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Report of the Workshop on Learning from Salmon Tagging Records (WKLUSTRE)

16–18 September 2009

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Executive summary

The Meeting of the Workshop on Learning from Salmon Tagging Records was held in London, UK, 16–18 September 2009 under the chair of Lars Petter Hansen, Norway. Six scientists participated representing four countries.

The objectives of the Workshop were to: Further develop the international database of marine tagging and tag recovery information for Atlantic salmon; use the database to investigate the distribution of salmon for differences in time and space, and assess changes in the distribution over time; investigate the use of the database to verify outputs from migration models and recommend future salmon tagging studies and investigations of salmon mortality at sea.

The Workshop described and updated the databases and suggested how the Faroese data could be analysed in relation to information from the fisheries.

Analysis of the proportion of recoveries from East Greenland suggested that MSW salmon from Northern Europe have a more easterly distribution that those from southern Europe.

From the Faroese tag recovery database slight reductions in fish size over years were shown but few were significant.

Multivariate analyses of the Faroese tag recovery data suggested that compared to salmon originating from other countries, a higher proportion of Norwegian fish were recovered in the spring, at higher latitudes and longitudes, that they weighed more and had spent a longer time at sea. On the other hand Irish recoveries consisted of smaller individuals which had spent less time at sea and were mainly caught at lower latitudes and longitudes (to the SW) in autumn.

The use of tags demonstrates the potential, particularly advanced electronic tags, to validate migration models, although the scarcity of recaptures in many parts of the ocean clearly limits its use. Furthermore, recent developments of genetic techniques to identify origin of the fish may add further information to validate migration models.

1 Opening of the meeting

The chair opened the Workshop and gave a brief introduction on the background.

2 Adoption of the agenda

The draft agenda was adopted (see Annex 2).

3 Introduction and background

Several initiatives have been taken by NASCO and ICES to improve knowledge about the distribution and migration of salmon at sea, which in turn may help to understand mortality of salmon during their marine phase. In home waters, salmon smolt tagging programmes have been conducted over many years, resulting in large numbers of tags being recaptured in the oceanic fisheries. There have also been adult salmon tagging programmes at sea, both at Greenland and in the Norwegian Sea. The Report of the Workshop on the Development And Use Of Historical Salmon Tagging Information From Oceanic Areas (WKDHUSTI) presented the first results from analyses of historical data on salmon at sea, and proposed a number of recommendations for further work (ICES 2007). This was followed up by a Workshop on Salmon Historical Information – New Investigations from old Tagging Data (WKSHINI) which made significant further progress (ICES 2008). The present report is the result of the third Workshop on the use of historical information (WKLUSTRE) and provides additional information on the distribution of salmon at sea. In 2008 an EU project (SALSEA MERGE) was funded and is expected to provide new and extensive information on salmon ecology and migration at sea.

4 Database updates

4.1 Greenland

The database of tag recoveries derived from fish recaptured in the Greenland fishery prepared by the previous Workshops (WKDUHSTI and WKSHINI) was available to WKLUSTRE . This currently consists of a series of separate worksheets. Most worksheets provide details of fish tagged with external tags originating from individual North Atlantic countries; Canadian data have been further sub-divided and are available for the Maritimes and the Sand Hill River. A separate worksheet includes a collation of all the CWTs recovered at Greenland (1985 to present) for all tagging countries. In addition, a further sheet includes details of the adult salmon tagged at West Greenland as part of the collaborative ICES/ICNAF investigation undertaken in the late 1960s/ early 1970s. The latter includes all the information for 1972, the main tagging year, but only a few entries for earlier years for some fish tagged by Canadian scientists. The whereabouts of the other data is unclear, despite efforts to locate this.

Some further checking of database entries was completed during the Workshop. This included the removal of a small number of duplicate entries and the standardisation of some variables to ensure consistent units and data entry formats were applied. All the NW Atlantic data were also combined into a single sheet. It was noted that there were still gaps in the datasets and also some apparent data entry anomalies. Corrections and queries would need to be addressed by the different agencies originally responsible for the data in order to finalise the database prior to this being stored by ICES or being made publicly available. Where it was not possible to resolve issues during the Workshop, it was agreed that these queries would be followed up with appropriate individuals as soon as possible after the Workshop.

4.2 NE Atlantic

The tagging database for the Northeast Atlantic (Faroese Recovery Database) was developed during the two previous workshops (WKDUHSTI and WKSHINI). The latest database version from 22 September 2008 (2651 records, 2509 with GIS coordinates) holds recovery information from smolt tagging only. A second database (Norwegian Sea Adult Database) holds recovery data from adult tagging experiments at sea (810 recoveries, 627 with GIS coordinates), and was completed during the present WKLUSTRE Workshop. The format of both databases is the same so they can be combined in the future.

4.2.1 The status of the "Faroese Recovery Database"

In an attempt to give an overview of the quality of the data in the smolt tagging database, some selected runs were made to look at various parameters (Table 1). In the interests of consistency the present version of the database from 22 September 2008 was used in all analyses. Some obvious errors in the database were detected, e.g. recapture year being 1900, or some records with for which the recapture date was inconsistent with the sea age. Such errors will be fixed in the future through consultation with different tagging agencies or, if a fix is not available, the record might be deleted. The plan is to update and finalise the database by correspondence over the coming months.

To get an overview of the database contents grouped by country, a series of selections were made to count the various parameters available (Table 1). The intention was to identify if some data were missing from the database or if obvious errors had been incorporated into the data. Table 1 indicates the number of tags recovered per country, those with GIS coordinates (position), those where fork length, weight and sea-age at capture were measured, and the numbers for which stage (e.g. smolt, parr, etc.) and status (i.e. hatchery / wild) at tagging were available.

Table1. Overview of selected contents of the Faroese Recovery Database, grouped by country.

						Type when tagged			Sea age				Life stage when tagged				
Tagging Country	No recaptures	GIS position	Fork Length	Round Wt	Gutted Wt	Un-known	hatchery	wild	Un-known	1SW	2SW	3SW	Un-known	adult	kelt	parr	smolt
USA	1	1	1		1	1					1		1				
Canada	6	5	5	5			4	1	3		1	1					5
Denmark	10	5	4	5			5			1	2	2					5
England&Wales	69	57	54	6	47		31	26	1	13	38	5	11			14	32
Faroes	99	75	75		75	75			5	1	66	3	75				
France	1	1	1		1	1					1		1				
Iceland	27	23	21		21	18	5			5	16	2	18				5
Ireland	158	133	133		133		133			103	30						133
N.Ireland	8	7	7		7	6	1			4	2	1	6				1
Norway	1760	1730	1443		1186	1730				229	1337	164	19				1711
Scotland	135	113	28	1	58	10	8	95	11	21	66	15	11	2	2		98
Spain	1	1	1		1	1				1			1				
Sweden	376	358		44	182		358		2	73	244	39					358
Total	2651	2509	1773	61	1712	1842	545	122	22	451	1804	232	143	2	2	14	2348

4.2.2 The status of the "Norwegian Sea Adult Database"

This database was initiated at the WKSHINI Workshop in 2008 and has now been updated with all available data on adult tagging experiments in the oceanic and coastal areas in the same format as the other databases. A file holding release information corresponding to the recaptures of the adult salmon was added to this database. This should enable proper analysis of unbiased estimates of recovery proportions. The database is still not complete, but contains 600 fish of which 587 have an exact release position. Fork length at tagging is recorded for all 587 fish and fork length at recovery for 513 fish; round weight was recorded for 535 of the recovered fish.

4.2.3 Use of the recapture data

There are several issues with the use of this database. Firstly, the distribution of tag returns depends on the distribution of fishing effort, both temporally and spatially. There is a need to scale the number of tags returned from each area so data represents the true distribution of fish and not just the distribution of fishing effort. Although fishing effort data are available for most of the Faroese fishery it was not possible in the time available to apply these coherently across the dataset and hence they were not used in the present analysis. Secondly, the tags recaptured are not adjusted by the number of fish originally tagged and nor are they adjusted for the relative production of salmon in each country. Thus, for countries which tag only a small proportion of their production, the number of tags in the database may be very low but still represent a large number of salmon in total. In addition, the Faroese fishery has been subject to various management measures over the period, for example shortening of season dates, the introduction of quotas and quota by-outs. Since it was not possible in the time available to standardise data for changes in effort, this inevitably added complexity to the tag return analyses and limited these to only broad general comparisons in the present report.

In the absence of information on the actual numbers of tags that were released from respective areas, it is not possible to scale the recaptures relative to a common denominator. Further, as noted above, a range of other problems exist that could confound interpretation of the results and need to be acknowledged when any analyses are carried out. Analysing data by individual seasons (or months) may address some of these problems, but is often likely to be constrained by the amount of data available in any time interval. Ideally, tag recaptures should be scaled to the numbers of fish caught and take account of catch-per-unit-effort.

