

The Atlanto-Scandian Herring Fishery in 1997

Ian Napier & Donna Goodlad

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Summary

During May 1997 the North Atlantic Fisheries College deployed fisheries observers onboard Shetland fishing vessels participating in the Atlanto-Scandian herring fishery. The observers collected data on about two-thirds of the catches taken by this fleet, all in international waters 300 to 400 miles north of Shetland. The data collected included length frequency and age frequency distributions, and age-length and length-weight relationships. The data suggests that the EU Atlanto-Scandian herring fishery is exploiting a different component of the stock from the main Norwegian fishery.

A review of available scientific information suggests that Atlanto-Scandian herring are unlikely to penetrate far into EU waters in significant numbers, although it seems likely that they do pass through EU waters to the north of Shetland during their annual migration.

Introduction

The Atlanto-Scandian Herring

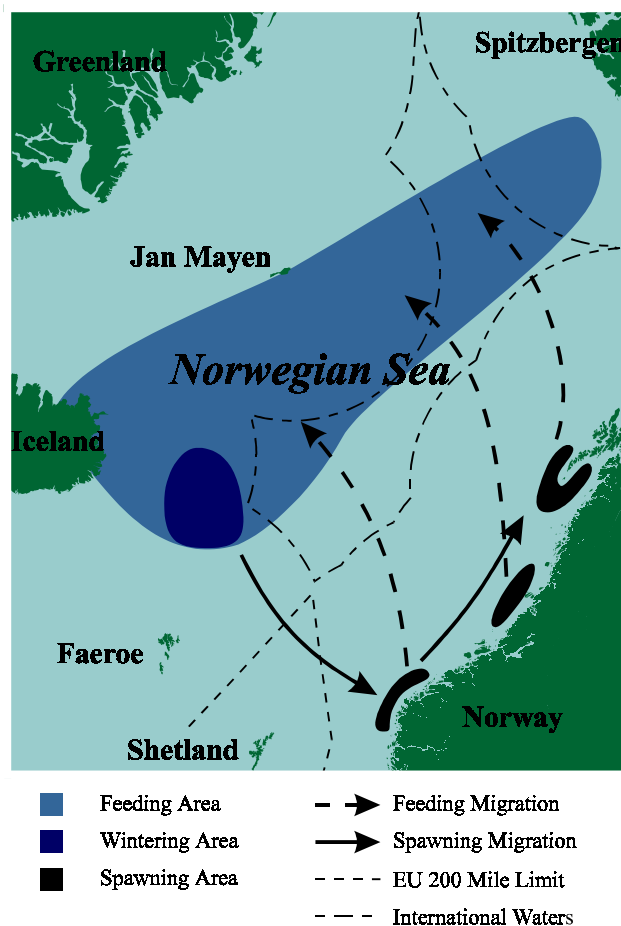
The Atlanto-Scandian herring is a northern group of herring (*Clupea harengus*) which occurs in the Norwegian and Barents Seas and is quite distinct from the North Sea herring. The group is actually comprised of three stocks of herring: Norwegian spring spawners, and Icelandic spring and summer spawners. The Norwegian spring spawning stock is the largest of these three, and the term "Atlanto-Scandian" is often applied to this stock alone. This term is used in this Note although the fishery which is the subject of this study is wholly for Norwegian spring spawning herring.

The Norwegian spring spawning herring follow an annual migration as shown in the map above right. After spawning along the Norwegian coast between February and April the herring move north-westwards into the Norwegian Sea where they feed heavily on the abundant zooplankton. By the summer they are distributed from Iceland in the south to Jan Mayen and Spitzbergen in the North. In the autumn the herring concentrate into the south western Norwegian Sea east of Iceland before migrating back eastwards to their spawning grounds during December and January. The path of this migration varies over time in response to oceanic factors and to changes in stock size; when the stock size is small the fish do not migrate as far from the Norwegian coast.

The young herring which hatch out from the eggs drift northwards with the currents and spend the first three years of their lives on nursery grounds along the Norwegian coast and in the Barents Sea. Most of them begin to follow the adult migration pattern from about four years old and they mature at between four and seven.

