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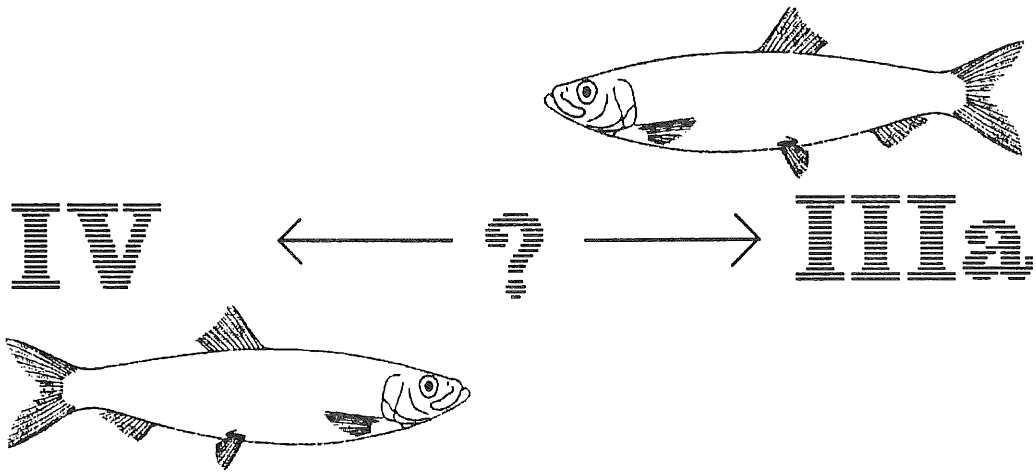

WORKSHOP ON METHODS OF FORECASTING HERRING CATCHES IN DIVISION IIIA AND THE NORTH SEA

LYSEKIL, 10-13 MARCH,

1992

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1 INTRODUCTION

1.1 Participants

A. Aglen	Norway
R.S. Bailey (Chairman)	UK
O. Hagström	Sweden
E. Kirkegaard	Denmark
E. Moksness	Norway
K. Popp Madsen	Denmark
O. Rechlin	Germany
B. Sjöstrand	Sweden

1.2 Terms of Reference

At the 79th Statutory Meeting, it was resolved (C.Res.2:7:23) that a "Workshop on Methods of Forecasting Herring Catches in Division IIIa and the North Sea" should be held in Lysekil, Sweden with the following terms of reference:

a) Evaluate methods and sampling required for stock separation of herring catches from Division IIIa and the northeastern North Sea with a view to establishing standard procedures.

b) Revise catch data on a stock and fleet basis, particularly for 1990.

c) Evaluate methods of forecasting catches of spring-spawning herring in the North Sea fishery and North Sea autumn-spawning herring in the Division IIIa fishery.

d) Report to the Herring Assessment Working Group for the Area South of 62°N and the Working Group on the Assessment of Baltic Pelagic Stocks.

To avoid clashes with other meetings, the dates of the Workshop were changed from 3-6 March to 10-13 March 1992.

1.3 Introductory Remarks

At its meeting in 1991 the Herring Assessment Working Group for the Area South of 62°N included catches of North Sea autumn-spawning herring taken in Division IIIa in its assessment and catch predictions of this stock. To partition the predicted catches into the management units in which North Sea herring are caught, it is necessary to provide a method of predicting the catches of the respective age groups in each of the areas concerned. The Working Group was unable to do this within the time available, and ACFM had to use an *ad hoc* method based on average historic catches (see Section 4.1). It was recognised, however, that information from surveys etc. may provide a way of allocating the catches on the basis of stock distribution rather than on the distribution of catches which depends on the historic distribution of fishing. A similar problem also arises in the case of Baltic/Division IIIa spring-spawning herring which are caught on their feeding migration in the eastern part of the North Sea.

At the same time, the assessment and prediction of these two stocks of herring requires a method for stock separation. While the methodology required has been developed over a number of years, the methods currently used are not in all cases reliable. In view of recent developments in determining the birth date of herring larvae the Workshop was asked to review available methods.

Finally, the Workshop was requested to revise, in so far as possible, the catch-at-age data, particularly for 1990, because sampling inadequacies had prevented the inclusion of 1990 data from Division IIIa in the assessments.

2 STOCK SEPARATION METHODS

2.1 Background

In previous years, catches of herring in Division IIIa have been allocated to their respective spawning stocks using a combination of modal length analysis and mean vertebral counts in individual samples.

The same method has been used for the eastern North Sea catches. The allocation of some catches in this area is done assuming that Baltic/IIIa spring-spawners and North Sea autumn-spawners have stable average numbers of vertebrae of 55.8 and 56.5, respectively. The Herring Assessment Working Group for the Area South of 62°N (*Anon.*, 1991a) pointed out that this takes no account of differences in stock meristic characters between year classes.

In Division IIIa it is frequently possible to identify more than one modal length group in samples of 0-, 1- and 2-ring herring. These modal length groups are then assigned to their respective stocks using mean vertebral counts. While this method has been generally acceptable, in some years vertebral counts have failed to provide confirmation of the stocks concerned. This first became a problem in 1985 when samples of 1-ringers from both commercial catches and the IYFS contained three modal length groups, the middle one of which could not be assigned to stock on the basis of vertebral counts (*Anon.*, 1985). This has remained a problem with the IYFS samples in most subsequent years (*Anon.*, 1991a).

In both the above areas, it is desirable to provide a more reliable method of stock separation. For this reason, the

Workshop evaluated all those methods that seemed to offer potential in the particular situation pertaining, and particularly those in which developments in methodology have been reported in recent years.

2.2 Review and Evaluation of Methods Available

2.2.1 Modal length analysis

The modal length analysis (Hagström, 1984) is based on the assumption that autumn-spawned herring, being hatched about 6 months earlier than spring-spawned herring, form a cohort with a larger mean length. The results of the separation are verified by comparing the mean vertebral counts of the cohorts with data from pure stocks. The method has been applied mostly on juvenile herring both in Division IIIa and the eastern North Sea. The method is sensitive to variation in growth of the different components and demands laborious sampling of vertebral counts for verification purposes. The method has been applied on herring data from the IYFS. In the mid-1980s, the results for 1-ring herring, both on survey data and in commercial catches, could not be verified by means of vertebral counts. The failure of the method coincided with increasing recruitment to the North Sea stock and decreasing growth of the year classes. The method has been more successful for separating 2-ring herring.

2.2.2 Meristic characters

Single meristic characters tend to have a low discriminatory power on mixed samples and are mainly used together with other information such as morphometric measurements or used for verification. Two methods using vertebral counts alone have, however, been used when other data have not been available. One method assumes constant mean vertebral counts for each component and the separation is based on the following formula:

$$\text{fraction of spring spawners} = (56.5 - v)/0.7$$

v = mean vertebral count in the sample

The method is very sensitive to variations in vertebral counts for each component and should be used with great care.

The other method splits the distribution of vertebral counts into two components. The method is based on a model described by Mann *et al.* (1983). It was used for separating North Sea autumn spawners and Division IIIa/Baltic spring spawners during the 1991 herring acoustic survey (*Anon.*, 1991b). When the split gave one component with mean count between 55.65 and 56.00 and the other between 56.35 and 56.60, the split was accepted. When the resulting components did not match these intervals, the mean count of one of the components was fixed at 56.44 (the mean value of a number of pure North Sea samples). Then the other component usually fell within one of the intervals. Another useful criterion was that the standard deviation of each component should be within the range 0.4 - 0.9. The method has shown promise, but it requires prior knowledge about the likely mean count of each component. The method requires further testing and comparisons with results from other stock separation methods.

2.2.3 Morphometric analysis

Discriminant analysis of a number of morphometric and meristic characters has been applied by Johannessen and Jörgensen (1990). They report a separation success close to 90% on an individual basis in the case of mixed samples of adult North Sea autumn spawners and Division IIIa/Baltic spring spawners. Their results also show that a separation success above 80% could be obtained from only two or three morphometric characters. The performance of the method, however, seems to be sensitive to the handling of the fish and to the measurement procedure. One reason why this method has not come into common use is that the stock reference data have not been made generally available.

2.2.4 Mitochondrial DNA

Stock separation based on mitochondrial DNA has shown promise for some fish stocks. The method does not seem promising for separating herring stocks in the North Sea and Division IIIa (Dahle and Eriksen, 1990).

2.2.5 Fatty acid profiles

A chemometric method for the direct determination of the composition of fatty acids in tissues from marine organisms has been developed at the University of Bergen. Herring from various stocks have shown different fatty acid profiles in their heart tissue (Grahl-Nielsen and Ulvund, 1990). This method may, therefore, be used for stock separation.

