

The North Sea Herring Fishery: An Abrogation of Management

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ABSTRACT

The paper describes the international fishery management regime in the Northeast Atlantic. From its inception in 1946, the International Fisheries Convention was focussed on the problems of the demersal fisheries. As its initial task it aimed at preserving the stocks of fish in the North Sea and other areas which had recovered from the low abundances of pre-World War years. It sought to introduce minimum mesh sizes for trawls and other towed gears which would conserve juvenile fishes. To assist in the enforcement of such a regulation, minimum landing sizes were specified for the most important species. The species for which minimum sizes were prescribed became known as the Protected Species. Implicitly, no other species required conservation and this included the herring. Though by 1955 an extensive trawl fishery for both adult and juvenile herring had developed the only regulation concerning the pelagic species lay in the limitation of the by-catches of under-sized protected species. The possibility that herring might need conservation had never been considered in the drafting of the Convention.

With the collapse of the southern North Sea herring fishery after 1955, repeated pleas for conservation action were turned down as not being within the terms of reference of the Permanent Commission. The Articles of the new North-east Atlantic Fisheries Commission (NEAFC) followed those of its predecessor and in 1964 found it necessary to pass a resolution to examine under what powers it could act in conserving the herring stocks. By 1971 only 7 out of the 14 governments had taken steps to activate a provision to institute regulation of catch and effort. By the time ratification was complete it was too late to take any

effective action. With UK's and Norway's extension of the limits of fisheries jurisdiction following UNLOSC and UK's accession to the European Community the regulation of the fisheries passed to the European Commission in consultation with Norway. A ban on herring fishing was imposed in February 1977. Total Allowable Catches (TAC) are based on the recommendations from ICES modified in consultation with Norway who as a riparian state has management responsibilities for shared stocks. These negotiations result in a agreed total package for all species and the final individual TACs may be very different from the conservative advice of ICES. The lessons of the past have not been learned and gross overfishing of the agreed TACs and lack of enforcement are currently leading to a further collapse of the North Sea herring stock.

1. INTRODUCTION

In considering the history of herring management in the North-east Atlantic area it is useful to briefly review the way the management bodies evolved. In 1902 at the setting up of the International Council for the Exploration of the Sea three activities were selected for its immediate attention, namely: hydrography, fish migration and overfishing. The two latter areas of study were specifically related to herring and plaice.

At that time, concern was being expressed over the large quantities of small plaice discarded. In 1913, a proposal was made to close the small plaice grounds of the continental coast. This would allow the small fish to put on weight as they migrated into deeper water and so become more valuable. This established a policy for the conservation of the demersal stocks and the maximization of the yield from their growth potential was the management principle behind the proposals of the unratified, 1937 Convention and its successor, the International Fisheries Convention of 1946.

In contrast, the investigations on herring were directed at describing the "racial" structures of the populations. Studies were initiated on the identification of the spawning grounds of the various stocks and the migration routes. The growth increments on the scales of the herring were established as annual; growth curves could be calculated for individual herrings and their patterns were utilized as a method of racial analysis, (Lea, 1929). The population structures by age of the various herring populations were studied with particular emphasis placed on the occurrence of good and bad year-classes. It was apparent that in the Atlanto-scandian stock, one good year class could sustain the fishery for, at least, a decade. The success or failure of the fishery was considered as dependent upon natural causes, which could effect recruitment or migration. Changes in the latter were believed to be the causes of the Norwegian/Swedish herring periods.

The herring fishery was dominated by the use of drift nets and its outlets lay in the cured herring trade. This required mature herring with a moderate level of fat content and careful handling of the fishes. In the nineteen thirties as part of a programme to upgrade the quality of the cured herring the British Government set up the Herring Industry Board and it introduced a regulation banning the use of small meshed drift nets. This was directed at a juvenile fishery off the English north east coast but was purely a marketing aid and not a conservation measure.

At the turn of the century, steam trawlers conducted a short-lived herring fishery off the estuary of the River Humber but the quality of the fish landed was so poor that there was little or no market demand. Fishermen disapproved of such trawling as they felt it was wrong to disturb herring when they were on the spawning ground. However, in the late nineteen thirties a major herring trawling development took place in the central North Sea. This time, a market existed for the spawning and spent herring, particularly in Germany. The main international criticism of these trawl fisheries lay in the use of the small meshed herring trawls which also took demersal fishes (including quantities of under-sized demersal fish which were supposed to be conserved under the minimum white-fish trawl mesh proposals). Thus, there was no comparable concern for conservation of the herring stocks as for the demersal species.

Those scientists working with the demersal fisheries were aware of the overfishing problem and were introducing statistical methods for analysing their data and developing mathematical models to study the dynamics of the populations, Graham(1935). In contrast, the herring biologists were more concerned with descriptive biology of the herring populations. The annual variation in the age structures of the herring catches were described in percentage numbers rather than absolute numbers. However, in this field the most significant advance was the introduction by Hodgson of stratified age/length sampling and the extensive use of sampling for length composition of the catches of herring on the fish market. This enabled Hodgson to describe the serial changes in the age composition of the catches during the fishing seasons, to estimate annual instantaneous mortalities from the abundance indices in catches per unit effort per age. In East Anglia he forecast the timing of the peak catches and the probable catch rates in advance of the commencement of the herring season, (Hodgson, 1939).

In March 1946, an International Conference met at the invitation of the UK Government to discuss the question of overfishing in the North Sea and, if possible, to draw up some form of regulatory agreement. The Conference based its proposals on those of the unratified 1937 Convention including specifying minimum mesh sizes and landing sizes for demersal fish, but in addition it recognised the need for international control of fishing effort. UK had proposed that Governments should agree to limit their fishing power to 75% of the pre-war figures or adopt some equivalent limitation. The Conference could not support such a blanket regulation. It did recommend, however, that each

Government should try to ensure that the size of its fishing fleet should be stabilized at its 1946 level or that of 1938, whichever was greater. A number of countries offered to adopt a number of interim measures for 1948 and 1949, until the proposals could be ratified. This was expected to be completed in two or three years but the last ratification was given in February 1953. By that time the opportunity was lost to control the growth of the post-war fishing fleets and with it the willingness to accept effort limitation.

