codes. Most of the codes can be related to statistical districts within the Maritimes, Quebec and Newfoundland provinces. Recoveries in the high seas can be related to the ICNAF subareas and divisions. For Newfoundland, hard copy records containing the names and addresses of the individuals who reported the recaptures are available. Similar hard copy details for the other areas may still be in storage but it would require substantial effort to find the information and code.

Dataset 2 - TAGRET – Oracle database held at Bedford Institute of Oceanography, Dartmouth, NS.

The data specific to tagging programs originating from facilities in Gulf Region are briefly summarized.

There are 8,233 records of tag recoveries for the tagging years 1966 to 1983. The tag recaptures are almost evenly split between smolt tagging and adult bright tagging programs. Within the adult bright programs, most of the fish tagged were of wild origin whereas for smolts, about two-thirds were of hatchery origin. The majority of the tagged fish were released in the Miramichi River followed by the Restigouche River.

In terms of the locations of recapture, most were reported from locations within Gulf Region with the vast majority of these from fresh water locations. There are over 2,500 recoveries in non-Gulf Region waters with just under 1,000 from West Greenland. The single reported tag recovery from Faroes was from a smolt tagged in 1974 but there is no recovery date information.

Based on the recaptures which occurred within three years post-tagging, the recoveries at West Greenland were primarily of reconditioned kelts from adult bright salmon tagged the previous year, and as non-maturing 1SW salmon one year post tagging at the smolt stage. Recoveries were most important during the months of August to October.

For Labrador, recoveries of bright salmon during the same year of tagging are undoubtedly reporting or data coding errors. Most bright salmon recoveries are of kelts. Recoveries of salmon originally tagged as smolts occurred in 1SW, 2SW and 3SW years post tagging.

The recoveries from Newfoundland of tagged bright salmon occurred as kelts in the year post tagging and presumably as bright repeat spawners two years post tagging, based on the month of recapture. Recaptures of tagged smolts occurred in 1SW, 2SW, 3SW years post tagging.

Dataset 3. DFO Science Branch Gulf Region Adult and Smolt Tagging Programs 1985 to present

Since 1985, adult bright salmon have been tagged at several locations within Gulf Region rivers as part of assessment programs to evaluate adult returns. Since 1998, smolt assessment programs in the three main rivers of Gulf Region (Restigouche, Miramichi, Margaree) have tagged upwards of 10,000 wild smolts annually using individually numbered streamer tags. Some recaptures of post-spawned adult salmon and post-smolts have been reported from numerous locations in the North Atlantic including Quebec, Newfoundland, Labrador and West Greenland.

The recapture data have not been assembled and reported in any previous publication. Recoveries at West Greenland from these tagging programs have been reported by the Working Group on North Atlantic Salmon.

Margaree River bright salmon tagging program

An example of the type of information available is shown using the Margaree River tagging and recapture data. During 1987 to 1996, adult salmon returning to the Margaree River were captured in estuary trapnets, tagged with individually numbered Carlin tags and released. Recoveries of previously tagged salmon from the Margaree were reported from fisheries in the north shore of Quebec (zone Q9), Newfoundland, Labrador and West Greenland. The recoveries in the north shore of Quebec, northern peninsula of Newfoundland and southern Labrador indicate that a proportion of post spawned salmon from Margaree pass through the Strait of Belle Isle rather than Cabot Strait.

Maritimes Region: Atlantic coast of Nova Scotia to the USA boarder

Data describing the application, distribution and recovery of individually unique identifiable tags applied externally to Atlantic salmon initiating mostly, but not exclusively, from Canadian government funded research was registered with the Atlantic Salmon Tag Clearing House of the Department of Fisheries and Oceans, Science Branch, Maritimes Region to 1985. These data are held and maintained in an Oracle Data base at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada. The overwhelming majority of tags applied were plastic Carlin type in two sizes which were applied based on the size of salmon being tagged. This data base contains data from the Maritimes Region from 1964 to 1985, from the Gulf Region from 1964 to 1980 and does not include tagging information from Newfoundland or Quebec.

Information is available on recovery dates and locations, tag information, biological information, broodstock information, and re-release information. Release information for 2,613,919 tags is available, with specific recovery data on 36,069 reported recaptures.

A summary of recoveries for five geographic areas for 66 rivers of release are presented in Annex 4a.

2.2 Denmark

Available information from recaptures of salmon tagged with Carlin tags in Denmark comes from a series of releases in 13 different streams, where salmon were released during the period 1965-79, and some more recent releases (1991-1993) in one river. In total approximately 56,000 salmon were tagged and released. The released fish originated from different strains, many of them hatchery strains and otherwise mostly Swedish strains. A list of releases of tagged salmon is provided in Appendix 1b.

Approximately 160 recaptures were reported from waters away from Denmark. The majority of these were recaptured near Norway. Second to these were recaptures near Sweden, while only relatively few were recaptured near the Faroe Islands, at West Greenland or Ireland. A few salmon were also recaptured to the south of Denmark near Germany or in Dutch waters.

An overview of the distribution of recaptures is presented in Appendix 1c.

2.3 Iceland

External tagging of Icelandic salmon smolts with Floy and Carlin tags started at Kollafjörður Experimental Fish Farm in the early 1960s. Tagging with coded wire tags started in 1974 and peaked in mid 1990s when a number of commercial ranching operation were releasing microtagged salmon. During the years 1982 to 1995, over 3 million smolts were microtagged and released in Iceland. Annual releases of microtagged smolts have decreased considerably after those operations closed down in the late 1990s and have averaged 150,000 smolts since 1997.Also, 55 salmon of Icelandic origin were caught in distant areas from 1967 through 1995. Most of the recaptured salmon (44) were microtagged and thus found in systematic surveys in the marine fisheries. The remaining salmon mostly from the 1960s and 70s were either carrying Carlin tags or Floy anchor tags. Out of the 55 salmon caught in distant areas, 26 were recaptured in the Faroese fishery and 24 in Greenland, mostly in the west Greenland fishery. In addition to the area and date of recapture information is also available on the type of tag, year of release as well as sex, length and weight when available. The exact location of recapture is not given in most cases in the West Greenland fisheries (location of landing is specified). However, more precise location data are provided for the recoveries in the Faroese fisheries.

Out of 2.2 million coded microtagged smolts released in southern and western Iceland from 1987 through to 1994, 14 were recaptured in West-Greenland fishery with one recovery in Faroes. Out of 0.8 million smolts released in northern and northeastern Iceland 22 were recovered in the Faroese with 4 recovered in the West Greenland fishery. In total 1.4 microtags from Iceland have been caught in distant fisheries out of each batch of 100 thousand smolts released in the years 1982 to 1995.

Icelandic strayers from west-coast ranching stations have been recaptured in: Western Norway (1), a Faroese lake (1), a Faroese ranching operation (1), river Don in Scotland (1) and off the east coast of England (1).

Recoveries in Icelandic homewater fisheries of 4 fish tagged in other countries comprised of salmon tagged as smolts from R. Screebe, Ireland (1) and from a Faroese ranching station (1), adult salmon tagged at West Greenland (1), adult salmon tagged at Faroes (1) and a salmon possibly tagged in Russia (1).

In the summer 1985, there was a joint Icelandic-Greenlandic fish finding survey at East-Greenland in two locations: Skjoldungen and Angmagsasalik. At Skjoldungen, 398 salmon were caught including 5 without adipose fin. Of these, two were microtagged, one from Iceland and one from Ireland. At Angmagsasalik, 3 salmon in total were landed. Of these, one had been microtagged in Ireland. A Norwegian origin Carlin tag was also recovered by a local fisherman in this area.

2.4 Ireland

Although extensive tagging programmes were carried out prior to 1980, these recoveries have not been placed in electronic format. Therefore for this workshop only data for the coded wire tag and tag recovery programmes which have been ongoing in Ireland since 1980 have been examined. While tag output has varied, generally over 100,000 salmon smolts are released annually and in the recent 10 years over 250,000 have been released consistently. While over 116,000 tags have been recovered since 1980, many of the recoveries have been in Irish rivers and homewaters. However, there have also been consistent recoveries in Greenland (approx. 140 tags) and Faroes (approx. 158 tags) during the time of the fisheries and also in subsequent research fisheries. Similarly, Irish tagged smolts have formed the vast bulk of the tagged salmon post-smolts captured in experimental fishing operations in the Norwegian sea since the early 1990’s and these provide valuable information on the distribution, timing of migration and behaviour of salmon from the southern NEAC area. In addition, due to the nature of the coastal net fishery, there have been significant recoveries of tagged salmon originating from other countries.

2.5 Norway

In Norway, there has been systematic tagging of Atlantic salmon since 1935, and numerous experiments have been carried out. The purpose of these experiments has been to investigate life history, behaviour and exploitation. Salmon have been tagged and released at different life stages, and external tags have mainly been used. Tagging of both wild and hatchery reared smolts has been carried out and these fish subsequently released in a number of rivers and in some fjord areas. Furthermore, salmon have been caught with longlines in the Norwegian Sea, released back into the sea and many recaptured later. Similarly, a large number of adult salmon have been captured in Norwegian coastal bagnets, tagged and released. Of great interest for the study of distribution and migration of salmon in oceanic areas are high seas recaptures of salmon tagged as smolts in homewaters and adult recaptures of adult salmon tagged in the ocean and released. Most of the information from the last 35 years has been digitized in spreadsheets and databases and is a result of about 2.5 million smolts tagged and released.

The Norwegian tag and recapture data are stored in an ACCESS database, and for the present purpose they have been made available as EXCEL files. Recaptures in the Norwegian Sea of salmon tagged in Norway have been prepared, and three levels of precision on recapture sites have been defined, good, medium and low.

Good precision data are those with exact information of both tagging and recapture sites (lat and long in decimals) dates of release and recapture and size of the fish at release and at recapture. Medium precision are those when recapture sites can be related to a specific geographical site (e.g. 50 nautical miles NW of Andenes). In such cases the long and lat can be estimated. Finally low precision data are those where the recapture site is related to a large are (e.g. north of the Faroes, or North Norwegian Sea).

Salmon tagged in Norway and recaptured in other oceanic areas, particularly at West Greenland and Ireland, which are of special interest are also available. Relatively few of those have latitude and longitude positions, but are rather linked to a specific recapture site, or an area. The Figure below shows the number of recaptures in areas outside Norway, including those from coastal areas and freshwater in Sweden, Denmark, Russia and UK.

