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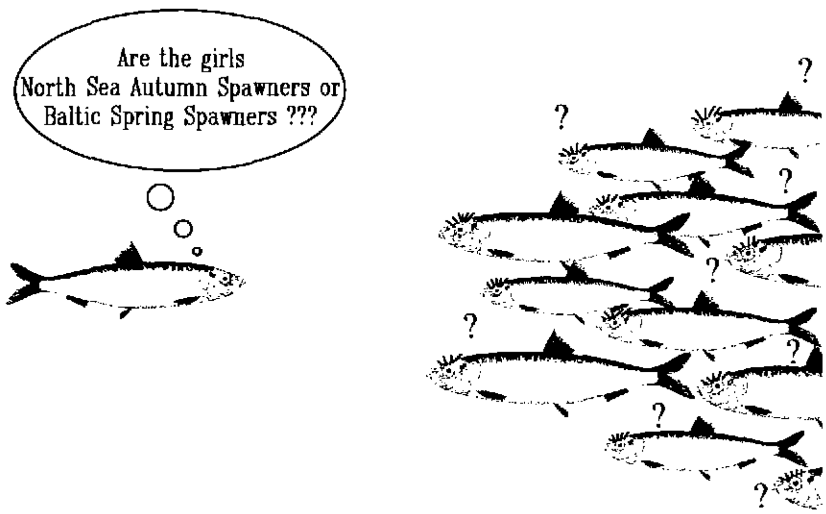
REPORT OF THE

STUDY GROUP ON IIIA HERRING (SG3AH)

Danish Institute for Fisheries Research, Charlottenlund, Denmark
11–15 January 1999



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1 INTRODUCTION

1.1 Terms of Reference

During the ICES 1998 Annual Science Conference (86th Statutory Meeting) in Cascais, Portugal, it was decided (C.Res. 1998/2:4:20) that a Study Group on IIIa Herring (SG3AH) should meet at the Danish Institute for Fisheries Research, Charlottenlund, Denmark from 11 to 15 January 1999 in order to:

a) review and update catch at age and mean weight at age data including information on proportions of North Sea autumn spawners and Western Baltic spring spawners for the period 1990–1997 and for all fishing fleets catching herring in Division IIIa and Sub-divisions 22–24,

b) review and update data including information on proportions of North Sea autumn spawners and Western Baltic spring spawners from acoustic surveys and bottom trawl surveys carried out in the eastern part of the North Sea, Division IIIa and in Sub-divisions 22–24 in the period 1990–1997,

c) further improve the migration model of Western Baltic spring spawning herring which can be used for the understanding of the results of an analytical assessment.

The German catch data in Sub-divisions 22 and 24 were decreasing from 45 500 t in 1990 to 15 800 t in 1991 (ICES CM 1998/ACFM:14) reflecting a changed fishing pattern after the reunification of the GDR and FRG in 1989. Due to this decrease in German catches and additional general problems in updating the year 1990 it was decided by the Study Group to revise only the years 1991 onwards assuming a constant fishing pattern for the period 1991–1997 (in accordance with ICES CM 1998/ACFM:14; ICES CM 1998/H:1, Ref. B).

1.2 Participation

The meeting was attended by:

Jørgen Dalskov	Denmark
Joachim Gröger	Germany
Tomas Gröhsler (Chairman)	Germany
Georgs Kornilovs	Latvia
Johan Modin	Sweden
Henrik Mosegaard	Denmark
Else Torstensen	Norway

1.3 Background

Catches of herring in the Kattegat, the Skagerrak and the Eastern part of the North Sea are taken from a mixture of two main spawning stocks (ICES CM 1991/Assess:15): the Western Baltic spring spawners (WBSS) and the North Sea autumn spawners (NSAS). In addition, several local stocks have been identified (Jensen, 1957). These are, however, considered to be less abundant and therefore of minor importance to the herring fisheries (ICES CM 1991/Assess:15). In assessment, all spring spawners caught in the eastern part of the North Sea, Skagerrak, Kattegat and Sub-divisions 22, 23 and 24 are considered to be one stock with spawning grounds surrounding the island Rügen in the Western Baltic area.

During the last decade the Herring Assessment Working Group (HAWG) has encountered a suite of difficulties in assessing the status of the spring spawning stock in Division IIIa and Sub-divisions 22–24. These problems were manifested as difficulties in finding convincing fits of various abundance indices to stock number estimated by the ICA (Integrated Catch at Age Analysis). The problems could be caused by:

- Incorrect or biased catch statistics.
- Biased age determination (discrepancies between otolith-readers).
- Large random variation of survey indices.
- Incorrect splitting of stocks in areas where stocks mix.
- Bias due to migration.

Since 1997 the ICES 'Baltic Herring Age Reading Study Group (BHARSG)' has been working on minimising the problems of a possible biased age determination in the Baltic area (ICES CM 1998/H:2).

The EU Study Project on 'Separation of Spring and Autumn Spawning Herring in the Skagerrak and Kattegat', which started in 1997, has the aim to evaluate traditional and new methods for a routine separation of the herring stocks in the Kattegat, Skagerrak and Western Baltic (Anon. 1998).

The ICES 'Study Group on the Stock Structure of the Baltic Spring-Spawning Herring (SGSSBH)' met for the first time in 1998 in Lysekil in order to describe and address the related problems concerning:

- the stock separation method
- commercial catch data
- and survey data

for the years 1991 and onwards (ICES CM 1998/D:1, Ref. H).

The HAWG in 1998 (ICES CM 1998/ACFM:14) recommended that a Study Group should initiate inter-sessional work to review and update commercial and survey data including information on proportions of North Sea autumn spawners and Western Baltic spring spawners in Division IIIa and Sub-divisions 22–24.

2 METHODS TO DISCRIMINATE STOCK COMPONENTS IN DIVISION IIIa AND IIIc

2.1 Past Methods to Calculate Proportions of North Sea Autumn and Western Baltic Spring Spawners by Quarter for the Years 1991–1997

The proportion of Western Baltic Spring spawners (%) by quarter for 1991–1997 as used by the Working Group are given in Table 2.1.

For **1991** the catches of herring in the area were allocated to their respective spawning stocks using a combination of modal length analysis and vertebral counts. The separation was based mainly on data from the Swedish catches taken in the 32-mm fishery. This procedure could have added to the uncertainties as the proposition of stocks in 32-mm fishery could have differed from the proportions in the small-mesh fishery. The number of herring measured for vertebral count was considered to be low and the estimated stock proportions uncertain.

For **1992** the landings in Division IIIa were allocated to spawning stock using a combination of modal length analysis and mean numbers of vertebrae. The split was mainly based on the Swedish and Danish samples where vertebral counts were made, and the split was applied for age classes 0 to 2.

For **1993** the landings in Division IIIa were allocated to spawning stock using a combination of modal length analysis and mean numbers of vertebrae. The split was mainly based on the Swedish and Danish samples of vertebrae counts. The proportion of autumn and spring spawners was given only for age classes 0 to 2.

For **1994** the landings in Division IIIa were allocated to spawning stock using a combination of modal length analysis and mean numbers of vertebrae. The split was based mainly on the Swedish samples of vertebrae counts. The proportion of autumn and spring spawners was given only for age classes 0 to 2.

For **1995** the landings in Division IIIa were allocated to spawning stock using Danish and Swedish vertebral counts averaged over ICES rectangles within Sub-division and raised by the relative survey area of each Sub-division (Skagerrak and Kattegat). The combined and weighted mean vertebral count was used to split the stock into autumn and spring spawners. Age group 3+ refers to all age classes of 3 years and older.

For **1996** a new method was employed using otolith microstructure analysis for separating Baltic spring spawners from North Sea autumn spawners (Mosegaard and Popp-Madsen, 1996). The method allows the stocks to be separated at the individual level for all age classes and will produce proportions directly from the samples taken. Double checking of readings gives an estimated error rate of less than 1% when separating autumn/winter from spring spawners (including possible local populations with similar characteristics). For the third and fourth quarters otolith analyses of samples from the Danish surveys were used to calculate proportions of spring spawners by ICES rectangle within Division IIIa. For the first quarter vertebral counts from the Swedish surveys were applied in the same manner as in previous years, where the fraction of spring spawners by ICES rectangle within Division IIIa was calculated. The mean proportion of spring spawners for each of the age classes 0, 1, 2, 3, and 4+ within each of the Sub-divisions, Skagerrak and Kattegat, was calculated as the average of the individual proportions over the respective ICES rectangles. For the second quarter the proportions for each Sub-division was calculated as the average of quarter one and quarter three of the age classes 1 to 4+.

For **1997** the split was performed on age classes 2, 3, and 4+ WR. For May and June 1997 the split was conducted according to Norwegian VS counts from a general unweighted average from May. In July the split was based on the average Norwegian VS counts from catches in July. For the rest of the year only Danish samples from October and November based on otolith microstructure were available. The distribution of sampling locations showed that the samples did not reflect that catches in the 4th quarter primarily were taken in the northern part of the area, which is assumed to consist predominantly of autumn spawners. It was, therefore, decided that all herring caught in the eastern transfer area in the North Sea should be calculated as being exclusively autumn spawners. The split of Danish catches was conducted using a random sub-sample of herring where analysis of individual otolith microstructure determined the spawning type. Swedish catches were split according to the mean VS count weighted by catches at age and quarter. In the western Baltic a large percentage of the herring caught in the small mesh fishery consisted of autumn spawned individuals. In the 4th quarter in Sub-division 22, 83% and in the 2nd quarter in Sub-division 24, 45% of the numbers caught were autumn spawners. Juvenile herring of age groups 0 and 1 comprised the dominating part of the catches. The small size at age however, indicated that herring were local autumn spawners rather than originating from the North Sea stock. Since this problem has not been investigated in earlier years and since it mostly affected the younger age classes (0 to 2 WR), the catches were treated as coming from the western Baltic spring spawning stock. The existence of autumn spawners in Sub-divisions 22–24, however, indicates a problem in the assessment that should be dealt with in a coming revision of the historical stock separation.

The discrimination of the herring stock in Divisions IIIa and IIIc is still one of the main problems encountered performing the assessment of the Western Baltic herring stock. During the past 7 years the HAWG has regularly changed the methods of stock discrimination that can be seen from the proportion values of Western Baltic herring in the stock (Table 2.1). The proportion has changed especially substantially for age groups 1 and 2 which are the most abundant age groups of North Sea herring in Divisions IIIa and IIIc.