At its first meeting in May 1953, the Permanent Commission of the International Fisheries Convention faced the need to arrest the renewed decline of the stocks, (Anon., 1953a). Even the mandate of the Commission was in question. Six of the twelve members held that it had general powers to discuss conservation measures, but, the four Scandinavian countries maintained that it was only empowered to consider regulation of mesh size and size limits. A second meeting was held in November 1953, (Anon., 1953b), when further discussions took place on the forms of the proposed regulations. Since 1946 there had been a major expansion of trawling for herring. This took two forms, the fishery for adult herring on and near the spawning grounds and the newly developing fishery for juveniles for reduction to fish meal and oil—the so-called industrial fishery. Article 6 of the Convention, as it was first drafted, limited the use of small meshed nets to the fisheries for mackerel and clupeoid fish, smelts, eels, great weavers and those for crustaceans and molluscs, with the requirement that any undersized fish should be discarded and returned to the sea. In 1955 sandeels and Norway pout were added to the list of species in Article 6. The whitefish fishermen were concerned that by-catches of legal sized whitefish could be taken by the herring trawl fisheries and could unfairly compete with them on the market. They held that some limitation should be placed on the quantity of by-catch landed. Denmark proposed that when fishing for herring and sprat up to 20% of the total catch in weight could be comprised of undersized whiting which was only to be used for animal feed or reduction to meal and oil. This new facet to the discussion was to lead to the polarization of the national fishing industries between those fishing for human consumption and those operating industrial fisheries for meal and oil.

In these formative days of the Convention, there had been the establishment of three separate groups of fish, those for which minimum sizes were prescribed which became known as the "Protected" species, those listed in Article 6 for which no conservation measures were described and a third "no man's land" of all the other fish species, such as saithe, gurnards, John Dory etc. which were not named in either Convention list. Subconsciously, politicians, administrators, many of the fishing industry and some scientists equated the concept of Conservation only with the 'protected' species. As far as the fisheries for Article 6 species were concerned, the administrators' sole interest was in preventing activities in those fisheries which might have a deleterious effect on the potential catch of the protected species. No recognition was made in the Convention's regulations or those incorporated in the Articles of the new

Northeast Atlantic Fisheries Commission that the 'unprotected' species might need conservation action in their own right. It was against this background that the attempts at obtaining conservation action for the North Sea and other herring stocks was started in 1957.

2. THE CONFLICTS FOR MANAGEMENT.

The collapses of the Northeast Atlantic herring stocks have been comprehensively reviewed by Burd, (1974, 1978, 1985), Jakobsson, (1985), and Seville and Bailey, (1980). Both the administrators and the scientific community were ill prepared in general to deal with a situation which required rapid decision making. Nor was it receptive to the idea that such an abundant species could possibly be subject to overfishing. Above all, neither the managers nor the scientists could respond to the rapid changes in activities by the fishermen. Indeed, throughout the past half century scientists and administrators have had to formulate their advice and decisions on scenarios of fleet operations from which the fishermen had already progressed. Some of the developments could not have been anticipated, being generated from events originally unconnected with the North Sea herring fisheries. Others, such as the developments in echo sounding and sonar and in mid water trawls and purse seines led to a complete changes in the exploitation pattern of the herring stocks. When in the stock-recovery situation scientists were having to make projections of the likely rates of recovery, their interpretations of the possible responses had to be based on the historic records which often referred to a very different exploitation pattern.

It is convenient to consider the recent history of the fishery in five distinct phases. Each of these introduced new elements in the exploitation and in the scientific data requirements. For each of the phases I shall draw attention to the scientific dilemmas encountered, the effectiveness of the research programmes developed and any administrative actions generated. The phases are:

1. The collapse of the Downs stock.
2. The development of the pelagic trawl.
3. The prerecruit purse seine fishery and recruitment failure.
4. The recovery of the stocks.
5. Current management.

2.1. The Collapse of The Downs Stock.

High priority was given to the re-establishment of both the herring and whitefish fisheries in the immediate post-war reconstruction period. The herring catches quickly reached the levels of pre-war years. For the drifters, the main markets remained the cured herring trade and in Germany, margarine production based on herring oils provided an outlet for trawled herring. There was unlimited demand for whitefish. Particular stress was laid in investment in large distant water trawlers

particularly by western Germany and UK. to take advantage of the recovered Arctic cod and haddock stocks. But by 1953 UK was expressing concern at the rates of decline of the fish stocks at Iceland and it was not long before discussions on conservation of the north east Arctic became a regular feature of NEAFC. With seasonally low catch rates in distant waters in summer, the Arctic demersal trawlers developed a fishery for spawning herring in August and September in the central North Sea. Later, the spawning grounds of the Downs stock were to attract trawlers from most countries. Thus, additional to the effort of the already re-established herring fleets, a new fleet of powerful and specialist trawlers was suddenly imposed on the herring stocks concentrating its effort on the vulnerable spawning herring shoals.