The main objection to the method is that the fatty acid profile will change with the diet. The recent findings indicate that this dependence on diet is less than generally anticipated, particularly in the case of specialized tissues, such as the heart, where the fatty acids are bound in biologically active phospholipids. Ongoing investigations show that North Sea herring and Baltic herring caught in the North Sea during summer 1991 had significantly different fatty acid profiles in five tissues: heart, brain, otolith, gill and muscle.

Seasonal and environmentally-caused changes in fatty acid profiles might obscure the usefulness of the method.

These possibilities are currently being investigated. It has been shown that the composition of the heart tissue of the local herring stock in Lindåspollene changed during the year, but this change was smaller than the differences between this stock and the North Sea or the Atlanto-Scandian stock.

This method has potential, but more research is needed before it can be routinely applied.

2.2.6 Otolith microstructure

In view of the recent developments in the methodology for determining the precise age of herring using primary growth zones in the otoliths, the Workshop examined the possibilities for using this technique for stock separation.

Otolith microstructure has been examined in otoliths from autumn-spawned herring larvae sampled in the North Sea and in the Skagerrak area, and from Norwegian spring-spawned herring larvae sampled along the western coast of Norway (Moksness and Fossum, 1991). The results show significantly larger increment widths within a distance of 30 to 60 μm from the nucleus in the otoliths from Norwegian spring-spawned herring larvae ($>2\mu$m) than in those from autumn-spawned North Sea herring larvae ($<2\mu$m). Moreover, larvae hatched in the northern North Sea have narrower increments ($\approx$ 1.0 μm) than those from the central and southern North Sea ($\approx$ 1.3μm) (Munk *et al*, 1991; Moksness, in press).

These results suggest that increment width within 30-60 μm of the otolith nucleus may be a potential tool for distinguishing spring- and autumn-spawned herring at all stages of their life-history.

The results available at present, however, are all based on samples of herring less than 200 days from hatching and have been limited to autumn-spawned North Sea herring and Norwegian spring-spawned herring. Before a final conclusion can be drawn about whether otolith microstructure can be used to distinguish between autumn- and spring-spawned herring in general, samples of spring-spawned Rügen herring (both larvae and adults) should be examined for otolith microstructure and the data used in the analysis.

Recently a technique has been developed to expose the otolith microstructure in the central area of otoliths from 0-group and older herring using a decalcification method (Zhang and Moksness, WP).

Results based on herring sampled in the North Sea and Skagerrak are shown in Figure 2.1 (from Zhang and Moksness, WP).

The increments close to the nucleus in adult fish sampled in the North Sea, and thought to be predominantly North Sea autumn spawners, had a modal width around 1.5 μm (range 0.9-2.1 μm with one outlier at 2.7 μm) which is within the range found in North Sea autumn-spawned larvae. In contrast, adults sampled in the Skagerrak had a much wider range of increment widths (1.3- 4.9 μm), with about 80% over 2.1 μm. There was not, however, the clear separation of increment widths found between autumn-spawned and spring-spawned larvae. While this method thus shows considerable promise, it is essential to examine increment widths in spring-spawned herring larvae and adults from the southwestern Baltic spawning area.

2.3 Application of Methods in Eastern North Sea

Only the adult (2-ringers and older) Division IIIa/Baltic spring spawners migrate into the North Sea. Modal length analysis (Section 2.2.1) has been shown to work satisfactorily for separating the two stocks for those age groups.

At the 1990 and 1991 meetings of the Herring Assessment Working Group for the Area South of 62°N, data from some of the samples were not available in the format necessary for such analysis and the method based on mean vertebral counts was applied (Section 2.2.2). Some samples have also been subjected to discriminant analysis of morphometric and meristic measurements (Section 2.2.3). Table 2.2.6 in *Anon.* (1990a) shows a reasonable agreement in results from these three methods.

2.4 Application of Methods in Division IIIa

As described in Section 2.2.1, the modal length analysis has been applied for some years, but has tended to fail for the 0- and 1-ringers during recent years. The method still performs satisfactorily for older fish.

2.5 Future Research Requirements and Recommendations

In the present state of the art, discriminant analysis of morphometric characters seems to be the most promising method. For the purpose of separating the two main stocks in question, measurements of snout-to-dorsal fin distance and peduncle height seem to give satisfactory results. These measurements are, therefore, recommended. In addition, vertebral counts should be continued until morphometric methods have been proved to be reliable. A routine application of the method, however, requires that the reference stock data and a manual for the method are published.

It is also recommended that further studies on otolith microstructure should be carried out. Further mapping of typical variations in growth pattern of larvae is needed. At present this is particularly lacking for the Baltic herring. The new method for studying otolith microstructure of adult fish should be further tested and developed.

3 CATCH DATA BY STOCK AND AREA

3.1 Description of Fisheries that take Herring in Division IIIa

Herring fishing in Division IIIa is carried out by Denmark, Norway and Sweden. The Norwegian share of the herring TAC is restricted to the Skagerrak. German vessels took small catches in earlier years but have not reported landings since 1986 and the same is the case with the Faroes which have had no allocation of the TAC in recent years.

The following fisheries that take herring may be distinguished:

(i) Directed fisheries for herring are carried out by Denmark, Norway and Sweden (Figure 3.1). The landings are mainly based on spring-spawning herring of which the Rügen spawners (southwest Baltic) are the most important, by far. Fishing is carried out by purse seine, pelagic pair trawl and single vessel bottom trawl. The Norwegian fishery is almost exclusively carried out by purse seine. The Danish and Swedish use of this gear is confined to the Skagerrak.

The Norwegian herring fishery consists of an open sea fishery based on the same stocks exploited in other countries' fisheries, and a fishery on herring in the Norwegian fjords. The fjord herring appears to be a specific stock.

The trawl fishery is carried out with 32 mm mesh and the legal landing size is 18 cm. Because of the rather mixed occurrence of young and adult herring in Division IIIa, the landings for human consumption contain varying amounts of unavoidable by-catch of young immature fish. These are mainly landed for reduction while discards may amount to about 10% of the total landings. Depending on market requirements a variable proportion of the smaller size categories of consumption herring may also be landed for reduction purposes.

(ii) Mixed clupeoid fisheries are carried out under a special "Sprat TAC" shared between Denmark, Norway and Sweden. The distribution of the Danish and Swedish fisheries is shown in Figure 3.1.

The Danish fishery was until 1991 carried out with 16 mm mesh and since January that year with a 32 mm minimum legal mesh size. For 1992 the Danish quota of 32,800 t has been divided between four periods as shown below:

1/1 - 31/3	9,830 t
1/4 - 30/4	3,300 t
1/5 - 31/8	0 t
1/9 - 31/12	19,700 t

The fishery may only be carried out by vessels having a special licence. This is only obtainable for vessels below 19 m o.a. in the Kattegat and 22 m in the Skagerrak. The licensed vessels may only have gears of or above the minimum mesh size on board, and they may only land 50 t per week and only make one landing per day. The total landing, irrespective of species composition, is counted against the quota. The species composition in 1990 and 1991 shows that herring only constituted about half of the Danish landings.

Swedish catches reported to have been taken by gear with meshes smaller than 32 mm are counted against the Mixed Clupeoid quota. The amounts of all species combined have been:

Year	Tonnes
1987	15,290
1988	13,024
1989	18,956
1990	12,330
1991	11,228 (prel.)

Both the age- and species composition of these catches are badly estimated. The main reason is lack of samples from the only Swedish fish meal plant. They nevertheless probably consist mainly of young herring.

The Norwegian fishery is exclusively carried out by purse seine. In the period 1987-1991, the average landing contained nearly 93% by weight of sprat which were landed to the canning industry. The term "mixed clupeoid fishery" is hardly appropriate in this case since the fishery is essentially a genuine sprat fishery.

(iii) By-catches in small-mesh fisheries (<32 mm) for industrial species like Norway pout, sandeel and blue whiting. These fisheries are only carried out by Danish vessels and the amount of herring caught in this connection is small, as are the landings.

3.2 Review of Historic Catch Data and Availability of New Material

No new data were available for the years prior to 1989. However, a revision to the catches in number was made for 1989 to take account of an additional catch of 20,000 t inadvertently omitted from the catch in number table for that year. A revised table of catch in number and mean weight at age for spring- and autumn-spawners is given in Table 3.2.1. This replaces Table 3.2.2 in the 1990 report of the Herring Assessment Working Group for the Area South of 62°N (*Anon.*, 1990a).

A new analysis of the 1990 data is given in Section 3.3.