4.2.4 Fishery data

CPUE (catch-per-unit effort) data from the Faroese longline fishery are available at the Faroe Marine Research Institute (formerly the Faroese Fisheries Laboratory) for the period since the late 1970s. CPUE data are needed in order to be able to separate potential changes in the distribution of tag recapture rates in various areas from changes in the fishery. As noted above these data have not yet been used in such an analysis.

The Faroese fishery data holds information on catch by numbers and weight, usually grouped into weight classes. The salmon were landed and sold in seven weight classes, with the highest prices paid for the largest salmon. The landings were monitored on shore and were recorded in a landings file. The vessels were obliged to use a logbook to record fisheries information from the daily sets, i.e. number of hooks used and number of salmon caught along with the time and position when the longline was hauled. A database of the fishery data is held by the Faroe Marine Research Institute (Laksabasa) and covers the fishery from the late 1970s to 1991, and the research fishery thereafter up to 2000.

It would therefore be possible to analyse the catch per unit effort (CPUE) as number of salmon caught per 1000 hooks employed by ICES statistical square (½ by 1 degree) and by month (or season if there were too few data disaggregated by month).

To identify the origin of salmon in the Faroese fishery the recapture data should be used, but in addition to that a large number of scale samples were taken from the salmon during observer trips in the fishery. River age and sea age have been read from some of the scales, but not from all samples. The scales are stored at NINA (Norway) and could be read in a future study, and be used to infer the broad region of origin of the fish. A low river age (1 and 2 years) would indicate a southern European origin while higher river ages would indicate a more northern European origin. The scales might potentially also be subjected to genetic analysis at some future date.

A discussion on how to analyse the fishery data in relation to the tag and recovery data revealed that when the recovery proportions are compared, the proportions should ideally be adjusted for number of tags released (by country and year) in addition to the fishing effort when recaptured. The first issue will not be discussed here, since the tag release data are not available (such data are stored in the various tagging agencies, but currently not associated with the recoveries). The second issue on how to "adjust" the recovery proportions will be dealt with below.

There are two ways to adjust the recoveries in a rectangle: a) scale the recoveries to a common CPUE denominator, e.g. recoveries per 1000 hooks employed; or b) use the recovery data as it is, grouped by a suitable regional scale (ICES rectangle, ½ by 1 degree) and then provide CPUE data for the same square and period to see if any major differences were observed in the fishery in terms of catch and effort. If not, then any statements/inferences from the recoveries were not violated due to changes in the fishery. However, it was not possible to undertake such an analysis during the present workshop.

5 Distribution of salmon at sea in relation to hydrographical factors

5.1 Greenland

5.1.1 Adult tagging

The majority of the tag recovery data available in the NW Atlantic database derive from fish tagged as juveniles in various North Atlantic countries; a small number of recaptures also derive from adult fish, including kelts, tagged in homewaters by national tagging agencies. However, the database also includes recapture information for some fish tagged at West Greenland as a part of a collaborative international adult tagging programme undertaken in the fishery itself.

Concerns generated by the rapid growth of the West Greenland salmon fishery in the early 1960s, and the keen scientific interest for further knowledge about salmon during the marine phase, led to a scientific Working Party on North Atlantic Salmon being established in 1965 following the annual meetings of ICES and the International Commission for the Northwest Atlantic Fisheries (ICNAF). The ICES/ICNAF Working Party's most important task was to co-ordinate data collection and research programmes, and a comprehensive report on these joint investigations was published in

1980 (Parrish and Horsted, 1980). This report included summaries of the tag recaptures at West Greenland arising from smolt tagging programmes and confirmed that Atlantic salmon from a number of different rivers in North America and Europe were present in the area (Swain, 1980; Ruggles and Ritter, 1980; Møller Jensen, 1980a). Subsequent analyses based on discriminant analysis of scale characteristics concluded that catches of salmon at West Greenland were split fairly evenly between the two continents (Reddin,1988; Reddin *et al.*, 1988). However, the proportion of salmon originating from Europe has decreased since this time (ICES, 2009).

The adult salmon tagging experiments off West Greenland commenced in 1965 and continued until 1972 (Møller Jensen, 1980b). Details are summarised in Table 2. Full details of the fish recaptured arising from the 1972 tagging programme, the year when by far the most fish were tagged, have been included in the database (most data for earlier years were unavailable). Over all years, 4657 salmon were tagged; 232 fish were subsequently recaptured within the Greenland fishery and 93 fish were recaptured outside Greenland in homewater fisheries. Of the latter, 28 fish were recaptured in North America (all in Canada) and 65 in Europe. The European tags were reported from UK(Scotland) (30), Ireland (16), UK (England & Wales) (14), Spain (3), and France (2). Taking into account the relative production of smolts in these countries, the data indicated that larger proportions of salmon from more southern areas of Europe are present at Greenland than from farther north.

Table 2. Summary of adult salmon tagged at West Greenland as part of the ICES/ICNAF collaborative tagging programme and which were subsequently recaptured (summarised from Møller Jensen, 1980b).

Year	No. salmon tagged	Number of recaptures							Totals	
		Greenland	Canada	Ireland	UK(Scot)	UK(E&W)	France	Spain	N. America	Europe
1965	227	3	1						1	0
1966	729	28	1		3				1	3
1967	375	6	1	2	1				1	3
1968	47	4	1						1	0
1969	444	18	7	2	1	3		1	7	7
1970	224	3	1	1	1				1	2
1971	247	6	4	3		2		1	4	6
1972	2364	164	12	8	24	9	2	1	12	44
Total	4657	232	28	16	30	14	2	3	28	65

Most of the fish recaptured within the West Greenland fishery were caught in the same year that they were tagged (Møller Jensen, 1980b). However, a small proportion was caught in subsequent years. Of the fish tagged in 1972, 164 were subsequently recaptured at West Greenland, 156 in 1972, 7 in 1973 and 1 in 1974. The data indicated that some fish spent two successive seasons at West Greenland, possibly overwintering in the area. No scale samples were available for the one fish recaptured in 1974, so it is not clear whether this was a virgin fish or had returned to home waters to spawn in 1973.

The pattern of recovery of adult salmon recaptured within the Greenland fishery area indicated that fish moved both north and south from the tagging and release area (Møller Jensen, 1980b). For fish tagged in 1972 and recaptured the same year, 71 (46%) were caught to the south of the tagging site, 45 (29%) to the north, with the remainder unknown (no recovery location available).

The 1972 tagging dataset was re-examined with GIS software to derive fish swimming speeds from the latitude and longitude of the tagging and recovery locations and the number of days elapsed between release and recapture. This was completed only for the fish recovered within the West Greenland fishery in the same year in which they were tagged. The average speed for fish recovered to the south of the tagging location was estimated at 0.27 body lengths/second (median 0.13 bls^{-1}, maximum 2.4 bls^{-1}). The average speed for fish recovered to the north of the tagging location was 0.21 body lengths/second (median 0.08 bls^{-1}, maximum 1.3 bls^{-1}).

5.1.2 Tag recaptures at East Greenland

In order to further explore the relative distribution of tag recoveries at both West (NAFO Divisions 1A to 1F) and East Greenland (NAFO Division 9A) for different countries, tag recovery data (external tags and CWTs) were extracted from the North West Atlantic database. Over the entire time series, 4,739 tags were recovered at Greenland, which were also assigned to a recapture location (i.e. NAFO Division). Of these, 4,683 (98.8%) were recovered at West Greenland and just 56 at East Greenland. This is consistent with relatively low fishing effort at East Greenland. The recaptures at East Greenland occurred on an intermittent basis between 1970 and 1999, with a period of above average recaptures in the mid 1980s (Figure 1). With the exception of one CWT, all the recoveries comprised external tags.

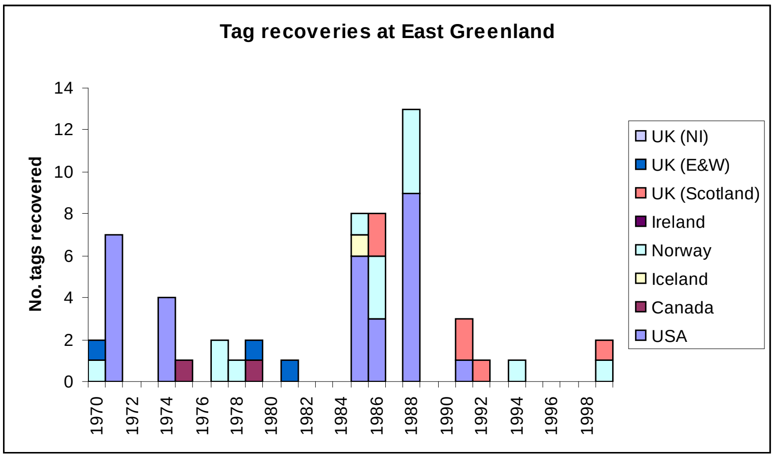


Figure 1. Tags recovered at East Greenland (NAFO Division 9A) by country of origin and year of recapture.