The Fishery

Atlanto-Scandian herring have traditionally been fished mainly by Norway, Iceland and Russia. Catches increased dramatically this century, from about 13,000 tonnes per annum at the end of



Map showing the general migration routes of Norwegian spring spawning Atlanto-Scandian herring

the 19th Century to about 500,000 tonnes in the 1940s and over 1,500,000 tonnes per annum in the mid-1950s. This increase resulted partly from development of the fishing industry, particularly in the reduction of the herring to fish meal and oil, and partly from a marked increase in stock size due to several years of good recruitment (i.e. years when large numbers of juvenile fish survived to join the adult stock).

In the late 1950s and early 1960s the size of the Atlanto-Scandian herring stock fell by about two-thirds, but catches continued to increase significantly, due primarily to improvements in the fishing fleet, particularly the introduction of modern purse-seiners. Poor recruitment (due to environmental fluctuations) and increasing catches caused the herring stock to decline through the 1960s, and by 1970 catches had fallen to under 50,000 tonnes per annum. As a result of the stock collapse the Atlanto-Scandian herring fishery was tightly restricted during the 1970s and 1980s.

The Atlanto-Scandian Herring Fishery in 1997

The Atlanto-Scandian herring enjoyed good recruitment in the late 1980s and early 1990s with the result that the stock is now increasing in size. It is predicted that if the stock is properly managed it could expand still further, and support a major fishery of over 1,000,000 tonnes per annum. (For comparison, annual catches of North Sea herring over the last decade have varied



between about 500,000 and 650,000 tonnes).

The pelagic trawler Serene pair trawling for Atlanto-Scandian herring north of the Arctic Circle in 1997. Photo - I. Napier.

Local and other EU fishing vessels became interested in exploiting Atlanto-Scandian herring in the mid-1990s as this fishery offered new catching opportunities at a time when the pelagic fleet was facing cutbacks in other fisheries, such as mackerel and North Sea herring. The traditional Atlanto-Scandian herring fishing nations believed that the EU was not entitled to a share of this fishery as (they claimed) the herring did not enter EU waters. As a result of the failure to reach agreement the EU set a unilateral quota of 150,000 tonnes in 1996 and a similar quota was agreed with the other nations in 1997. EU fishing vessels are able to fish for Atlanto-Scandian herring without the consent of the nations which traditionally fish this stock because, as can be seen from the map on page 1, a large part of the centre of the Norwegian Sea is International Waters, lying outside the 200 mile limits of Norway, Færoe, and Iceland.

Given the disagreement over whether or not EU fishermen were entitled to a share of the Atlanto-Scandian herring fishery, there is interest in the extent to which these fish enter EU waters, or did so historically. Between the First and Second World Wars, and up until the early 1950s, there was a winter fishery for herring around January and February in an area about 10 to 40 miles north of Shetland. These herring were ripe (i.e. ready to spawn) and appeared to be larger and more densely shoaling than the usual North Sea herring (which are predominantly Autumn spawners), and it has recently been assumed by many fishermen that these were in fact Atlanto-Scandian herring. There are also anecdotal reports of large "Atlanto-Scandian" herring occurring in catches of North Sea herring. If it could be demonstrated that Atlanto-Scandian herring do enter EU waters during their migrations, or have done so historically, then the claim of EU fishermen to a share of this important fishery would be considerably strengthened.

In order to provide data on the Atlanto-Scandian herring fishery from an EU perspective, and to investigate the extent to which Atlanto-Scandian herring enter EU waters, the North Atlantic Fisheries College initiated a project in 1997 to study the Atlanto-Scandian herring fishery. This involved placing observers onboard local fishing vessels to collect information on the distribution of fishing effort and catches, and to analyse samples of the catches. The project also included the training of College staff in techniques for ageing Atlanto-Scandian herring, and the commissioning of a review of the historical evidence for the occurrence of Atlanto-Scandian herring in Shetland waters. The Marine Laboratory in Aberdeen has also been participating in the

study, placing observers onboard a number of N.E. Scottish fishing vessels.

Results

During April and May 1997 seven College staff spent a total of 70 man-days as observers onboard four local pelagic fishing vessels participating in the fishery for Norwegian spring spawning Atlanto-Scandian herring. During this time the observers sampled and collected data on catches totalling almost 8,000 tonnes, two thirds of the Shetland fleet's Atlanto-Scandian herring quota.