2.2 Overview over Statistical Discrimination Methods Based on Vertebrae Counts

In order to analyse the characteristics of two major herring populations mixing in Division IIIa (Skagerrak, Kattegat) as well as in ICES-Sub-division 23 (Sound) and to be able to separate them two learning samples of vertebra counts have been taken in 1995 (Gröger and Gröhsler 1995, 1996). Some general results on these two learning samples show that within each of the two areas the VS means do not vary significantly by age ($p_F = 0.8729$ for the North Sea, $p_F = 0.8792$ for the Baltic Sea). But the area related variances (0.48 for the North Sea, 0.67 for the Baltic Sea) differ significantly from each other ($p_{\chi^2}= 0.0008$). These two learning samples of vertebra counts were taken in order to detect and verify different stochastic herring separation models which should be compared with each other. The best of these is recommended to be used for splitting independent routine samples into fractions of North Sea and Baltic Sea individuals. This splitting will be done by estimating the associated VS sample means estimated from the underlying routine samples into the final separation model which will lead to sample proportions of Baltic and North Sea herring individuals. The herring samples which were analysed during the study group meeting are time series from Sweden of the years 1991 to 1997. The calculations units used are quarter x year x area x age whereby the basic area units have been defined as Skagerrak, Kattegat, Sound. The methods investigated here are based on results presented in Gröger and Gröhsler (1995, 1996) as well as in Gröger (1999).

Regression approach

The linear regression approach leads to the following probability model of Baltic Sea membership of herring (see following page).

$$\hat{P}_{Baltic}(vs_{new}) = \begin{cases} 1 & if\ vs_{new} \leq (\hat{a} - \hat{b}) \\ -\left(\dfrac{vs_{new} - \hat{a}}{\hat{b}}\right) = \dfrac{\hat{a} - vs_{new}}{\hat{b}} & if\ (\hat{a} - \hat{b}) < vs_{new} < \hat{a} \\ 0 & if\ vs_{new} \geq \hat{a} \end{cases}$$

$$\hat{P}_{North\ Sea}(vs_{new}) = 1 - \hat{P}_{Baltic}(vs_{new})$$

(1)

for which the estimation of the regression coefficients $\hat{a}$ and $\hat{b}$ were done by a weighted Ordinary Least Squares (OLS) technique, i.e. through

$$\begin{bmatrix} \hat{a} \\ \hat{b} \end{bmatrix} = (X'WX)^{-1} X'Wvs$$

(2)

The complement is valid for the fraction of North Sea herring in the samples to be splitted up. W contains the inverse area related variances of the vertebra counts in order to compensate inherent heteroscedasticity, VS means vertebra counts in Eq. (1). The hats on $\hat{a}$ and $\hat{b}$ indicate that these are OLS estimators and not the associated unknown exact values. For statistical and mathematical details see Dhrymes (1985), Fahmeir and Hamerle (1984), Hartung and Elpelt (1989), Lütkepohl (1992), Neter *et al.* (1985). The identification of the linear herring discrimination model was based on 425 observations from the North Sea and 391 observations from the Baltic (two learning samples from 1995). The estimated OLS parameters of the model are $\hat{a} = 56.53$ ($p = 0.0001$) for the intercept and $\hat{b} = 0.93$ ($p = 0.0001$) for the slope which corresponds to a North Sea sample mean of 56.53 and a Baltic sample mean of 55.60 VS. The model is also highly significant on a global level ($p = 0.0001$) but resulting in a relatively low $r^2 = 0.2721$.

Unfortunately this linear approach has some negative properties. One is the necessary inversion of the underlying regression model which can only be performed if the estimation error of $\hat{b}$ is small ($cv(\hat{b}) < 0.1$, see Miller 1996). From the relatively low estimated r^2 can be inferred that this is probably not the case. Hence, this method cannot be recommended. In case of the traditionally used splitting model (see following page).

$$\hat{F}_{Baltic} = \left(\frac{56.5 - \overline{vs}_{new}}{56.5 - 55.8} \right)$$

$$= \left(\frac{56.5 - \overline{vs}_{new}}{0.7} \right) \quad \textbf{(3)}$$

which is in principle similar to that used here three further negative arguments leads to its rejection:

1. this splitting model is not weighted by variance resulting in a problem due to heteroscedasticity,
2. the difference between the two VS means (0.7) is much smaller than that estimated here (0.93) leading to the impression that the historical learning samples have not been pure ones,
3. negative fractions can result, especially when inserting individual VS values.

Discriminant analysis

The problems with the linear approach are the reason why one should look for other more appropriate splitting models. In principle, the calculation of herring fractions based on discriminant splitting rules is of better statistical nature. The decision rules used here are expressed as Maximum Likelihood (ML) distance functions with heterogeneous (non-pooled) group variances, one function for the Baltic herring population, the other for the North Sea herring population (see Eq. (4)). They measure the (average) number of vertebra of later routinely sampled herring (vs_{new}) as difference from the mean vertebra count of either the Baltic ($\overline{vs}_{Baltic}$) or the North Sea herring population ($\overline{vs}_{N.S.}$) (see following page).

$$\hat{d}_{Baltic}(vs_{new}) = -\frac{1}{2} x (vs_{new} - 55.60)^2 x \frac{1}{0.67} - \frac{1}{2} x \ln(0.67)$$
$$= -(vs_{new} - 55.60)^2 x 0.746 + 0.200$$

$$\hat{d}_{North\ Sea}(vs_{new}) = -\frac{1}{2} x (vs_{new} - 56.53)^2 x \frac{1}{0.48} - \frac{1}{2} x \ln(0.48)$$
$$= -(vs_{new} - 56.53)^2 x 1.042 + 0.367$$

or in terms of posterior probabilities

$$\hat{P}(Baltic \mid \overline{vs}_{new}) = \frac{e^{(d_{Baltic}(\overline{vs}_{new}))}}{e^{(d_{Baltic}(\overline{vs}_{new}))} + e^{(d_{North\ Sea}(\overline{vs}_{new}))}}$$

$$\hat{P}(North\ Sea \mid \overline{vs}_{new}) = 1 - \hat{P}(Baltic \mid \overline{vs}_{new})$$

(4)

It can be seen that the two distance functions in the upper part of Eq. (4) contain the uncertainty of the two learning samples. They are standardised through the inclusion of the associated inverse sample variances 0.67^{-1} for the Baltic and 0.48^{-1} for the North Sea. The distance functions were then used to calculate the two so called posterior probabilities as expressed in the lower part of Eq. (4). The basic idea of the posterior probabilities is to allocate a single herring into that group for which this single herring receives the highest probability. I.e. for which the difference between the average and the individual vertebra count is smallest and for which the (underlying) distance function is largest, respectively. Inserting a VS mean of a herring sample leads to calculations which can be interpreted as Baltic Sea herring fraction. Its complement gives the fraction of North Sea herring individuals for this sample. The discriminatory power of the decision rules was empirically checked by calculating non-parametric misclassification and error rates, respectively, on the basis of jackknifing (for reclassification purposes exactly one single herring from the calculation of the decision rules was left out) and bootstrapping experiments (which excludes not only one but by random a larger subset of herring data from the calculation of the decision rules for any reclassification). The estimated overall jackknife error rate was 0.29, that of the bootstrap experiment 0.24 meaning that between 71% and 76% of the individuals could be correctly classified (50% would indicate a random assignment). For further statistical and mathematical details see Dhrymes 1985, Fahmeir and Hamerle 1984, Hartung and Elpelt 1989, Lütkepohl 1992 and Neter *et al.* 1985.

Logistic Regression

A weighted logistic regression approach for herring separation in Division IIIa and Sub-division 23 can be formulated for the Baltic Sea membership of herring individuals as follows:

$$logit(\, p_{Baltic} \mid vs) = \log\left(\frac{p_{Baltic}(vs)}{1 - p_{Baltic}(vs)}\right) = a + b\, x\, vs$$

<u>*where*</u>

$$p_{Baltic}(\, vs_{neu}\,) = \frac{1}{\left(\frac{1}{e^{logit(\, p_{Baltic} \mid vs_{neu}\,)}}\right) + 1} = \frac{1}{e^{-\, logit(\, p_{Baltic} \mid vs_{neu}\,)} + 1} \quad . \tag{5}$$

The logistic regression coefficient a is a horizontal shift parameter, b is the slope. On the basis of the two learning samples a and b were estimated as $\hat{a} = 94.35$ and $\hat{b} = 1.69$ leading to the following logits:

$$\hat{l}ogit(\, p_{Baltic} \mid vs_{new}) = 94.35 - 1.69\, x\, vs_{new} \tag{6}$$

which must be translated into $\hat{p}_{Baltic}(\, vs_{neu}\,)$ in order to be a separation rule. The complement of North Sea membership is then simply given by $1 - \hat{p}_{Baltic}(\, vs_{neu}\,)$. The model is highly significant on a 5% significance level ($p_{-2\, LOG\, L,\, \chi^2} = 0.0001$), also the partial marginal p values concerning the estimated parameters $\hat{a}$ and $\hat{b}$ indicate both as highly significant ($p_{Wald,\, \chi^2} = 0.0001$). The associated pseudo r^2 is 0.48, the adjusted one is 0.52, both indicating a relatively good fit since these are higher than 0.4 (see Urban 1993).

2.3 Discrimination by Logistic Regression Model Based on Vertebrae Counts

Due to the implicit statistical problems (high inversion associated estimation error of $\hat{b}$) of any linear regression model type it is not recommended either to use the version of Eq. (1) nor the historical approach of Eq. (2). Discriminant and logistic regression separation models do not have such inherent statistical problems. Hence, the Group decided to use the logistic regression approach in order to split the data of the Swedish routine data sets of the years 1991 to 1997 into Baltic Sea as well as North Sea fractions of herring based on mean vertebra counts for the sampling units quarter x year x age x area. The realisations of area are defined here as Sound, Skagerrak and Kattegat. Since the Swedish samples are length stratified it is recommended to weigh the yearly VS means per quarter, age and area by the following sample weighting factor:

$$Sample\ Fraction = \frac{n_{per\ length\ group}}{n_{total\ sample}}$$

$$Subsample\ Fraction = \frac{n_{subsample}}{n_{per\ length\ group}}$$

$$Sample\ Weight = Sample\ Fraction\ x\ Subsample\ Fraction. \tag{7}$$

Table 2.3.1 contains the estimated weighted VS means of the routinely sampled Swedish data by year x quarter x area x age as sampling units under consideration of Eq. (7). Therefore these can serve as basis for any splitting rule. Table 2.3.2 contains the correspondingly estimated fractions of Baltic Sea individuals based on the calculated VS sample means of Table 2.3.1 and Eq. (5) and (6), respectively.