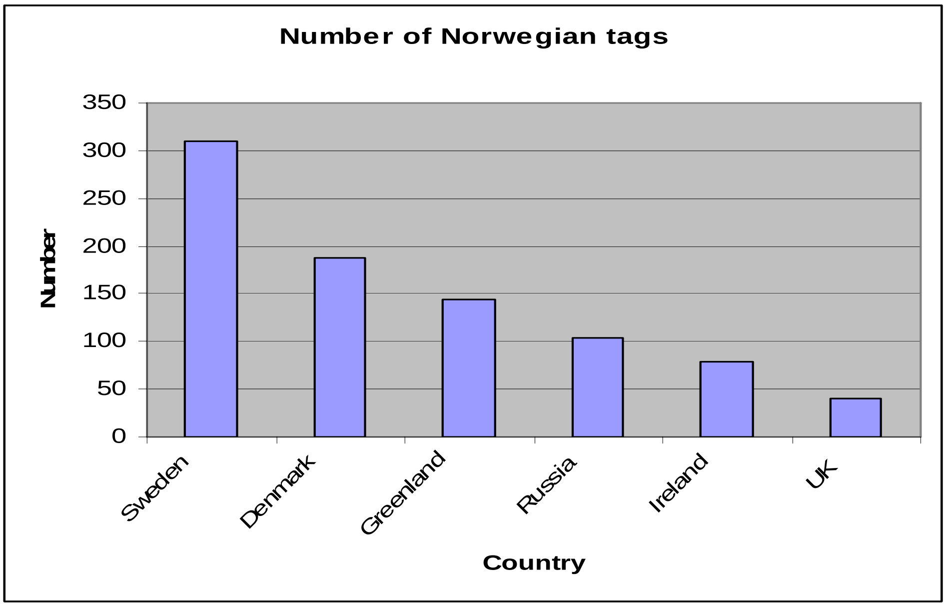

Fig. 3. Number of salmon tags of Norwegian origin reported recovered in countries outside Norway.

During April-June 1969-1972, 4,225 salmon were caught with longlines in the Norwegian Sea, tagged and released. The data are digitised and can be related to a specific position (latitude and longitude). In total 520 salmon were recaptured.

2.6 Russia

In the period from 1969 to 1974, 13,606 smolts were tagged with external tags from various rivers and hatcheries of the USSR. By early 1975, 120 salmon were recaptured (Bakshtansky et al., 1976) including 12 tags returned from abroad. Seven tagged salmon were caught in the Norwegian Sea and five salmon were caught in the territorial waters of Norway (Appendix 1f).

The first adult Atlantic salmon tagging experiments conducted in the coastal zone of Norway (near Breivik, Finnmark) showed that Atlantic salmon from Russian rivers made their feeding migrations in the Norwegian Sea and came back to the native rivers through Norwegian coastal waters (Bakshtansky, 1970). The first salmon with a Norwegian tag was caught in the USSR in 1935 in the Vyg River, White Sea basin (Berg, 1948). This salmon had been tagged nearby in Trondheim. In 1936, 18 salmon also tagged in Norwegian coastal waters were caught (Danilchenko, 1938) in different rivers and coastal areas of the USSR.

Bakshtansky and Nesterov (1973) in their work on the impact of foreign fisheries on Atlantic salmon from Russian rivers, presented some data on tagged Atlantic salmon recaptured in Russian “home waters”. Over a period of 11 years (1962-1972), a total of 240 tagged salmon were recaptured. Information on location and date of tagging was available for only 38 fish (Appendix 1g). Most of them were tagged near Breivik, Finnmark and recaptured between 9 and 97 days after tagging (59 on the average). Two fish were recaptured in the Pechora River more then one year after tagging suggesting that salmon from Russian rivers migrated through Norwegian coastal waters not only for spawning but also for feeding (Bakshtansky, Nesterov, 1973).

Antonova and Chuksina (1987), with reference to the report by the Direktoratet for Jakt, Viltstell og Fersvannsfiske (Anon., 1974) analyzed data on the recapture rate of Pechora salmon tagged among other Atlantic salmon in different areas of the Norwegian Sea in 1962-1973. In that period, 5,228 salmon were tagged which had been taken from bendnet and bagnet catches near Breivik, Finnmark and from catches by driftnets at Sørøy, Norwegian Sea. Of these, 162 salmon were recaptured in Russian “home waters” including 14 fish caught in the Pechora River. Also between 1968 and 1972, 4,899 salmon from long-line catches were tagged in different areas of the Norwegian Sea. Of these, 71 were recaptured in Russian “home waters” including 25 fish in the Pechora River (Antonova and Chuksina 1987).

According to Bakshtansky and Yakovenko (1976), 1,923 kelts were tagged with external tags in the Varzuga River in 1968-1971. 72 fish were recaught later. Of them, 37 repeat spawners were recaptured in the Varzuga River, whereas 35 were caught in saltwater in different areas including two salmon in the Norwegian Sea. One of these (tagged in 1969) was caught by a Danish fishing vessel north-east of Vesteraalen on 18 February 1970. The other (tagged in 1971) was caught by a Norwegian fishing vessel nearby Nordkapp on 15 June 1972 (Bakshtansky and Yakovenko, 1976).

2.7 UK (England and Wales)

Salmon tagging programmes in UK(England & Wales) have been carried out since the late 1950s. Most of the tagging has focused on juveniles (mainly smolts, but some parr) and both wild and hatchery-reared fish have been tagged. Small numbers of fish have also been tagged as adults and as kelts. UK(E&W) also hold certain international tagging and tag recovery data derived from previous collaborative programmes. This report summarises the tagging and recovery data currently held by UK(England & Wales).

Juvenile salmon have been tagged with external tags (Carlin tags and predecessors) from a variety of catchments over the period 1958 to 1984. In total, around 250,000 fish have been tagged over this period. Wild smolts have been tagged in 11 catchments, although some of these programmes were only carried out for one year, caught few fish and resulted in no recaptures outside homewaters. Hatchery parr/smolts were tagged and released in 10 catchments.

Details of each tag recovery have been extracted from paper records and are now held in spreadsheet form. Information on release location is available for all recoveries and origin of the fish (wild or hatchery) is available for many fish (more work is needed to fully categorise these). For most entries the date of tagging is also available, although in some cases this is only reported as month, season, and/or year. For the high seas recoveries (West Greenland and Faroes), the precision of the recapture information varies considerably. Of the 308 fish recovered at West Greenland, precise position (latitude and longitude) is only available for 68 fish (22%). For other W. Greenland recoveries, the recapture position is either reported as a specific place (in many cases the port of landing) or simply as ‘West Greenland’. All the tags recovered in the Faroes fishery over the period are simply reported as ‘Faroes area’. Recoveries in other countries are usually given for a particular fishery area or port. There is considerable variation for all fisheries in the precision with which date recovered is reported (either day, month, season or year). A range of other information may also be associated with recovered tags, for example fish length and weight.

There has been only limited tagging of adult fish and kelts in UK(E&W) and some studies have focused on relatively local issues (e.g. adult fish tagged in the English NE coast fishery and recovered in NE England and in eastern Scotland). These latter data have not been included in this report. However, kelts (n=979) were tagged on the River Axe between 1960 and 1965 and these resulted in a small number of recaptures (n=8) in the West Greenland fishery. Tagging and recapture information are as for the externally tagged smolts; precise recovery locations (latitude and longitude) are available for two of these fish.

Coded wire microtagging programmes started in UK(E&W) in 1984 and have been continued to the present time. To date, over 3.3 million hatchery fish and around 200k wild smolts have been tagged. Fish have been released into around 40 different catchments. Recoveries of CWTs require targeted screening programmes and these have operated in the high seas fisheries at Faroes and Greenland in many years, in the net fisheries in Ireland and UK(N. Ireland) and in the net fisheries along part of the east coast in UK (Scotland).

2.8 UK (Scotland)

Tagging programmes in UK (Scotland) have, in the main, focussed on juvenile salmon (parr & emigrating smolts) from three areas, the North Esk, river mouth (56^0 42” N 2^0 25” W), the Tay system, river mouth (56^0 21” N 3^0 17” W), and the Girnock & Baddoch, two tributaries of the River Dee, river mouth (57^0 08” N 2^0 04” W). Information on release date and location, origin of the fish (wild or hatchery) and fork length are also generally available from these studies as are, for a subsample of tagged fish, weight and river age from scale samples. Where available, these data have been collated with tag returns.

A range of information may also be associated with the recovered tag, including when & where recovered, fish length and weight. In common with recoveries from other fisheries, however, there is considerable variation in the precision with which date recovered (either day, month, season, year or even decade) and location (country, NAFO division caught, grid reference caught, port landed, location where tag recovered during fish processing) are recorded.

Tagging and recovery data for 129 external and microtagged salmon of Scottish origin are available from recovery year 1967 to the present. Tagging and recovery data are also available for recoveries of 77 Scottish tagged salmon in the Greenland fishery since 1980 to the present. A small number of records from earlier years are included where these were reported since 1980.

Approximately 580 Scottish microtags have also been recovered in the Irish coastal net fishery since 1985. Details of release location and date, landing location, length, date of capture are generally available for these also.

Correspondence held at Fisheries Research Services suggests that steps were taken in the late 1970s to produce a comprehensive list of tag recoveries at Greenland to date and that details of records held were reported at the time.

2.9 USA

Carlin tags

A total of 1.65 million Carlin tagged fish were released between 1962 and 1996. There are approximately 4,200 records of high seas recaptures and 4300 homewater recaptures. Homewater recaptures were not considered further within the framework of this workshop. Approximately 50% of the high seas recapture data have latitude and longitude co-ordinates associated with them. Of the 50% that don't have locations, there is either a community name or a community code which can be connected to a standardized set of locations once they are developed.

The majority of the releases were of 1+ hatchery reared smolts (64%) whereas 35% were of 2+ hatchery reared smolts. Over 50% of the high seas recoveries come from Greenland while eastern Canada (Maritimes, Quebec, Newfoundland and Labrador) accounts for the rest. The Faroese and Saint Pierre et Miquelon fishery also each produced a single tag recovery. Most of the recaptures came from Penobscot River releases (80%) with a few other river releases dispersed through the dataset.

Coded wire tags (CWT)

A total of 6.4 million cwt tagged fish were released between 1982 and 1994. There are 425 records of high seas recaptures. None of the high seas recapture data have latitude and longitude co-ordinates associated with them, but they all have either a community name or a community code which can be connected to a standardized set of locations once they are developed.

The majority of the releases (75%) were of 1+ hatchery reared smolts and overall, 92% of the releases were of hatchery reared smolts. Over 75% of the recaptures came from Greenland with the remainder coming from Canada (Nfld/Labrador). The US origin cwt Greenland recapture data is also reported below (CWT recoveries (all countries) from W. Greenland scanning programme (1985-92)). Over 50% of the recaptures came from the Penobscot River releases.

Visible implant tags VIE

A total of 1.5 million VIE tagged fish have been released since 2000. There have been only 13 recoveries recorded to date. None of the high seas recapture data have latitude and longitude co-ordinates associated with them, but they all have an associated community name which can be connected to a standardized set of locations once they are developed.

All of the releases were of 1+ hatchery reared smolts and the majority of them were in the Penobscot (75%). All of the recaptures came from Greenland with the majority of them coming from the Penobscot River releases.

2.10 Greenland

CWT recoveries (all countries) from W. Greenland scanning programme (1985-92) UK(E&W) is the designated tag clearing house for CWTs recovered in the West Greenland fishery. Targeted screening of catches in the fishery between 1985 and 1992 resulted in the recovery of 631 CWTs, 407 from USA and Canada and 224 from NEAC countries. This data is available as a spreadsheet and provides information on release location and origin of the fish (wild or hatchery) for most recoveries (there are a few gaps which need to be filled). The recapture data (location and date) all relate to the port in which the screening was carried out. Recovery data are summarized in Appendix 1l. Detailed information on each year's screening programme were provided in annual ICES papers.