The distribution of tag recoveries at both West and East Greenland, by country of origin, is summarised in Table 3. Recoveries at East Greenland comprised 1.2% of all the records for which recapture location was available. However, the proportional distribution of recoveries was significantly different between countries (chi-square test, $p<0.01$). The proportion of tags recovered at East Greenland was particularly low for fish originating from Canada and Ireland. In contrast, the proportion at East Greenland was well above average for Norwegian and Icelandic fish, although the sample size for Iceland was very small. The European origin MSW salmon exploited at West Greenland mainly originate from southern Europe (Reddin and Friedland, 1999; ICES, 2009). The relatively high proportion of Norwegian fish at East Greenland suggest MSW salmon from northern Europe have a more easterly distribution than those from southern Europe, possibly in the Irminger Sea.

Table 3. Numbers of tags recovered at Greenland for which recapture location (NAFO Division) was specified, by country of origin, and the percentage of all recoveries for each country reported from East Greenland.

	W. Greenland	E. Greenland	Total	% of country recoveries taken at E. Greenland
USA	2128	30	2158	1.4
Canada	1814	2	1816	0.1
Iceland	16	1	17	5.9
Norway	116	14	130	10.8
Ireland	139	0	139	0
UK (Scotland)	273	6	279	2.2
UK (E&W)	195	3	198	1.5
UK (NI)	2	0	2	0
Total	4683	56	4739	1.2

5.2 NE Atlantic

5.2.1 Recaptures of salmon tagged as smolts

Fork lengths

Fork lengths of salmon in the Faroes tag recovery database were extracted. In total 1812 entries were present covering the time period 1966 to 1998. Of the fork lengths 345 were for 1SW fish, 1305 for 2SW fish and 162 for 3SW fish. Catches were divided by sea age and catch season classified as "Autumn" (October to December) and "Winter" (January to September) and compared against catch year to examine variation with time.

Comparing recaptures from all countries together, Autumn and Winter caught 1SW and 2SW fish showed a very slight reduction in length over the years. While only one of these correlations was significant (Winter catch of 1SW fish; Table 5), all showed significant differences in lengths over the years according to Kruskal-Wallis tests of median lengths (Table 4 to 7).

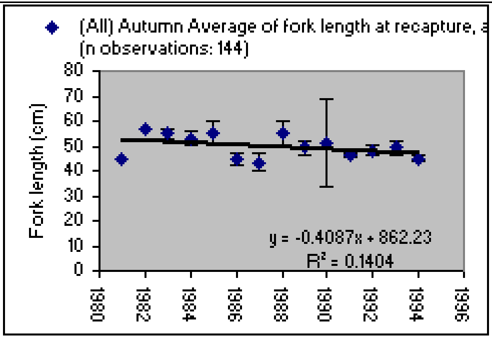
For 3SW Autumn fish a slightly positive trend was suggested by the data, although neither the correlation or differences in length with years were significant (Table 8). Winter caught 3SW fish exhibited no apparent change in length over time (no significant correlation or differences in length with year; Table 9).

A similar mix of results was shown when the data were split by country of origin. In many instances there were too few data for meaningful analysis and tests were not appropriate. Those where sufficient data existed are summarised in Table 10. In the majority of cases fork length showed a reduction with time, however in only a few instances where the correlations and/ or Kruskal-Wallis results found to be significant. Fish from Norway showed some instances of significant decreases in fish length over the time series: 1SW fish caught in winter and 2SW fish caught in autumn and winter. 1SW fish from Ireland, caught in both autumn and winter, also showed significant differences in length.

While most relationships are negative, with fish becoming shorter over the years, there are instances of positive relationships. Notable examples include Swedish winter caught 2SW fish; Norwegian autumn caught 3SW fish and; Irish autumn caught 2SW fish.

Table 4. Correlation of fork length on year during the autumn (Oct–Dec) fishery, 1 SW fish.

All tagging locations Autumn catch sea age 1 year



Pearson Correlation coefficient

All tagging locations Autumn Average of fork length at recapture, at sea age 1 (n observations: 144)

Pearson's r	-0.375	weak correlation	
r^2	0.140	(coef of determination)	
	0.860	proportion variation not explained by year	
N	14		H0: $\rho = 0.00$
Df	12		H1: $\rho > 0.00$
Critical value	0.53		
Since	0.375	<	0.53
the correlation is	not significant	accept	H0 at p0.05

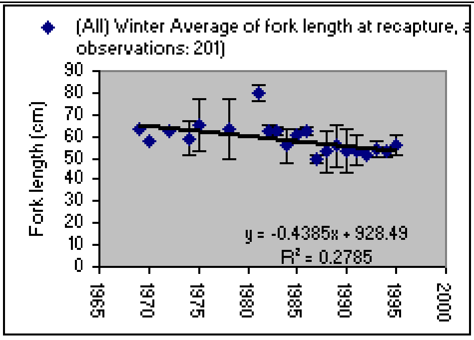
Kruskal-Wallis comparison of median fork lengths across catch years

All tagging locations Autumn Average of fork length at recapture, at sea age 1 (n observations: 144)

Number of years fork length data:	14
H	39.404
adjusted H:	39.698
d.f.:	13
p value:	0.000
Critical value at p=0.01:	27.69
Significant differences at p=0.01:	

Table 5. Correlation of fork length on year during the winter (Jan–Sep) fishery, 1 SW fish.

All tagging locations	Winter catch	sea age 1 year



Pearson Correlation coefficient

All tagging locations Winter Average of fork length at recapture, at sea age 1 (n observations: 201)

Pearson's r	-0.528	modest correlation	
r^2	0.279	(coef of determination)	
	0.721	proportion variation not explained by year	
n	21		H0: ρ = 0.00
df	19		H1: ρ > 0.00
Critical value	0.43		
Since	0.528	>	0.43
the correlation is	Significant	reject	H0 at p0.05

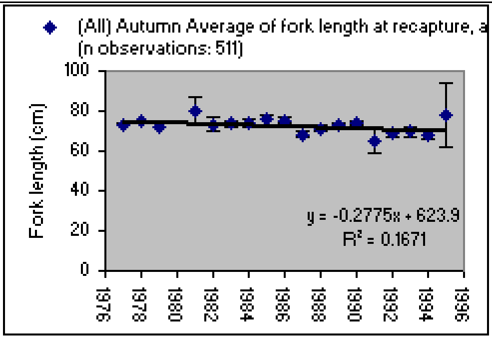
Kruskal-Wallis comparison of median fork lengths across catch years

All tagging locations Winter Average of fork length at recapture, at sea age 1 (n observations: 201)

Number of years fork length data:	21
H	67.582
adjusted H:	67.847
d.f.:	19
p value:	0.000
Critical value at p=0.01:	36.19
Significant differences at p=0.01:	

Table 6. Correlation of fork length on year during the autumn (Oct–Dec) fishery, 2 SW fish.

All tagging locations Autumn catch sea age 2 year

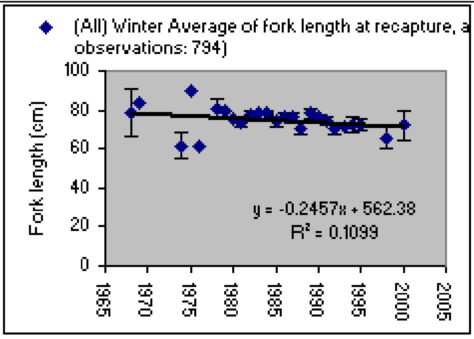


Pearson Correlation coefficient **All tagging locations Autumn Average of fork length at recapture, at sea age 2 (n observations: 511)**					
Pearson's r	-0.409	modest correlation			
r^2	0.167	(coef of determination)			
	0.833	proportion variation not explained by year			
N	18		H0: ρ	=	0.00
Df	16		H1: ρ	>	0.00
Critical value	0.47				
Since	0.409	<	0.47		
the correlation is	not significant	accept	H0 at	p	0.05

Kruskal-Wallis comparison of median fork lengths across catch years **All tagging locations Autumn Average of fork length at recapture, at sea age 2 (n observations: 511)**	
Number of years fork length data:	18
H	98.505
adjusted H:	98.799
d.f.:	17
p value:	0.000
Critical value at p=0.01:	33.41
Significant differences at p=0.01:	

Table 7. Correlation of fork length on year during the winter (Jan–Sep) fishery, 2 SW fish.

All tagging locations	Winter catch	sea age 2 year



Pearson Correlation coefficient

All tagging locations Winter Average of fork length at recapture, at sea age 2 (n observations: 794)

Pearson's r	-0.331	weak correlation	
r^2	0.110	(coef of determination)	
	0.890	proportion variation not explained by year	
n	25		H0: ρ = 0.00
df	23		H1: ρ > 0.00
Critical value	0.40		
Since	0.331	<	0.40
the correlation is	not significant	accept H0 at	p 0.05

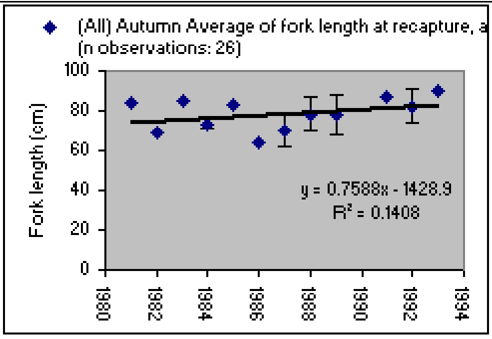
Kruskal-Wallis comparison of median fork lengths across catch years

All tagging locations Winter Average of fork length at recapture, at sea age 2 (n observations: 794)

Number of years fork length data:	25
H	66.702
adjusted H:	66.904
d.f.:	19
p value:	0.000
Critical value at p=0.01:	36.19
Significant differences at p=0.01:	

Table 8. Correlation of fork length on year during the autumn (Oct–Dec) fishery, 3 SW fish.