The traditional East Anglian drift net fishery commenced in early October in the vicinity of the north Norfolk Banks and a continuous stream of migrating Downs herring maintained a fishery up to Christmas. The three and four year old herring arrived first, to be followed by the older fish in November and later. Due to the nature of the bottom topography of the Southern Bight the herring were funneled towards the Straits of Dover. While in the last stages of maturation of their spawning products, they aggregated for some time off the Flemish Banks. Some would spawn nearby and others would rapidly move through the Straits into the Eastern Channel spawning as far west as Dieppe, Figure 1. The first major spawning took place in the channel between the Sandettié and Outer Ruytigen Banks, off Calais, at the end of November, when both old and young were present in the shoals. The intensity of this fishery can be judged when it is recalled that commonly 250 Arctic trawlers towed through the channel in line astern during the short winter days. The spawning itself took place on a flint and gravel bed, 3 200m long and only 300-350m wide, Bolster & Bridger, (1957). Bridger, (1961) recorded that any large shoals of ripe fish in the Sandettié-Ruytingen channel were broken up and dispersed by the trawler fleet within two to three hours of their arrival. Even when the bottom trawl catches were low, large quantities of spawn were brought up and destroyed. By 1953 the trawl catch from these grounds had reached 156kt., taken in about an eight week period. It was with alarm that the drifermen saw their catches of old fish in November decrease sharply, their average catches per effort fell by 50% between 1949 and 1952 and by a further 50% between 1952 and 1958. Until 1954, the October catches which consisted of recruit herring, maintained their post-war average but from 1955-1958 these too were reduced by 50%. The drifter catches per unit effort showed the classic symptoms of overfishing in a demersal stock with a rapid decline in abundance and increase in instantaneous mortality of the older fish.

Those countries concerned with the Downs fishery expressed concern at the rapid decline in the yields and approached the Permanent Commission to take action to halt the decline. The Commission considered itself unable to comment on the conservation needs for the Downs stock. It encouraged ICES to support cooperative research programmes, in particular, tagging programmes aimed at making direct estimates of fishing mortality

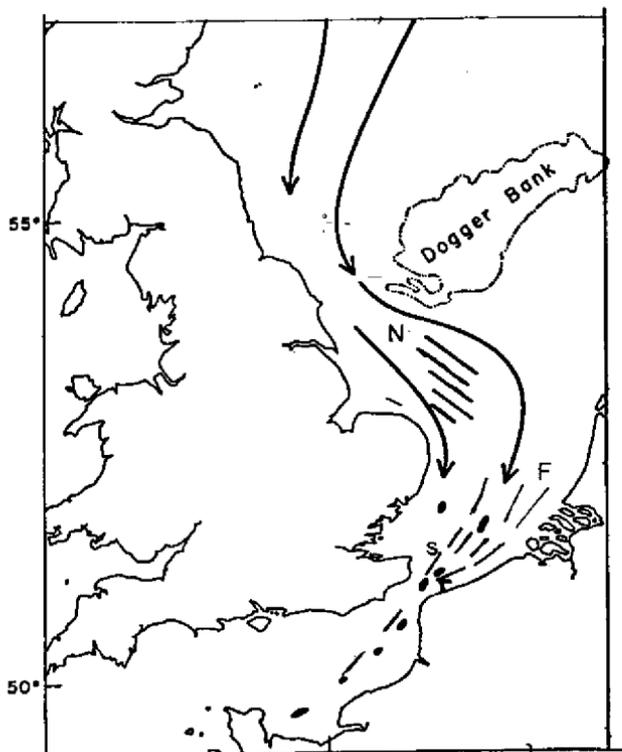


Figure 1. Spawning route of Downs herring.

N: Norfolk Banks

F: Flemish Banks

Spawning grounds indicated:

s: Sandettie Bank.

r: Outer Ruytingen Bank.

in the spawning fishery and in the newly commenced juvenile fishery on the Bløden ground. Ancellin and Nédélec(1959) estimated the fishing rate on the Sandettie spawning grounds at 1.2% per day. Over a 17 day spawning fishery following tagging, Cushing and Bridger(1966) calculated that the fishing mortality generated was of the order of 50%. This was comparable with that derived from drift-net catch per unit effort data. Fishery independent sources of stock size were also sought and in 1955 internationally coordinated larval surveys were commenced. In 1956 acoustic surveys were undertaken by England over the East Anglian area, partly, to provide more searching power for the diminishing fleet of drifters and, partly, to obtain independent estimates of abundance.

In 1957-8 the catch of the French trawl fishery on the spawning grounds had declined to about 8 kt from an average of over 20kt. in 1951-1955. Between 1955 and 1957 the mean catch per unit effort had halved, Maucorps (1964). In 1957, the Netherlands proposed that the Permanent Commission should invite the ICES Liaison Committee to advise on arresting the decrease of the herring catches in the southern North Sea and Channel. However, the Commission again considered that the proposal was outside its terms of reference, Anon.(1958). In May 1960, the fishing industry members of the French delegation to the Permanent Commission meeting again pressed for ICES to investigate the causes of the decline but, the response was similar to that three years earlier, Anon.(1961). Although there was an underlying concern about the overfishing of the Downs stock, each nation's fishermen sought that the attribution of blame should be directed at any activity in which they themselves did not indulge. Thus much vehemence was expressed over the Danish Bløden fishery for juvenile herring, mainly from the moral standpoint that it was wrong to catch juveniles and to reduce them to meal and oil. Few of these fishermen and their supporters accepted the results the ICES tagging experiments in 1957 and 1958 which estimated the fishing rate on the juvenile stock of the whole North Sea at 15-20%. At that time the autumn Bløden fishery took 70kt. This fishing mortality alone could not account for the observed decrease in the adult Downs stock. As a follow-up of the tagging experiment, annual cooperative trawl surveys for young herring were set up with the objective of obtaining estimates of the incoming recruit classes and if possible to identify the areas of distribution and abundance of the individual stocks of Bank, Downs and Buchan recruits in the nursery areas. Because of the interannual variability of meristic characters it was found that identification of the juveniles had to be made retrospectively once they had recruited to the adult stock. Discriminant function analysis was successfully used, Andersen et al(1969). This also indicated for the first time the presence in the northeastern North Sea of juvenile fishes from west of Scotland spawnings. This was confirmed from a later Bløden tagging experiment.