International adult tagging programme at W. Greenland

An international adult salmon tagging programme was undertaken in the West Greenland fishery between 1965 and 1972. In total, 4,632 adult fish were tagged; just over 50% of these in 1972. A summary of the recovery data is provided by Møller Jensen (1980). Detailed tagging and recapture information for 1972 are held by UK(E&W) and have been entered into spreadsheet form; it is not clear whether detailed recapture information are available for the earlier years (1965-71). The spreadsheet data provide the date and place of tagging with a high level of precision (tagging carried out by research vessels). The precision of the recapture information is more variable. The majority of tag recoveries occurred in the West Greenland fishery (n=164) and just over half of these have position (lat/long) recorded. The remainder mostly have either a place of capture or port of landing given, although some are only reported as 'West Greenland'. There are also a number of recoveries in homewater fisheries (n=52); these are given as place of recapture, but do not have associated positions, although these could be added.

2.11 Faroes

The tagging data in the Faroese repository (at the Faroese Fisheries Laboratory) is mainly recovery information of salmon tagged in rivers or in coastal areas in homewaters. These fish have been caught in the Faroese long-line fishery around the Faroes and north of the Faroes. These data have in most cases been reported back to the tag clearing houses in the various countries of oringin, and as such most of the data should be in duplicate form, one in the

Faroes and the other in the country of origin (or at the tag clearing house). Prior to around 1985 tag recaptures were also from the areas north of the present 200 nm fishery limit, i.e. from the areas north to Jan Mayen. A couple of tagging programmes have been undertaken in the Faroese area in addition to very limited tagging in Faroese rivers.

CWT recoveries (all countries) from Faroes commercial and research fishery scanning programme (1984-96)

Ireland is the designated tag clearing house for CWTs recovered in the Faroese longline fishery and research fishery. This provides information for approximately 380 CWTs (Fig. 4a). This data is available as a spreadsheet and provides information on release location and origin of the fish (wild or hatchery) for most recoveries. Many of the recaptures have latidude and longitude co-ordinates associated with them (maps are shown in Annex 5a). Detailed information on each year's screening programme has been provided in annual ICES reports of the Working group on North Atlantic Salmon.

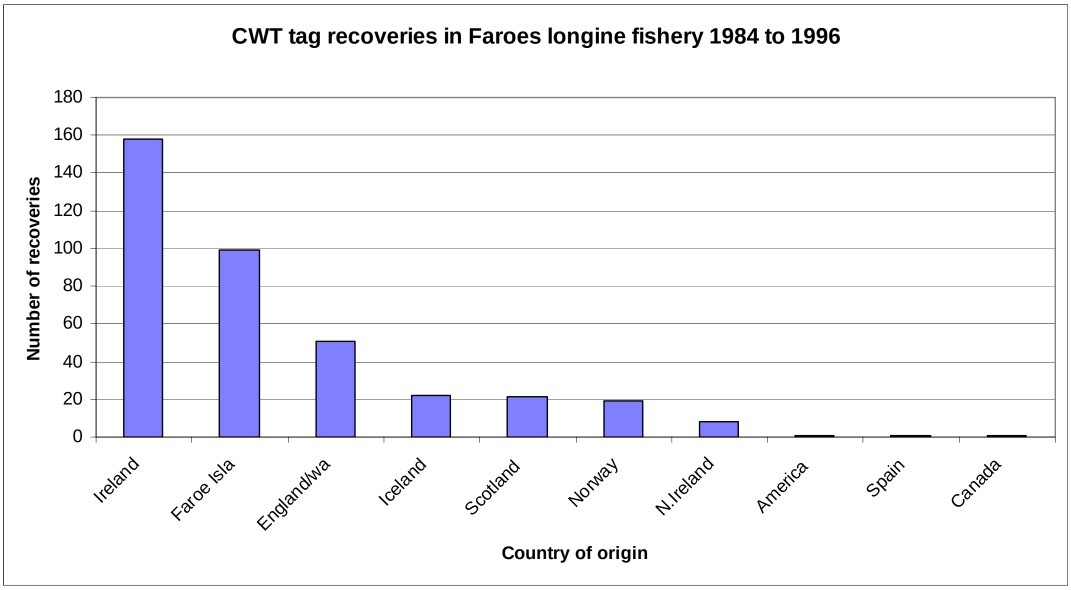

Fig. 4a. Coded Wire tag recoveries in Faroes longline fishery 1984-1996

Carlin tags

A large number of salmon carrying Carlin tags were recaptured in the long-line fishery for salmon at Faroes during the period 1965 – 1995. In total 2,696 tagged salmon were recaptured originating from 12 countries (Fig. 4b and text table below).

Total number of external tags recaptured in the long-line fishery around the Faroes with indication of the accuracy of the recapture location. Status: 0 exact position, 1 “north of the Faroes”

Country	Status=0	Status=1	Total
Canada	3		3
Denmark	2		2
Faroes	175	5	180
France	2		2
Iceland	3	1	4
Ireland	1	1	2
Norway	1,267	739	2,006
Russia	1	4	5
Sweden	228	168	396
UK(E&W)	6	7	13
UK(Scotland)	46	35	81
USA	1		1
Unknown	1		1
Total	1,736	960	2,696

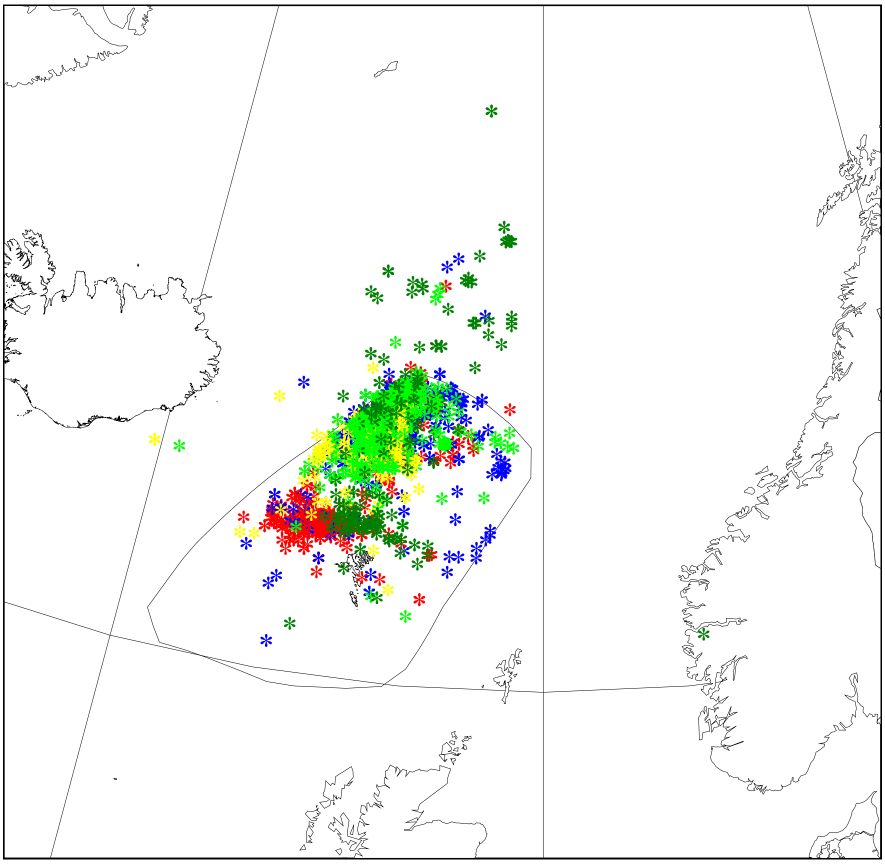

Fig. 4b. Recaptures of salmon tagged with external tags as smolts in homewaters. Data from the Faroese long-line fishery since 1968, separate colours have been applied for each fishing season, i.e. ”autumn” (Oct-Dec) and ”spring” (Jan-Apr) each year in the period 1968–1995.

Adult tagging program at Faroes

Two adult (subadult) tagging programs have been carried out in the sea around the Faroes, one during the period 1969-76 and the second during 1992-95 (see text table below).

AREA	TIME PERIOD	NO TAGGED	NO RECAPTURED
Faroes	1969-76 1992-95	1,946 5,448	90 106
Total		14,431	810

Exact tagging and recapture positions along with other relevant information are available for the most recent tagging program (in electronic format). The recapture by country from this experiment is shown in Fig. 4c, adjusted for homewater exploitation rates and tag reporting rates.

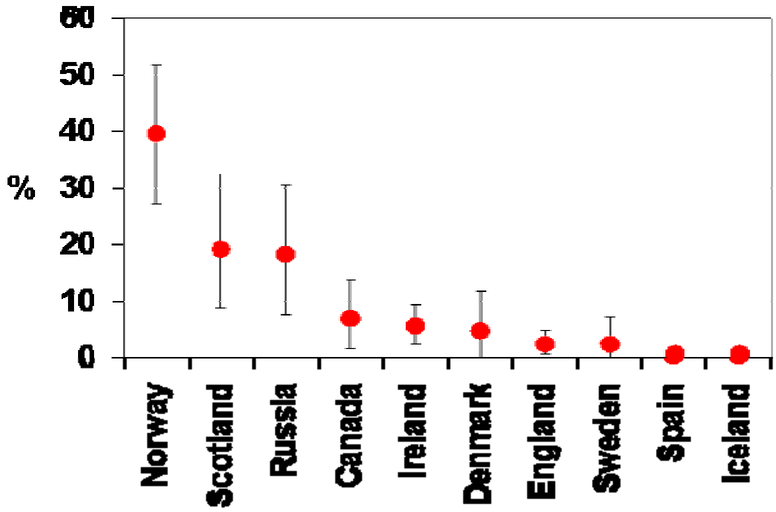

Fig. 4c. Estimated proportions (% with 95% confidence limits) of subadult salmon tagged at Faroes returning to different countries. Recoveries were adjusted for homewater exploitation rates and tag reporting rates. Data from the tagging programme 1992–1995.

2.12 Sonic tracking

Increasingly, salmon scientists are employing new sonic telemetry techniques to track salmon in the sea. The salmon are fitted with an internal (surgically implanted) or external tag, which emits a coded signal specific for that tag. This permits individual identification of fish when they are detected either by a moored receiver, or by active tracking. New models of tag have been (or are being) developed that will record and transmit to receivers environmental information such as depth and temperature.

A limited number of research groups in Europe and North America are already using these technologies to track Atlantic salmon in freshwater, and within coastal salt water zones. One study has followed Atlantic salmon smolts across the Gulf of St. Lawrence to the Strait of Belle Isle. Thus this technology has the potential to provide information on course tracks and swimming speeds of individual fish. In addition, where strategic migration bottlenecks are known to exist, these locations can be fitted with multiple receiver units with overlapping detection ranges so that no fish passes by undetected, then quantitative estimates can be obtained of the fraction of tagged salmon that have survived to that point of the migration. The two exits of the Gulf of St. Lawrence (Cabot Strait between Cape Breton and the island of Newfoundland; Strait of Belle Isle between Labrador and the Island of Newfoundland) are good examples of strategic bottlenecks amenable to deployment of sonic receivers.