All tagging locations	Autumn catch	sea age 3 year



Pearson Correlation coefficient

All tagging locations Autumn Average of fork length at recapture, at sea age 3 (n observations: 26)

Pearson's r	0.375	weak correlation			
r^2	0.141	(coef of determination)			
	0.859	proportion variation not explained by year			
N	12		H0: ρ	=	0.00
Df	10		H1: ρ	>	0.00
Critical value	0.58				
Since	0.375	<	0.58		
the correlation is	not significant	accept	H0 at	p	0.05

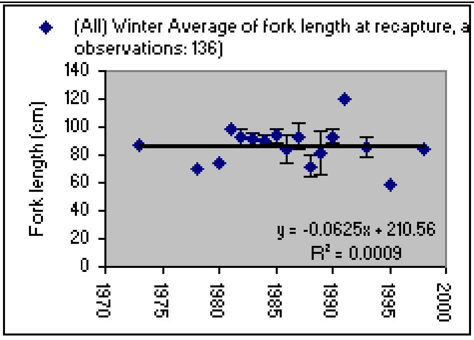
Kruskal-Wallis comparison of median fork lengths across catch years

All tagging locations Autumn Average of fork length at recapture, at sea age 3 (n observations: 26)

Number of years fork length data:	12
H	11.415
adjusted H:	11.435
d.f.:	11
p value:	0.408
Critical value at p=0.05:	19.68
No significant differences	

Table 9. Correlation of fork length on year during the winter (Jan–Sep) fishery, 3 SW fish.

All tagging locations Winter catch sea age 3 year



Pearson Correlation coefficient

All tagging locations Winter Average of fork length at recapture, at sea age 3 (n observations: 136)

Pearson's r	-0.030	very weak correlation			
r^2	0.001	(coef of determination)			
	0.999	proportion variation not explained by year			
n	17		H0: ρ	=	0.00
df	15		H1: ρ	>	0.00
Critical value	0.48				
Since	0.030	<	0.48		
the correlation is	not significant	accept	H0 at	p	0.05

Kruskal-Wallis comparison of median fork lengths across catch years

All tagging locations Winter Average of fork length at recapture, at sea age 3 (n observations: 136)

Number of years fork length data:	17
H	26.055
adjusted H:	26.097
d.f.:	16
p value:	0.053
Critical value at p=0.05:	26.30
No significant differences	

Table 10. Summary correlation and Kruskal-Wallis statistics comparing fork length with year, by country of origin and sea-age at recapture (Significant instances highlighted in bold)

Country	Catch season	Sea age (years)	Correlation (Pearsons *r*)	n	Significance	Kruskal-Wallis H (adjusted)	Significance	No. years
Sweden	Autumn	1	-0.721	3	not sig.	N/A	N/A	N/A
Sweden	Winter	1	-0.399	7	not sig.	N/A	N/A	N/A
Sweden	Autumn	2	-0.876	21	not sig	7.188	No sig. differences	5
Sweden	Winter	2	*0.760*	*20*	*Sig at p 0.05*	8.710	No sig. differences	9
Scotland	Autumn	1	-0.871	4	not sig.	N/A	N/A	N/A
Scotland	Winter	1	-0.896	6	not sig.	N/A	N/A	N/A
Scotland	Autumn	2	-0.358	10	not sig.	7.868	No sig. differences	5
Norway	Autumn	1	0.004	12	not sig.	13.551	No sig. differences	12
Norway	Winter	1	*-0.471*	*153*	*Sig. at p 0.05*	*43.729*	*Sig. diff. at p 0.01*	19
Norway	Autumn	2	*-0.593*	*384*	*Sig. at p 0.05*	*71.143*	*Sig. diff. at p 0.01*	17
Norway	Winter	2	*-0.513*	*717*	*Sig. at p 0.05*	*85.424*	*Sig. diff. at p 0.01*	24
Norway	Autumn	3	0.535	16	not sig.	8.349	No sig. differences	11
Norway	Winter	3	-0.027	129	not sig.	25.412	No sig. differences	17
Ireland	Autumn	1	-0.414	77	not sig.	*29.505*	*Sig. diff. at p 0.01*	11
Ireland	Winter	1	-0.395	25	not sig.	*17.884*	*Sig. diff. at p 0.05*	8
Ireland	Autumn	2	0.475	18	not sig.	9.008	No sig. differences	9
Ireland	Winter	2	-0.283	11	not sig.	2.407	No sig. differences	11
Iceland	Autumn	2	0.004	13	not sig.	6.284	No sig. differences	5
Iceland	Winter	2	-0.973	3	not sig.	N/A	N/A	N/A
Faroes	Autumn	2	0.254	40	not sig.	*20.112*	*Sig. diff. at p 0.01*	4
Faroes	Winter	2	0.330	25	not sig.	4.412	No sig. differences	5
England & Wales	Autumn	1	0.534	10	not sig.	2.741	No sig. differences	5
England & Wales	Winter	1	-0.854	4	not sig.	N/A	N/A	N/A
England & Wales	Autumn	2	-0.585	21	not sig.	10.913	No sig. differences	9
England & Wales	Winter	2	-0.501	14	not sig.	5.633	No sig. differences	8
England & Wales	Autumn	3	0.923	3	not sig.	N/A	N/A	N/A

Gutted weight

Gutted weights were extracted from the Faroes data set. Of the 1502 data entries 276 were from 1SW fish, 1089 from 2SW fish and 137 3SW fish. Changes in weight were examined with time, based upon sea age of fish and catch season classified as "Autumn" (October to December) and "Winter" (January to September).

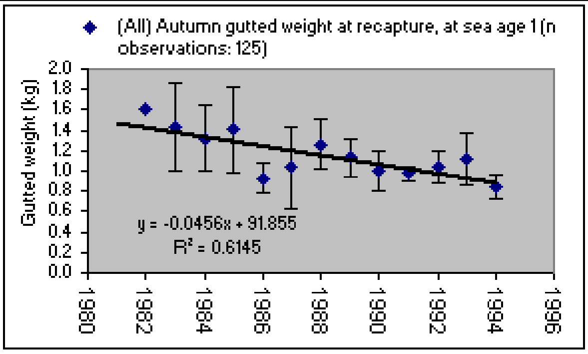
The apparent trend across all countries, sea ages and catch seasons was negative, with weight reducing over time (Table 11 to 16) with the exception of autumn 3SW catch where a positive relationship was apparent. Kruskal-Wallis tests found significant differences (at p 0.01) in weight with time for all sea-age/season groups, except for the autumn and winter catches of 3SW fish.

Data gaps prevent exploration of gutted weights for all tagging countries, catch seasons and sea-age classes. Instances where sufficient data were available are detailed in Table 17. Most trends and differences in gutted weights are not significant, though generally correlations are negative with gutted weight reducing over time. There are four instances where positive trends (increases in weight) are apparent: Norwegian autumn caught 3SW fish; Irish autumn caught 2SW fish and; Faroes autumn and winter caught 2SW fish.

Significant differences in weight over time are apparent for Norwegian winter caught 1SW fish, and autumn and winter caught 2SW fish. Irish autumn and winter caught 1SW fish also showed significant differences.

Table 11. Correlation of gutted weight on year during the autumn (Oct–Dec) fishery, 1 SW fish.

All tagging Countries	Autumn catch	sea age 1 year

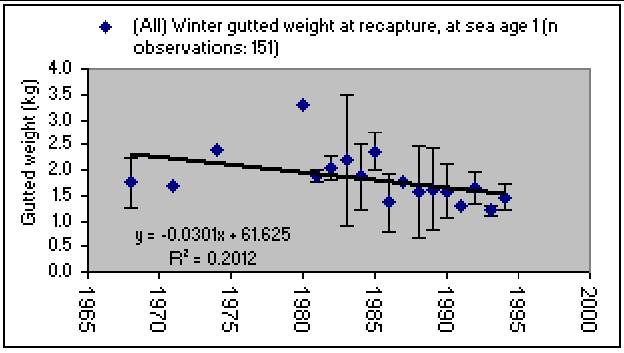


Pearson Correlation coefficient					
All tagging Countries Autumn gutted weight at recapture, at sea age 1 (n observations: 125)					
Pearson's r	-0.78	strong correlation			
r^2	0.61	(coef of determination)			
	0.39	prop variation not explained by year			
N	13.00	H0: ρ	=	0.00	
Df	11.00	H1: ρ	>	0.00	
Critical value	0.55				
Since	0.78	>	0.55		
the correlation is	significant	reject	H0 at	p	0.05

Kruskal-Wallis comparison of median fork lengths across catch years	
All tagging Countries Autumn gutted weight at recapture, at sea age 1 (n observations: 125)	
Number of years fork length data:	13.00
H	25.93
adjusted H:	26.42
d.f.:	12.00
p value:	0.01
Critical value at p=0.01:	26.22
Significant differences at p=0.01:	

Table 12. Correlation of gutted weight on year during the winter (Jan–Sep) fishery, 1 SW fish.