From Table 2.3.1 can be seen that there is a principle tendency from lower VS means towards larger from south (Sound) to north (Skagerrak) where especially the winter rings 3 and 4 are indicated by lower VS means in contrast to winter rings 1 and 2. This confirms the principle theory. But it can also be seen that this tendency varies with time so that a clear picture or pattern cannot be expected as stable in each year. This holds especially for the winter ring 4 herring.

Considering the logistic probabilities of Table 2.3.2 the splitting results concur with the general view on stock components in the Skagerrak and the Kattegat as expressed in the reports of the HAWG (ICES CM 1997/Assess:8 and ICES CM 1998/ACFM:14):

The estimated fractions of Baltic spring spawners based on the VS means show a corresponding tendency of getting smaller from south to north. The fraction of the spring spawning component (WBSS characteristics) increased by age but also by distance from the North Sea (i.e. lowest fraction in the Skagerrak and highest fraction in the Sound) but not as drastic as assumed by the theory. It should be noted in this context that although the VS estimates correspond with the expected trends the calculated fractions of spring spawners among older age groups are generally much smaller than what has previously been considered accurate (ICES CM 1997/Assess:8). Beside a comprehensive effect due to incorporating the stock related VS variances which drive all estimates towards 50% a further explanation may be possible: the assumption that the abundance of local spring spawning stocks is negligible might be false. The documented high VS estimates of the Skagerrak spring spawners (VS around 57.0) can therefore confound the separation of the WBSS (VS around 55.7) and the NSAS (VS around 56.5).

Considering external results the theory may be better supported by the calculated fractions derived by the two linear splitting models presented here (see equations (1) and (2)) although these methods are statistically not that proper. This can be speculated as being either a random artefact or a matter of the fact that the underlying theory may be logically influenced by historical vertebra count considerations based on simple linear VS means calculations.

But in principle, there are three general interacting sources of problems. Lack of information is the first problem meaning that all splitting models are only based on vertebra count calculations. I.e. only one meristic variable is considered (which is practically an advantage due to a lower preparation effort). Incorporating further stock characterising information may increase the separability of the two stock components. Furthermore, when considering the vertebra frequency distribution per age it can be seen that the Baltic Sea learning sample has a range of VS between 52 and 58 with a main focus on 55 and 56 vertebrae leading in total to a variance of 0.67 VS^2. The North Sea learning sample has a range from 53 to 58 vertebrae with a main concentration on 56 and 57 vertebrae leading to a variance of 0.48 VS^2. I.e. the addressed problem here is that of uncertainty expressed in terms of the two variances which also differ significantly from each other (heteroskedasticity). Models (as the linear ones) which are ignoring the existing overlapping or shared information, i.e. the stock related variances have the tendency to stretch the splitting results. Models (as the logistic or the discriminant splitting rules) which include the stock related variances lead to more compressive splitting results. This phenomenon is further accompanied by the fact that the probability to be a Baltic Sea herring should be higher for, say, a young herring with 0 or 1 winter rings and 57 vertebra caught in the Baltic Sea near Rügen than for a 0 or 1 winter ring herring with 57 vertebra caught in the North Sea. This means that two probability components are interacting, one expressed by some VS splitting model, the other expressed by some model which describes the occurrence probability. The latter component should include not only an area but also an age and time (season) related effect. It is statistically plausible to multiply both components with each other to give the final vertebra splitting rule as represented by the following equation:

$$\hat{P}(Baltic \mid vs_{neu},\ quarter\ x\ age\ x\ area) = \hat{p}_{Baltic}(vs_{new})\ x\ \hat{p}_{Baltic}(quarter\ x\ age\ x\ area) \quad \textbf{(8)}$$

Its complement gives the final North Sea membership probability. For the occurrence probability it may be thinkable to empirically sample some information about age, season and area stratified frequency distribution (for example with the help of otolith microstructure analysis) or, if not possible, to express the occurrence probability through a more or less linearly interpolated distance function standardised for values between 0 and 1 (with, for example, having the starting point near Rügen). These probabilities can also come from a migration model.

2.4 Discrimination by Otolith Microstructure Analysis

Otolith microstructure analyses (OM) have been successfully used to separate spring and autumn spawned juveniles (Moksness and Fossum 1991). The method is based on the observation that growth of autumn spawners is lower than of spring spawners during early life-stages. Early life growth can be inferred from relative widths of primary increments ("daily rings") at the centre of otoliths. Since the formation of otoliths is a cumulative process these early life increments can also be identified in otoliths of adult individuals (Zhang and Moksness 1993). The otoliths have to be prepared (ground and polished) before analysis. Mosegaard and Popp-Madsen (1996) showed that processing speed can be accelerated by image analyses and training. The disadvantage of lower number measurements (due to pre-processing time) compared to traditional vertebra counts is outweighed by a higher precision (individual rather than population assignment).

2.4.1 Material and methods

Sagitta otoliths were prepared according to Mosegaard and Popp-Madsen (1996). An image analysis system was applied to give the necessary resolution of 7 to 10 pixels per micrometer to count and measure daily structures between one and two μm wide.

Two principal steps were employed in the analysis. Firstly, otoliths from known spawning types were described and analysed in order to establish a reference on spawner characteristics. Otoliths from different herring populations were analysed as thin slices polished on both sides using a meticulous preparation technique. Herring in spawning stage (pure stocks) were obtained from the English Channel in late November (n=25), Dogger Banks in mid September (n=25) and Aberdeen Banks in mid August (n=25) as well as maturing Baltic herring (n=25) from the Sound between Denmark and Sweden in February. Otolith microstructure was recorded by video scanning of otolith radial subsections along the rostrum axis at increasing distances from the nucleus. A series of otoliths (n=36) from herring caught by the Danish fishing fleet in the North Atlantic area (65°N 7°W) was also prepared and used for analysis.

Secondly, results from the reference classification were used as a template for routine identification of otolith types in mixed samples. Sampled otoliths were mounted with the sulcus side facing up and for most small otoliths (predominantly less than 3 years old herring) only this side was ground and polished. Occasionally (in about 10% of the cases) larger otoliths had to be flipped over and polished on both sides in order to visualise microstructure characteristics. The zone where incremental widths increased from less than 2 to more than 2.5 μm was used as a marker for the onset of spring increased growth conditions. In cases of uncertainty in routine visual inspection, measurements of radial distances and increment widths were added to identify otolith types. All otoliths were classified as belonging to either autumn, winter, or spring spawning stocks.

Routine classification by central microstructure analysis was used to classify otoliths from the Danish acoustic survey in the North Sea, July 1996. The samples were taken from the Kattegat, the Skagerrak, and the North Sea, East of 6°E, and North of 56,5°N using standard sampling protocols (Simmonds *et al.* 1995).

The method was also applied for a small number of samples from the Danish fishery. During the 2nd half of 1997, 12 samples were collected from landings in the Kattegat/Skagerrak and six samples from the eastern North Sea. In addition five samples were obtained from the Baltic Sub-divisions 22 and 24. Altogether 605 individual identifications were made.

The effects of experience on the classification by visual inspection were tested by a comparison of results obtained by an inexperienced and by an experienced operator. A total of 823 herring otoliths from the Kattegat, the Skagerrak and the North-Eastern North Sea were randomly selected. None of the preparations that indicated crystalline or otherwise abnormal otolith formation were selected. About 7% were destroyed to illegibility during the grinding procedure. Preparations were identified to either autumn-winter spawners or to spring spawners.

2.4.2 Results on reference evaluation

Measurements based on specimen from pure stocks (spawning or maturing stage) indicated distinct differences between spawner type:

North Sea Autumn Spawners (NSAS):

Otolith increments less than 2.5 μm wide were found more than 200 μm from the nucleus. All increments appeared to have rather constant widths. Most often primary increments were visible from the centre to the end the larval zone if the optical focus is produced right at the polished surface of the preparation. A zone with more than 30 legible increments near the end of the larval zone (about 200 μm from the centre) was considered safe for the identification purposes. During preparation the existence of a wide transparent central area with an abrupt change to less transparent otolith material at the edge was indicative for this type.

Downs Winter Spawners (DWS):

Otolith increments increased gradually from about 1 μm near the end-of-yolk-sac-structure to more than 3 μm at a distance of 150 μm from the centre. The increase in increment widths accelerated at about 200 μm from the centre. The structural appearance changed gradually from faint increments in an inner zone with high transparency to very pronounced increments with a high visual contrast and less transparency at about 100 μm from the centre.

Western Baltic Spring Spawners (WBSS):

Otolith increments changed rapidly from about 2.5 μm to more than 4 μm wide within less than 100 μm from the end-of-yolk-sac-structure. The larval structures were always rather opaque even at a close distance from the centre. The variation in increment widths near the centre was higher in this group than in the other groups.

Results from the routine classification (applying the results from the description of pure stocks) are only preliminary but indicated that individual classification of herring from research surveys and landings is feasible.

2.4.3 Otolith microstructure determined spawning type in 1996 and 1997

The proportions of spring spawners in the Sound, the Kattegat and the Skagerrak were calculated from Danish herring samples from research vessels and commercial landings in 1st and 3rd quarter in 1996 and 1997.

The method of otolith microstructure analysis was used to identify the number of spring spawned individuals from otolith sub-samples stratified by age-classes 0 to 4+ (winter-ringers).

The proportion from each unweighted sample was used to get an average by year, quarter, Sub-division and age-class. Only sample sizes of more than 4 individuals per age-class were used.

The results of otolith microstructure determined proportion of spring spawners based on Danish scientific and commercial samples of 1 to 4+ winter ringers are shown in the Table 2.4.