Sonic telemetry differs from historic tagging procedures where typically there are only two records for a fish, viz. the point of tagging and the point of re-capture. Sonic telemetry has the potential to provide multiple records of single fish detection over the lifetime of a fish (or life time of the tag: tag life varies with the size of the battery in the tag, ranging from months for smolt tags to years for adult salmon tags). In addition, information from environmental sensors may also be available for these fish. Receiver detection range at present is typically about 800 m, which means positions of detected fish will be known with considerable accuracy. As the Working Group develops the format for the tag database, the ability to utilize the multiple and accurate information from sonic tagging should be borne in mind.

New sonic telemetry studies are expected to be highly complementary to, and to build on, historic tagging work. Present salmon migration routes documented with telemetry can be compared to historic tag recovery patterns to determine if migration pathways have shifted over time. Telemetry may similarly provide a rapid and cost-effective way of testing many of the other hypotheses that are being developed from the Working Group's analysis of historic tagging information. Canada has announced a program (The Ocean Tracking Network Project, based at Dalhousie University) to provide $35 million (Can) to moor sonic telemetry receivers in key ocean areas. This should greatly facilitate Atlantic salmon migration hypothesis testing with sonic telemetry.

3 Inventory

The workshop noted that the tag recovery information available to it was held in a variety of formats and agreed that it would aid data analysis and ease future expansion of the data set if a common framework were developed. Agreed fields are described in Table 1 together with required formats. The workshop recommended that this framework be used for future contributions to the tag recovery data set. An EXEL file with the appropriate form is available at ICES.

Table 1. The agreed data fields for recording tag recoveries from the oceanic areas frequented by salmon.

		Attribute Table Fields	Description	Format						
		Tag #	the number/code physically associated with the tag	alphanumeric						
		Trace var	information which, together with tag # may be used to uniquely identify individual tag	free format						
Tag Info		Tag type	Description of the type of tag applied	drop down list	CWT	Carlin	T-Bar	Lea	PIT	Other
		Tagging agency	Agency responsible for holding the data	free format						
		Day		dd						
	WHEN	Month		mm						
		Year		yyyy						
		Description	comments field which allows general description of tag site	free format, or custom codes						
		Country	3 fields which allow the tag site to be filtered to 3 levels of precision from the widest geographic range, "country" to the narrowest, "District"	free format						
		District		free format						
		Location		free format						
	WHERE	NAFO	NAFO Division code							
Tagging		ICES	ICES area code							
		ICES square	ICES square code							
		Lat	Latitude	decimal degrees						
		Long	Longitude, west indicated by -ve values	decimal degrees						
		Fork Length (cm)								
		Weight (g)								
	WHAT	Wild/Hatchery etc		drop down list	wild	hatchery	mixed	unknown		
		Life History Stage		drop down list	parr	smolt	post-smolt	adult	kelt	other
		river age	river age of fish in years							
		Day		dd						
	WHEN	Month		mm						
		Year		yyyy						
		Description	comments field which allows general description of recovery site	free format						
		Country	3 fields which allow the recovery site to be filtered to 3 levels of precision from the widest geographic range, "country" to the narrowest, "District"	free format						
		District		free format						
	WHERE	Location		free format						
		NAFO	NAFO Division code							
		ICES area	ICES area code							
		ICES square	ICES square code							
		Lat	Latitude	decimal degrees						
Reporting		Long	Longitude, west indicated by -ve values	decimal degrees						
		Fork Length (cm)								
		Round Weight (Kg)								
		Gutted Weight (Kg)								
		Life History Stage		drop down list	parr	smolt	post-smolt	adult	kelt	other
		river age	river age of fish in years							
	WHAT	sea age	sea age of fish in years							
		sex		drop down list	male	female	unknown			
		recovery operation	code to indicate whether the reporting location	drop down list	fishing	landing	processing	tag found	unknown	
		how reported	was report part of a directed screening programme ?	drop down list	report	screen	unknown			
		gear type		free format						
		scale sample	are scale samples available	drop down list	yes	no				
		General comments	comments field which allows any other useful comments	free format						

4 Framework for data analyses

Display of recaptures and release positions in GIS

In order to illustrate some potential ways of displaying and analysing positions of release and recapture, examples of data were drawn from a couple of databases and imported into ESRI ArcGIS software. A basic map of the Northern Atlantic was used together with ICES Fishing areas, ICES Squares and NAFO fishing areas.

Data of salmon tagged in Norway and Ireland from the 1970s and 1980s as well as catches of salmon in the fishery in the Northwest Atlantic between 1965 and 2003 were used when producing examples on the way results may be visualised (Fig. 5). Points of release as well as recapture were mapped and linked together to show crude migration routes in the Northeast Atlantic, indicating northernmost stocks to be recaptured more northerly than southern stocks.

It was demonstrated, that recaptures where the position of recapture was known with less precision only to a certain area could be associated for example to ICES squares, and illustrated as categories with colours reflecting the number of tags recovered from the area (Fig. 6). In the same way, recaptures with more precise information (exact positions) could be illustrated in the same way. This allows the reader to make some judgement on the veracity of the resulting migration and distribution maps.

As an example of how data may be related to environmental conditions, a sample of temperature data were extracted from the ICES website and illustrated together with recapture positions. Due to the large amount of data on temperature only a small sample was extracted and illustrated to show the potential of displaying and analysing data together (Fig. 7).

For the Norwegian and Irish data as well as for the Northwest Atlantic fisheries data, the density of recaptures were displayed as density traces after spatial analysis with kernel polygons. The visualisation of this indicated a slightly more southern distribution pattern of salmon from Ireland than from Norway. The illustrations also revealed that catches of the tagged fish in certain months was very concentrated spatially. See Appendix 5.

As an example of tagging at sea combined with later recapture either in freshwater or the sea results from salmon tagged in the Norwegian Sea off the Norwegian coast were illustrated with a resolution in tagging time of months (Fig. 8).

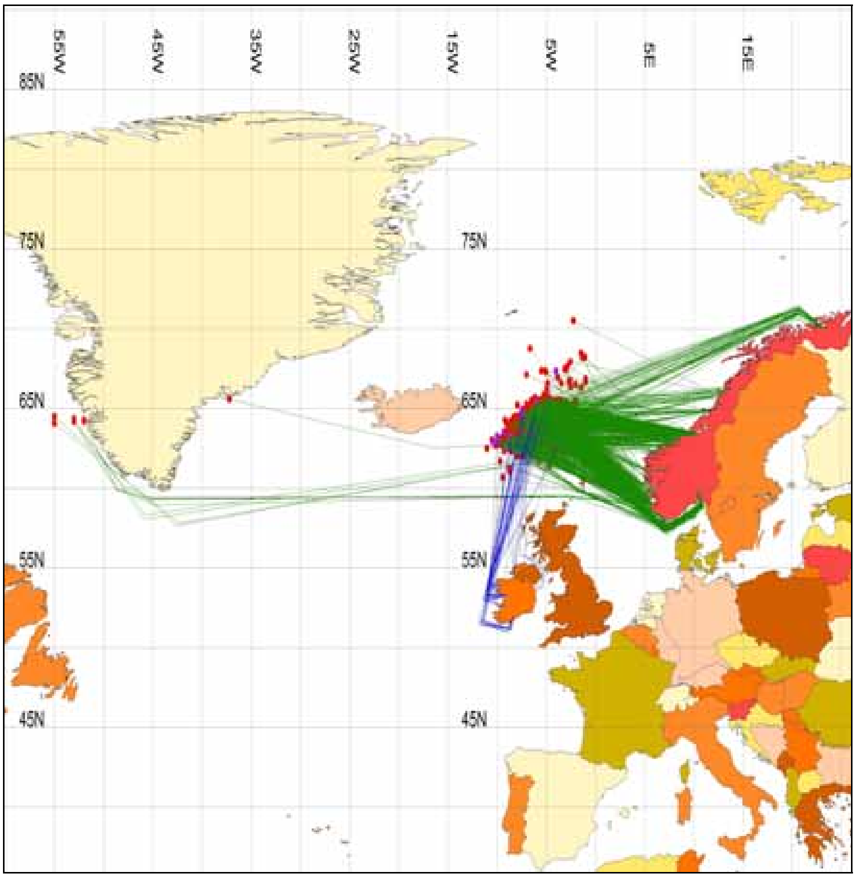

Fig. 5. An example of geographical positions of salmon tagged in Norway and Ireland and recaptured at sea. (Incomplete and provisional figures).

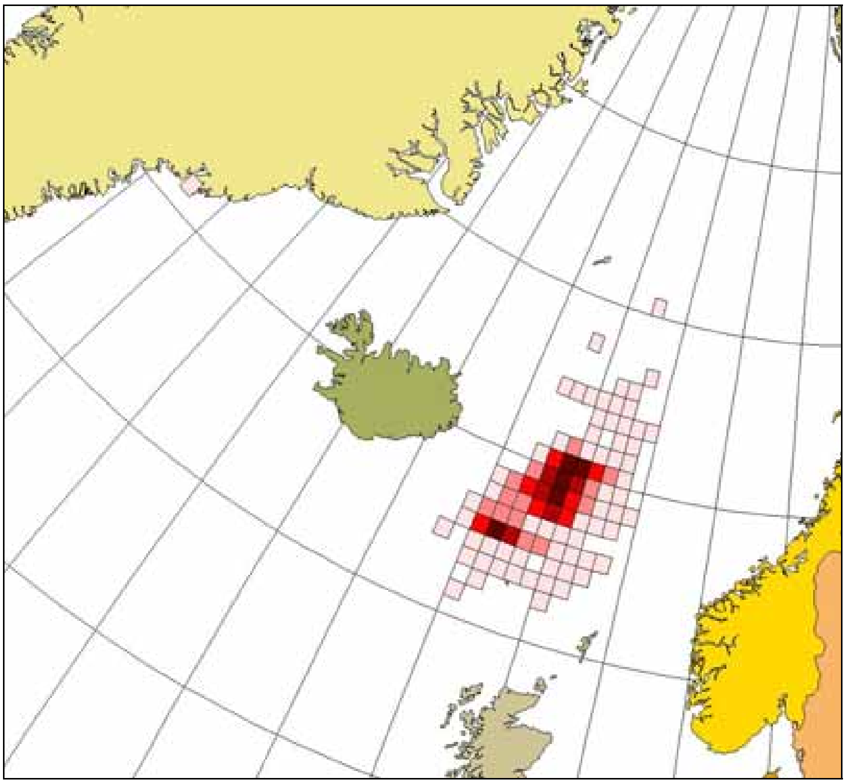

Fig 6. Number of tags recaptured inside ICES squares. The darkest colours indicate high numbers of recaptures