All tagging Countries Winter catch sea age 1 year

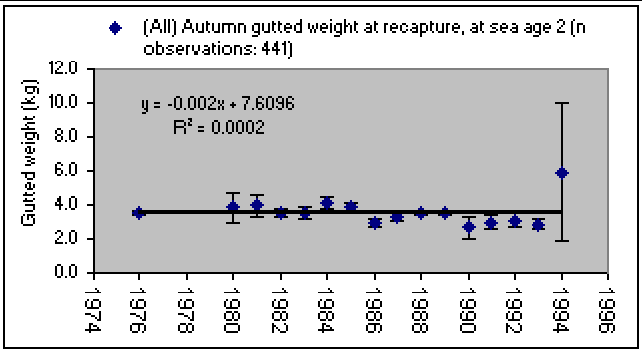


Pearson Correlation coefficient				
All tagging Countries Winter gutted weight at recapture, at sea age 1 (n observations: 151)				
Pearson's r	-0.45	modest correlation		
r^2	0.20	(coef of determination)		
	0.80	prop variation not explained by year		
N	18.00	H0: ρ	=	0.00
Df	16.00	H1: ρ	>	0.00
Critical value	0.47			
Since	0.45	<	0.47	
the correlation is	not significant	accept	H0 at p	0.05

Kruskal-Wallis comparison of median fork lengths across catch years	
All tagging Countries Winter gutted weight at recapture, at sea age 1 (n observations: 151)	
Number of years fork length data:	18.00
H	90.55
adjusted H:	90.68
d.f.:	16.00
p value:	0.00
Critical value at p=0.01:	32.00
Significant differences at p=0.01:	

Table 13. Correlation of gutted weight on year during the autumn (Oct–Dec) fishery, 2 SW fish.

All tagging Countries	Autumn catch	sea age 2 year



Pearson Correlation coefficient

All tagging Countries Autumn gutted weight at recapture, at sea age 2 (n observations: 441)

Pearson's r	-0.01	very weak correlation		
r^2	0.00	(coef of determination)		
	1.00	prop variation not explained by year		
n	16.00	H0: ρ	=	0.00
df	14.00	H1: ρ	>	0.00
Critical value	0.50			
Since	0.01	<	0.50	
the correlation is	not significant	accept	H0 at	p 0.05

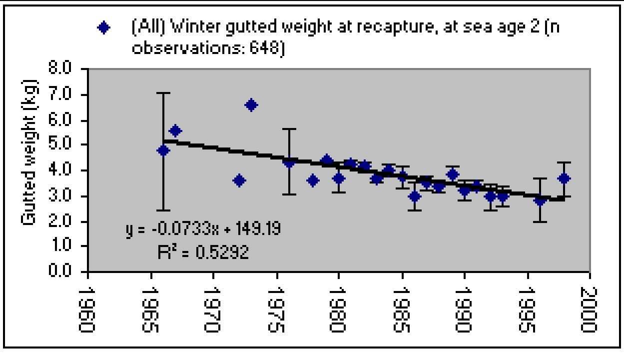
Kruskal-Wallis comparison of median fork lengths across catch years

All tagging Countries Autumn gutted weight at recapture, at sea age 2 (n observations: 441)

Number of years fork length data:	16.00
H	65.86
adjusted H:	65.92
d.f.:	15.00
p value:	0.00
Critical value at p=0.01:	30.58
Significant differences at p=0.01:	

Table 14. Correlation of gutted weight on year during the winter (Jan–Sep) fishery, 2 SW fish.

All tagging Countries Winter catch sea age 2 year



Pearson Correlation coefficient

All tagging Countries Winter gutted weight at recapture, at sea age 2 (n observations: 648)

Pearson's r	-0.73	strong correlation			
r^2	0.53	(coef of determination)			
	0.47	prop variation not explained by year			
n	23.00	H0: ρ	=	0.00	
df	21.00	H1: ρ	>	0.00	
Critical value	0.41				
Since	0.73	>	0.41		
the correlation is	significant	reject	H0 at	p	0.05

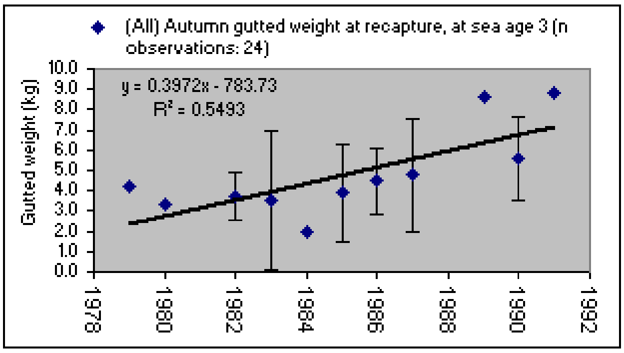
Kruskal-Wallis comparison of median fork lengths across catch years

All tagging Countries Winter gutted weight at recapture, at sea age 2 (n observations: 648)

Number of years fork length data:	23.00
H	924.49
adjusted H:	925.76
d.f.:	17.00
p value:	0.00
Critical value at p=0.01:	33.41
Significant differences at p=0.01:	

Table 15. Correlation of gutted weight on year during the autumn (Oct–Dec) fishery, 3 SW fish.

All tagging Countries Autumn catch sea age 3 year



Pearson Correlation coefficient

(All) Autumn gutted weight at recapture, at sea age 3 (n observations: 24)

Pearson's r	0.74	strong correlation		
r^2	0.55	(coef of determination)		
	0.45	prop variation not explained by year		
n	11.00	H0: ρ	=	0.00
df	9.00	H1: ρ	>	0.00
Critical value	0.60			
Since	0.74	>	0.60	
the correlation is	significant	reject	H0 at	p 0.05

Kruskal-Wallis comparison of median fork lengths across catch years

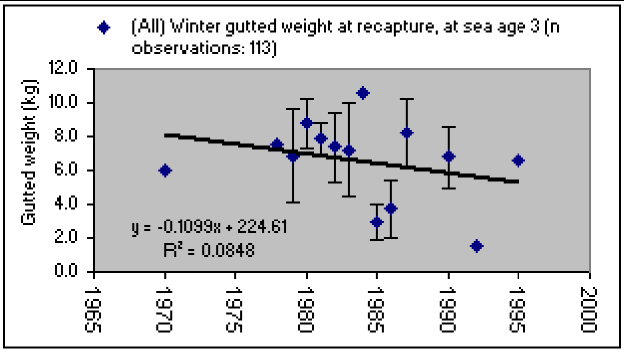
(All) Autumn gutted weight at recapture, at sea age 3 (n observations: 24)

Number of years fork length data:	11.00
H	9.30
adjusted H:	9.32
d.f.:	10.00
p value:	0.50
Critical value at p=0.05:	18.31

No significant differences

Table 16. Correlation of gutted weight on year during the winter (Jan–Sep) fishery, 3 SW fish.

All tagging Countries Winter catch sea age 3 year



Pearson Correlation coefficient **All tagging Countries Winter gutted weight at recapture, at sea age 3 (n observations: 113)**				
Pearson's r	-0.29	weak correlation		
r^2	0.08	(coef of determination)		
	0.92	prop variation not explained by year		
N	14.00	H0: ρ	=	0.00
Df	12.00	H1: ρ	>	0.00
Critical value	0.53			
Since	0.29	<	0.53	
the correlation is	not significant	accept	H0 at p	0.05

Kruskal-Wallis comparison of median fork lengths across catch years **All tagging Countries Winter gutted weight at recapture, at sea age 3 (n observations: 113)**	
Number of years fork length data:	14.00
H	14.47
adjusted H:	14.47
d.f.:	13.00
p value:	0.34
Critical value at p=0.05:	22.36
No significant differences	

Table 17. Summary correlation and Kruskal-Wallis statistics comparing gutted weight with year, by country of origin and sea-age at recapture. (Significant instances highlighted in bold)