Data for 1991 were not available at the Workshop and will be made available at the meeting of the Herring Assessment Working Group for the Area South of 62°N.

To provide as complete a series as possible, numbers at age in the catches are given by management area (North Sea, Division IIIa) and where possible by stock in Table 3.2.2 for the years 1970-1990. A comparable series is given for the southwestern Baltic (22-24) in Table 3.2.3. The data for earlier years are taken from previous reports of the Herring Assessment Working Group for the Area South of 62°N and the Working Group on Assessment of Pelagic Stocks in the Baltic and represent the most up-to-date estimates available.

3.3 Revised and New Data for 1990

At its 1991 meeting, the Herring Assessment Working Group for the Area South of 62°N found it impossible to convert part of the industrial landings in weight of herring taken in Division IIIa in 1990 into number at age owing to insufficient biological sampling of these landings. As a consequence, no catch-at-age data for herring in Division IIIa were available, and it was not possible for the Working Group on Assessment of Pelagic Stocks in the Baltic to update the assessment for the Division IIIa/Western Baltic spring-spawning stock. For the North Sea herring stock it was possible to carry out an assessment only using 1990 catch data for the North Sea.

The total landings of herring in Division IIIa in 1990 were 202,000 t of which 118,000 t were landed for reduction purposes. Approximately 60,000 t of the industrial landings were not sampled (*Anon.*, 1991a, Table 3.2.2). These landings are expected to consist mainly of 0-, 1- and 2-ringers (see Section 3.4).

Even though no new data were available, the Workshop decided to calculate the catch-at-age by stock in Division IIIa for 1990 using the incomplete data available at the meeting of the Herring Assessment Working Group for the Area South of 62°N in 1991 (see Table 3.2.3 in *Anon.*, 1991a). The resulting catches in numbers at age are given in Tables 3.3.1 and 3.3.2. The catches in numbers at age by quarter are allocated to spring- and autumn-spwning components in Table 3.3.3.

The human consumption catch in numbers at age was estimated as described in *Anon.* (1991a, Section 3.2.3). The industrial landings were converted to numbers using age compositions as indicated in Tables 3.3.1 and 3.3.2.

The Workshop agrees with the Herring Assessment Working Group for the Area South of 62°N that the biological sampling for 1990 was insufficient and the catch-at-age data given in Tables 3.3.1 and 3.3.2 are considered to be very uncertain with respect to the number of 0-, 1- and 2-ringers caught.The estimated number of 3-ringers and older are considered to be less uncertain as they are mainly taken in the human consumption fishery.

3.4 Quality of Sampling Data

The Herring Assessment Working Group for the Area South of 62°N pointed out the grossly inadequate level of biological sampling in Division IIIa in 1990 (*Anon.*, 1991a). This relates primarily to Danish and Swedish landings at reduction plants from the Skagerrak (36,000 t totally unsampled) and some human consumption landings from the Skagerrak (11,000 t unsampled). Even in the case of landings categories and quarters that were sampled, the numbers of fish aged was in some cases inadequate. For these reasons, the Herring Assessment Working Group for the Area South 62°N and the Working Group on Assessment of Pelagic Stocks in the Baltic did not use the 1990 catches in number in Division IIIa in their assessments in 1991. This is particularly serious for the assessment of Baltic spring-spawners where catches of adults in Division IIIa contribute a major quantity to the catches in numbers at age.

The Workshop has made the best estimates it can of catches in numbers from the few data available, but it should be stressed that this new analysis can in no way make up for the lack of samples. The reliability of assessments using these data is thus permanently impaired.

The Workshop strongly recommends that all fisheries that take herring in Division IIIa should be adequately sampled.

4 FORECASTING CATCHES IN THE NORTH SEA AND DIVISION IIIA

4.1 Introductory Remarks

At its 1991 meeting ACFM based the allocation of predicted catches of North Sea autumn-spawning herring to management area on the historic pattern of catches. The following assumptions were made:

The catches in Division IIIa consist of 1- and 2-ringers (0-ring herring are not included in the predictions). In the period 1983 to 1989, on average 60% of the total catch of 1-ring, and 12% of the total catch of 2- ring, herring were taken in Division IIIa. Using the same catch rates and the predicted catch of 1- and 2-ringers in 1991 of, respectively, 120,000 t and 65,000 t and in 1992 of 50,000 t and 95,000 t, the catches of autumn spawners in Division IIIa are calculated to be 80,000 t in 1991 and 41,000 t in 1992.

In the case of spring-spawners in the North Sea, the expected catch in 1992 was an approximate figure based on the catches of this stock in the North Sea in previous years.

At the present meeting, the Workshop examined a number of possible ways of predicting the catches of North Sea autumn spawners in Division IIIa (see Section 4.3). However, only those methods that could be explained by what is understood about the biology of the stock were considered to be appropriate. The simple fact of correlation alone was not considered to be a basis for prediction because of the dangers of spurious correlation in examining many series of data.

4.2 Baltic/Division IIIa Spring-Spawning Herring in the North Sea

An estimate of spring-spawning herring caught in the eastern part of Divisions IVa and IVb based on meristic characters has been carried out since 1986. The catches have been estimated back to 1984 but a breakdown by age group was available to the Workshop only from 1986 onwards.

The yearly catches in number at age have been used in the combined stock assessment of spring-spawning herring in Sub-divisions 22 to 24 (Western Baltic) and Division IIIa since then.

The estimated catches of spring-spawners varied between 8,358 (1990) and 23,306 (1988) t with an average of 17,076 t from 1986 to 1990. To investigate possible causes of this variation, the annual catches in number in the North Sea were examined in relation to estimates of the size of the spring-spawning stock (*Anon.*, 1990b). There seems to be a correlation ($r^2 = 0.66$) between the annual catch in numbers of spring-spawners in the North Sea and the estimated number of 2- and 3-year old fish in the Western Baltic/Division IIIa spring-spawning herring stock for the rather short period under consideration (Figure 4.1).

In addition to the variation in catch, and presumably abundance, of this spring-spawning stock in the North Sea, there is also evidence of variation in the migration pattern. The feeding migration of spring- spawners from Division IIIa into the North Sea seems to be influenced by the amount and/or distribution of the main food item, *Euphausia*.

The herring fishery that takes place in the area of the border between Divisions IIIa and IVa in the third quarter demonstrates, by the fluctuating proportions of catches taken inside and outside Division IIIa, the variable distribution of herring shoals from year to year.

From the data and information available at present, the Workshop did not feel able to give soundly-based advice on how to predict yearly catches of Baltic/Division IIIa spring-spawning herring in the North Sea.

4.3 North Sea Autumn-Spawning Herring in Division IIIa

Young autumn-spawned herring from the North Sea enter Division IIIa as larvae and probably also as post-metamorphosed 0-group. The influx of larvae depends largely on the prevailing currents during the pelagic phase, while the small 0-group fish are capable of active movement with or against the currents.

It is not clear whether emigration from the North Sea also takes place in later developmental stages, e.g. as 1-group fish, but existing data do not indicate that this is of any importance. On the contrary, the indications are that the young autumn spawners return to the North Sea when they have reached a certain length and that this migration stage is reached by fast-growing individuals of the 1-ringer population in the second half of the year. The last individuals of this spawning component have largely left Division IIIa by their third summer, i.e., as 2-ringers.

In evaluating methods of forecasting catches of North Sea autumn spawners in Division IIIa, the migration pattern described above should be taken into consideration since unpredictable factors like water movements and variation in growth rates may influence the reliability of any prognoses to an unknown degree.

The Workshop considered two angles of approach in forecasting the catches of young autumn spawners in Division IIIa:

(i) <u>A direct approach</u> based on the possible existence of significant and useful relationships between historic catches and available abundance indices. The pertinent data used by the Workshop were extracted from the reports of the Herring Assessment Working Group for the Area South of 62°N and are shown in Table 4.3.1.

Catches of 0- and 1-group North Sea autumn spawners in Division IIIa were regressed against:

IYFS larval indices in Division IIIa
IYFS larval indices for Division IIIa and the southeastern North Sea
IYFS larval indices for Division IIIa and the total North Sea combined

IYFS 1-group indices
Acoustic indices of 0- and 1 group in Division IIIa.