2.5 Calibration of Vertebrae Counts and Otolith Microstructure Based Proportions

The individual based comparisons between VS and otolith microstructure determined fractions of spring spawners from the years 1991–1997 are presently being worked up.

With no full data set available Swedish IBTS samples stratified by ICES rectangles by year (1996 and 1997), quarter (I and III), Sub-division (20, 21, and 23), and age class (1, 2, 3, and 4+) were used to convert VS counts to fractions. Herring samples from Danish research vessels and commercial landings stratified in the same way were used to estimate fractions directly from individual data on microstructure.

The overall relationship was plotted in Figure 2.5.

The results from Figure 2.5 do not encourage a transformation of the results from VS-based to a geographically weighted and otolith based estimate.

2.6 Comparison of Individual Vertebral Counts and Spawning Type from Otolith Microstructure

From the Swedish IBTS surveys in the 1st and 3rd quarters in 1996 and 1997 six samples taken in Kattegat and the Skagerrak areas were analysed. Only 2-ringers were analysed for this comparison. Hatch month from otolith microstructure analysis and VS counts were compared from the same individuals.

The results are plotted as hatch month versus VS count in Figure 2.6.1.

When the means from the six samples were analysed a reasonable good correspondence between VS based and otolith microstructure based proportions was found (Table 2.6 and Figure 2.6.2).

The results shown in Figure 2.6.2 show a reasonably good correlation between proportions based on the logistical transformation of VS counts and individually derived proportions of spring spawners in the samples. The present results reflects the general trend found using logistical transformation of VS based results (Figure 2.5) that otolith microstructure based proportions having a full range from 0 to 1 transform into a more narrow range from about 0.1 to 0.6. The close relationship in the individual based material would suggest that a calibration of the time series of VS based proportions (Table 2.4) is possible. However the individual material consists of only age-class 2 herring, further the number of samples (6) and the total number of individuals analysed (91) is still too low to apply any relationship to calibrate the VS-derived proportions in Table 2.4.

Analysis of further material on corresponding individual data on otolith microstructure and VS counts may yield the sufficient power to allow a robust calibration.

3 REVISION OF COMMERCIAL CATCH DATA

3.1 Catch at Age Data

3.1.1 Review 1991–1997

For the purpose of producing new/revised-input data for the assessment of the Western Baltic Spring Spawning Herring all data for the period 1991–1997 were reviewed.

Fleet definitions:

For management purposes, fleet definitions have been made by the HAWG (ICES CM 1997/Assess:8). The stock assessment is based on estimates of total removals from the stock combined with a series of stock indicators obtained from research vessel survey. The stock estimates therefore only depend on the fleet definitions in as much as the catch and effort statistics and the biological sampling use these "fleets" for stratification in the sampling scheme.

The North Sea autumn spawning herring stock is exploited in the North Sea as well as in Division IIIa. The Western Baltic spring spawning herring stock is exploited in the eastern part of the North Sea, Division IIIa and in the western Baltic area (Sub-divisions 22–24). Fleet definitions have therefore been made for all fisheries exploiting these herring stocks.

North Sea:
Fleet A: Directed herring fisheries with purse seiners and trawler.
Fleet B: All other vessels where herring is taken as by-catch.

Division IIIa:
Fleet C: Directed herring fisheries with purse seiners and trawler.
Fleet D: Vessels fishing under the mixed clupeoid (sprat) quota.
Fleet E: All other vessels where herring is taken as by-catch.

Sub-divisions 22–24:
Fleet F: All vessels participating in herring fisheries or where herring is taken as by-catch:

In the time period reviewed, the fleet definitions have not strictly been followed. Norwegian landings from Skagerrak were listed under fleet C for all years, despite the fact that some of the catches have been taken as by-catch in fisheries where a mesh size less than 32 mm has been used. All Danish landings for human consumption purposes, 32 mm mesh size, caught in Skagerrak and Kattegat have been listed under fleet C. In the Swedish herring human consumption fishing fleet, sorting (grading) machines have been used. It was therefore at sea possible to separate the herring in a human consumption part and a part, which were landed for reduction purposes. The landings for human consumption were listed under fleet C. The part for reduction purposes were for the period 1991–1994 listed under fleet E.

Only the Danish "Mixed" fishery were listed under fleet D. Danish by-catches in the sandeel and in the Norway pout fishery were listed under fleet E.

All herring landings taken by Denmark, Germany, Poland and Sweden in Sub-divisions 22–24 have been listed under fleet F.

3.1.2 Calculation method and quality of data

In general, samples from the commercial fishery have been used to calculate numbers of fish landed. When reviewing sampling levels, it should be taken into account that the recommended sampling level should be one sample per 1 000 tonnes fish landed per quarter (ICES CM 1997/Assess:8). In the SGSSBH report (ICES CM 1998/H:1, Ref. B) an overview of sampling level for the years 1993–1996 was made. It was shown that in most quarters, the recommended sampling level was reached. Still, despite of a rather high sampling level, not all landings by the different fishing fleets were covered by samples.

For Denmark and Sweden the human consumption fishery has been sampled at a level, which can be regarded as reliable. The Danish "Mixed" fishery as well as the "Other" fishery has in all years been sampled at a reasonably level and therefore also these estimated figures can be regarded as reliable. The landings for reduction purposes taken by the Swedish human consumption fishing fleet (32 mm mesh size) in Skagerrak and Kattegat have for the years 1991–1995 not been sampled adequately, if sampled at all. These landings are disaggregated by using Danish samples from the "Mixed" fishery. When using these samples, it may be expected that the estimated numbers of fish caught were too high and may have biased the age distribution (0, 1 and 2 w-ringers). As the human consumption fishery took place in the deeper part, more than 75 m depth, in Skagerrak, it may be expected that the age distribution mainly consisted of older fish (1, 2, 3 and 4 w-ringers). As the catches of older herring in Division IIIa mainly consisted of spring spawners, the total numbers of spring spawning herring caught may be too low.

The landings of herring taken in Sub-divisions 22–24 have not been sampled adequately. For some years Danish and Swedish landings have not been sampled in all quarters. German landings in the period 1991–1997 have been at a rather low level, between 7 000–15 000 t. The major part of these landings has been taken in trap- and gill nets. In some quarters no samples have been taken and for some quarters survey data have been used to estimate numbers caught by age group. It may be expected that in the quarters where survey catches have been used, the estimated numbers caught might have been too high as the age distribution in surveys are different compared to gillnet catches.

3.1.3 Revised total catch in numbers

At this Study Group meeting it was decided that for the purpose of producing input-data for the ICA (Integrated Catch Analyses) only total catch by year and quarter was needed.

During the revision of the historical data some changes have been made. The changes, compared with the data listed in the HAWG reports from 1992–1998 (ICES CM 1992/Assess:11, ICES CM 1992/Assess:13, ICES CM 1993/Assess:15, ICES CM 1993/Assess:17, ICES CM 1994/Assess:13, ICES CM 1995/Assess:13, ICES CM 1996/Assess:10, ICES CM 1997/Assess:8, ICES CM 1998/ACFM:14) are listed below.

1992:
In the figure for Skagerrak 1992, Danish misreporting human consumption catches in quarter 1, 2 and 4 were excluded. In the HAWG, these landings were included in Skagerrak, but when splitting in autumn and spring spawners the landings were in advance transferred to the North Sea as autumn spawners (ICES CM 1993/Assess:15).

1993:
Danish misreporting human consumption catches in quarter 1and 4 in Skagerrak excluded. In the HAWG, these landings were included in Skagerrak, but when splitting in autumn and spring spawners the landings were in advance transferred to the North Sea as autumn spawners (ICES CM 1994/Assess:13).

The revised total catch data (tonnes) are shown by country and year for the period 1991–1997 in Table 3.1.1.

Total catch, spring and autumn spawners, in numbers and mean weight by year and quarter for Skagerrak, Kattegat and Sub-divisions 22–24 are shown in Tables 3.1.2, 3.1.3 and 3.1.4. It was not possible to give landings in numbers for Sub-divisions 22–24 by quarter in 1991.

As mentioned above, there is still uncertainty in the estimated catch at age data. A main concern is the Swedish landings for reduction purposes taken by the human consumption fleet. If possible all these landings for the period 1991–1997 should be worked up again, as they constitute up to 30% of the total landings in Division IIIa.

The Study Group therefore recommends all countries, Denmark, Germany, Norway and Sweden, which have caught herring in Division IIIa and Sub-divisions 22–24, to recalculate estimates of number of herring caught and mean weight by fleet per year for the period 1991–1997. It is recommended that all countries should finalise these data before the 1999 HAWG meeting.

3.2 Mean Weight at Age Data

3.2.1 Review 1991–1997

The mean weights at age (g) per year in each of the areas Skagerrak, Kattegat and Sub-divisions 22–24 in 1991–1997 are given in Tables 3.1.2, 3.1.3 and 3.1.4. The data are the mean weights at age in the total catches covering both the North Sea autumn spawners and the Western Baltic spring spawners. They are, with few corrections, copied from tables in the annual assessment reports from 1992–1998.

Some mean weights in the original tables were considered to be incorrect; i.e. Skagerrak 1993, 1Q, age 8+ and Kattegat 1991, 4Q, age8+. These mean weights were corrected by weighting mean weights for the respective age groups and quarters over the period.

The mean weights at age in the catches are estimated by weighting with the numbers caught. These numbers are generally calculated by using data from commercial samples. As presented in Section 3.1.2, the estimated numbers in the catches may be both over- and under-estimated due to lack of adequate samples.

The mean weights at age in the catches from Sub-divisions 22–24 in 1991–1997, assumed to contain pure Baltic spring spawners, show no trends in any age groups (Figure 3.2).

3.2.2 Revised data

The mean weights at age are calculated from mixed samples including both autumn and spring spawners. They are therefore considered to be too high. The Study Group was not able to revise the data, as new, stock related data could not be presented at the meeting.

Since the Study Group decided that all commercial catch estimates on numbers and mean weight should be recalculated, it was decided not to conduct further revisions on the present data sets.

4 REVISION OF SURVEY DATA

4.1 Review 1991–1997

Research surveys have been conducted regularly for all seasons in Division IIIa and the Sub-divisions 22, 23 (the Sound) and 24. However, none of the available fishery independent surveys were specifically designed to account for the two major problems in the assessment of the WBSS:

- to provide reliable discrimination between stock components over the WBSS distribution,
- to describe spatial distribution by stock components and migration patterns between seasons.