The idea that herring could be overfished was foreign to those fisheries biologists with knowledge of the Atlanto-scandian herring. It was then generally accepted that the great fluctuations in yields and in year class strengths were associated with natural causes. The commencement of the Bløden

fishery coincided with the increase in growth rate of the North Sea herring which led to an advancement in the age of first recruitment by about half a year. Planktologists had also noted changes in distribution and abundance of certain plankton organisms, Glover(1957). Thus, environmental change was also cited as an explanation for the loss of Downs stock. Kreffit, Schubert and Sahrhage(1955) interpreted its effect as a differential northward shift of the three populations, with Downs herring becoming Bank spawners and Bank becoming Buchan spawners. No convincing evidence could be produced to support this hypothesis. All evidence indicated that differences at recruitment between Bank, Downs and Buchan stocks in their meristic and growth characters were maintained until a year class's extinction.

Only in 1963 did the Permanent Commission accede to a further French memorandum and it was agreed that ICES would report on the situation at the meeting of NEAFC in 1964, and a Herring Assessment Working group was set up. Anon., (1964). By this time the Southern Bight and Channel fishery had virtually ceased to be commercially viable, and the drift net fishing was being abandoned in the North Sea.

2.2. The Development of The Pelagic Trawl.

The second phase in the over-exploitation of the North Sea stocks was engendered by the invention of the Süberkrub otter board and the perfecting of the design of the single boat mid water trawl by Herman Engels. No longer were trawlers confined to grounds whose bottoms did not damage their trawls. The trawl nets could be used as bottom skimming gear and in addition the prespawning mid-water aggregations could be hunted using acoustic gear, setting the nets at the optimal depth with headline transducers. The mid-water trawlermen became opportunistic fishers shifting from one area to another where the dense pre-spawning and spawning shoals aggregated. In other seasons of the year, they turned their attention to herring stocks outside the North Sea, to mackerel, horse mackerel and pilchards. Their economic viability lay in their ability to operate intensive short-time fisheries when catch rates were high. The biologists and fishery inspectors were slow to react to the advent of these new highly efficient and very mobile fishing units. Many vessels processed the fish at sea and on landing could deliver fish caught in many sea areas (from the west of Ireland to the North Sea grounds). For the Inspectors there were the problems of allocating catches and fishing time to the different fishing grounds and for the biologists difficulties of obtaining herring samples which could be related with confidence to a particular area. At a time when there was need to monitor the rapid events in the fisheries the quality of the data fell to unacceptable levels. The ICES Herring Assessment Working Group in February, 1964, only had complete statistical data up to 1961 and the ICES Liaison Committee's report gave general advice on management based on yield per recruit criteria. At the NEAFC meeting which discussed the report in 1964, some delegates considered that the current demand for herring was such that conservation of the stocks could not be

justified. Others considered that more rational exploitation was required (an anti-fish meal theme) and that fishing effort should be restricted on the spawning grounds and in the juvenile fishery. Over the next 5 years a dialogue ensued between NEAFC and ICES on methods to regulate the failed Downs herring fishery with a search for equality of sacrifice in any conservation action.

The southern North Sea fishery failed completely in 1966 and 1967 and even in the absence of fishing in the southern North Sea the mortality rates remained high. It was concluded that these levels must have been maintained from catches of Downs herring taken in the northern feeding areas. Interest was again focussed on the identification of Bank, Downs and Buchan fishes in the northern and central North Sea fisheries. Though increased herring catches were being taken from the north-eastern North Sea, after years of intensive exploitation no major fishery by German trawlers took place on the Dogger Bank spawning grounds. No newly hatched larvae were taken in October Dogger Bank surveys from 1967 to 1970. NEAFC recognised that discussion of conservation measures could no longer be restricted to the Downs stock, but that more widespread measures were required, and in 1966 it set up a Working Group to make conservation proposals, Anon., (1965). It called for further investment in research, particularly in relation to the juvenile fishery. It, therefore, proposed an extended Bløden herring tagging programme which started in 1969 with the objective of estimating the fishing mortalities generated. The experiment was too late to provide the diagnostic statement which NEAFC desired, on the fishing mortalities and recruitment mechanisms of the different spawning populations. The falling recruitment in the North Sea limited the tagging both in number liberated and their locations. Important observations on the migration of immatures from the nursery areas in the eastern North Sea to the areas to the west of Shetland and the northwestern North Sea were obtained. The return of the metal internal tags depended upon the reduction of the herring catches to fish meal. The chances of recovering tagged fish from the pelagic trawl catches for human consumption were very low, so few recoveries came from the central and southern North Sea.

2.3. The Pre-recruit Purse-seine Fishery and Recruitment Failure.

Following the failure of the Norwegian coastal winter fishery for Atlanto-scandian herring, over 28 000t of autumn spawning herring were taken from the Skagerrak by 15 Norwegian purse seiners in the winter of 1963-64. The catches consisted of relatively old fishes and were taken from an area which had been recognised in earlier years as an overwintering area of recovering northern and central North Sea spawners. In the following years the timing and area of the fishery changed and was directed at the immature fish (20-24cm in length), about to join the spawning shoals for the first time. This was a totally new phase of exploitation in the life history of the herring. It led rapidly to the total collapse of the recruitment in the North Sea. The development of this Norwegian purse-seine fishery in the North Sea is given below.