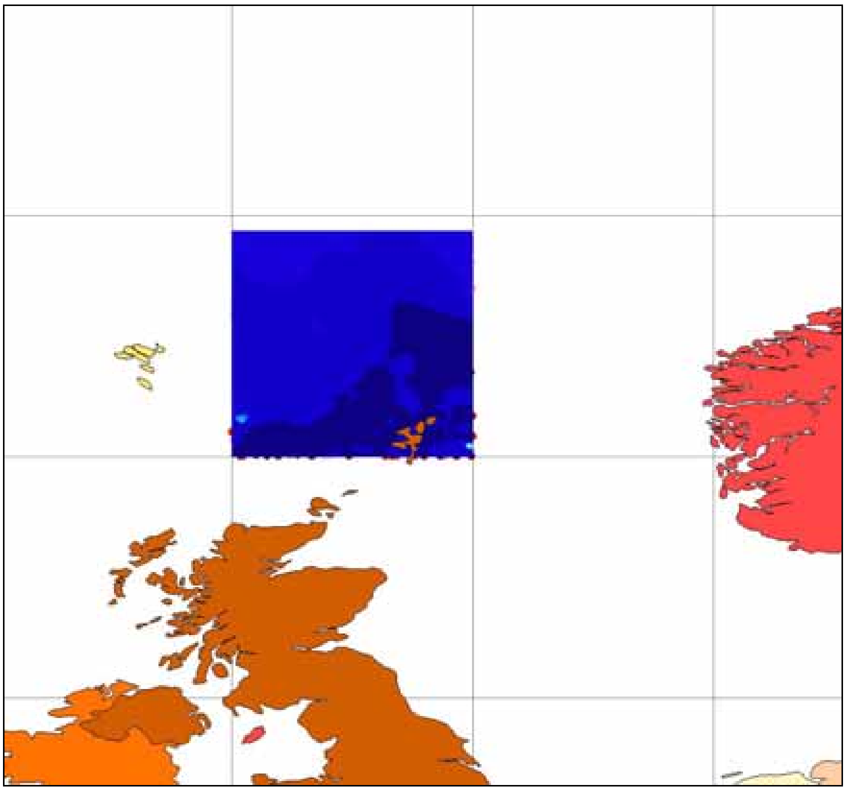

Fig. 7. Interpolation of winter sea surface temperatures 1979-70 in the Norwegian Sea (Data from ICES).

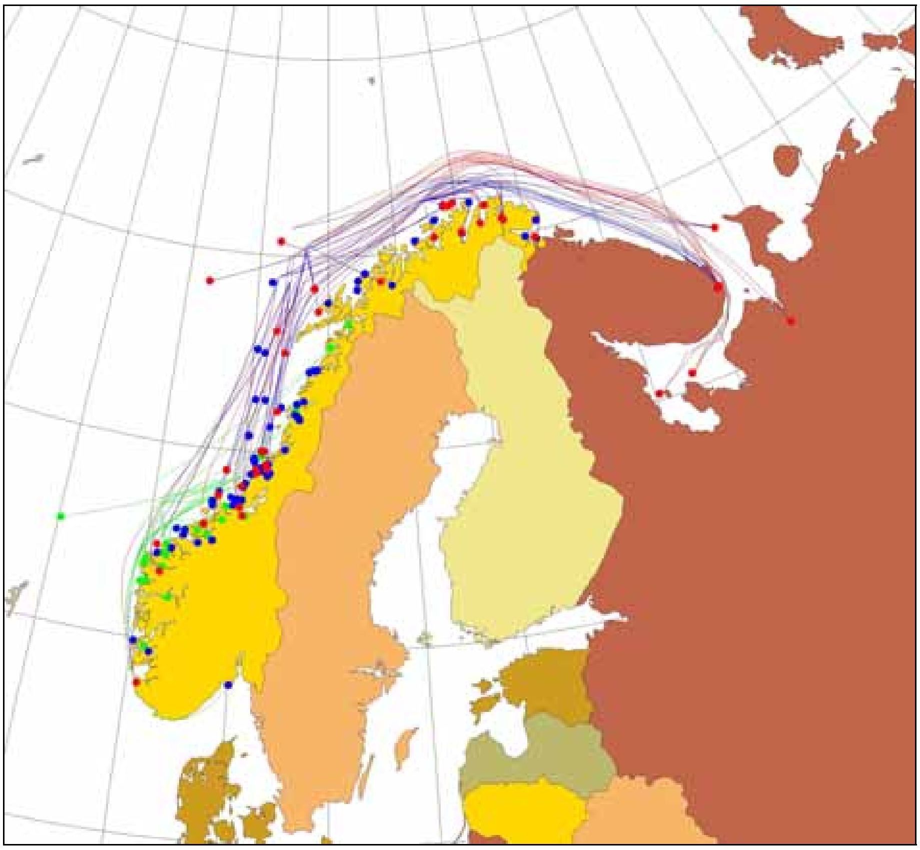

Fig. 8. Recaptures of adult Atlantic salmon tagged and released in the Norwegian Sea in the spring 1970. Red lines and dots represent fish tagged in April, Blue are May and Green are June.

5 Questions and hypotheses

The Workshop was also requested to provide a series of hypotheses that could be tested with the GIS data when complete. The ocean distribution and migration of Atlantic salmon can be influenced by numerous factors including, but not limited to, stock origin, life history, environment, and interceptory fisheries. Compilation of national tag recovery data sets into a standard format may provide a means by which various questions or hypotheses can be explored in the context of larger meta-analyses of available data. Elucidating the distribution and migration of salmon at sea in time and space, and clarifying or updating current beliefs regarding ocean migration routes, will improve current knowledge regarding the ocean life-history of salmon. Analyses may also provide insight into how migration and subsequent distribution of salmon at sea could be influenced by changing biological and physical conditions in the North Atlantic.

Examples of potential questions or hypotheses are provided below as a guide to initiate potential analyses of data. They are also intended to stimulate additional thought rather than be considered exclusive.

General – Migration and Distribution

- The distribution of salmon at sea is random;

- The migration of salmon to marine feeding areas is consistent over time (years, months) and space (route);

- Descriptive models that hind-cast or predict the migration of salmon at sea could be formulated and tested using the tag recovery observations;

Life History

- The distribution and migration of salmon at sea is independent of sea-age;

- The distribution and migration of salmon at sea is independent of rearing origin (i.e. hatchery vs wild);

- The distribution and migration of salmon at sea is independent of river (smolt) age;

- The distribution and migration of salmon at sea is independent of rate of growth;

- The distribution and migration of salmon at sea is independent of spawning history (i.e. maiden vs repeat spawners; alternates vs MSW salmon);

-The distribution and migration of salmon at sea is independent of geographical origin of stocks (e.g. northern vs southern stocks);

- The ocean distribution and migration of salmon at sea is independent of salmon run type (e.g. early vs late; spring vs fall runs);

- The distribution of European and North American salmon at West Greenland has not changed over time;

- The distribution of North American salmon caught at West Greenland is independent of stock origin (e.g. USA, Quebec, Maritime, Newfoundland-Labrador, etc.);

-The distribution of European salmon caught at the Faroe Islands is independent of country of origin (e.g. Norway, Sweden, Finland, Denmark, Ireland, Iceland, United Kingdom, Russia etc.);

-The distribution of European salmon caught at West Greenland is independent of country of origin (e.g. Norway, Sweden, Finland, Denmark, Ireland, Iceland, United Kingdom, Russia etc.);

Physical Environment

- The distribution of salmon at sea is independent of optimal temperature requirements;

- The distribution of salmon at sea is independent of sea-surface temperature;

- The distribution of salmon at sea is independent of salinity;

- The distribution and migration of salmon at sea is independent of the aerial extent of pack ice in the Labrador sea;

- The distribution of salmon at sea is independent of ocean current patterns and/or areas of potential upwelling;

- The distribution of salmon at sea is independent of photoperiod;

Biological Environment

- The distribution of salmon at sea is independent of availability and abundance of prey species;

- The distribution of salmon at sea is independent of predator abundance and distribution;

- The distribution of salmon at sea is not influenced by competition from other pelagic fish species;

- The distribution of salmon at sea is not influenced by productivity of individual stocks;

- The distribution and migration of salmon at sea is independent of local or distant water salmonid aquaculture operations;

- The distribution and migration of salmon at sea is independent of the abundance and distribution of escaped farmed salmon;

Fisheries

- The distribution and migration of salmon at sea is independent of local, home-water directed fisheries;

- The distribution and migration of salmon at sea is independent of local, home-water by-catch fisheries;

- The distribution and migration of salmon at sea is independent of distant water interceptory fisheries;

Approach

Geographic Information System (GIS) is a tool to organise and map data, and can be used to illustrate and possibly quantify changes in the distribution and migration of salmon in time and space. For example, the relative distribution of European versus North American salmon caught at West Greenland can be provided by country or region of origin, by year, season (month), and life-history stage. This could be further partitioned into respective rearing origin comparing the distributions of wild versus hatchery salmon and whether hatchery salmon were river age one versus two years of age. GIS analyses also allow for the layering of supplementary information such as sea-surface temperatures, current patterns and/or the distribution of known concentrations of directed fishing activities to further elucidate the distribution and migration of salmon at sea. However, the detailed analysis and testing of hypothesis requires additional tools and may require advanced statistical methods and modelling. Basically the data base will facilitate the selection of tag applications and distributions of recaptures to test hypotheses about the expected recapture distribution or rates assuming the test hypothesis is true. Or conversely prove it is untrue.

Tag recovery information could be complemented by genetic analyses of time series of available scale or tissue samples in relation to salmon life-history information derived from scale pattern analyses of freshwater and marine growth characteristics. Integration of historical tag recovery information with new technological advances in marine telemetry (e.g. data storage tags, PIT tags, archival tags, acoustic tags, global positioning tags, etc.) could be coupled with directed research investigations at sea in conjunction with hydrographic information. Stable isotopes of the marine growth sections of salmon scales from archived collections could be examined for evidence of differences in the trophic ecology among stocks, and whether changes over time have occurred, while analyses of chemical composition of scales or otoliths have proven merit in identifying stock origin of local salmon populations.

Information on the distribution and abundance of potential predators (e.g. seals, whales, sharks, sea-birds, etc.) and availability of likely prey species (fish, invertebrates) needs to be compiled from various sources including the grey literature.

6 Recommendations

1) The Workshop attendees recommended that a similar Workshop be held sometime in 2007-08 to complete compilation of available data and analyses of the resulting distributions of salmon at sea. In this regard, the Workshop considered that the integration of historical tagging data for NEAC and NAC provides a significant opportunity to advance the state of knowledge of the marine distribution and migration of salmon.

2) The Workshop noted that while tag recapture data can indicate spatial and temporal information gaps for the distribution of salmon at sea, with present research fishing gear, opportunities to fill in the information gaps will not be possible due to the constraints of adverse environmental conditions in some areas. These constraints are particularly notable in the north western Atlantic in winter. Thus, the Workshop noted that evolving technologies such as acoustic tags and arrays, acoustic chat tags, archival business card tags, passive integrated transmitter tags, passive global positioning tags, popup satellite tags will integrate well with this assemblage of historical tag data and increase the spatial and temporal coverage of the distribution of salmon in the marine environment. The Workshop recommends that any use of new tagging technology should consider the information available from previous tag studies including those of this Workshop. It is also recommended that consideration be given to ways of collecting data from areas/times when research vessels cannot operate.

3) The Workshop noted that the tag recovery information available to it was held in a variety of formats and agreed that it would aid data analysis and ease future expansion of the data set if a common framework were developed. The workshop recommended that this framework be used for future contributions to the tag recovery data set. Each tagging agency should utilize the framework to prepare data for analysis at the next Workshop.