In addition none of the surveys cover the total distribution and there is little temporal overlap between these surveys. Available data series have been:

Survey	Area	Month	Comments
International Bottom Trawl Survey	Division IIIa	Feb., Aug.	Updated for 1995–97
German Larval Survey	Sub-division 24	March–June	Recruitment estimate
Danish Hydroacoustic Survey	Division IIIa, E. North Sea	July	
Danish Monitoring Hydroacoustic Survey	Sub-division 23 (Sound)	Sept.–April	
German Bottom Trawl Survey	Sub-division 24	Jan./Feb.	Target species cod
German Bottom Trawl Survey	Sub-division 22,24	Nov./Dec.	
German Hydroacoustic Survey	Sub-division 22, 23, 24	Sept./Oct.	Revised for 1993–97

An overview of the surveys, that have been available during the HAWG meetings 1991–1998, is presented in Table 4.1.

4.1.1 Trawl surveys

The following trawl surveys are conducted every year:

- German bottom trawl survey (GBTS) in Sub-divisions 22 and 24 in November/December since 1979,
- German bottom trawl survey in Sub-division 24 in January/February since 1979,
- International bottom trawl survey (IBTS) in Division IIIa in quarter 1 (since 1974), quarter 2 (1991–1995) and quarter 3 (since 1990).

The main purpose of the GBTS (gear HG 20/25 with a net opening of about 4 m) is to estimate recruitment indices for cod stocks. The IBTS was originally designed for herring (gear: GOV with a net opening of 5.5 m) but is currently conducted as a standard survey. However, the survey results on herring are weighted by specific area strata which are used to calculate herring indices.

4.1.2 Acoustic surveys

The following two acoustic surveys are carried out every year:

- Danish survey in Division IIIa in July/August since 1986,
- German/Danish survey in Sub-divisions 21–24 in September/October since 1987.

In addition a Danish monitoring program was carried out in Sub-division 23 from autumn to spring in 1993–1997.

The acoustic surveys are conducted every year to supply the HAWG with an index value for the stock size of herring in the Western Baltic area. However, the design of these surveys was not tailored to study the dynamics of the WBSS. The Danish survey in July has been co-ordinated with other hydroacoustic surveys conducted by national institutes around the North Sea in order to provide stock estimates of the North Sea autumn spawners. The German survey in September/October was traditionally co-ordinated with other international surveys in the Baltic. The main objective has been to assess clupeoid resources in the Baltic Sea. The German hydroacoustic data series have been recalculated and revised for 1993–1998. The revision followed procedures recommended in the Baltic International Acoustic Survey manual (ICES CM 1998/H:4).

The main purpose of the Danish acoustic monitoring in Sub-division 23 was to provide information on herring migration and an evaluation of possible environmental impacts from the construction of the Sound bridge between Denmark and Sweden. The survey series have been terminated and there are no plans for future activities.

4.1.3 Larval survey

One German larval survey is carried out annually since 1977 from March/April to June on the main spawning grounds of the Western Baltic spring spawning herring in Greifswalder Bodden and adjacent waters. To get the index for the estimation of the year class strength used by the HAWG, the number of larvae which will reach the length of TL=30 mm (larvae after metamorphosis) are calculated taking into consideration growth and mortality (Klenz, 1993, and Mueller and Klenz 1994).

It was shown previously that larval index (0-group) and the estimated age 1 from the hydroacoustic surveys in the subsequent year in Sub-division 24 differ substantially (ICES CM 1998/ACFM:14). The Study Group members assume that an alternative use of the data could be to back-calculate spawning biomass. Such an approach might necessitate an extended and redesigned sampling strategy. The Study Group members recommend that the possibility to extend the sampling design to include estimates of spawning biomass should be explored.

4.2 Revised Data and Considerations for Improved Survey Design

All available survey indices are tabulated in Tables 4.2.1–4.2.10. Two survey indices have been revised:

- Results from the International Bottom Trawl Surveys in for both quarter 1 (February) and 3 (August) have been updated for 1996–1997. Data are shown in Tables 4.2.2 and 4.2.3 for quarter 1 and 3, respectively.
- Results from the German hydroacoustic survey 1993–1997 in Sub-divisions 22, 23 and 24 have been recalculated according to the Baltic International Acoustic Survey Manual (ICES CM 1998/H:4, appendix 3). The data series for 1991–1997 are presented in Table 4.2.8.

Results from the Danish monitoring hydroacoustic surveys have been revised for the whole data sets including 1993–1998. Results are presented in Table 4.2.9. There are no plans to continue the surveys.

The Study Group members discussed a possible co-ordination between the current surveys. The lack of a survey that covers the total WBSS distribution during the same season was thought to be a major obstacle to obtain a reliable analytical analysis. A possible solution might be to organise an international bottom trawl or hydroacoustic survey. The Study Group members considered that the stable stock distribution during summer would suggest an extended hydroacoustic survey in July. However, it was recognised that trawl sampling has been difficult in the Kattegat due to enormous by-catches of jellyfish.

Available data suggest that a large part of the WBSS stock have migrated south to the Sound or at least to the southern Kattegat by October (ICES CM 1998/H:1). Therefore, the German hydroacoustic survey was considered to have an appropriate coverage. It was agreed that the survey could provide a major input for the assessment of the WBSS stock. The design of the survey can be further improved in order to increase precision of the survey results.

In addition, the Study Group members agreed that further studies on the spawning ground should be encouraged. Results from the present larval surveys might be used to investigate the possibility for a back-calculation of spawner biomass. Such analysis may provide a better estimate of the spawning population. Complementary studies on homing would indicate problems due to mixing between spawning "stocks" at the spawning site. The larval surveys may also be extended to include other spawning areas along the German, Danish and Swedish coasts. Pilot studies were recommended to evaluate the possibility to use larval surveys for assessment purposes.

5 PURPOSE AND STRUCTURE OF A MIGRATION MODEL

Heinke (1898) was the first to suggest a relation between the spring spawning herring in the Rügen area and along the Swedish west coast. Since then a number of studies have indicated that this assumption could be sustained (review in ICES CM 1998/H:1). In 1992 the ICES Baltic pelagic assessment Working Group started to perform combined assessments on spring spawners in the Division IIIa and Sub-divisions 22, 23 and 24. The task was later transferred to the HAWG.

Unfortunately, the assessments of the WBSS by analytical analysis have not been successful. Problems include inconsistencies in year class survival, conflicting recruitment and biomass indices, as well as in anomalies in results from the stock discrimination. These problems have been related to insufficient sampling of landings, allocation between fleets with different selectivity and incomplete coverage of surveys. However, most of these problems can be almost fully explained from imprecise methods to identify stock components within the WBSS total distribution.

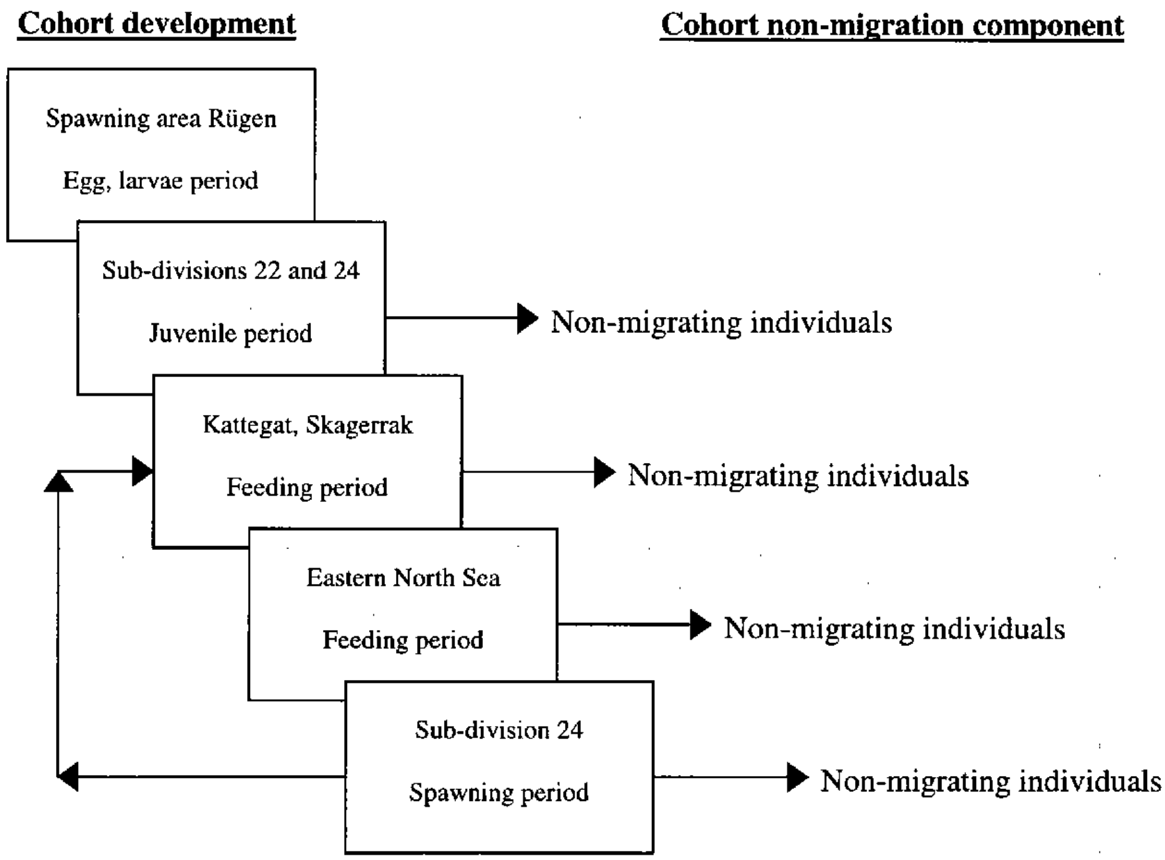
New methods to discriminate between stock components are currently tested. Even though these methods might increase the knowledge of the spatial distribution of the WBSS they will not be sufficient to provide input for a complete analytical analysis. Such knowledge can be used to estimate the relation between the SSB and recruitment. However, advice for a sustained fishery on the WBSS must also include the effects of site and season specific exploitation, i.e. to account for the spatial and temporal disparity between different types of fisheries.