Table 1. The Norwegian purse-seine fishery in the North Sea.
(Haraldsvik, 1968; Anon., 1970)

Year	Number of boats	Total catch (tonnes)
1963	16	32 419
1964	195	189 668
1965	284	604 754
1966	334	454 900
1967	326	335 071

The ICES Liaison Committee's report for 1967 warned that biological sampling was too poor in this northern area to allow any assessment of the nature of the stock exploited and noted the escalation in fishing mortality in the central North Sea following the increase in trawling activity. It also recommended a total closure of the whole Downs fishing area from 53°N to 1°W in the Channel for 6 to 9 years. The sudden expansion of the fishery in the north-eastern North Sea and off Shetland, again led to the speculation that the changes in stock might not be induced by fishing but by natural changes in the distribution of the herring stocks and in recruitment survival in the northern areas. Parrish and Saville, (1967) made an extensive review of the whole problem but could find no evidence for an environmental cause or how it might have operated. The comments and recommendations of ICES found little favour within NEAFC. No proposals for any form of management were considered as delegates demanded that proof of the effects of fishing on the stock should be established and that the gains and losses from any management proposal should be statistically quantifiable, Anon (1966).

With the lack of progress on conservation action at an international level, in 1968, the UK government tried to come to an agreement with the Dutch and German governments to accept an experimental closure for five years of the Yorkshire coastal spawning grounds within the UK 12 mile limit. The discussions foundered on the problem of racial distinction of the Whitby spawners and on who might gain from the experiment. In 1970 a NEAFC Ad Hoc Study Report discussed possible actions such as a closure of various areas for the spawning period 20 August to 30 September. Its effect was recognised as below the 50% reduction in effort which ICES considered necessary. Most of the countries which would be affected by such a regulation asked for exemptions to meet special difficulties. Similarly, a proposed 22cm minimum size was considered as discriminatory against some fisheries and 'inequality of sacrifice' should be avoided, Anon (1970a). A Recommendation was finally agreed which prohibited fishing in May and from 20 August to 30 September in the North Sea and Skagerrak for the period 1 March 1971 to 28 February 1972 with various allowances. A 10% by catch by weight of each landing was allowed of herring caught when fishing for other species. This virtually left the juvenile fishery uncontrolled as many herring catches could be claimed to be by-catches and to distinguish between young herring and sprats in the 'soup' landed for fish meal was not a task relished by the fisheries inspectors. It is of little surprise that from this date the recorded sprat catches soared in both the North Sea and Skagerrak. Finally NEAFC proposed to take powers to activate Article 7(2) of the Convention which would

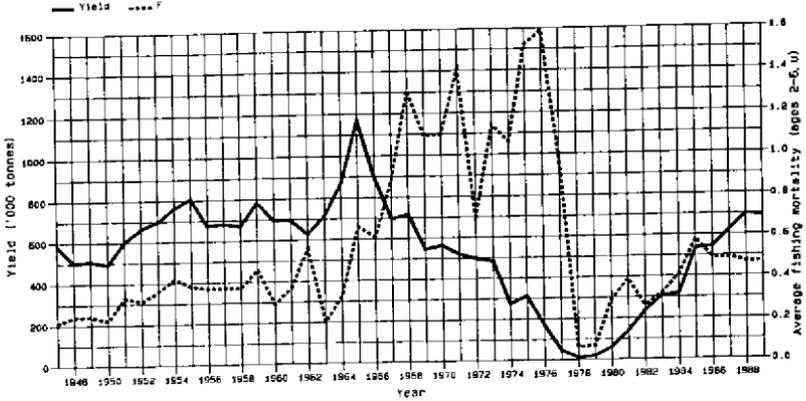
institute measures for regulation of catch and effort and the allocation of quotas to contracting states., Anon., (1970b). Needing unanimous agreement for it to be operative only 7 of the 14 member countries had ratified Article 7(2) in 1971. As no progress could be made it was agreed to continue the regulations for 1971 into 1972. A special NEAFC meeting on herring in December 1971 recommended a prohibition on fishing for herring in the North Sea and Skagerrak for the period 1 February 1973 to 15 June 1973; the 10% by catch allowance was maintained. At a meeting of Ministers which was held immediately followed this meeting the discussions on the herring stocks was to a large extent overshadowed by the Icelandic announcement of its intention to extend its exclusive fishery limits to 50 miles. This signalled the start of a new era in fisheries management.

The final ratification was communicated in 1975 and by a unanimous decision, NEAFC banned industrial fishing for herring in the North Sea. The Liaison Committee later in 1975 recommended a total ban on all fishing for herring in the North Sea and a 20 cm minimum size, Anon. (1977). This was accepted by NEAFC but it adopted a TAC of 160kt for 1976. With the aim of supporting this TAC UK imposed a ban on all herring fishing from October to December within its limits, but despite this 175kt. was caught. Following the extension by UK and by Norway of their fishery limits under the UNLOSC formula and the accession of UK to the European Community a total ban on fishing for herring in the North Sea and eastern Channel was imposed in February 1977. The Commission and Norway became the joint management authority for the North Sea and Skagerrak fisheries.

2. 4. The Recovery of The Stocks.

During the final ten years of the collapsing North Sea fishery, it had become increasingly difficult to monitor the state of the individual stocks. This arose partly from the changes in fishing techniques which destroyed the long term series of data on catches per unit effort, partly due to the hit and miss nature of the biological sampling programmes which were not attuned to the new dynamic pelagic fisheries and partly from the unwillingness of the fishermen to provide information about their catches. This was particularly true of the Danish industrial fishermen. For them, herring was no longer the mainstay of their industry and they saw the proposed minimum size regulations as introducing restrictions which would penalize them in their legitimate fisheries for sand eel, Norway pout, and not least sprat. In 1971 the ICES Herring Assessment Working Group abandoned its previous methodology and, considering the North Sea stock as a single unit, subjected the catch at age data to Virtual Population Analysis. This has remained the method of monitoring the recovery and exploitation of the North Sea stock. Figure 2 summarizes the trends in spawning stock biomass, recruitment, yield and fishing mortality. The parlous state of the North Sea in 1977 is clearly seen. Catches from the Skagerrak have been excluded due to the difficulties with the unreliable catch data and the presence of unquantifiable numbers of herring of the Kattegat and Baltic stocks.