Distribution of Fishing Effort and Catches

The observed vessels concentrated their fishing effort between 300 and 400 miles north of Shetland in the area of international waters which lies between the 200 mile limits of Iceland, Færoe, and Norway. Ninety percent of their catches were taken in the area between latitudes 66° 30' and 67° 00' North and longitudes 1° and 3° West. Most catches were landed in Norway, Denmark and Iceland with most of the fish going for reduction to fish meal and oil, although a small quantity was landed for human consumption.

Catch rates appeared to decline markedly after about the middle of May, from an average of about 85 tonnes per hour fishing during the first half of May to about 30 tonnes per hour during the second half. Catch per hour is a crude measure of catch per unit effort which takes no account of the different vessels fishing at different times. However, all the vessels were similar in size and power, and a similar decrease in catch rate was recorded on one vessel which fished in both halves of May, so it appears that this was a real trend.

It was evident onboard the fishing vessels during the second half of May that the herring had become harder to catch than they had been earlier in May, and (according to the fishermen) throughout the 1996 season. The drop in catch rates appeared to result from a change in the behaviour of the herring, with the shoals (as seen on sonar) deeper and more broken than what was considered "normal", and more likely to scatter or disappear as the trawl net approached.

The reasons for this change in behaviour are not known, but there is some evidence (from engine-room instrumentation) of an increase in surface water temperature from about 3°C in the first half of May (and, reportedly, throughout the 1996 season) to 5°C in the second. Atlanto-Scandian herring are known to favour colder temperatures, so an increase in surface water temperature could have pushed them deeper than normal. It may also be significant that the herring contained less "feed" (i.e. stomach/gut contents) than in 1996 which would appear to indicate a change in feeding behaviour or in food availability, perhaps related to the change in water temperature or to some other factor. The absence of feed also resulted in the herring keeping better once caught than they had in 1996.

Length Frequency Distribution



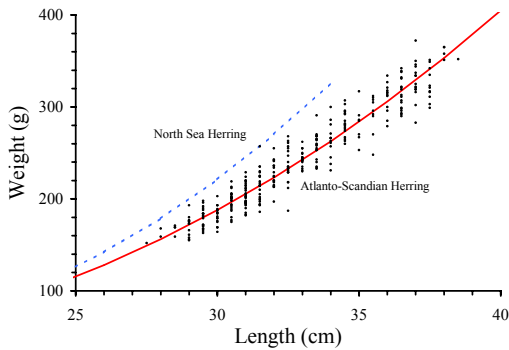
Measuring an Atlanto-Scandian herring at sea

Photo - C. Hepburn

The lengths of 6,670 fish (weighing over 1,600 kg in total) were

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individually measured, and the graph below shows the proportion of fish in each 0.5 cm size class.

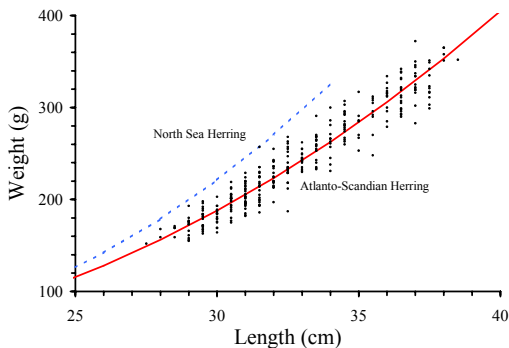


Length frequency distribution of Atlanto-Scandian herring taken by the Shetland fleet (n=6,670).

The fish ranged from 27.5 to 40.0 cm in length and, as can be seen, the greatest proportion were around 32.0 cm in length. Fish around 37.0 cm were also relatively abundant, as indicated by the second, smaller peak on the graph.

Age Frequency Distribution

Over 1,200 otoliths (ear bones) were collected from measured fish. Ten otoliths from each size class (or as many as had been collected) were analysed to determine the ages of the fish from which they had come. The graph below shows the proportion of fish of each age. The youngest fish encountered were a very small number of three year olds (born in 1994), while the oldest were 14 (born in 1983).



Age frequency distribution of Atlanto-Scandian herring taken by the Shetland fleet, with year of birth of each year class (n=196).

Of the many millions of fish eggs which are spawned each year, and the larval fish which hatch out, only a very few survive to become adults. The numbers which do survive can vary markedly from year to year depending on even slight changes in environmental conditions. The survival rate each year in the past is reflected in the relative size of each year class (i.e. the numbers of fish born in that year) in the adult stock.