Current assessment tools (VPA, ICA, etc.) assumes that both individual fishes and fishing boats diffuse over the entire distribution of the studied species. The fishing on the WBSS is characterised by distinct fleets that operate apart both in time and space. Thus the exploitation impact on a year class differ by different fisheries. If the effects of these fisheries are simply added there will be no way to manage these fisheries individually.

A possible solution is to construct a general migration model. The objective should be to predict age distribution and the corresponding fishing mortalities between area and space delimited compartments in the model. Each compartment should be designed a specific time and place for a growing year class. A crucial task will be to estimate migration rates and patterns between these compartments.

An illustration to how this design might be achieved was outlined during the last HAWG meeting (ICES CM 1998/ACFM:14). The illustration was used to indicate possible bias in the age composition and the achieved unrealistic mortalities by areas and seasons. However, it should be possible to elaborate further on this illustration. A complete model should use survey and fishery estimates to estimate year class history, i.e. the model should run backwards in a VPA like manner. A prerequisite to the model must be that fractions of the WBSS can be identified for all relevant input data.

A simple box model illustrates the concept:



Members of the Study Group agreed that a proper migration model could not be assembled without access to extensive preparation and external expertise trained for model construction. The Study Group therefore recommends that modelling experts should work together with herring biologists to supply an operational model based on appropriate data on the stock discrimination of the WBSS stock. Such data can be made available from Study Group members.

- The model should specify all underlying biological assumptions,
- It should be able to exploit a number of new and updated biological data on the Division IIIa and Western Baltic herring stock components:
  a) mixing of different stock components,
  b) growth and maturation patterns of the different stocks,
  c) seasonal and area specific biomarkers.
- The model should specify a host of testable predictions,
- It should reflect the relative distribution of each age-class in the different areas, with a quarter of a year resolution,
- It should account for area-specific partial mortality rates,
- The model should be operational for both VPA and forecast purposes.

6 TASK BEFORE THE HAWG 1999

- The Study Group recommends all countries, Denmark, Germany, Norway and Sweden, which have caught herring in Division IIIa and Sub-divisions 22–24 to recalculate the catch in numbers and the mean weight by fleet per years 1991–1997. It is recommended that all countries should finalise these data before the 1999 HAWG meeting.

7 RECOMMENDATIONS

1. The Study Group recommends maintaining the German hydroacoustic survey in October. It is considered that the Western Baltic herring starts its spawning (southward) migration in late summer and by October it has left the

Skagerrak-Kattegat area. Thus the hydroacoustic survey covers all the area of the Western Baltic spring spawner distribution during that period.

2. The Study Group recommends extending the area of larval investigations in the Baltic Sea (Sub-divisions 22 and 24) to reveal other important reproduction areas for Baltic herring. It would be desirable that historical and future larval surveys could be used to provide an index of spawning stock biomass of Western Baltic herring.

3. The Study Group recommends increasing the sampling of Western Baltic herring from commercial trap-net catches during the spawning period. It is recommended to collect samples of spawning herring along the entire coast in Sub-divisions 22, 24 and Division IIIa. The purpose of the sampling should be to estimate the importance of all local spring spawning stocks and to obtain pure samples for analysis of vertebral counts and other biological characteristics.

4. The Study Group recommends that all institutes, which collect samples of herring in areas where Western Baltic herring is mixed with North Sea autumn herring, should retain and store otolith samples for microstructure analysis.

5. The Study Group recommends that modelling experts work together with biologist in order to supply an operative migration model which can be tested with appropriate data on stock discrimination. Such data can be made available from Study Group members.

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Table 2.1 **Proportion of Western Baltic spring spawners by quarter for years 1991-1997 as used by the Working Group, (%)**

Age	Year	Skagerrak				Kattegat			
		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4
0	1991	-	-	0	0	-	-	0	34(0)
	1992	-	-	0	0	-	-	0	0
	1993	-	-	0	0	-	-	0	0
	1994	-	-	0	0	-	-	0	0
	1995	-	-	0	10	-	-	0	22
	1996	-	-	35	0	-	-	17	0
	1997	-	-	0	0	-	-	0	0
1	1991	0	0	0	0		0	0	100(64)
	1992	0	0	0	0	0	0	0	88
	1993	0	0	0	0	0	0	0	69
	1994	0	0	0	0	0	0	0	0
	1995	0	0	46	22	25	24	41	69
	1996	16	13	10	15	12	33	54	55
	1997	0	0	0	25	0	0	0	0
2	1991	0	0	70	29	100(69)	97(51)	100(93)	100
	1992	0	0	25	93	78	67	100	100
	1993	0	0	23	100	100	95	100	100
	1994	0	0	13	0	0	35	90	100
	1995	27	6	89	52	50	50	79	81
	1996	31	55	79	99	70	81	83	83
	1997	0	29	0	67	0	69	69	79
3	1991	100	100	100	100	100	100	100	100
	1992	100	100	100	100	100	100	100	100
	1993	100	100	100	100	100	100	100	100
	1994	100	100	100	100	100	100	100	100
	1995	46	60	100	100	100	100	100	100
	1996	43	65	86	93	54	65	76	100
	1997	54	87	56	67	63	75	75	75
4+	1991	100	100	100	100	100	100	100	100
	1992	100	100	100	100	100	100	100	100
	1993	100	100	100	100	100	100	100	100
	1994	100	100	100	100	100	100	100	100
	1995	100	100	100	100	100	100	100	100
	1996	100	100	100	100	100	100	100	100
	1997	75	87	56	67	63	75	75	75

for **1991** separate proportions for spring spawning herring in landings for industrial purposes (first value) and in landings for human consumption (value in brackets) were given
for **1991-1994** the split was performed for age classes 0 to 2
for **1995** the split was performed for age classes 1 to 3+
for **1996** and **1997** the split was performed for age classes 1 to 4+,

Table 2.3.1 **Weighted mean vertebrae counts of mixed herring in Division IIIa and Sub-division 23 based on Swedish data 1991-1997 (by year x quarter x area x age (0-4 wr).**

Year	Quarter	Skagerrak					Kattegat					Sound				
		Winter rings														
		0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
1991	I		56.52	56.45	56.05	56.59		56.19	56.20	55.65	55.75		56.02	56.16	55.99	55.91
	II		56.57	56.35	56.19	56.15		56.28	55.81	55.77	55.93		56.12	56.18	55.74	56.06
	III	56.34	56.18	56.23	56.50	55.55	56.45	56.34	55.83	55.98	55.69	56.00	56.05	55.37	55.79	55.79
	IV															
1992	I		56.43	56.26	56.28	56.52		56.23	56.16	56.07	55.90					
	II															
	III	56.40	56.11	56.00	56.00	55.64	56.44	55.97	55.81	55.82	55.71	56.20	56.03	55.73	55.70	55.65
	IV															
1993	I		56.39	56.55	56.79	56.50		56.54	56.16	55.96	55.93	57.00	56.13	56.24	55.84	55.97
	II		56.48	56.20	56.15	55.76		56.35	55.76	55.82	55.79		56.42	55.74	55.83	55.86
	III	56.43	56.33	55.87	55.53	56.66	56.04	56.19	55.83	55.99	55.85	56.00	56.09	55.86	55.69	55.88
	IV															
1994	I		56.42	56.32	55.89	55.91		56.27	56.37	55.83	55.80		56.06	56.15	55.88	55.88
	II		56.42	56.49	56.45	55.90		56.20	56.22	55.66	55.97		56.25	56.06	55.44	55.95
	III	56.53	56.47	56.13	55.79	55.70	56.43	56.34	56.06	55.75	55.82	55.72	56.07	56.21	55.99	55.77
	IV															
1995	I		56.36	56.47	56.38	55.52		56.16	56.08	56.54	56.21		56.12	55.92	56.12	55.80
	II		56.36	56.42	56.07	55.93		56.17	56.20	56.08	55.79		56.00	55.99	56.02	55.98
	III	56.37	56.41	56.51	55.79	55.91	56.46	56.22	56.07	55.78	55.75		55.65	56.07	55.59	55.79
	IV															
1996	I		56.45	56.32	56.34	55.99		56.48	55.98	56.30	56.12		56.03	55.74	55.99	55.70
	II															
	III	56.22	56.47	55.76	56.21	55.94	56.39	56.25	55.71	56.04	56.14		55.81	55.80	56.06	55.80
	IV															
1997	I		56.47	56.72	56.15	55.87		56.37	56.38	55.79	55.79		56.07	55.88	55.75	55.70
	II															
	III															
	IV															

Table 2.3.2 **Results of logistic regression model based on Swedish data 1991-1997. Results in fractions of WBSS (by year x quarter x area x age (0-4 wr).**

Year	Quarter	Skagerrak					Kattegat					Sound				
		Winter rings														
		0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
1991	I		0.24	0.26	0.42	0.22		0.36	0.35	0.58	0.54		0.43	0.37	0.44	0.47
	II		0.23	0.30	0.36	0.37		0.33	0.52	0.53	0.46		0.39	0.36	0.54	0.41
	III	0.30	0.36	0.34	0.25	0.62	0.26	0.30	0.51	0.44	0.56	0.44	0.42	0.69	0.53	0.52
	IV															
1992	I		0.27	0.33	0.32	0.24		0.34	0.37	0.41	0.48					
	II															
	III	0.28	0.39	0.44	0.44	0.59	0.27	0.45	0.51	0.51	0.56	0.36	0.42	0.55	0.56	0.58
	IV															
1993	I		0.29	0.23	0.17	0.25		0.24	0.37	0.45	0.47	0.12	0.38	0.34	0.50	0.45
	II		0.25	0.35	0.37	0.54		0.30	0.54	0.51	0.52		0.27	0.54	0.50	0.49
	III	0.27	0.31	0.49	0.63	0.20	0.42	0.36	0.51	0.44	0.50	0.44	0.40	0.49	0.57	0.49
	IV															
1994	I		0.27	0.31	0.48	0.47		0.33	0.29	0.51	0.52		0.41	0.37	0.49	0.49
	II		0.28	0.25	0.26	0.48		0.36	0.35	0.58	0.45		0.33	0.41	0.67	0.46
	III	0.24	0.26	0.38	0.53	0.56	0.56	0.30	0.41	0.54	0.51	0.55	0.41	0.35	0.44	0.53
	IV															
1995	I		0.29	0.26	0.29	0.64		0.37	0.40	0.24	0.35		0.38	0.47	0.39	0.52
	II		0.30	0.28	0.41	0.47		0.37	0.35	0.40	0.52		0.44	0.44	0.43	0.45
	III	0.29	0.28	0.25	0.52	0.47	0.26	0.35	0.41	0.53	0.54		0.58	0.41	0.61	0.52
	IV															
1996	I		0.27	0.31	0.30	0.44		0.26	0.45	0.32	0.39		0.42	0.54	0.44	0.56
	II															
	III	0.35	0.26	0.54	0.35	0.46	0.28	0.33	0.56	0.42	0.38		0.52	0.52	0.41	0.52
	IV															
1997	I		0.26	0.19	0.38	0.49		0.29	0.29	052	0.52		0.41	0.49	0.54	0.56
	II															
	III															
	IV															