4) It is recommended that agencies coordinate their efforts to ensure that datasets are not duplicated.

5) It is recommended that the next Workshop include oceanographers to assist with describing the salmon distributions and relating them to the ocean environment.

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Annex 2: List of Working documents

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Annex 4: National tagging and tag recovery summaries

Annex 4a: Numbers of tags applied to Atlantic salmon and recoveries in five geographic areas for 66 rivers in Maritime provinces of Canada.

Description	Number Released	Outside Scotia/Fundy	Gulf of St Lawrence	Newfoundland	Quebec & Labrador	Greenland or farther
RESTIGOUCHE RIVER	40921	931	527	90	176	93
UPSALQUITCH RIVER	9186	75	9	23	3	38
KEDGWICK RIVER	18393	41	14	5	2	15
RESTIGOUCHE RIVER	16749	77	17	33	3	24
NEPISIGUIT RIVER	15699	110	68	27	10	4
TABUSINTAC RIVER	916	0	0	0	0	0
MIRAMICHI RIVER	44290	3416	2915	282	38	171
NORTHWEST MIRAMICHI RIVER	22752	101	39	20	5	35
SOUTHWEST MIRAMICHI RIVER	200	5	4	0	1	0
SOUTHWEST MIRAMICHI RIVER	116907	1712	885	493	36	289
BARTHOLOMEW RIVER	47922	1067	747	176	27	104
RICHIBUCTO RIVER	1687	20	12	5	0	3
BUCTOUCHE RIVER	1588	23	11	8	0	4
SHEDIAC RIVER	1675	29	23	4	0	2
RIVER PHILIP	84391	412	172	101	8	130
DISTRICT TWELVE NS	300	0	0	0	0	0
SOUTH RIVER	500	1	0	0	0	1
MARGAREE RIVER	68355	180	71	49	5	53
DISTRICT ONE NS	3121	4	0	0	0	4
NORTH RIVER	7961	13	0	3	0	10
MIDDLE RIVER	28145	81	19	16	1	44
DISTRICT SIX NS	2999	0	0	0	0	0
SALMON RIVER CAPE BRETON	4992	0	0	0	0	0
GRAND RIVER	17454	7	0	5	0	2
ST MARY'S RIVER	37001	49	1	4	1	43
LISCOMB RIVER	126569	148	2	65	6	72
MOSER RIVER	5280	0	0	0	0	0
EAST RIVER SHEET HARBOUR	108117	186	2	94	9	73
WEST RIVER SHEET HARBOUR	24701	35	0	25	1	9
MUSQUODOBOIT RIVER	25634	46	0	6	0	40
INGRAM RIVER	2084	0	0	0	0	0
MUSHAMUSH RIVER	11894	8	0	1	1	6
DISTRICT TWENTY-SEVEN NS	188	4	0	2	1	1
LAHAVE RIVER	339309	604	3	209	19	371
PETITE RIVIERE	2000	2	0	0	0	2
MEDWAY RIVER	107257	130	1	33	3	93
MERSEY RIVER	1948	3	0	0	2	1
JORDAN RIVER	15	0	0	0	0	0
CLYDE RIVER	19741	11	0	6	1	4
TUSKET RIVER	39238	30	0	6	1	23
SALMON RIVER	3778	3	0	0	0	3
ANNAPOLIS RIVER	6830	5	0	1	0	4
GASPEREAU RIVER	9446	2	0	1	0	1
STEWIACKE RIVER	41830	1	1	0	0	0
DISTRICT FORTY-THREE NS	212	0	0	0	0	0
GREAT VILLAGE RIVER	318	0	0	0	0	0
DISTRICT FORTY-FOUR NS	4275	9	1	5	2	1
PETITCODIAC RIVER	33961	9	0	4	2	3
POINT WOLFE RIVER	7493	0	0	0	0	0
BIG SALMON RIVER	125317	12	3	3	1	2
SAINT JOHN RIVER	25338	25	5	9	0	8
SAINT JOHN RIVER (LOWER)	688531	1113	32	460	83	508
SAINT JOHN RIVER (MIDDLE)	3741	6	2	3	1	0
SAINT JOHN RIVER (UPPER)	56	0	0	0	0	0
SAINT JOHN RIVER	11530	14	0	10	2	0
HAMMOND RIVER	30804	35	0	16	5	14
KENNEBECASIS RIVER	12983	12	0	6	3	3
NASHWAAK RIVER	67280	67	8	21	3	33
TOBIQUE RIVER	57187	82	15	31	3	30
AROOSTOOK RIVER	745	0	0	0	0	0
SAINT JOHN RIVER	1150	0	0	0	0	0
MAGAGUADAVIC RIVER	2	0	0	0	0	0
CHAMCOOK LAKE	2000	0	0	0	0	0
ST CROIX RIVER	61788	72	3	26	9	30
DISTRICT FIFTY-TWO NB	400	0	0	0	0	0
MORELL RIVER	8845	47	1	25	4	11
4	2613919	11075	5613	2412	478	2415

Annex 4b: Tagged salmon released in Denmark between 1960 and 1992.

Origin	Age	Avg. Length	Number	Date	Release locality	Long	Lat
			1000	24-04-1960	Gudenå	10.07	56.46
	2		799	24-04-1960	Gudenå	10.07	56.46
Hatchery	2	18.3	896	23-04-1965	Varde Å	8.31	55.58
Hatchery	1	?	77	23-04-1965	Varde Å	8.31	55.58
Hatchery	2	?	425	25-05-1965	Varde å, Linding Å	8.31	55.58
Hatchery	1	?	473	27-05-1965	Varde å, Linding Å	8.31	55.58
Hatchery	2	13.9	1000	25-03-1966	Garverrenden, Tempelkrogen	11.77	55.66
Hatchery	2	14.3	975	02-04-1966	Kongeå	8.64	55.38
Hatchery	?	14.9	298	04-04-1966	Brøns Å	8.68	55.19
Hatchery	2	14.6	998	07-04-1966	Varde Å ved Tarphage	8.31	55.58
Hatchery	2	14.8	999	07-04-1966	Varde Å ved Rabekke Bro	8.31	55.58
Hatchery	2	16.8	1197	16-03-1967	Varde Å Karlsgårde Bro	8.31	55.58
Hatchery	2	15.9	1000	23-03-1967	Brøns Å, uden for slusen	8.68	55.19
Hatchery	2	16.6	499	23-03-1967	Brøns Å, inden for slusen	8.68	55.19
				28-03-1968	Storå	8.29	56.32
				28-03-1968	Storå	8.29	56.32
Hatchery	2	16.2	500	06-04-1968	Ribe Å, Stampemøllen	8.67	55.34
Hatchery	2	17.3	500	06-04-1968	Ribe Å, Stampemøllen	8.67	55.34
Hatchery	2	?	277	18-04-1968	Garverrenden, Munkholmbroen	11.81	55.67
Hatchery	2	?	223	18-04-1968	Garverrenden, Munkholmbroen	11.81	55.67
Hatchery	2	?	391	18-04-1968	Vejlemølle Å	11.95	55.83
Hatchery	2	?	298	18-04-1968	Vejlemølle Å	11.95	55.83
Hatchery	3	?	198	22-03-1969	Garverrenden, ved kroen	11.77	55.66
Hatchery	2	?	221	22-03-1969	Garverrenden, ved kroen	11.77	55.66
Hatchery	3	?	50	22-03-1969	Vejlemølle Å	11.95	55.83
Hatchery	3	?	400	22-03-1969	Vejlemølle Å, ved slusen	11.95	55.83
	1	?	739	28-03-1969	Storå	8.29	56.32
	2		156	28-03-1969	Storå	8.29	56.32
Hatchery	1	12.3	893	29-03-1969	Varde Å, Rebekke Bro	8.31	55.58
Hatchery	2	14.1	81	02-04-1969	Kongeå, Jedsted Bro	8.64	55.38
Hatchery	1	12.3	519	02-04-1969	Kongeå, Jedsted Bro	8.64	55.38
	2	?	580	18-04-1969	Ribe Å	8.67	55.34
			477	07-04-1970	Vejle Å	9.56	55.7
Hatchery	2	12.8	493	09-04-1970	Kongeå ved Vilslev	8.64	55.38
			406	09-04-1970	Ribe Å	8.67	55.34
			1000	1970	Lagan	10.13	57.12
Hatchery	2	16.44	1000	05-04-1974	Lindenborg Å	10.13	57.12
Hatchery	2	17.09	978	05-04-1974	Gerå	10.51	57.2
Hatchery	2	18.09	998	05-04-1974	Havmølle Å	8.29	56.32
Lagan	2	24.2	1000	26-04-1974	Ribe Å	8.67	55.34
Hatchery	2	18.6	974	26-04-1974	Ribe Å	8.67	55.34
Hatchery	3	30.36	999	04-04-1975	Lindenborg Å	10.13	57.12
Hatchery	3	28.11	998	05-04-1975	Ribe Å	8.67	55.34
Hatchery	2	15.25	174	05-04-1975	Ribe Å	8.67	55.34
Lagan	2	21.45	1000	15-04-1975	Ribe Å	8.67	55.34
Lagan	2	23.22	1000	15-04-1975	Lindenborg Å	10.13	57.12
Lagan	2	22.3	995	23-04-1976	Lindenborg Å	10.13	57.12
Hatchery	2	19.6	999	23-04-1976	Lindenborg Å	10.13	57.12

Origin	Age	Avg. Length	Number	Date	Release locality	Long	Lat
Lagan	2	22.1	996	23-04-1976	Ribe Å	8.67	55.34
Hatchery	2	18.9	976	23-04-1976	Ribe Å	8.67	55.34
Hatchery	2	16.8	1000	04-04-1977	Lindenborg Å	10.13	57.12
Hatchery	2	17.2	998	04-04-1977	Voers Å	10.4	57.12
Hatchery	2		867	28-04-1979	Gudenå	10.07	56.46
Hatchery	2		898	28-04-1979	Gudenå	10.07	56.46
Hatchery	2		897	28-04-1979	Gudenå	10.07	56.46
Ätran	1		496	24-04-1991	Gudenå	10.07	56.46
Corrib	1		1499	24-04-1991	Gudenå	10.07	56.46
Lagan	1		3995	24-04-1991	Gudenå	10.07	56.46
Ätran	1		2442	07-05-1992	Gudenå	10.07	56.46
Corrib	1		2496	07-05-1992	Gudenå	10.07	56.46
Conon	1		2480	7. maj 1992	Gudenå	10.07	56.46
Ätran	1		1963	07-05-1992	Gudenå	10.07	56.46
Corrib	1		1998	07-05-1992	Gudenå	10.07	56.46
Conon	1		1993	07-05-1992	Gudenå	10.07	56.46

Annex 4c: Distribution of recoveries (%) from releases in different parts Denmark

	Tagged fish released in			
	Northern Jutland	West Jutland	Inner Danish Waters	Total
Danish homewaters	76.0	88.7	94.7	82.9
Sweden Sea	4.4	0.3	2.1	2.6
Sweden River	1.2	0.0	0.0	0.6
Sweden unknown	0.0	0.0	1.1	0.1
Norway Sea	15.8	4.5	2.1	10.1
Norway river	1.2	0.3	0.0	0.7
Scotland	0.5	0.0	0.0	0.2
Ireland	0.9	1.0	0.0	0.8
Greenland	0.0	0.3	0.0	0.1
Faroe Islands	0.0	0.6	0.0	0.2
Netherland	0.0	0.3	0.0	0.1
Germany Sea	0.0	3.2	0.0	1.2
Germany River	0.0	0.6	0.0	0.2

Annex 4d: Recaptures of salmon in Irish marine salmon fisheries which were tagged in other countries.