Trends in yield and fishing mortality (F)



Trends in spawning stock biomass (SSB) and recruitment (R)

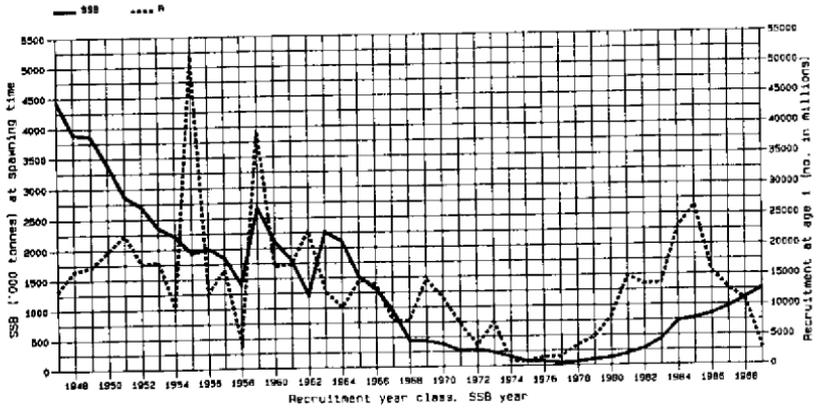


Figure 2. North Sea Herring Stock: VPA outputs.
Source: ACFM annual report for 1990.

During the period of low stock abundances a new factor came into play. This was the extraction of marine sands and gravels which were in demand for building construction. From geological marine surveys the gravel extractors identified the main spawning grounds around the Dogger Bank as prime targets. National governments controlled the allocation of dredging sites by licence, but surveillance of the dredging concessions themselves was difficult and much illegal extraction took place. Allied to this was the development of Rotterdam as a terminal for deep-draught supertankers, and other vessels. To allow these safely to enter the North Sea a dredged channel was required in the southern North Sea. The route chosen was through the Sandtietie-Ruytingen Channel, which had been the main area of the Downs spawning fishery. It is scarcely surprising that little larval production has since been observed in the Sandtietie-Ruytingen area or in many of the historic Dogger Bank spawning sites.

ICES defined its primary conservation objective in 1975 as allowing the spawning stock biomass to reach an historic level which previously had ensured stable recruitment. In the absence of a fishery to efficiently sample the age structure, the question arose as to how the recovery should be monitored. Recruitment as I group was estimated from the ICES International Young Herring survey. These research vessel catches per unit effort correlated with the stock estimates from VPA. The larval surveys gave independent indices of the size of the individual Bank, Downs and Buchan spawning stocks. Previously, it had been demonstrated that the larval stock indices could be correlated with catches per effort indices taken from the spawning fisheries. However, their combination in a single North Sea larval index to compare with the total population VPA was equivocal in view of differences in fecundity between the stocks, differences in timing of spawning and in possible survival. The Working Group was faced with the dilemma of having abandoned the attempts at monitoring individual stock fluctuations in favour of a North Sea unit approach only to find its material for assessing spawning stock size was by individual stocks. Attention was given to the possibility of partitioning the North Sea VPA to give estimates applicable to the individual stocks and, as a first approximation, this was based on the sub divisions, IVa, IVb, and IVc plus VIIde.

The management objective assumed the total North Sea population would respond as a single unit, however, very quickly a remarkable recovery took place in recruitment to the Downs stock alone. In 1979, an illegal catch of some 5 kt was taken from the Channel spawning grounds based on recruitment of the 1976 yearclass. The following year there was increased recruitment of the 1977 yearclass and combined with the survivors from the previous year an illegal catch of 39kt was taken out of a total North Sea adult catch of 45kt. By 1981 the European Commission (EC) could no longer hold back the demands from various industries that at least the southern North Sea and Channel should be reopened for fishing. Following advice from ICES, EC set a catch quota of 20kt to be taken between October 1981 and March 1982. In the event 42kt were taken resulting in a fishing mortality of 0.8 a value estimated at the start of the Downs collapse in 1955/6. 50kt was taken in the rest of the North Sea as by-catches. In

1982, the 1979 year class recruited to the northern stocks in much bigger numbers than expected, and with continuing increases in the Downs spawning stock biomass it appeared that the 1983 North Sea spawning stock biomass would approach the target value. It became inevitable that the total North Sea fishery would re-open in that year despite the fact it had not reached the target recovery level. 308kt were caught in comparison with a recommended ICES TAC of 98kt and an EC TAC of 145kt. Thus the pattern of the eighties was set, with neither the national managers nor the Commission making much attempt to enforce the agreed allocations.

It was clear that the North Sea herring population was not responding as a single stock unit. The incipient recovery of the Downs stock had been missed in the larval surveys as a result of their design which concentrated on surveying in December and early January but ignored the production from the eastern Channel in late January and February. In the 1979 young herring survey, conducted in severe weather conditions was thought, to have underestimated the 1977 yearclass. The 1978 year class sampled in the following year had the same abundance as that of 1976 year class and in view of its small mean length and the very small otolith nuclei it was concluded that yet another good Downs recruitment was likely in 1981. This led to the opening of the fishery that year. Once again, research was directed at attempting to obtain indices of recruitment of the individual stocks. Wood(1983) showed that indices of 0-group Downs herring from the English coast correlated with 2-ringed recruits from the IVC VPA, and Burd and Hulme (1984) showed that both were correlated with the abundances of small fish in the Young Herring Surveys. The full potential for separation of juvenile recruitment using otolith measurements and typing as in the 1950s, or the use of meristic characters as in the discriminant function analysis of the 1960s has never fully been tested in the recovery situation.