Country	Catch season	Sea age (years)	Correlation (Pearsons *r*)	n	Significance	Kruskal-Wallis H (adjusted)	Significance	No. years
Sweden	Autumn	1	0.50	4	not significant	N/A	N/A	N/A
Sweden	Autumn	2	-0.62	21	not significant	5.57	No sig. differences	5
Sweden	Winter	2	-0.23	16	not significant	5.56	No sig. differences	7
Scotland	Winter	1	-0.91	5	not significant	N/A	N/A	N/A
Scotland	Autumn	2	-0.14	9	not significant	7.50	No sig. differences	5
Norway	Autumn	1	-0.29	33	not significant	7.73	No sig. differences	11
Norway	Winter	1	-0.20	111	not significant	*41.51*	*Sig. diff. at p 0.01*	17
Norway	Autumn	2	-0.46	322	not significant	*48.39*	*Sig. diff. at p 0.01*	15
Norway	Winter	2	*-0.70*	*579*	*Sig. at p 0.05*	*450.68*	*Sig. diff. at p 0.01*	*23*
Norway	Autumn	3	*0.87*	*15*	*Sig. at p 0.05*	7.04	No sig. differences	10
Norway	Winter	3	-0.29	107	not significant	12.98	No sig. differences	14
Ireland	Autumn	1	-0.53	71	not significant	*25.83*	*Sig. diff. at p 0.01*	11
Ireland	Winter	1	-0.44	25	not significant	*15.46*	*Sig. diff. at p 0.05*	8
Ireland	Autumn	2	0.50	16	not significant	6.46	No sig. differences	8
Ireland	Winter	2	-0.38	9	not significant	0.93	No sig. differences	6
Iceland	Autumn	2	-0.06	12	not significant	7.52	No sig. differences	5
Faroes	Autumn	2	0.35	39	not significant	*15.04*	*Sig. diff. at p 0.01*	4
Faroes	Winter	2	0.49	25	not significant	5.92	No sig. differences	5
England & Wales	Autumn	1	-0.42	10	not significant	7.93	No sig. differences	5
England & Wales	Autumn	2	-0.38	18	not significant	7.19	No sig. differences	7
England & Wales	Winter	2	0.02	13	not significant	6.34	No sig. differences	13

Multivariate analyses of the Faroes tag recovery data set

The basic sources of data for this analysis were the Faroes recovery data consisting of latitude and longitude positions of tag recaptures (classed by the country of origin as 'dummy variables'), gutted weight (kg) of the salmon recaptured, its sea age, whether it was recaptured during autumn (October to December) or at winter (January to September) and the year of recapture. No hydrographical variables like sea temperature or sea currents were included in this preliminary analysis. The original data set consisting of 2651 recaptures was reduced to 1730 by deleting rows (recaptures) with poor data quality or missing values for some variables.

Principal component analysis was performed on the matrix according to ter Braak and Prentice (1988) using CANOCO v. 4.5 (ter Braak and Smilauer 2002). PCA was run on the correlation matrix of centred, standardized, and transformed variables using correlation biplot scaling of the PCA axes. Skewness and kurtosis were standardized for all predictor variables by dividing by their expected deviations, estimated as $(6/n) \times 0.5$ (Sokal and Rohlf 1995). Homogeneity of variance (homoscedasticity) was achieved by transforming all variables to zero skewness.

The first PCA axis accounted for 72.5% of observed variance in variables (Figure 2). The variable 'year of recovery' gave high negative loadings on PCA1; while the other variables showed less correlation with this axis (length of vectors indicates correlation strength to the axis). Consequently, PCA1 can only be interpreted as an annual gradient that has very limited relationship with the other variables. In other words, other variables in this data set show only modest temporal variability. Variables such as recapture rates from different countries, gutted weight, and sea age have not changed much over the period 1968–2000.

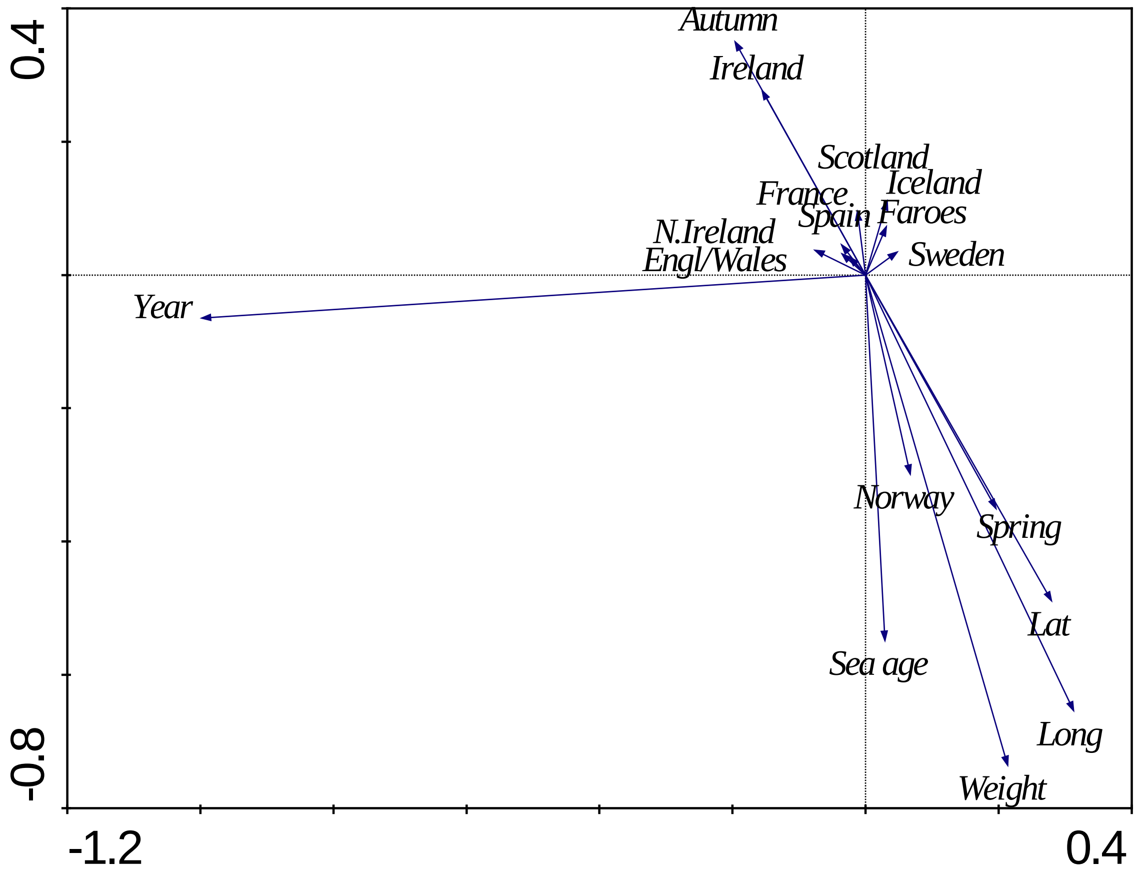


Figure 2. PCA variable loadings, axes 1 and 2. Data set including the variable "year of tag recovery".

The PCA, excluding the 'year of recovery' variable, accounted for 82.2% of observed variance in variables along the two first axes (Figure 3). Some variables showed considerable variation along both axes. Gutted weight and sea age vectors point in the same direction, meaning they are highly inter-correlated. The longitude and latitude vectors point in a direction that is almost 90 degrees different from weight and sea-age, meaning that these two groups of variables are almost uncorrelated. Thus, there is no indication of fish having larger sizes or higher sea-ages in some recovery areas than others.