Table 2.4 **Results of otolith microstructure determined proportion of spring spawners based on Danish scientific and commercial samples of 1 to 4+ winter ringers.**

Year		Skagerrak				Kattegat				Sound			
		Winter rings											
	quarter	1	2	3	4	1	2	3	4	1	2	3	4
1996	I						0.73	1.00	1.00			1.00	1.00
	II										1.00	1.00	0.98
	III	0.09	0.82	0.98	0.95	0.49	0.95	1.00	1.00				
	IV		0.00	0.00		0.15	0.79			0.24	0.87	0.96	0.98
1997	I						0.00	0.63	0.60				
	II										1.00	0.94	0.97
	III	0.07	0.51	0.85	0.82	0.02	0.73	0.84	0.88				
	IV						0.79	0.89					

Table 2.6 **Proportions based on estimated sample mean values from the same individuals using VS based and otolith based methods.**

VS-BASED

Average of VS					Proportion	
Year	Quarter	Area	Haul	Total	**logist**	**linear**
1996	1	Kattegat	6	56.28	**0.32**	**0.32**
		Skagerrak	36	56.50	**0.24**	**0.00**
	3	Skagerrak	150	55.82	**0.50**	**0.97**
1997	1	Kattegat	62	56.67	**0.20**	**0.00**
		Skagerrak	109	56.90	**0.14**	**0.00**
	3	Skagerrak	566	56.11	**0.38**	**0.56**
Gesamtergebnis				56.40	**0.28**	**0.14**

OTOLITH MICROSTRUCTURE

Count of spawner				spawner			**Proportion**
Year	Quarter	Area	Haul	1	2	Grand Total	**otolith**
1996	1	Kattegat	6	14	13	27	**0.48**
		Skagerrak	36	5	7	12	**0.58**
	3	Skagerrak	150	1	10	11	**0.91**
1997	1	Kattegat	62	12		12	**0.00**
		Skagerrak	109	19	1	20	**0.05**
	3	Skagerrak	566	2	7	9	**0.78**
Gesamtergebnis				53	38	91	**0.42**

Table 3.1.1 HERRING in Division IIIa and Sub-division 22-24. 1985-1997.
Landings in thousands of tonnes.
(Data provided by HAWG and Study Group members).

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Skagerrak													
Denmark	88.2	94.0	105.0	144.4	47.4	62.3	58.7	41.9	73.4	44.9	43.7	28.7	14.3
Faroe Islands	0.5	0.5											
Norway	4.5	1.6	1.2	5.7	1.6	5.6	8.1	13.9	24.2	17.7	16.7	9.4	8.8
Sweden	40.3	43.0	51.2	57.2	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9
Total	133.5	139.1	157.4	207.3	96.9	124.4	121.5	143.8	154.0	129.0	108.9	70.8	56.0
Kattegat													
Denmark	69.2	37.4	46.6	76.2	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8
Sweden	39.8	35.9	29.8	49.7	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0
Total	109.0	73.3	76.4	125.9	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8
Sub. Div. 22+24													
Denmark	15.9	14.0	32.5	33.1	21.7	13.6	25.2	26.9	38.0	39.5	36.8	34.4	30.5
Germany	54.6	60.0	53.1	54.7	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8
Poland	16.7	12.3	8.0	6.6	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9
Sweden	11.4	5.9	7.8	4.6	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5
Total	98.6	92.2	101.4	99.0	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7
Sub. Div. 23													
Denmark	6.8	1.5	0.8	0.1	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2
Sweden	1.1	1.4	0.2	0.1	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1
Total	7.9	2.9	1.0	0.2	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3
Grand Total	349.0	307.5	336.2	432.4	286.4	279.9	257.8	288.6	280.5	234.4	231.0	172.7	149.8

Table 3.1.2 **Total landings of Herring from Skagerrak in 1991-1997**

Catch in numbers (millions) and mean weight (g) at age by year and quarter.

	1991		1992		1993		1994		1995		1996		1997	
1. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0														
1	69.60	26	124.24	25	851.73	16	111.67	15	204.84	22	351.23	15	29.42	29
2	70.00	67	16.79	82	114.66	53	59.86	55	86.36	74	44.72	68	44.41	50
3	14.00	96	5.87	162	16.38	162	13.79	88	6.87	129	17.19	107	16.00	107
4	7.30	138	3.74	189	11.17	126	2.81	107	0.94	158	4.24	157	1.45	140
5	4.60	139	1.19	175	4.66	274	0.80	141	0.21	184	1.60	197	0.41	190
6	1.20	145	1.59	181	3.39	267	0.42	165	0.12	198	0.79	238	0.32	213
7	0.40	144	0.50	205	3.58	176	0.06	179	0.12	204	0.62	257	0.10	236
8+	0.20	169	0.30	216	1.07	221	0.06	177	0.14	234	0.54	277	0.14	261
TOTAL	167.30		154.22		1006.64		189.47		299.60		420.92		92.25	
Land. (SOP)(t)		9,751		6,835		27,199		6,704		12,110		11,799		5,195
2. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0														
1	331.90	29	183.95	37	194.21	26	354.71	18	183.90	30	42.96	34	85.50	41
2	138.10	79	106.93	78	74.41	104	85.68	84	51.16	77	46.44	82	44.41	57
3	111.10	93	20.78	91	30.36	126	42.51	118	17.87	139	18.52	155	31.69	143
4	54.20	114	18.53	101	13.13	134	14.40	141	12.23	144	9.28	190	13.86	194
5	23.60	127	10.41	129	12.96	157	12.66	168	3.66	161	4.15	161	4.69	218
6	7.30	147	9.32	138	9.45	173	6.67	180	2.48	193	1.87	191	1.81	208
7	2.80	152	3.94	152	5.33	196	1.82	202	1.51	199	1.72	200	0.35	260
8+	1.40	182	3.88	163	3.30	215	0.96	195	1.98	205	2.62	190	0.94	220
TOTAL	670.40		357.74		343.15		519.41		274.79		127.56		183.25	
Land. (SOP)(t)		41,922		22,680		23,828		24,311		15,417		11,772		14,954
3. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	45.20	23	1121.35	11	1666.37	11	192.96	11	865.28	9	64.24	7	13.69	16
1	134.60	68	399.11	73	325.51	59	169.96	89	259.79	68	61.45	77	17.73	41
2	83.40	125	142.58	107	141.92	113	127.65	122	114.75	116	117.86	122	40.98	106
3	94.20	139	41.49	132	100.71	122	77.00	136	50.83	150	31.08	148	61.39	134
4	43.90	151	43.68	153	27.42	154	74.39	153	32.07	171	22.34	176	12.82	168
5	36.40	179	21.51	186	16.00	156	39.82	161	36.22	188	16.10	191	5.91	181
6	6.00	179	11.95	199	14.07	187	20.21	195	5.17	221	6.83	206	1.38	190
7	2.00	192	2.76	208	3.95	186	5.38	202	1.56	283	2.90	190	0.81	187
8+	0.30	190	0.41	266	0.67	210	1.98	229	0.48	249	1.60	227	0.65	181
TOTAL	446.00		1784.84		2296.62		709.35		1366.15		324.39		155.36	
Land. (SOP)(t)		48,393		75,538		76,398		66,628		60,617		33,562		17,271
4. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	322.10	25	588.59	16	631.54	17	220.71	19	319.21	18	255.41	12	34.37	21
1	24.30	110	392.96	64	161.93	73	194.30	92	48.29	76	62.23	48	108.46	64
2	24.80	138	48.52	75	49.53	120	40.80	131	41.82	129	42.05	97	26.08	110
3	24.20	158	16.88	111	43.97	152	14.14	156	23.15	163	12.52	152	40.75	143
4	11.60	166	9.82	137	17.60	162	3.63	190	9.69	167	4.67	183	6.78	161
5	9.00	180	5.83	149	8.37	178	1.66	204	1.65	181	2.22	209	4.22	176
6	1.50	218	6.87	202	3.87	214	1.46	211	1.30	211	0.76	223	1.03	173
7	0.70	237	1.63	219	2.36	217	0.43	228	3.45	227	0.11	218	0.44	165
8+	0.40	287	0.70	234							0.20	212	0.99	186
TOTAL	418.60		1071.80		919.17		477.13		448.55		380.17		223.12	
Land. (SOP)(t)		21,966		44,211		40,871		31,145		21,598		13,573		18,628
TOTAL														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	367.30	24	1709.94	13	2297.91	13	413.67	16	1184.49	12	319.65	11	48.06	20
1	560.40	42	1100.26	58	1533.38	33	830.64	49	696.82	45	517.87	28	241.11	50
2	316.30	93	314.82	91	380.52	94	313.99	100	294.09	99	251.07	101	155.88	77
3	243.50	117	85.02	120	191.42	133	147.44	128	98.72	150	79.30	142	149.83	135
4	117.00	134	75.77	140	69.32	148	95.23	151	54.93	164	40.53	178	34.91	176
5	73.60	160	38.94	165	41.99	174	54.94	164	41.74	185	24.07	188	15.23	191
6	16.00	166	29.73	180	30.78	195	28.76	192	9.07	212	10.24	207	4.54	195
7	5.90	175	8.83	185	15.22	192	7.69	203	6.64	234	5.34	202	1.70	199
8+	2.30	200	5.29	183	5.04	216	3.00	217	2.60	215	4.97	212	2.72	200
TOTAL	1702.30		3368.60		4565.58		1895.36		2389.09		1253.05		653.98	
Land. (SOP)(t)		122,032		149,264		168,295		128,787		109,742		70,707		56,048

Table 3.1.3 **Total landings of Herring from Kattegat in 1991-1997**

Catch in numbers (millions) and mean weight (g) at age by year and quarter.