A feature common to most of these regressions is the strong influence of the 1986 year class which gave very high catches in Division IIIa, while the 1987 year class in some cases fell below the lower confidence limit of the fitted regression. Since about 1988, a significant change has taken place in the herring fisheries in Division IIIa, for example the TAC of mixed clupeoids has been reduced and the control has been more vigorously enforced. Low prices of herring and of industrial catches in some of the most recent years have motivated a number of vessels to turn to fishing for e.g., *Nephrops* or sandeel which produced a number of strong year classes in the late 1980s. Although some of the regressions look promising, they cannot dependably be used for forecasting because of the change in fishing pattern and fishing effort mentioned above. The Workshop, therefore, examined the possibilities for:

(ii) Forecasting the stock of 1-group North Sea herring in Division IIIa. This would be more closely related to the general practice in which a number of management options are given by applying an array of fishing mortalities to the calculated stock in number.

In order to be of practical use the indices on which the forecast is based should refer to a stage or stages as early in the life history of the individual year class as possible. In order to counteract the unpredictable factors mentioned at the beginning of this section, the indices should on the other hand also refer to stages at which the immigration of North Sea fry into Division IIIa has ceased and at which the occurrence in the Skagerrak and Kattegat is largely stabilized.

These requirements left three options open to the Workshop: Indices of 0-group larvae from the IYFS, 0-group from acoustic surveys in August and again in November.

The stock numbers of 1-ring herring in Division IIIa were obtained by applying the relative abundance of 1-ringers in the North Sea and Division IIIa, as calculated from IYFS data (*Anon.*, 1991a, Table 2.3.4), to the total estimates of 1-ringer autumn spawners in the combined North Sea-Division IIIa VPA (*Idem.*, Table 2.7.8).

The IYFS partitioning of 1-group between the North Sea and Division IIIa is not converted to allow for the presence of the spring-spawned component in Division IIIa estimates. This could lead to an overestimate of the North Sea component in that area. The occurrence of spring-spawned 1-group in Division IIIa in winter is, however, too small to be of serious consequence and, in terms of management procedures, any distinction between spring and autumn spawners will not be possible, in any case.

The stock numbers used in this context are shown in Table 4.3.1 and the regressions on the three indices mentioned above are shown in Figure 4.2. The larval indices in Figure 4.2 comprise the total larvae in Division IIIa and the North Sea on the presumption that a large production of larvae in the North Sea will be reflected in an increased influx in Division IIIa.

The Workshop considered that all three regressions (Figure 4.2) demonstrate promising possibilities for obtaining a forecast of North Sea 1-ringers in Division IIIa and that they should be followed up in future.

The approach described above may also be of value for estimating the numbers of 2-ring North Sea autumn-spawning herring in Division IIIa, but the Workshop had insufficient time to investigate this possibility.

5 RECOMMENDATIONS

Recommendations given elsewhere in the report are restated here.

Stock separation

a. Measurements of snout-to-dorsal fin distance and peduncle height should be made. In this connection, reference stock data and a manual of measurement methods should be published.

b. Vertebral counts should be continued until the reliability of morphometric methods has been established.

c. Further studies on otolith microstructure should be carried out.

d. The new method for studying otolith micro-structure in adult fish should be tested and developed.

e. Discrimination by fatty acid analysis should be further evaluated.

Quality of sampling data

The Workshop strongly recommends that all fisheries that take herring in Division IIIa should be adequately sampled.

Forecasting catches

The Workshop recommends that the possibility of using the three regressions given in Figure 4.2 should be examined further as a means of providing forecasts of the number of North Sea 1-ringers in Division IIIa.

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Table 3.2.1. Herring in Division IIIa, 1989

Revised table giving numbers (millions) and weights (grams) at age of catch by quarter and stock

Year class	Autumn/spring		Age in rings										Landings (tonnes)
			0	1	2	3	4	5	6	7	8	≥9	
			1988/89	1987/88	1986/87	1985/86	1984/85	1983/84	1982/83	1981/82	1980/81	pre 1980/81	
Quarter													
I	spring	no	-	-	-	186.7	19.4	4.0	1.2	0.4	-	-	
		w	-	-	-	67.8	70.8	104.6	122.3	186.1	-	-	
	autumn	no	-	543.2	461.8	-	-	-	-	-	-	-	48,003
		w	-	18.4	51.7	-	-	-	-	-	-	-	
	combined	no	-	543.2	461.8	186.7	19.4	4.0	1.2	0.4	-	-	
		w	-	18.4	51.7	67.8	70.8	104.6	122.3	186.1	-	-	
II	spring	no	-	-	253.8	144.2	18.8	4.8	0.9	0.3	-	-	
		w	-	-	38.8	71.2	78.7	102.6	110.7	194.1	-	-	
	autumn	no	-	159.2	143.1	-	-	-	-	-	-	-	33,588
		w	-	23.8	53	-	-	-	-	-	-	-	
	combined	no	-	159.2	397.0	144.2	18.8	4.8	0.9	0.3	-	-	
		w	-	23.8	43.9	71.2	78.7	102.6	110.7	194.1	-	-	
III	spring	no	-	283.8	203.6	96.2	27.0	7.1	2.1	0.8	0.4		
		w	-	33.7	65.5	86.2	147.9	167.1	187.5	188.5	214.3		
	autumn	no	874.1	203.8	33.5	-	-	-	-	-	-		62,646
		w	14.8	54	66	-	-	-	-	-	-		
	combined	no	874.1	487.6	237.1	96.2	27.0	7.1	2.1	0.8	0.4		
		w	14.8	42.2	65.5	86.2	147.9	167.1	187.5	188.5	214.3		
IV	spring	no	-	242.5	84.2	74.2	15.6	3.2	1.0	0.1	0.03		
		w	-	39.6	73.9	87.4	109.7	138.8	138.4	147.5	217		
	autumn	no	154.1	264.3	16.4	-	-	-	-	-	-		42,413
		w	24.3	54	74	-	-	-	-	-	-		
	combined	no	154.1	506.8	100.6	74.2	15.6	3.2	1.0	0.1	0.03		
		w	24.3	47.1	73.9	87.4	109.7	138.8	138.4	147.5	217		
Total	spring	no	-	526.3	541.6	501.3	80.8	19.1	5.2	1.6	0.43		
		w	-	36.4	54.3	75.2	105.9	133.1	149.7	186.4	214.5		
	autumn	no	1028.2	1170.5	654.8	-	-	-	-	-	-		186,650
		w	16.2	33.4	53.3	-	-	-	-	-	-		
	combined	no	1028.2	1696.8	1196.4	501.3	80.8	19.1	5.2	1.6	0.43		
		w	16.2	34.3	53.8	75.2	105.9	133.1	149.7	186.4	214.5		

Spring spawners caught in subarea IV and transferred to the Baltic/IIIa stock are not included. Mean weights at age and the allocation of numbers to stock are as given in CM 1990/Assess 14 (see Tables 3.1.1, 3.2.2, 3.2.3 and 3.2.4 in that report).

Table3.2.2 Estimated numbers (millions) at age of herring caught in the North Sea and Division IIIa by stock, 1970-1990

	Age in rings											
	0-ring						1-ring					
	North Sea			IIIa			North Sea			IIIa		
	Spring	Autumn 1)	Total	Spring 6)	Autumn 2)	Total 3)	Spring	Autumn 1)	Total	Spring 6)	Autumn 2)	Total 3)
1970	*	898.1					*	1196.2				
1971	*	684.0					*	4378.5				
1972	*	750.4					*	3340.6				
1973	*	289.4					*	2368.0				
1974	*	996.1				2499	*	846.1				910
1975	*	263.8				2006	*	2460.5				1471
1976	*	238.2				433	*	126.6				1474
1977	*	256.8				934	*	144.3				1437
1978	*	130.0				147	*	168.6				876
1979	*	542.0				457	*	159.2				168
1980	*	791.7		211	471	682	*	161.2		383	84	467
1981	*	7888.7		1993	1631	3624	*	447.0		541	425	966
1982	*	9556.7		934	2400	3334	*	840.4		709	276	985
1983	*	10029.9		1609	3267	4876	*	1146.6		1301	1302	2603
1984	*	2189.4		497	4472	4969	*	561.1		1765	1177	2942
1985	*	1292.9		1014	2886	3900	*	1620.2		792	1608	2400
1986	*	704.0		740	2960	3700	*	1763.2		740	2960	3700
1987	*	1797.5		0	6238	6238	*	3522.4		350	3153 5)	3503
1988	*	1292.9		0	1830	1830	*	1970.8		0	5792	5792
1989	*	1955.8		0	1028	1028 4)	*	1899.5		526	1171	1697 4)
1990 10)	*	853.9		0	398	398	*	1477.4		141	1424	1565