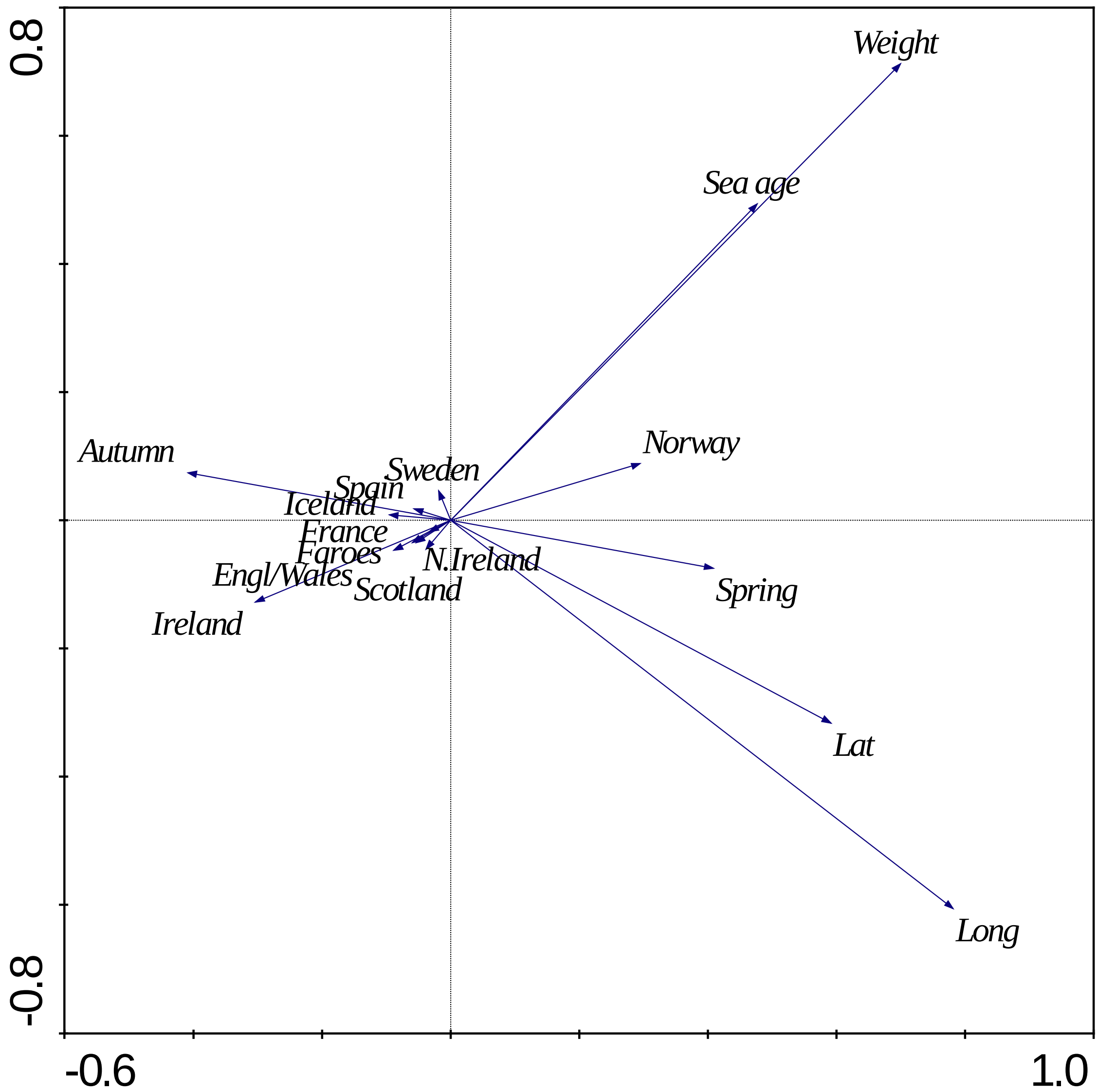


Figure 3. PCA variable loadings, axes 1 and 2. Data set excluding the variable 'year of tag recovery'.

The recoveries in autumn versus winter vectors point in separate directions along PCA1. The spring recovery vector points in the same direction as both sea-age and weight but also longitude and latitude, meaning that larger individuals (with higher sea-ages as well) are recovered during spring, and that these recoveries are at higher latitudes and longitudes (i.e. to the NE). The opposite situation occurs in autumn,

The pattern of recoveries of Norwegian fish was most distinct from those originating in other countries, pointing close to the spring vector discussed above. A higher proportion of Norwegian fish is thus recovered at spring, at higher latitudes and longitudes, and they weigh more and have spent a longer time at sea. Irish recoveries, with the vector pointing in the opposite direction, consist of smaller individuals which have spent less time at sea, mainly caught at lower latitudes and longitudes (to the SW) and in autumn. Other countries have shorter vectors in the PCA diagram and thus show less clear trends according to for example sea-age, recapture position and time of recapture. Thus, Norwegian and Irish fish are the most dissimilar. The other countries are more similar to Ireland, with the possible exception of the Swedish fish.

Multivariate analyses like PCA are mathematical tools for finding structures in large data sets and databases. PCA, which is an indirect ordination method (ter Braak and Smilauer 2002), does not provide any test for statistical significance for observed patterns or gradients, but is merely a hypothesis generating method. The relationships discovered and discussed above might thus be focused on in another setting and analysed with other statistical tools for significance if desired.

5.2.2 Recaptures of adult tagging

Multivariate analyses of the adult tagging data set

The PCA (Figure 4) of the adult tagging data set from Norway (518 records) shows that adult fish released north of 69 degrees north are likely to go further north (both variables have positive loadings along the second axis). The opposite is observed for the fish released south of 69 degrees latitude. Those individuals that are released late are also more likely to go south (but more fish seem to be released further south later). Individuals that went north travelled longer distances (not shown) but also travel with increased speed. Recovery weights increased with sea residence and growth (highly correlated with PCA 1). While these analyses provide useful preliminary results, further analyses and interpretation needs to be performed on this data set.

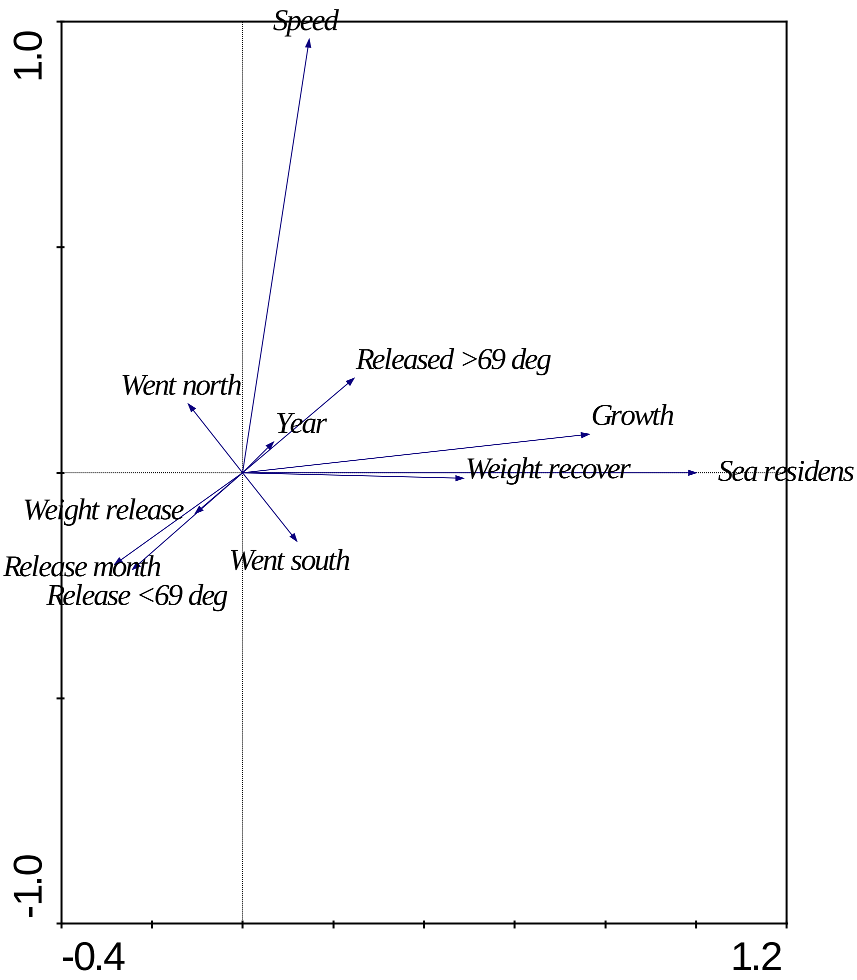


Figure 4 PCA variable loadings, axes 1 and 2

6 Verification of outputs to migration models

The Workshop was requested to investigate the use of the tagging database to verify the outputs from salmon migration models. There is only a relatively small published literature relating to modelling of Atlantic salmon movements in the sea, and these publications principally relate to factors affecting the distribution and mortality of salmon which do not require tagging data to validate them. The group was aware of only three migration models - i.e. models that attempt to account for the migration routes of individual or groups of fish - for Atlantic salmon. One model is currently under development as part of the EU-SALSEA-MERGE project and was not available to the Workshop.

A second model had been developed by Kevin Friedland and reported by the ICES Working Group on North Atlantic Salmon (ICES, 1994), although it has not been published in the scientific literature. The model simulated the movement of individual fish for the whole of the marine phase through sea surface temperature and surface current fields of the North Atlantic. The model is presented with a set of initial conditions and with three parameters that control swimming and orientation; a scalar that increases or decreases the amount of swimming done each month at liberty; a scalar that influences the effect of temperature on migration; and a scalar that influences the effect of currents on migration. In addition to these fixed parameters is a series of month-at-liberty parameters used to define the behaviour of the fish for each month at sea. These address: the mean water temperature sought by the fish, with its standard deviation; the number of kilometres swum per month, based on swimming speed at the rate of 0.25 body lengths per sec, which can be scaled so that model scenarios of various swimming speeds can be evaluated; and a factor that influences the east-west orientation of the fish. The model is capable of performing simulations in a time series mode. In this mode, the model is run sequentially with sea surface temperature data for the North Atlantic for the years 1946 to 1992. The variation in model output over time can be examined.

ICES (1994) presents some preliminary results from the model and notes that the simulation outputs could be validated by comparison to the known patterns of stock behaviour. Behaviour at the beginning and end of the migration can be inferred by migration timing of both smolts and spawners, ocean fisheries provide information of the movement of large stock groups, and tagging studies provide information on the movement of individual stocks. However, tag data were not used to validate the preliminary results, and the Workshop was not aware of any later publications relating to this model.