It can be seen from the graph that the catches of Atlanto-Scandian herring were dominated by six year old fish, indicating that a relatively large number of the fish born in 1991 survived, presumably because environmental conditions were particularly favourable that year. Conditions must also have been fairly good in 1989, 1990 and 1992, as those year classes are also relatively strong.

Amongst the older fish, 12 and 14 year olds are relatively abundant. As a high proportion of fish will have been caught or died before reaching these ages the 1983 and 1985 year classes must have been large in the past, and environmental conditions in

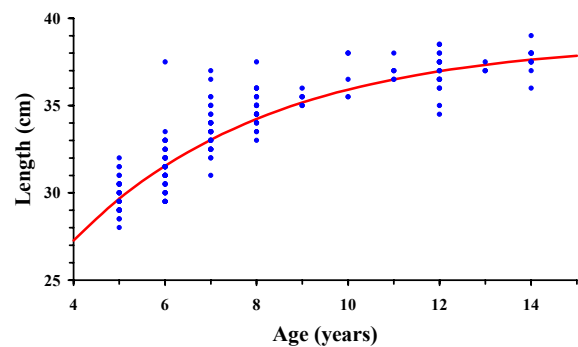
these years must have been particularly favourable.

The virtual absence of fish less than four years old in the samples is not surprising as it is known that Norwegian spring spawning Atlanto-Scandian herring spend the first three years of their lives in nursery grounds along the Norwegian coast and in the Barents Sea, and so would not be expected to be present in the area where this fishery takes place. The absence of four year olds is somewhat surprising, however, particularly since data from the Norwegian Atlanto-Scandian herring fishery and from Norwegian surveys show that four year old fish are relatively abundant, while five year olds are more abundant in Norwegian catches than in catches taken by the Shetland fleet.

This discrepancy suggests that the Shetland fleet is exploiting an older component of the Atlanto-Scandian herring stock than the main Norwegian fishery in which the younger age groups are not fully represented. This would fit with the results of Norwegian surveys in 1997 which found that the Norwegian spring spawning herring tended to be larger and older in the area where the Shetland fleet fished, than in other areas.

Age-Length Relationship

The graph below shows the relationship between the lengths and ages of the Atlanto-Scandian herring. The points represent the individual fish which were measured and aged, while the line represents the mathematical relationship calculated from this age-length data.



Age-length relationship for Atlanto-Scandian herring taken by the Shetland fleet (n=196). Von Bertalanffy growth curve; $L_t = 38.739 [1 - e^{-0.233(t+1.216)}]$.

As would be expected the graph shows that older fish are larger, but the fishes' rate of growth slows down as they grow older causing the curve to flatten out. The mathematical relationship suggests that 40 cm is about the maximum length to which these Atlanto-Scandian herring will grow.

This age-length relationship demonstrates the correlation between the age frequency and length frequency distributions shown above. The length frequency distribution showed that fish of about 32 cm were most abundant, and from the age-length relationship it can be seen these fish are about six years old which matches with the peak of the age-frequency distribution. Similarly, it can be seen that the second peak in the length frequency distribution, at about 37 cm, equates to fish of about 12 years old which we again know from the age-frequency distribution to be relatively abundant.

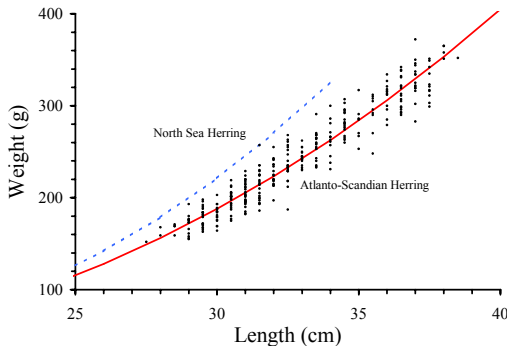
Length-Weight Relationship

In addition to the analyses carried out at sea onboard fishing vessels, a sample of Atlanto-Scandian herring was collected from a vessel landing at the Shetland Catch factory in Lerwick. These fish were returned to the College where over three hundred of them were measured and weighed in order to determine the length-weight relationship for these herring. The fish weighed

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varied from about 150 g to 400 g, although most were just over 200 g in weight.

The graph below illustrates the length-weight relationship, with the points representing the individual fish weighed and measured and the line the mathematical relationship calculated from this data.