Notes * = Assumed to be zero
Blank = No information

1) CM 1991/Assess:15, table 2.2.2
2) CM 1991/Assess:15, table 2.2.3
3) CM 1990/Assess:14, table 3.1.3
4) This report: table 3.2.1. (no change in proportion of spring and autumn spawners)
5) CM 1990/Assess:14, 3127 given in table 3.2.4
6) By subtraction
7) CM 1989/Assess:15, table 3.2.2
8) CM 1988/Assess:17, table 3.2.2
9) CM 1988/Assess:17, table 3.2.3
10) This report: tables 3.3.1, 3.3.2 and 3.3.3
11) CM 1991/Assess:15, table 2.2.6
12) CM 1986/Assess:19, table 3.2.2
13) CM 1985/Assess:12, table 3.2
14) CM 1984/Assess:12, table 3.2

Table 3.2.2 continued

	Age in rings											
	2-ring						≥3-ring					
	North Sea			IIIa			North Sea			IIIa		
	Spring 11)	Autumn 1)	Total	Spring 6)	Autumn 2)	Total 3)	Spring 11)	Autumn 1)	Total	Spring	Autumn	Total 13)
1970		2002.8						1152.2				
1971		1146.8						9267.4				
1972		1440.5						514.0				
1973		1344.2						905.0				
1974		772.6				375		574.5				221 14)
1975		541.7				149		487.3				140
1976		901.5				325		215.7				38
1977		44.7				329		210.5				85
1978		4.9				455		11.9				77
1979		34.1				583		23.9				87
1980		108.1		207	26	233		150.0				220
1981		264.3		636	20	656		172.9				256
1982		268.4		283	31	314		297.5				287
1983		544.8		461	29	490		406.9				185
1984		986.5		728	119	847		759.1				241
1985		1223.2		538	93	631		1771.9				484 12)
1986	*	1155.1		324	91	415	115.4	1522.4				
1987	35.5	2005.4		650	117	767	72.6	1533.3		288 9)	*	216 8)
1988	44.6	1955.5		2029	292	2321	139.2	2033.8		529	*	529 7)
1989	27.3	927.7		542	654	1196 4)	117.0	2652.1		608	*	608 4)
1990 10)	12.4	592.8		994	284	1278	46.3	2163.0		499	*	499

Table 3.2.3 Estimated numbers (millions) at age of spring-spawning herring caught in the SW Baltic (Sub-divisions 22-24), 1970-1990,

Year	0-ring	1-ring	2-ring	≥3-ring
1970	14	176	270	370
1971	23	175	135	394
1972	19	299	50	505
1973	25	165	44	563
1974	31	340	62	554
1975	91	466	150	573
1976	256	438	258	399
1977	89	1310	156	427
1978	60	703	426	323
1979	204	239	447	435
1980	84	259	197	773
1981	40	110	302	567
1982	99	391	245	712
1983	100	475	334	703
1984	58	335	334	649
1985	159	243	312	765
1986	313	280	131	808
1987	771	1090	221	668
1988	611	861	364	674
1989	179	682	285	778
1990	n/a	286	162	621

1) C.M. 1990/Assess:18 table 3.2.6.2
2) C.M. 1991/Assess:18 table 3.2.9
n/a: not available

Skagerrak	Total		Human consumption total		Danish mixed clupeoid		Danish other indust. landings		Swedish industrial landings	
Quarter 1	N	W	N	W	N	W	N	W	N	W
Sampel used			Swedish+Norwegian human consumption		Danish industrial		Danish industrial		Swedish industrial	
0	0.0	0.0	0.0							
1	162.4	28.8	6.6	39.2	78.1	28.3	47.3	28.3	30.4	28.4
2	166.9	52.5	65.6	64.7	60.0	44.9	36.4	44.9	4.9	38.4
A 3	25.5	75.9	17.0	88.3	5.1	51.2	3.1	51.2	0.3	41.4
G 4	11.0	90.0	10.4	91.7	0.4	60.0	0.2	60.0		
E 5	3.4	96.4	3.4	96.4						
6	0.9	151.9	0.9	151.9						
7	0.7	170.3	0.7	170.3						
8	0.3	188.2	0.3	188.2						
9	0.0	0.0	0.0	194.1						
10+	0.0	0.0	0.0							
Total N	371.1		104.9		143.6	36.0	87.0		35.6	
Catch/SOP	16139.0	16132.5	6752.0	6760.0	5186.0	5165.5	3140.0	3131.7	1061.0	1062.7
Quarter 2	N	W	N	W	N	W	N	W	N	W
Sampel used			Swed.(1.q)+Norwegian human consumption				Swedish industrial		Swedish industrial	
0	0.0									
1	660.5	20.8	5.4	39.2			120.0	20.6	535.1	20.6
2	125.0	51.6	41.4	64.7			15.3	45.1	68.3	45.1
A 3	17.8	83.7	11.8	88.3			1.1	74.8	4.9	74.8
G 4	16.7	100.6	7.6	91.7			1.7	108.0	7.4	108.0
E 5	2.0	96.4	2.0	96.4						
6	0.5	151.9	0.5	151.9						
7	0.4	170.3	0.4	170.3						
8	0.2	188.2	0.2	188.2						
9	0.0			194.1						
10+	0.0									
Total N	823.1		69.3		0.0		138.1		615.7	
Catch/SOP	23708.0	23704.4	5017.0	5007.4	0.0	0.0	3423.0	3427.9	15268.0	15269.1
Quarter 3	N	W	N	W	N	W	N	W	N	W
Sampel used			Swedish+Norwegian human consumption		Swedish industrial		Swedish industrial		Swedish industrial	
0	0.0	0.0			0.0		0.0			
1	125.3	82.6	52.1	90.1	0.9	77.3	32.4	77.3	39.9	77.3
2	302.6	87.0	91.4	101.9	2.7	80.5	93.4	80.5	115.1	80.5
A 3	74.9	109.2	36.8	128.5	0.5	90.7	16.9	90.7	20.8	90.7
G 4	75.1	145.4	34.6	188.3	0.5	108.8	17.9	108.8	22.1	108.8
E 5	36.6	127.1	12.4	169.4	0.3	105.6	10.7	105.6	13.2	105.6
6	2.3	201.4	2.3	201.4	0.0		0.0			
7	14.2	161.1	10.2	173.7	0.1	128.8	1.8	128.8	2.2	128.8
8	0.0	0.0			0.0		0.0			
9	0.1	233.7	0.1	233.7	0.0		0.0			
10+	0.0	0.0			0.0		0.0			
Total N	631.2		239.9		5.1		173.0		213.2	
Catch/SOP	63249.0	63211.9	29617.0	29608.6	435.0	434.6	14869.0	14856.3	18328.0	18312.3
Quarter 4	N	W	N	W	N	W	N	W	N	W
Sampel used			Swedish+Norwegian human consumption		Swedish industrial		Swedish industrial		Swedish industrial	
0	310.2	30.5		45.3	69.0	30.5	108.7	30.5	132.5	30.5
1	19.8	45.0	2.5	80.6	3.8	39.9	6.1	39.9	7.4	39.9
2	77.1	87.3	77.1	87.3						
A 3	22.6	98.3	22.6	98.3						
G 4	5.0	101.0	5.0	101.0						
E 5	4.1	112.3	4.1	112.3						
6	0.8	152.7	0.8	152.7						
7	0.1	200.0	0.1	200.0						
8	0.0	0.0								
9	0.0	0.0								
10+	0.0	0.0								
Total N	439.7		112.2		72.8		114.8		139.9	
Catch/SOP	19811.0	20402.0	9676.0	10264.6	2254.0	2254.5	3552.0	3552.8	4329.0	4330.0

TOTAL	N	W
0	310.2	30.5
1	968.0	30.6
2	671.6	71.9
A 3	140.8	98.2
G 4	107.8	130.7
E 5	46.1	122.2
6	4.6	177.3
7	15.4	162.0
8	0.5	188.2
9	0.1	233.7
10+	0.0	
Total N	2265.1	
Catch/SOP	122907.0	124319.5

Table 3.3.1 Herring spring- and autumn spawners combined. Skagerrak 1990. Landings in numbers (millions and tonnes) and mean weight (g) at age (winter rings) by fleet.