Fishing year	Countries of Origin: N. Ireland	England/Wales	Scotland	France	Spain	Norway	Denmark	Germany	Faroe Islands
1985		7	129						
1986		22	114						
1987	143	66	65						
1988	122	128	78						
1989	101	68	17	6					
1990	33	111	81	2					
1991	221	57	57						1
1992	429	107	5	5					
1993	172	101	2	1	8	1			
1994	86	80	3		4	1			
1995	51	147	4	62	3		23		
1996	98	77	10	1	3		1		
1997	168	44			2				
1998	51	34	7		16		14		
1999	46	118		2	7		35	1	
2000	153	113	2	1	17			1	
2001	198	54			8				
2002	86	41	2		6		1	1	
2003	58	27			17			1	
2004	32	8	2		2		2		
2005	28	10			7		1	5	
2006									
TOTAL	2276	1420	578	80	100	2	77	9	1

Annex 4e: Data on tagging smolts in the USSR and tag returns for 1969-1974 (Bakshtansky et al., 1976).

Marking season	Number Marked: Hatchery	Number Marked: Wild	Release Location	Number Recaptured: Norwegian Sea	Number Recaptured: Territorial Waters of Norway	Number Recaptured: USSR
1969	600		Kola River	1		5
		500	Z. Zolotitsa River			
1970	986		Kandalaksha bay			
		180	Z. Zolotitsa River			
		100	Porya River	1		1
1971	805		Kola River			
	2,930		Luvenga River			3
		700	Porya River	2	1	10
		1,507	Z. Zolotitsa River	2		1
1972		600	Porya River	1	2	6
		100	Z. Zolotitsa River			
1973	950		Kola River		1	48
		148	Porya River		1	1
		1,600	Soyana River			33
1974		700	Soyana River			
	1,000		Kandalaksha bay			
		200	Porya River			

Annex 4f: Data on recapturing adult salmon in the areas outside the USSR (Bakshtansky et al., 1976).

MARKING SEASON	RELEASE LOCATION	RECAPTURE DATE	RECAPTURE LOCATION	AGE	WEIGHT, KG	DISTANCE FROM PLACE OF RELEASE, KM
1969	Kola River	02 May 1970	60 miles North of Trondheim	1SW	1.4	3,000
1970	Porya River	08 June 1971	Tysfjord, East of Ralen	1SW	2.4	1,890
1971	Porya River	09 May 1973	Norwegian Sea, 69°30N, 05°00E, long line	2SW	2.4	3,800
1971	Porya River	03 May 1973	Kjofjord	2SW	3.2	1,290
1971	Porya River	29 June 1973	Bought at the Hammerfest fish market	2SW	3.3	1,365
1971	Z. Zolotitsa River	25 June 1973	Norwegian Sea	2SW	2.1	
1971	Z. Zolotitsa River	25 July 1973	Norwegian Sea	2SW	2.1	
1972	Porya River	16 May 1973	Norwegian Sea, 70°10N, 06°50E, long line	1SW	1.5	3,900
1972	Porya River	07 June 1973	Eidsfjord, Vesteraalen	1SW	1.8	1,905
1972	Porya River	19 June 1973	Henningsvaer	1SW	2.0	1,920
1973	Porya River	13 June 1974	Skrovkjosen	1SW	1.7	1,890
1973	Kola River	02 July 1974	Paz River	1SW		

Annex 4g: Recapture data on adult salmon tagged in the areas outside the USSR (Bakshtansky, Nesterov, 1973).

Release Location	Release Date	Recapture location	Recapture Date
Breivik, Finnmark, Norway	04 June 1962	Strelna, White Sea	01 July 1962
	09 June 1962	Pechora River	12 September 1962
	09 June 1962	Pechora River	28 June 1962
	10 June 1962	White Sea	07 September 1962
	10 June 1962	White Sea	17 July 1962
	11 June 1962	Teriberka Bay	01 July 1962
	10 June 1962	Kola Bay	23 July 1962
	10 June 1962	Kola Bay	09 July 1962
	17 June 1962	Voronya River	12 July 1962
	17 June 1962	Pechenga River	30 June 1962
	17 June 1962	Iokanga River	02 July 1962
	18 June 1962	Kola Bay	07 August 1962
	01 July 1962	Kola River	01 October 1962
	02 July 1962	Kola Bay	25 July 1962
	09 June 1963	Vestern Litsa	12 July 1963
	09 June 1963	Eastern Litsa	05 July 1963
	09 June 1963	Pechora River	05 September 1963
	09 June 1963	Titovka River	15 July 1963
	09 June 1963	Voronya River	10 July 1963
	10 June 1963	Eastern Litsa	05 July 1963
	10 June 1963	Teriberka Bay	08 July 1963
	17 June 1963	Titovka River	15 July 1963
	13 June 1966	Voronya River	27 June 1966
	05 June 1966	Sidorovka River	13 July 1966
	19 June 1966	Sidorovka River	08 July 1966
	12 June 1966	Pechora River	01 August 1967
	13 June 1966	Pechora River	14 August 1967
	19 June 1967	Pechora River	20 August 1967
	09 June 1968	Kola River	18 July 1968
	09 June 1968	Tuloma River	17 July 1968
	01 July 1968	Vestern Litsa	09 July 1968
	01 July 1968	Chapoma, White Sea	19 July 1968
	07 July 1968	Varzuga River	29 July 1968
	08 July 1968	Knyajaya Bay	04 August 1968
	15 July 1968	Chapoma, White Sea	01 August 1968
	08 July 1968	Paz River	28 August 1968
Norwegian Sea, 69°49N, 13°58E,	16 May 1969	Pechora River	1970
Norwegian Sea, 70°00N, 16°20E,	20 March 1971	Pechora River	1971

Annex 4h: Tagging and recapture data on adult salmon tagged in the areas outside the USSR (Antonova, Chuksina, 1987).

Marking season	Gear	Release Location	Number Marked	Number Recaptured		
				Total	USSR	Pechora River
1962-1967	Bagnets, Bendnets, Driftnets	Breivik, Finnmark, Sørøy	4,316	994	124	12
1968-1973	Bagnets, Bendnets,	Breivik, Finnmark	912	280	38	2
1968-1971	Long-line	Norwegian Sea, 63°N - 68°N	1,781	230	14	1
1970	Long-line	Norwegian Sea, 68°N - 71°N, East of 23°E	948	113	13	1
1971-1972	Long-line	Norwegian Sea, North of 68°N, 09°E - 17°E	2,170	178	44	23

Annex 4i: Details of smolt tagging programmes in UK(E&W), 1958-84, and a summary of tag recoveries, by river, in fisheries outside UK(E&W) homewaters.

River	No. tagged	Tagging years	No. recoveries								
			Distant water		Other Areas						
			Greenland	Faroes	Canada	Norway	Denmark	Sweden	Ireland	NI	Scotland
Coquet	579	1968-69	1								
Esk		1980-84	3	15		3		1	2	2	22
Ure	16,571	1968-79	104	1	3	2			2		
Avon	6,364	1968-71	18			1			4		
Frome		1977-78		1					2		
Axe	55,119	1960-71	90			1			2		
Exe	25,949	1968-71	36			2					
Dart	544	1968									
Taw	2,082	1968									
Severn	23,241	1958-64	7								
Wye	21,270	1958-64	5								
Usk	48,710	1958-73	44		1		1		28		
Lledr/Erch/ Ogwen	1,816	1968-70									
Clwyd	639	1968-69									
Lune	563	1968									
Total (E&W)			308	17	4	9	1	1	40	2	22

Annex 4j: UK(E&W) CWT recoveries, by year (1985-2006), in fisheries outside UK(E&W) homewaters.

Year	Distant Water		British Isles		
	Greenland	Faroes	Ireland	N. Ireland	Scotland
1985			7		
1986	22	3	22	10	43
1987	17	7	66	61	10
1988	8	11	128	42	8
1989	12	9	71	4	32
1990	2	5	111	5	8
1991	3	8	57	3	1
1992	4	5	107	9	5
1993		3	101	5	6
1994		1	80	4	10
1995			148	2	28
1996			76	2	14
1997			44	5	
1998			36	2	
1999			117	4	
2000			113	4	
2001			54	3	
2002			41	2	
2003	2		27	0	
2004			8	0	
2005			10	0	
2006			9	1	
Total	70	52	1433	168	165

Annex 4k: Numbers of Scottish tags recovered from Faroese and Greenlandic fisheries by year. Comprehensive data for Greenland before 1980 not included (see text).

YEAR	FAROES	GREENLAND
1967	2	
1968	1	1
1969		
1970		2
1971	1	
1972		3
1973	3	1
1974		
1975		1
1976	4	2
1977	3	
1978		
1979		
1980	19	8
1981	25	2
1982	36	2
1983	3	
1984	7	6
1985	5	12
1986	3	8
1987	1	3
1988	3	2
1989	4	3
1990	2	10
1991	1	6
1992		
1993	3	
1994		
1995		
1996		2
1997		1
1998		1
1999		
2000		
2001		
2002		1
2003		
2004		
2005		
Unknown	3	

Annex 4l: Summary of CWT recoveries by country and year from the catch screening programme at West Greenland, 1985-1992.

YEAR OF	NAC		NEAC				
recovery	Canada	USA	Iceland	UK (Sc)	UK (E&W)	UK (N.I.)	Ireland
1985			1	2			31
1986	19	7	2	2	22		18
1987	21	82		2	17		24
1988	22	59	3	1	8		17
1989	2	70		2	12	1	12
1990	9	37	3		2		3
1991	2	26	2	1	3	1	2
1992	15	36	5	1	4		20
Total	90	317	16	11	68	2	127

Annex 4m: Summary of tag recoveries arising from the international adult salmon programme at West Greenland, 1965-1972 (detailed tag recovery information only available for 1972).

YEAR	NO. TAGGED	NO. RECAPTURES						
		W. Gr	Canada	UK (Scot)	UK (E&W)	Ireland	France	Spain
1965	223	3	1	0	0	0	0	0
1966	729	28	1	3	0	0	0	0
1967	375	6	1	1	0	2	0	0
1968	47	4	1	0	0	0	0	0
1969	444	18	6	1	3	2	0	1
1970	224	3	2	1	0	1	0	0
1971	226	6	4	0	2	3	0	1
1972	2364	164	12	24	9	8	2	1

Annex 4n: Number of salmon tagged in Norway and recaptured in the Norwegian Sea with different precision levels of the geographical site of recapture. About 2.5 mill. smolts have been tagged and released.