Length-Weight relationship for Atlanto-Scandian herring landed in Lerwick (n=316). Power curve; $wt = 0.021415 L^{2.67}$.

Comparison of this length-weight relationship with published figures for North Sea herring suggests that the Atlanto-Scandian herring may be longer for a given weight (or lighter for a given length) than North Sea herring, i.e. that the body shape differs between the two races. However, with data from only a single month it is uncertain whether this represents a real difference, or an artefact due to the fact that the Atlanto-Scandian herring were spent, having spawned within the previous month.

Bycatch

Very small numbers of a few other species were taken with the Atlanto-Scandian herring in some hauls, although the amounts were negligible in terms of the total catches taken. These included: the Deepwater Redfish (*Sebastes mentella*), a relatively common pelagic species found at depths of between 300 and 900 metres throughout the Norwegian Sea; *Notolepis rissoi*, a pelagic eel-like species (with no common name) found at depths of between 200 and 1,000 metres throughout the world; and the Jelly Wolffish (*Anarhichas denticulatus*), an offshore relative of the more familiar wolffish (or "stane-biter").

Atlanto-Scandian Herring in Shetland Waters

The review of historical evidence for the occurrence of Atlanto-Scandian herring in Shetland waters indicated that these herring (specifically Norwegian spring spawners) are, and have been, regularly taken in the summer fishery for North Sea herring. However, these Atlanto-Scandian herring represent only a very small, and unquantifiable, proportion of total catches in this fishery. The Atlanto-Scandian herring are more frequent in catches taken at the northern extremity of the North Sea herring fishery, just inside the edge of the continental shelf, which marks the southern boundary of the Atlanto-Scandian herring's normal range.

The frequency of Atlanto-Scandian herring in the North Sea fishery declined sharply in the 1960s, coinciding with the collapse of the former stock. Anecdotal accounts from fishermen of an increase again in recent years would correspond with the recent recovery of the Atlanto-Scandian herring stock.

From the known migration pattern of the Norwegian spring spawning Atlanto-Scandian herring, it appears likely that the largest proportion of this stock passes through EU waters (at about 62° N) between December and February, during the annual migration from the wintering grounds near Iceland to the spawning grounds on the Norwegian coast (see map on page 1).

It is difficult to draw a definite conclusion as to whether the fish taken in Shetland's winter herring fishery up until the 1950s were Atlanto-Scandian herring. While it is known that Atlanto-Scandian herring generally remain in the cooler waters beyond the edge of the continental shelf, the shelf edge is only 25 to 50 miles north and west of Shetland so it is not inconceivable that Atlanto-Scandian herring could have been present in the area where the winter fishery was prosecuted. On the other hand, if significant quantities of Atlanto-Scandian herring were being taken in a Scottish fishery one would expect to find evidence for this in the fisheries data collected at the time by the Marine Laboratory in Aberdeen. Given that no such evidence has been found the balance of probability seems to be that the fish taken in the winter herring fishery were not Atlanto-Scandian.

An alternative possibility is that these fish were a spring spawning component of the North Sea herring (most North Sea herring spawn in the autumn). Little is known about these North Sea spring spawning herring and little research has been carried out since the 1950s. There is evidence, however, which suggests that this group is in some way related to the Norwegian spring spawning stock, which make up a large component of Atlanto-Scandian herring. It has been speculated that the North Sea spring spawners split off from the main Norwegian spring spawning stock during their spawning migration along the Norwegian coast. North Sea spring spawning herring were relatively abundant in Scottish herring fisheries, accounting for up to 30% of catches, until about the 1950s. Thereafter, their importance declined and their contribution to the main North Sea herring fishery remains low. If there is a relationship between Norwegian and North Sea spring spawning herring then it is possible that the recent recovery in the former stock could lead to a resurgence in the latter.

Conclusions

This study has provided data on the Atlanto-Scandian herring fishery from an EU perspective. The evidence collected indicates that it is unlikely that Atlanto-Scandian herring do, or did, enter EU waters to any great extent. However, it appears likely that these fish do pass through EU waters not far to the north of Shetland during the annual migration from their Icelandic wintering grounds to the Norwegian coastal spawning grounds. If this is so there may be the potential for a winter/spring fishery for Atlanto-Scandian herring within EU waters. The College intends to conduct a survey during 1998 to test this hypothesis.

Acknowledgements

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