Kattegat		Total N	Total W	Human consumption total N	Human consumption total W	Danish mixed clupeoid N	Danish mixed clupeoid W	Danish other indust. landings N	Danish other indust. landings W	Swedish industrial landings N	Swedish industrial landings W
Quarter 1		N	W	N	W	N	W	N	W	N	W
Sampel used				Swedish human consumption		Danish industrial		Danish industrial		Swedish industrial	
	0	0.0	0.0								
	1	231.6	21.8	16.6	51.0	158.6	18.1	30.5	18.1	25.9	29.8
	2	284.2	43.3	55.7	59.0	75.7	32.9	14.5	32.9	138.3	43.8
A	3	32.9	69.3	16.0	69.6	7.7	81.8	1.5	81.8	7.8	54.0
G	4	15.9	83.1	12.4	78.3	2.1	113.1	0.4	113.1	1.0	67.8
E	5	5.6	102.4	3.0	118.5	2.2	84.0	0.4	84.0		
	6	0.8	123.8	0.8	123.8						
	7	0.4	124.1	0.4	124.1						
	8	0.2	161.7	0.2	161.7						
	9	0.0			182.0						
	10+	0.0			230.0						
Total N		571.7		105.1		246.3		47.3		173.0	
Catch/SOP		21695.0	21708.4	6740.0	6753.8	6411.0	6413.4	1232.0	1232.5	7312.0	7308.7
Quarter 2		N	W	N	W	N	W	N	W	N	W
Sampel used				Swedish human consumption				Danish industrial		Swedish industrial	
	0	5.1	5.5					5.1	5.5		
	1	46.2	28.7	0.2	37.0			15.5	28.6	30.5	28.7
	2	98.6	39.5	4.0	58.2			13.6	37.6	81.0	38.9
A	3	16.2	64.4	8.6	72.0			0.6	51.5	7.0	56.3
G	4	16.3	79.5	13.0	82.7			0.1	62.1	3.2	66.6
E	5	2.8	88.1	2.6	89.1					0.2	73.4
	6	0.5	92.0	0.5	92.0						
	7	0.6	91.0	0.6	91.0						
	8	0.0			135.2						
	9	0.0			142.1						
	10+	0.0									
Total N		186.3		29.5		0.0		34.9		121.9	
Catch/SOP		7949.0	7925.5	2292.0	2266.6	0.0	0.0	1018.0	1019.8	4639.0	4639.0
Quarter 3		N	W	N	W	N	W	N	W	N	W
				Swedish human consumption		Swedish industrial		Swedish industrial		Swedish industrial	
	0	2.1	24.6			0.4	24.6	0.5	24.6	1.2	24.6
	1	74.2	51.9	4.6	86.5	14.5	49.6	15.8	49.6	39.3	49.6
	2	112.9	69.5	36.2	87.1	16.0	61.3	17.4	61.3	43.3	61.3
A	3	32.6	86.8	17.8	97.9	3.1	73.5	3.4	73.5	8.4	73.5
G	4	17.7	95.1	13.0	104.5	1.0	69.4	1.1	69.4	2.7	69.4
E	5	2.5	117.9	2.2	122.9	0.1	83.7	0.1	83.7	0.2	83.7
	6	0.8	122.6	0.8	122.6						
	7	0.4	132.3	0.4	132.3						
	8	0.1	173.3	0.1	173.3						
	9	0.0			213.8						
	10+	0.0									
Total N		243.3		75.1		35.1		38.1		94.9	
Catch/SOP		16846.0	16729.0	7201.0	7087.4	2015.0	2014.3	2186.0	2185.2	5444.0	5442.1
Quarter 4		N	W	N	W	N	W	N	W	N	W
				Swedish human consumption		Swedish industrial		Swedish industrial		Swedish industrial	
	0	80.5	33.0	0.8	53.2	21.9	32.8	4.2	32.8	53.6	32.8
	1	245.2	65.6	75.1	81.4	46.7	58.6	9.0	58.6	114.4	58.6
	2	110.2	80.2	66.9	88.2	11.9	68.0	2.3	68.0	29.1	68.0
A	3	22.7	88.1	15.9	95.4	1.9	71.0	0.4	71.0	4.6	71.0
G	4	12.7	101.3	11.2	103.1	0.4	88.0	0.1	88.0	1.0	88.0
E	5	1.5	99.8	1.5	99.8	0.0		0.0			
	6	0.4	128.5	0.2	156.9	0.1	101.2	0.0	101.2	0.1	101.2
	7	0.2	201.9	0.2	201.9	0.0		0.0			
	8	0.2	91.7			0.1	91.7	0.0	91.7	0.2	91.7
	9	0.0									
	10+	0.0									
Total N		473.6		171.8		82.8		16.0		203.0	
Catch/SOP		31023.0	31131.4	15050.0	14947.4	4441.0	4441.3	857.0	857.1	10675.0	10885.7

Total		N	W
	0	87.6	31.2
	1	597.2	44.0
	2	605.9	54.3
A	3	104.5	78.1
G	4	62.6	89.3
E	5	12.4	102.0
	6	2.5	117.8
	7	1.6	123.5
	8	0.5	132.9
	9	0.0	
	10+	0.0	
Total N		1474.9	
Catch/SOP		77513.0	77494.2

Table 3.3.2 Herring spring and autumn spawners combined. Kattegat 1990. Landings in numbers (millions) and mean weight (g) at age (winter rings) by fleet.

Table 3.3.3

Catches the Skagerrak (Div. IIIa) in 1990 Autum and spring spawners

Numbers in (mill.) and mean weigth in g.

1. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		162.4	166.9	25.5	11.0	3.4	0.9	0.7	0.3	371	
Mean w.		28.8	52.5	75.9	90.0	96.4	151.9	170.3	188.2		16139
SOP	0.0	4677.1	8762.3	1935.5	990.0	327.8	136.7	119.2	56.5	17005	

2. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		660.5	125.0	17.8	16.7	2.0	0.5	0.4	0.2	823.1	
Mean w.		20.8	51.6	83.7	100.6	96.4	151.9	170.3	188.2		23708
SOP	0.0	13738.4	6450.0	1489.9	1680.0	192.8	76.0	68.1	37.6	23732.8	

3. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		125.3	302.6	74.9	75.1	36.6	2.3	14.2	0.1	631.1	
Mean w.		82.6	87	109.2	145.4	127.1	201.4	161.1	233.7		63249
SOP	0.0	10349.8	26326.2	8179.1	10919.5	4651.9	463.2	2287.6	23.4	63200.7	

4. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	310.2	19.8	77.1	22.6	5.0	4.1	0.8	0.1		439.7	
Mean w.	30.5	45.0	87.3	98.3	101.0	112.3	152.7	200.0			19811
SOP	9461.1	891.0	6730.8	2221.6	505.0	460.4	122.2	20.0	0.0	20412.1	

Total Year	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	310.2	968.0	671.6	140.8	107.8	46.1	4.5	15.4	0.6	2265.0	
Mean w.	30.5	30.6	71.9	98.2	130.7	122.2	177.3	162.0	195.8	54.9	122907
SOP	9461	29656	48269	13826	14095	5633	798	2495	117	124351	

Table 3.3.3 cont'd

Catches in the Skagerrak (Div. IIIa) in 1990 — Autum spawners

Numbers in (mill.) and mean weigth in g.

1. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		162.4	166.9							329.3	
Mean w.		28.8	52.5								
SOP	0.0	4677.1	8762.3	0.0	0.0	0.0	0.0	0.0	0.0	13439.4	

2. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		660.5	83.6							744.1	
Mean w.		20.8	45.1								
SOP	0.0	13738.4	3770.4	0.0	0.0	0.0	0.0	0.0	0.0	17508.8	

3. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		125.3	20.1							145.4	
Mean w.		82.6	101.9								
SOP	0.0	10349.8	2048.2	0.0	0.0	0.0	0.0	0.0	0.0	12398	

4. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	310.2	19.8	13.1							343.1	
Mean w.	30.5	45	87.3								
SOP	9461.1	891.0	1143.6	0.0	0.0	0.0	0.0	0.0	0.0	11495.7	

Total Year

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	310.2	968.0	283.7	0.0	0.0	0.0	0.0	0.0	0.0	1561.9	
Mean w.	30.5	30.6	55.4	0.0	0.0	0.0	0.0	0.0	0.0	35.1	
SOP	9461	29656	15724	0	0	0	0	0	0	54842	

Table 3.3.3 cont'd

Catches in the Skagerrak (Div. IIIa) in 1990 Spring spawners

Numbers in (mill.) and mean weigth in g.

1. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0.0	0.0	0.0	25.5	11.0	3.4	0.9	0.7	0.3	41.8	
Mean w.	0.0	0.0	0.0	75.9	90.0	96.4	151.9	170.3	188.1		
SOP	0.0	0.0	0.0	1935.5	990.0	327.8	136.7	119.2	56.5	3565.6	

2. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0.0	0.0	41.4	17.8	16.7	2.0	0.5	0.4	0.2	79.0	
Mean w.	0.0	0.0	64.7	83.7	100.6	96.4	151.9	170.3	188.1		
SOP	0.0	0.0	2679.6	1489.9	1680.0	192.8	76.0	68.1	37.6	6224.03	

3. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0.0	0.0	282.5	74.9	75.1	36.6	2.3	14.2	0.1	485.7	
Mean w.	0.0	0.0	85.9	109.2	145.4	127.1	201.4	161.1	233.5		
SOP	0.0	0.0	24278.0	8179.1	10919.5	4651.9	463.2	2287.6	23.4	50802.7	

4. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0.0	0.0	64.0	22.6	5.0	4.1	0.8	0.1	0.0	96.6	
Mean w.	0.0	0.0	87.3	98.3	101.0	112.3	152.7	199.8	0.0		
SOP	0.0	0.0	5587.2	2221.6	505.0	460.4	122.2	20.0	0.0	8916.37	

Total Year

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0	0	387.9	140.8	107.8	46.1	4.5	15.4	0.6	703.1	
Mean w.	0.0	0.0	83.9	98.2	130.7	122.2	177.3	162.0	195.8		
SOP	0	0	32545	13826	14095	5633	798	2495	117	69508.7	

Table 3.3.3 cont'd

Kattegat (Div. IIIa) catches in 1990 Autum and spring spawners

Numbers in (mill.) and mean weigth in g.

1. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		231.6	284.2	32.9	15.9	5.6	0.8	0.4	0.2	571.6	
Mean w.		21.8	43.3	69.3	83.1	102.4	123.8	124.1	161.7		21695
SOP	0.0	5048.9	12305.9	2280.0	1321.3	573.4	99.0	49.6	32.3	21710.5	
2. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	5.1	46.2	98.6	16.2	16.3	2.8	0.5	0.6		186.3	
Mean w.	5.5	28.7	39.5	64.4	79.5	88.1	92	91			7949
SOP	28.1	1325.9	3894.7	1043.3	1295.9	246.7	46.0	54.6	0.0	7935.1	
3. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	2.1	74.2	112.9	32.6	17.7	2.5	0.8	0.4	0.1	243.3	
Mean w.	24.6	51.9	69.5	86.8	95.1	117.9	122.6	132.3	173.3		16846
SOP	51.7	3851.0	7846.6	2829.7	1683.3	294.8	98.1	52.9	17.3	16725.2	
4. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	80.5	245.2	110.2	22.7	12.7	1.5	0.4	0.2	0.2	473.6	
Mean w.	33	65.6	80.2	88.1	101.3	99.8	128.5	201.9	91.7		31023
SOP	2656.5	16085.1	8838.0	1999.9	1286.5	149.7	51.4	40.4	18.3	31125.86	
Total Year	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	87.7	597.2	605.9	104.4	62.6	12.4	2.5	1.6	0.5	1474.8	
Mean w.	31.2	44.1	54.3	78.1	89.2	102.0	117.8	123.5	136.0	52.5	77513
SOP	2736	26311	32885	8153	5587	1265	295	198	68	77497	

Table 3.3.3 cont'd

Kattegat (Div. IIIa) catches in 1990 Autum spawners

Numbers in (mill.) and mean weigth in g.

1. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers		231.6								231.6	
Mean w.		21.8									
SOP	0.0	5048.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5048.9	

2. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	5.1	46.2								51.3	
Mean w.	5.5	28.7									
SOP	28.1	1325.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1354.0	

3. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	2.1	42.2								44.3	
Mean w.	24.6	53.6									
SOP	51.7	2261.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2313.6	

4. Quarter	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	80.5	136.3								216.8	
Mean w.	33.0	71.2									
SOP	2656.5	9704.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12361.1	

Total Year	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	87.7	456.3	0	0	0	0	0	0	0	544	
Mean w.	31.2	40.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
SOP	2736.2	18341.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21077.5	

Table 3.3.3 cont'd

Kattegat (Div. IIIa) catches in 1990 Spring spawners

Numbers in (mill.) and mean weigth in g.

1. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0	0	284.2	32.9	15.9	5.6	0.8	0.4	0.2	340	
Mean w.	0.0	0.0	43.3	69.3	83.1	102.4	123.8	124.1	161.6		
SOP	0.0	0.0	12305.9	2280.0	1321.3	573.4	99.0	49.6	32.3	16661.6	

2. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0	0	98.6	16.2	16.3	2.8	0.5	0.6	0	135	
Mean w.	0.0	0.0	39.5	64.4	79.5	88.1	92.0	91.0	0.0		
SOP	0.0	0.0	3894.7	1043.3	1295.9	246.7	46.0	54.6	0.0	6581.1	

3. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0	32	112.9	32.6	17.7	2.5	0.8	0.4	0.1	199	
Mean w.	0.0	49.7	69.5	86.8	95.1	117.9	122.6	132.3	173.1		
SOP	0.0	1589.1	7846.6	2829.7	1683.3	294.8	98.1	52.9	17.3	14411.6	

4. Quarter

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0	108.9	110.2	22.7	12.7	1.5	0.4	0.2	0.2	256.8	
Mean w.	0.0	58.6	80.2	88.1	101.3	99.8	128.5	201.8	91.7		
SOP	0.0	6380.6	8838.0	1999.9	1286.5	149.7	51.4	40.4	18.3	18764.8	

Total Year

	0 WR	1 WR	2 WR	3 WR	4 WR	5 WR	6 WR	7 WR	8 WR	Sum	Catch
Numbers	0	140.9	605.9	104.4	62.6	12.4	2.5	1.6	0.5	930.8	
Mean w.	0.0	56.6	54.3	78.1	89.2	102.0	117.8	123.5	136.0		
SOP	0.0	7969.6	32885.2	8152.8	5586.9	1264.6	294.5	197.5	68.0	56419.1	

Table 4.3.1 Abundance indices and catch in number of juvenile herring by year class (autumn/spring)

Year-class	Acoustic Surveys in Div IIIa (mill.)				Catches in Div. IIIa (millions)					
	August	August	Novemb	Novemb	All types	All type	Autumn	Autumn	Spring	Spring
	0-ring	1-ring	0-ring	1-ring	0-ring	1-ring	0-ring	1-ring	0-ring	1-ring
1976/77						876				
1977/78		367				168				
1978/79	317	286			457	467		84		383
1979/80	265	419			682	966	471	425	211	541
1980/81	814	1409			3624	985	1631	276	1993	709
1981/82	3394	2116			3334	2603	2400	1302	934	1301
1982/83	783	1195			4876	2942	3267	1177	1609	1765
1983/84	552	667		574	4969	2400	4472	1608	497	792
1984/85	3583	3166	5814	489	3900	3700	2886	2960	1014	740
1985/86	8187	5745	6513	3619	3700	3503	2960	3153	740	350
1986/87	11548	6617	10192	2803	6238	5792	6238	5792	0	0
1987/88	3706	1871	2527	375	1830	1697	1830	1185	0	512
1988/89	1058	865	224	686	1028		1003		0	
1989/90	77		463							

Year-class	Index larvae in		February	IYFS index, Feb.		Stock in number from VPA (millions)				
	Div IIIa	Area IV	Total IV	Div IIIa	Area IV	NS+IIIa: autumn		IIIa+22.24: spring		IIIa:autumn
		SE part	Div IIIa	1-ring	1-ring	0-ring	1-ring	0-ring	1-ring	1-ring [1)]
1976/77	1	1	1658		575	4433	1482	5027	3885	
1977/78	2	4	1273		139	4738	1668	5622	4522	
1978/79	22	2	5061	2311	535	10626	3596	2737	2187	
1979/80	30	43	9821	3246	551	16791	5450	5796	4561	
1980/81	74	102	7455	2560	1293	37952	8632	4164	3142	
1981/82	33	194	13016	5419	1797	65007	17142	7569	4371	3411
1982/83	141	93	8918	6035	2663	62992	15676	8737	6223	2540
1983/84	102	142	11173	7994	3416	54115	16097	8952	5792	3815
1984/85	83	215	17617	21489	3667	85380	28993	4414	3114	14352
1985/86	26	233	17242	11733	5717	103344	35896	7593	5160	7323
1986/87	14	274	26381	67753	4192	88478	27931	11067	8112	20054
1987/88	145	186	16415	17451	3468	39550	12752	5298	3643	4986
1988/89	54	123	6935	3544	2146	31616	9931	5866	4252	2095
1989/90	12	11	2520	3588	2433	19103		935	649	

[1]The proportions used to estimate the number of 1-ringers in Division IIIa at the beginning of the year are given in Table 2.3.4 of *Anon.* (1991a). These are likely to be overestimates of the number of autumn spawners because the IYFS index of 1-ringers in Division IIIa is not divided into component stocks. In recent years, the proportion of spring spawners in the 1-group catches made in the IYFS is likely to have been very low. See text for further details.