Extensive acoustic surveys were made in the northwestern North Sea in association with a trial micro-wire tagging programme in 1983 and 1984. These acoustic surveys conducted in July/August have become a regular part of the age distribution monitoring programmes. They cover the distribution of the Bank and Buchan stocks, but it is doubtful whether coverage of the Downs component is adequate. Nevertheless, they have developed into a major feature in relation to the tuning of the VPA.

2.5. Current Management.

The ICES Herring Assessment Working Group in 1980 had as one of its terms of reference a review of the biological criteria for re-opening the herring fisheries, Anon., (1980). A minimum spawning stock biomass had been identified and the Working Group considered that a very limited fishery should only be allowed before this goal had been reached if two basic criteria had been fulfilled: 'Firstly, there should be evidence of a recovery of the spawning stock, and of improved recruitment. This means that, for example,

a re-opening of the fishery should not be based only on expected increases in the spawning stock compared to an estimated level of a past year, and/or expected improved recruitment from an increasing spawning stock.... Secondly, the observed increases in spawning stock and recruitment should be of an order that ensures that the rebuilding to the defined goal will take place with a limited fishery operating.' The Working Group using these criteria could not recommend any fishery in 1980. It also reiterated the words of ACFM that the stock components might be recovering at different rates and as the level of recruitment to these components might differ, re-opening the total North Sea fishery might prevent one stock from recovering while another might remain lightly fished, depending on the distribution of fishing effort. The French and Dutch members of the Working Group could not agree with the management advice. They maintained that a small fishery would only prolong the period of below average recruitment and that the management objective of optimal stock size and the rate at which it should be achieved could not be based on biological criteria alone, but should take economic and social considerations into account.

With the extension of exclusive fishery limits by the member countries of EC and Norway, third countries were excluded from fishing except if they had special bilateral agreements. Between EC and Norway, agreements had to be reached on identification of those stocks which were subject to shared management and those regarded as entirely within the EEZ of either party, - the autonomous stocks. Under the Common Fisheries Policy, (CFP), an historic period dating from 1964 was chosen as the basis from which member countries shares of TACs were to be calculated. The choice of date negated the claims of those countries whose herring fisheries flourished prior to that date and recognised a major catch by Norway during the rapid decline of the stocks. EC accepted ICES as its independent source of advice on the biological management of fisheries through its Advisory Committee on Fisheries Management, (ACFM). It noted that ICES would not consider the inclusion of economic and social factors in the development of its advice on stock management. Within the Commission it set up a Scientific and Technical Committee on Fisheries, which consists of nominated scientists from member countries and gear technologists, and whose purpose is to comment on and interpret the ACFM advice in relation to the special needs of the member countries. This meant it could include the economic and social comment excluded by ICES. The Commission itself proposes the magnitude and the allocation of TACs between member countries of the autonomous stocks and acts as negotiator with Norway over shared stocks. Its proposals are discussed in internal management committees of EC, which unlike NEAFC, are conducted without industry observers. The final TACs which emerge from the negotiations may bear little resemblance to the initial proposals of ACFM having been bid up to facilitate negotiations on transfers of allocations from Norway and others countries. A comparison of recommended annual TACs, the agreed TACs and landings are given in Table 2. Examination of the record between the TACs and the annual catches is an indictment of the lack of enforcement to the agreed catch limits. The catches recorded here are those considered as most representative of the true catches and are those used for the calculation to the ACFM TACs. They

include estimates of discards which particularly in the fishery for roe is an important part of the mortality generated.

Table 2. Recommended TACs, agreed TACs, estimated catch and spawning biomass thousand tonnes,(kt).

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
ICES Divisions IVa,b.										
Recomm. TAC	0	0	62	95	166	235	500	500	484	373/332
Agreed TAC	-	-	72	-	-	500	560	500	484	385
Catch used	99	167	244	274	466	496	580	646	620	
ICES Divisions IVC,VIIId										
Recomm. TAC	20 ²	60 ²	36 ²	49	62	42	10	15	30	30
Agreed TAC	20	72	73	55	90	70	40	30	30	30
Catch used	42	69	64	46	70	52	45	31	48	
Total North Sea and Division VIIId.										
Spawning stock biomass.	214	293	434	732	777	847	964	1102	1256	1262 ¹

¹ Predicted or assumed

² Season, October-March

The minimum management objective of a spawning stock biomass of 1.200kt has been reached. This was selected from the historic data series and was chosen because in that period recruitment was fairly stable (only three year classes out of 15 fell far below the median) and adult fishing mortality was fairly constant at about 0.3. How applicable is such a target? At that time the Downs herring was being heavily fished in the southern North Sea and recruitment to the individual stocks could hardly be regarded as stable. The total catch was taken by many vessels at a rather low mean catch per effort and spread over the year from May to December. In contrast, the present exploitation is by purse seine and pelagic trawls over relatively short periods of intensive fisheries at very high catch rates. Little fishing begins before July; there is concentration on spawning herring in the central North Sea; a major exploitation takes place in the northeastern North Sea (unknown in the previous period); and the spawning grounds in the south are exploited for the roe market. One might question how relevant is an objective set under the early exploitation pattern in relation to a completely different exploitation in which the mix of stock components might well be very different.