PRECISION LEVEL	NO OF RECAPTURES
Good	1836
Medium	50
Low	732
Total	2618

Annex 4o: Number of salmon recaptured from tagging experiments with adults in the Norwegian Sea 1969-1972.

YEAR OF TAGGING	NUMBER OF FISH TAGGED	NUMBER OF RECAPTURES
1969	846	87
1970	973	160
1971	1688	195
1972	718	78
Total	4225	520

Annex 4p: Number of tags applied to Atlantic salmon and recoveries by region for the USA.

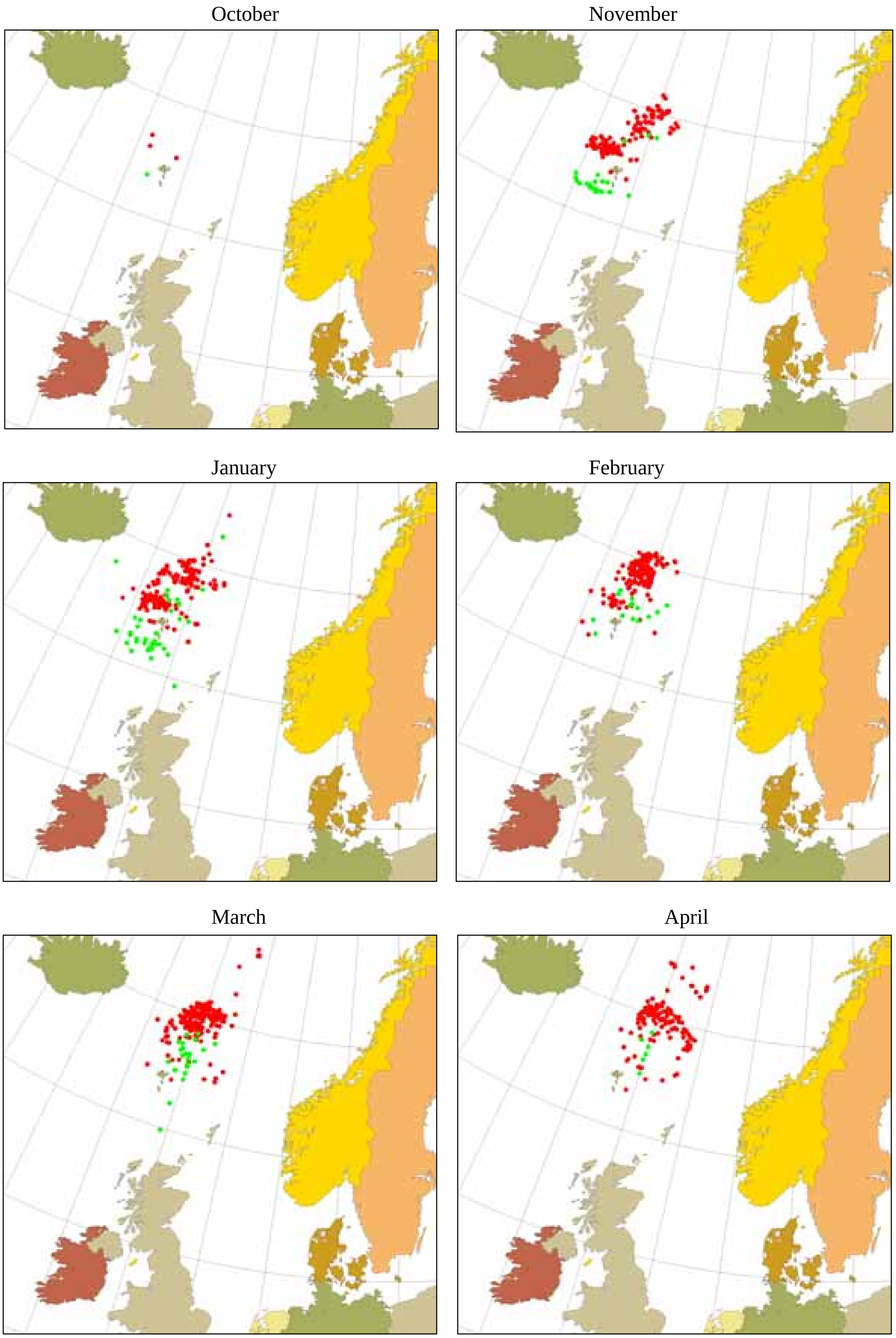
Release location	# released	Greenland	Canada-Maritimes/Quebec	Canada-Newfoundland/Labrador	Faroes	France-St. Pierre et Miquelon	UNK	USA-coastal
Carlin Tags								
Machias	131,019	144	46	97				2
Narraguagus	145,847	140	80	115			1	5
Orland	38,425		23	2			4	3
Penobscot	1,302,154	1,886	235	1,190	1	1		20
Union	31,586	43	5	167				
Saco	73							
St. Croix	28							
Unk		1		20				

	Release location	# released	Greenland	Canada-Maritimes/Quebec	Canada-Newfoundland/Labrador	Faroes	France-St. Pierre et Miquelon	UNK	USA-coastal
CWT									
	Connecticut	3,351,581	37						
	Merrimack	1,511,286	44						
	Narragansett Bay	40,500	1						
	Narraguagus	3,033							
	Penobscot	1,505,263	247						
	Unk				96				
VIE									
	Penobscot	1,264,740	6						
	Dennys	250,000	3						

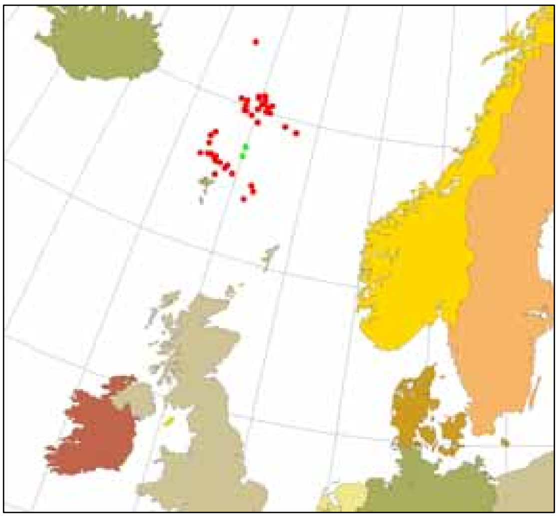
Release location	# released	Greenland	Canada-Maritimes/Quebec	Canada-Newfoundland/Labrador	Faroes	France-St. Pierre et Miquelon	UNK	USA-coastal
Unk		4						
totals	**9,575,535**	**2,556**	**389**	**1,687**	**1**	**1**	**5**	**30**

Annex 5: Tagging localities

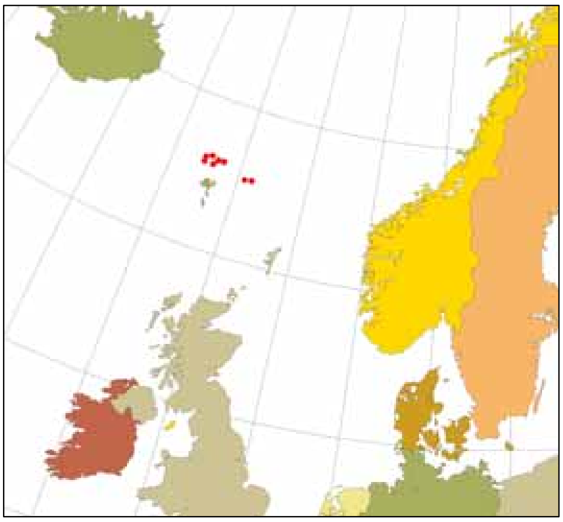
Annex 5a. Geographical distribution of tagged salmon recaptured in the Norwegian Sea by months. Red spots are recaptures of salmon tagged in Norway and green spots are tagged in Ireland.



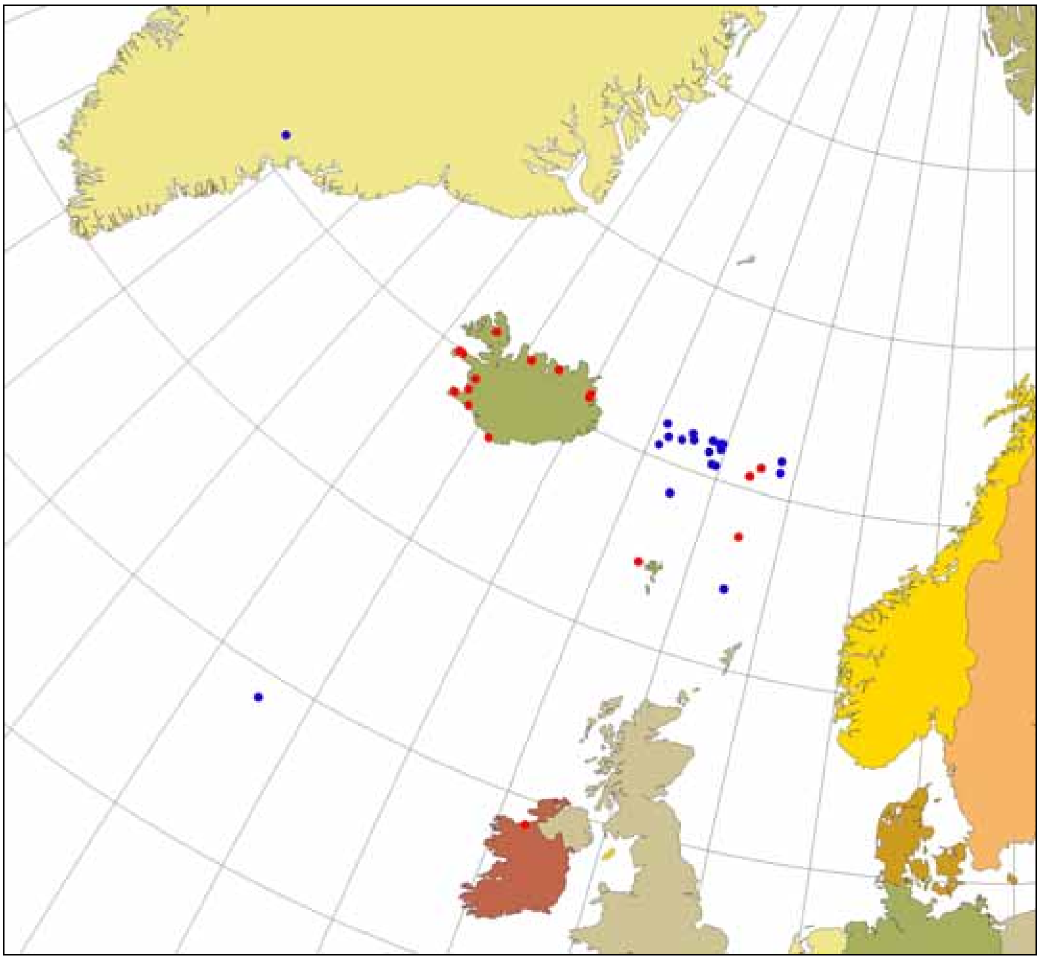
May



June



Annex 5b. Tagging localities in Iceland (red spots) and recapture sites (blue spots).



Annex 5.c. Recapture locations of Carlin tagged salmon released as smolts in US rivers 1963-1988.