The third model, described by Booker *et al. (*2008), simulated trajectories of salmon post-smolts in the ocean using surface currents and temperature as boundary conditions and used tag data to assess the outputs. Migration trajectories were calculated over a series of time steps using three different direction-finding mechanisms (random swimming, rheotaxis and thermotaxis) overlaid on the residual currents. For the rheotaxis simulation, swimming direction was equal to the current direction, and for the thermotaxis simulation, swimming direction was dependent upon local temperature gradients such that the fish attempted to find and remain within a temperature range of 4–8degC (Reddin *et al.*, 2000). Post-smolts were given a standard swimming speed of 0.2 ms^{-1} and other simple constraints were placed in the model (e.g. fish could not travel over land). One hundred trajectories were then simulated for each of 15 post smolts that had been tagged in Irish rivers and recaptured off the west coast of Scotland within a few weeks. Overall, the closest correspondence between calculated trajectories and observed recapture positions was obtained with the rheotaxis model, but it is evident that the model correspondence was likely to break down quite quickly for longer migration trajectories. Unfortunately previous contact with the authors of this work has indicated that this model is no longer available for further development.

There are a number of phases in the ocean migration of Atlantic salmon which are related to changes in navigational behaviour, and the Workshop considered that models might usefully be developed for three different stages of the marine phase: post-smolt migration from rivers of origin and through continental shelf water; adult migration in the open ocean; and return migration from oceanic areas to the rivers of origin. Navigation close to river systems has been related to sensory cues such as olfaction that ensure river specific homing, while the transoceanic migration that salmon accomplish is likely to be related to a more complex set of navigational cues.

The work described above clearly demonstrates the potential for using tag release and recovery data to validate migration models, although the scarcity of recaptures in many parts of the ocean clearly limits its use. In addition, the fact that tag recoveries are nearly all obtained from areas where fisheries have been permitted to operate means that they may provide a biased picture of the movements of the whole population. Tag data must therefore be used with great care for model validation purposes.

The recent development of genetic techniques to identify the origin of salmon in mixed stocks is promising as been shown in Ireland (Dillane *et al.*, 2007). The EU project SALSEA-MERGE is presently testing the potential of this method.

The Workshop recommended that further work be carried out to improve and develop predictive models of annual migration and distribution and noted that it is important that the tag database be made available to scientists developing such models in accordance with the publication schedule discussed in section 8.

7 Future tagging studies

The Workshop considered the future use of tagging studies to investigate migration patterns and mortality. As indicated previously, the use of conventional tagging studies to investigate fish movements and distribution at sea is constrained by the location and size of the fisheries in which tags may be recovered. The significant reduction in salmon fisheries in recent years, both in distant and home waters, has thus greatly reduced the potential for undertaking tagging studies for this purpose. The only fishery for Atlantic salmon operating outside home waters is currently the small subsistence fishery at west Greenland. In home waters, many coastal fisheries which previously intercepted fish on their return migration to neighbouring countries have been closed or greatly reduced. As a result, both smolt tagging in rivers and adult tagging at sea may be expected to generate far fewer tag recoveries than in the past, and these will come from more limited areas. Given that the small number of recoveries has been a significant constraint to the analyses discussed in this report, it is therefore unlikely that conventional tagging will be a suitable approach for investigating salmon movements in most circumstances in the future. This means that it will also be difficult to use such tagging studies to compare the pattern of movements of salmon in the future with results observed in the past to see whether they have changed as a result of changing climatic factors.

It has been suggested that smolt tagging programmes could be co-ordinated with marine surveys for post-smolts and adults to investigate salmon migratory patterns. However, relatively few tags have been recovered from the marine surveys for post-smolts that have been conducted to date. As a result, this is not considered to be a practical way to compare the movements and distribution of fish from a number of stocks in most circumstances, unless the number of smolts tagged is considerably increased, because of the difficulty of obtaining sufficient recoveries to make statistically significant comparisons. One exception may be studies of post-smolt movements in the first few days and weeks after the fish leave freshwater. Such work has successfully been conducted in USA, Norway and Ireland where it has been possible to direct surveys to areas where fish are likely to be present at this time.

Smolt or parr tagging (with external tags or CWTs) still provides a sound method for studying growth and mortality during the marine phase when emigrating smolts and returning adults can be monitored at a trap or counting fence/weir. Indeed the closure of many fisheries removes one of the potential confounding factors in such studies. However, interest is now focused on determining how growth and mortality vary during the marine phase and there is only limited potential to elucidate this by such studies (e.g. by use of maturity schedule method).

An alternative experimental approach which may be less dependent upon fisheries is the use of electronic tags. Acoustic tags, either 'pingers' or transponders, allow fish to be actively followed, but this is both very difficult and expensive in the open ocean. As a result, archival tags are now used in most studies, and these are now small enough to be used on large smolts. However, the data from these tags needs to be recovered, by recapturing the fish, recovering the tag (which may be deliberately released from the fish ('pop-up tags') or recovered after the fish dies, or by transmitting the data to a satellite, usually after the tag is released from the fish. Recovery of the fish is still largely dependent upon fisheries and so is even more constrained than conventional tagging due to the relatively small number of tags that will be released. Recovery of tags that have been released from fish has been used successfully in coastal waters (e.g. on cod around the UK coast) but is less likely to be practical in areas frequented by Atlantic salmon, such as the Norwegian Sea. Pop-up tags that can transmit to satellites are now small enough to be deployed on adult salmon (e.g. they are being used on eels down to about 1.5kg as part of the EU EELIAD project (David Righton pers. comm.)) but not on smolts or post-smolts. Thus there is potential to use this technique to study salmon during the open ocean or return stages of their marine migration but not on post smolts. However, it is to be hoped that future generations of electronic tags will be small enough and cheap enough to be applied to smolts in sufficient numbers to overcome the problem of low return rates.

8 Recommendations

The Workshop made the following recommendations:

1) All the tag data used by the Workshops should be compiled into a single database and made available to all Workshop members.

2) Arrangements should be made for the long-term storage of the tag database so that the data are not lost. Permission should be sought from the owners of the tag data to store the data centrally, and the ICES Data Centre should be asked whether they would be willing to act as the central repository.

3) Access to the tag database should be restricted two years after a final approved version is available to those involved in the three Workshops to fulfil the analyses initiated by the Workshop members. After that time the data should be made freely available, where this is acceptable to the owners.

4) The reports of the three Workshops on salmon tagging data, WKDHUSTI, WKSHINI, WKLUSTRE, should be combined into a single Co-operative Research Report which should be designed to provide a permanent record of the background to the tagging studies and the data in the tag database.

5) The analyses initiated by the Workshops should be written up in peer-reviewed papers; provisional topics and leader authors are:

   - Tag recoveries and adult salmon tagging at Greenland– Dave Reddin
   - Adult salmon tagging in the Norwegian Sea – Lars Petter Hansen
   - Tag recoveries at Faroes – Jan Arge Jacobsen

6) Additional papers could address recoveries in coastal waters although these tag recoveries are not included in the database.

7) Further work should be carried out to improve and develop predictive models of annual migration and distribution and the tag database should be made available to scientists developing such models.

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Annex 2: Agenda

1) Welcome
2) Housekeeping at DEFRA
3) Introduction by the chair
4) Documents/presentations
5) NE Atlantic/Greenland
6) Historical tagging at sea (Greenland, Faroes, Norwegian Sea)
7) ToR a. Updates of the database
8) ToR b. Distribution of salmon at sea in relation to hydrographical factors
9) ToR c. Use of the tagging database to verify outputs of migration models
10) ToR d. Recommendation for future tagging studies
11) Additional information, publications etc.

Annex 3: Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
1. All the tag data used by the Workshops should be compiled into a single database and made available to all Workshop members.	The W Greenland database is held by Ian Russell and NE Atlantic by Jan Arge Jacobsen. The use of the database should be discussed with the data originators at the next WGNAS.
2. Arrangements should be made for the long-term storage of the tag database so that the data are not lost. Permission should be sought from the owners of the tag data to store the data centrally, and the ICES Data Centre should be asked whether they would be willing to act as the central repository.	The database to be distributed to and communicated with all members of WKDHUSTI, WKSHINI and WKLUSTRE and approved by the originators before forwarded to the ICES Data Centre.
3. Access to the tag database should be restricted two years after a final approved version is available to those involved in the three Workshops to fulfil the analyses initiated by the Workshop members. After that time the data should be made freely available, where this is acceptable to the owners.	The ICES Data Centre.
4. The reports of the three Workshops on salmon tagging data, WKDHUSTI, WKSHINI, WKLUSTRE, should be combined into a single Co-operative Research Report which should be designed to provide a permanent record of the background to the tagging studies and the data in the tag database.	The editorial group should be the Chair and two scientists appointed by the Chair.
5. The analyses initiated by the Workshops should be written up in peer-reviewed papers; provisional topics and leader authors are: • Tag recoveries and adult salmon tagging at Greenland– Dave Reddin • Adult salmon tagging in the Norwegian Sea – Lars Petter Hansen • Tag recoveries at Faroes – Jan Arge Jacobsen	Dave Reddin, Lars Petter Hansen, Jan Arge Jacobsen
6. Additional papers could address recoveries in coastal waters although these tag recoveries are not included in the database.	
7. Further work should be carried out to improve and develop predictive models of annual migration and distribution and the tag database should be made available to scientists developing such models.	