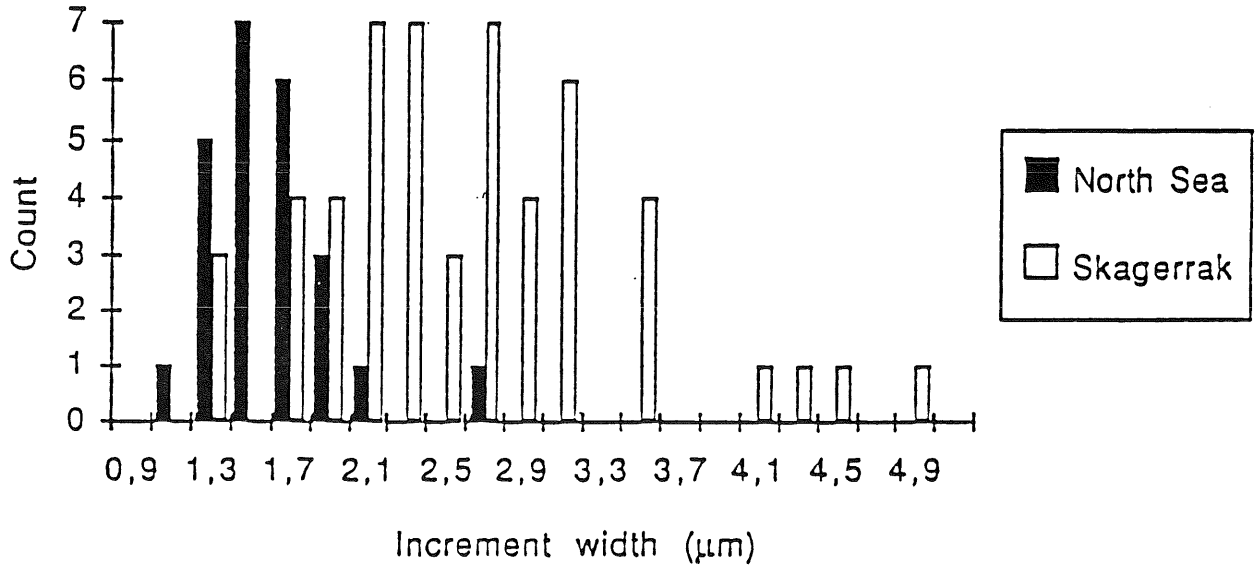

Figure 2.1. Average increment widths (µm) measured in the region 30-60 µm off the nucleus in the decalcified otoliths from herring caught in the North Sea (61.27 N 0.15 E) and in the Skagerrak (from Zhang and Moksness, WP).

Figure 3.1 Main areas in Division IIIa for the mixed clupeoid fishery and for the directed fishery for herring.

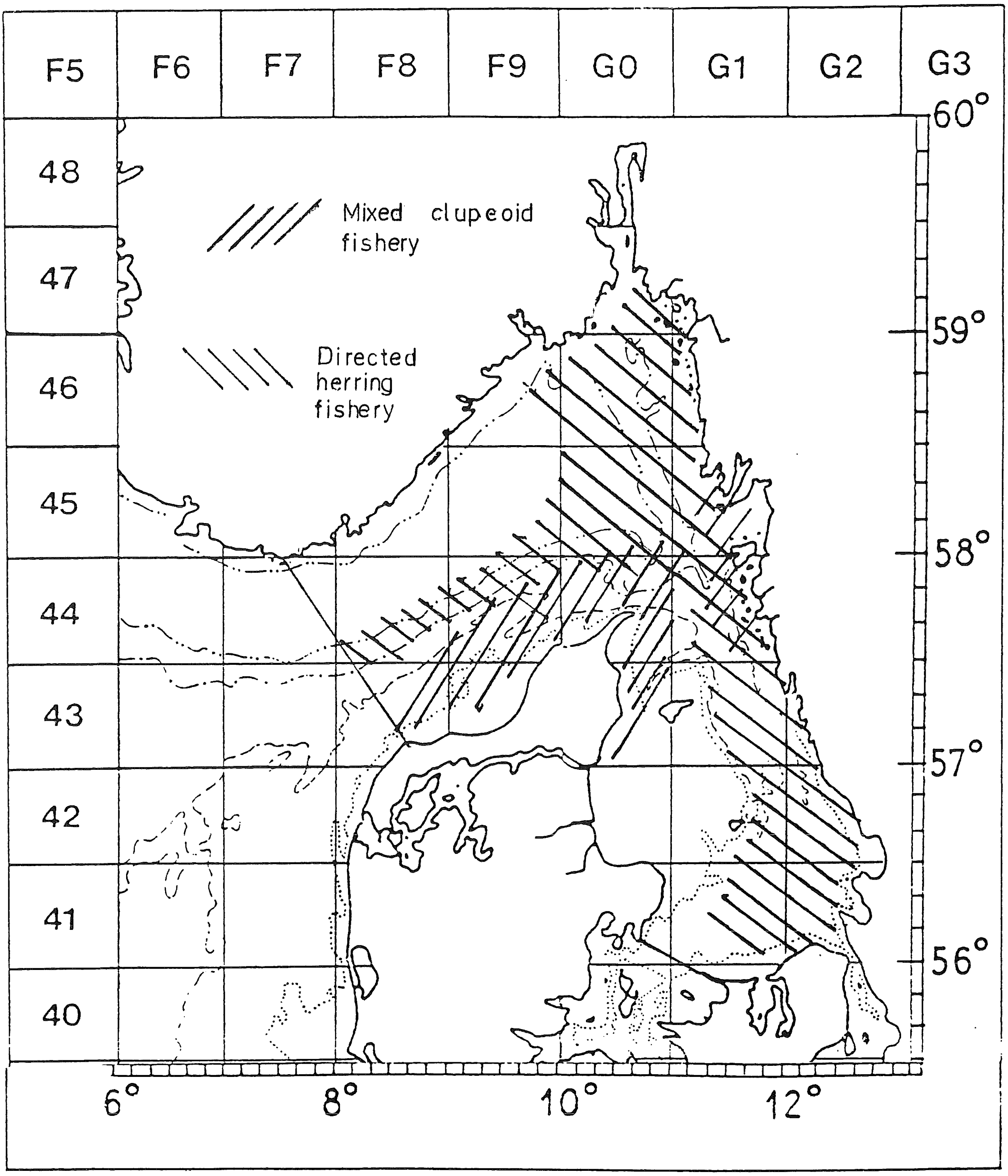

Figure 4.1 Spring-spawning herring. Stock sizes (*Anon.*, 1990b) *vs* catches in the North Sea.

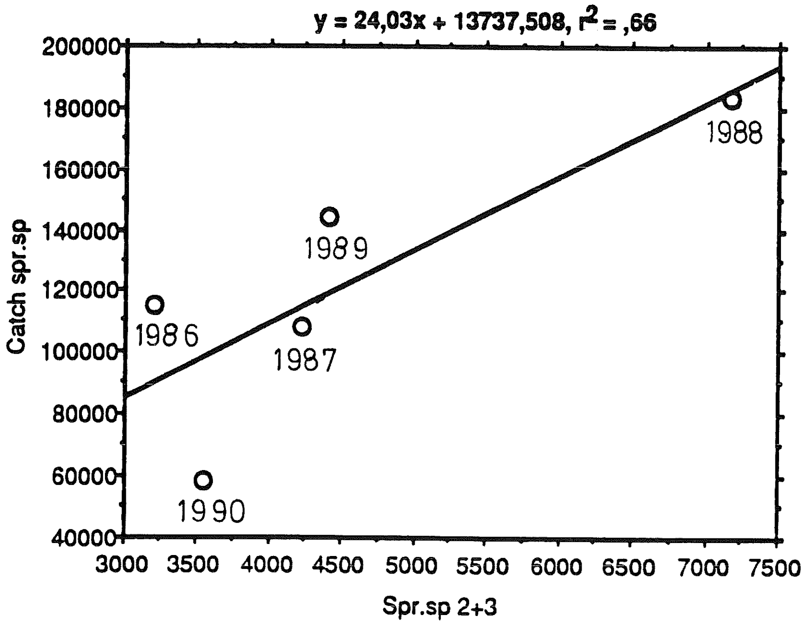

Figure 4.2 **Regressions of 1-wr autumn spawner in Div. IIIa against total larvæ in IIIa+IV and 0-wr from Acoustic surveys.**