ACMF in its advice for 1990 expressed concern that in spite of a series of good year classes the spawning stock had increased very little since 1984 and the proportion of the stock taken was already at a high level (around 40%). How confident can one be that the recovery can be continued and the hard won gains

maintained. Far from improving as the management regimes became established the data have continued to decline in quality and quantity. One of the major stumbling blocks in obtaining an overall assessment of the North Sea herring stocks has been the inability to make any appraisal of the effects of the Skagerrak fisheries on the North Sea. Throughout the history of these juvenile herring fisheries, the species composition of the catches landed for fish meal have been in doubt. The problem intensified when regulations to limit the industrial fisheries for herring in the North Sea began to be enforced. The reductions in catches simply reflected a change in the area of operation as boats moved to work in the Skagerrak. Of the reported 333kt of herring caught in the Skagerrak and Kattegat in 1988, an estimated 200kt were North Sea spawners of which 183kt were 0- and 1-group. This represents a very severe loss of potential recruitment to the North Sea. Regulations introduced to limit the activities of the industrial vessels and the by-catches of the sprat fisheries have been continuously ignored. Apart from this, there is a lack of adequate biological sampling which would allow the different stock components to be satisfactorily analysed.

The fears for the future of the North Sea herring industry were expressed at a meeting of delegates from the main Danish, UK, Dutch, German and French fishermen's organisations. Their communique submitted to the European Commission and the EC Council of Fisheries Minister on 27 June 1990 has a marked *déjà vu* sentiment. Their summarised demands are as follows:

- 1 a reduction of fishing for fishmeal in the Skagerrak/Kattegat;
- 2 adequate control of illegal herring-fishing practices in the Skagerrak/Kattegat and in the North Sea;
- 3 reduction of the directed fishing for herring for fishmeal and fishoil in the North Sea, by closed periods/additional closed areas, other technical measures and reduction of sprat-fishing for fishmeal
- 4 any catch reductions in the next few years should not be imposed on those fishermen who are not to blame for the overfishing
- 5 measures are needed to control the total catch not only the landed catches.

3. THE SCIENTIFIC DILEMMAS.

In the previous section the description of the events has been restricted to those concerned with the activity of the fishery and the responses from management to advice from ICES. The scientific arguments were far deeper than indicated. Every aspect of the biology and population dynamics were studied minutely and perhaps it is fair to say that too much is known about the herring to present a sufficiently simple case on which managers might act. The case for conservation of the Downs stock was confounded by the coincidence of the increased fishing mortality on the adult stock, the commencement of the Blöden fishery and the growth change with its implication of an environmental effect. The commencement of herring larval surveys required the development of a totally new quantitative sampling gear which

could be used routinely with a known degree of accuracy. Its initial purpose was to obtain independent evidence of the changes in size of the spawning stock. With the application of fecundity data, Bridger (1961) showed that with fewer older fish in the spawning stock the relative abundance of larvae decreased much faster than would be expected from the spawning potential in terms of eggs. One untested hypothesis was that three year old recruit spawners had lower egg viability, and for maintenance of viable spawning stock it was essential to have a buffer stock of older fish. Another hypothesis drew attention to the intensity of the trawling on the spawning grounds which would disrupt the spawning behaviour of the herring—the old fishermen's belief. I calculated that at the time of peak trawling, the spawning ground in the Sandettie/Ruytingen channel must have been ploughed 4 times per season by the trawl doors and ground ropes of the 250 trawlers. Perhaps the present Herring Assessment Working Group's observation of reducing larval numbers per gramme of spawning stock biomass might reflect Bridger's observation. In this case, it could be the activity of the fishery for roe which would result in reduced larvae at a period of increasing biomass.

When the growth increment increased in the 1950s it was first linked to an observed increase in the abundance of Calanus. In later years the plankton production in the North Sea decreased but growth continued to increase. Burd (1985) showed a density dependence between the mean lengths of fully recruited Bank and Downs herring and their biomass in their first year. The increased growth had a number of profound effects in diverse ways. At L₁ values of less than 11cm the Downs herring had opaque central zones to their otoliths. The size of the recruit class to the Downs stock could be forecast from the catches in the Bløden fishery. Can it be that with the current reduced growth, Downs herring could be again identified in the juvenile catches? The increased growth resulted in earlier recruitment to the adult stock changing from complete recruitment at 4 years old to three and even partial recruitment at two years old. Effectively a years natural mortality was saved. The Bløden fishery commenced just at this period when the year class would be at its most concentrated in the nursery area. In the thirties when recruitment was only complete at five years old the main nurseries were in the north western North Sea. Is the Bløden fishery then dependent on high incremental growth, and that the present apparent low abundances of juveniles in the Young Fish Survey a reflection of a return to low growth?

Growth has been supposed to be a reflection of environmental change. If growth is simply a density dependent effect has there been an additional environmental effect? Despite intensive research no evidence could be found to support the hypothesis that the mechanism of recruitment to Bank, Downs and Buchan stocks had changed. Indeed what is most striking is the maintenance of the differences of meristic characters over the years. It has been suggested that increasing temperatures on the Dogger spawning grounds was deleterious to survival, Corten, (1986). As vertebral sum is temperature dependent one might expect some trend in their means, but this cannot be demonstrated. Munk and Christensen (1990) found unacceptable

Corten's explanation of the increased larval abundance in the southern parts of the North Sea during the early eighties as a consequence of a return to 'normal' current circulation. The sudden recurrences of larval distributions in previously barren areas may be more readily explicable by the revival of spawning stocks previously reduced to very low numbers following heavy fishing. The revival of the Whitby stock and the Channel component of the Downs herring may be cited and, more dramatically, that of the Georges Bank herring, Stephenson and Kornfield (1990).

Finally, the past controversy over the impact of the juvenile herring fishery was to some extent resolved as a result of the intensive studies of predation in the North Sea. The use of a natural mortality of 0.1 for all age groups was shown to be a gross underestimate for the 0- and 1-groups. The values obtained were 1.00 and 0.30 for the two groups respectively. The very high catches of 0-group represent a very serious reduction in potential recruitment. Their contribution to the yield of fish meal and oil from the sprat fishery must be minimal as at that size, unlike sprat, their oil and protein contents are very low. It is thus also economically inefficient to utilize such fishes, and their catching should be eliminated.

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