	1991		1992		1993		1994		1995		1996		1997	
1. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0														
1	231.60	22	337.04	26	688.02	14	261.35	19	432.72	18	429.24	15	19.21	27
2	284.20	43	56.41	71	66.58	28	78.81	56	32.86	55	84.73	59	63.71	64
3	32.90	69	18.84	92	10.20	161	35.46	89	9.10	110	7.65	124	32.41	111
4	15.90	83	13.20	112	4.79	137	9.98	116	7.30	159	6.81	172	2.19	163
5	5.60	102	6.24	138	2.84	191	4.23	152	3.05	193	1.63	180	0.93	180
6	0.80	124	4.38	171	1.45	274	3.41	150	1.88	197	1.24	226	0.73	208
7	0.40	124	1.35	193	0.69	320	0.66	190	0.93	240	0.23	261	0.22	236
8+	0.20	162	0.49	207	0.36	316	0.42	217	0.79	269	0.10	221	0.27	261
TOTAL	571.60		437.95		774.93		394.32		488.63		531.63		119.67	
Land. (SOP)(t)		21,710		17,992		15,304		14,877		13,062		14,359		8,992
2. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	5.10	6	0.20	10										
1	46.20	29	39.34	36	61.30	23	66.12	20	115.49	35	34.24	18	36.41	39
2	98.60	40	67.01	65	53.73	49	34.47	59	11.69	65	22.68	55	8.60	83
3	16.20	64	33.51	74	11.45	68	20.00	77	3.79	102	4.20	83	7.26	126
4	16.30	80	25.61	94	4.50	101	5.71	92	3.36	112	1.89	122	1.18	148
5	2.80	88	9.53	118	3.80	121	3.77	121	1.12	150	1.50	135	0.38	165
6	0.50	92	6.32	136	1.88	147	2.62	127	0.97	152	0.92	136	0.23	160
7	0.60	91	1.22	155	1.22	156	1.55	144	0.78	153	0.31	158	0.03	151
8+			0.93	176	0.50	179	1.19	148	0.48	181	0.21	170	0.02	246
TOTAL	186.30		183.67		138.38		135.43		137.68		65.95		54.11	
Land. (SOP)(t)		7,935		12,968		6,246		6,616		6,027		2,843		3,332
3. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	2.10	25	487.21	11	348.69	10	11.98	12	380.91	13	8.77	7	0.24	17.00
1	74.20	52	96.89	51	44.62	41	12.83	83	213.10	32	30.20	30	39.43	48.00
2	112.90	70	61.60	75	16.36	70	10.38	109	10.05	85	194.46	55	42.05	68.00
3	32.60	87	16.46	89	8.64	98	9.52	130	4.46	139	20.92	85	8.97	113.00
4	17.70	95	8.40	117	5.10	122	5.05	145	7.24	152	3.72	132	2.59	141.00
5	2.50	118	4.07	173	3.13	153	2.22	174	2.25	204	2.29	160	1.44	163.00
6	0.80	123	0.85	180	1.47	144	0.88	210	1.39	209	0.93	176	0.47	177.00
7	0.40	132	0.44	211	0.67	157	0.31	194	0.62	230	1.10	171	0.06	180.00
8+	0.10	173	0.62	241	0.28	179	0.28	146	0.45	228	0.36	187	0.10	198.00
TOTAL	243.30		676.54		428.96		53.45		620.47		262.75		95.35	
Land. (SOP)(t)		16,725		18,330		8,686		4,969		15,508		14,744		6,483
4. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	80.50	33	209.77	14	310.10	15	116.58	20	238.51	17	327.62	11	45.31	19.00
1	245.20	66	76.10	53	76.70	60	68.71	72	100.62	47	31.88	30	42.55	57.00
2	110.20	80	21.91	83	32.05	84	16.10	101	10.69	101	115.51	61	26.79	91.00
3	22.70	88	6.47	101	13.05	103	8.93	143	4.92	150	7.05	77	13.98	131.00
4	12.70	101	5.11	113	5.75	122	4.71	178	5.42	196	0.58	145	1.98	162.00
5	1.50	100	1.56	132	2.91	138	4.04	190	2.14	210	0.51	169	0.61	170.00
6	0.40	129	0.82	155	2.20	181	1.68	206	1.26	230	0.26	167	0.26	173.00
7	0.20	202	0.32	84	1.37	193	1.16	236	0.77	230			0.07	187.00
8+	0.20	263							0.31	260			0.04	263.00
TOTAL	473.60		322.06		444.13		221.91		364.64		483.41		131.59	
Land. (SOP)(t)		31,160		10,378		15,115		12,413		12,621		12,266		8,049
Total														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	87.70	31	697.18	12	658.79	12	128.56	19	619.42	15	336.39	11	45.55	19.0
1	597.20	44	549.37	35	870.64	20	409.01	30	861.93	27	525.56	17	137.60	45.5
2	605.90	54	206.93	71	168.72	49	139.76	65	65.29	69	417.38	57	141.15	71.5
3	104.40	78	75.28	84	43.34	106	73.91	97	22.27	123	39.82	91	62.62	117.5
4	62.60	89	52.32	104	20.14	121	25.45	128	23.32	159	13.00	152	7.94	153.3
5	12.40	102	21.40	135	12.68	148	14.26	158	8.56	194	5.93	160	3.36	169.2
6	2.50	118	12.37	153	7.00	183	8.59	160	5.50	200	3.35	183	1.69	187.5
7	1.60	123	3.33	171	3.95	198	3.68	185	3.10	214	1.64	181	0.38	211.4
8+	0.50	205	2.04	203	1.14	222	1.89	163	2.03	238	0.67	187	0.43	245.8
TOTAL	1,474.80		1,620.22		1,786.40		805.11		1,611.42		1,343.74		400.72	
Land. (SOP)(t)		77,531		59,668		45,351		38,875		47,218		44,213		26,856

Table 3.1.4 **Total landings of Herring from Sub-Area 22-24 in 1991-1997**

Catch in numbers (millions) and mean weight (g) at age by year and quarter.

	1991		1992		1993		1994		1995		1996		1997	
1. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0														
1			108.65	15	58.24	18	28.27	20	666.89	12	125.21	22	302.28	13
2			194.81	38	37.23	39	20.73	44	128.16	37	26.39	41	27.98	39
3			90.45	75	60.72	79	43.67	79	44.99	59	24.49	76	23.99	100
4			79.05	101	63.27	104	49.99	106	14.79	119	19.57	96	13.52	128
5			50.52	126	78.47	135	32.81	138	12.26	162	10.34	108	8.69	164
6			36.36	157	33.77	158	28.20	157	13.43	188	2.54	116	13.41	193
7			16.39	168	26.42	180	9.72	176	10.04	207	0.94	106	7.85	208
8+			6.86	185	8.91	190	8.59	202	5.85	229	2.37	117	12.27	225
TOTAL	0.00		583.09		367.03		221.98		896.41		211.85		409.99	
Land. (SOP)(t)		0		39,860		36,281		22,633		25,044		9,334		17557
2. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0														
1			31.62	20	50.42	19	37.56	20	522.46	16	261.86	22	149.16	23
2			31.35	49	92.98	41	40.79	46	84.25	47	31.54	42	57.95	51
3			55.54	73	94.83	70	63.12	70	58.37	72	38.02	76	65.80	102
4			69.73	92	72.40	86	53.37	85	65.56	82	37.25	93	31.17	119
5			44.06	120	52.60	110	44.53	106	35.91	117	29.08	124	19.83	154
6			43.10	149	21.88	138	40.26	120	19.40	139	17.38	152	20.85	174
7			15.31	168	13.28	149	23.77	146	10.35	184	9.44	181	11.26	191
8+			6.05	191	5.19	168	15.34	158	7.22	181	12.23	200	8.86	188
TOTAL	0.00		296.76		403.58		318.74		803.52		436.80		364.88	
Land. (SOP)(t)		0		28,033		29,359		27,012		32,112		23,912		27,305
3. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0			0.20	20	21.70	15	100.17	13	233.53	9	1.97	12	86.93	39
1			2.40	40	17.63	35	9.19	49	76.78	34	9.54	36	50.71	54
2			15.30	64	22.38	55	18.15	66	7.99	61	10.18	55	17.40	82
3			19.00	73	21.29	69	22.57	71	10.36	78	26.12	72	2.70	98
4			14.08	86	12.87	83	10.46	77	11.08	84	20.44	89		
5			6.08	91	8.40	111	4.57	89	3.38	104	26.19	113		
6			1.85	122	2.49	134	1.08	86	3.33	102	14.32	103		
7			1.72	138	0.74	145	0.84	116	0.34	120	6.04	110		
8+			0.68	107	0.92	189	0.13	116	0.14	162	2.24	166		
TOTAL	0.00		61.31		108.42		167.16		346.93		117.04		157.74	
Land. (SOP)(t)		0		4,762		6,249		5,952		7,779		10,093		7,820
4. Q.														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0			35.81	19	23.15	17	102.41	13	257.46	9	3.33	12	263.90	28
1			68.04	38	32.92	36	21.27	45	92.04	34	16.48	35	93.04	52
2			39.31	69	27.54	54	24.17	67	13.55	61	16.94	52	27.29	80
3			25.85	99	19.22	78	31.65	90	15.16	75	35.69	70	4.37	96
4			16.66	132	18.33	99	22.24	103	12.58	91	27.50	87	0.44	45
5			4.21	170	11.60	112	8.93	117	2.02	98	34.17	112	0.44	53
6			2.70	184	3.66	149	4.48	120	2.66	103	19.00	103	0.89	173
7			1.33	155	1.77	168	0.78	187	0.14	100	7.74	110	0.35	168
8+			0.45	201	1.29	185	0.41	190	0.01	162	2.77	167	0.69	189
TOTAL	0.00		194.36		139.48		216.34		395.62		163.62		391.41	
Land. (SOP)(t)		0		12,233		8,752		10,829		9,122		13,484		15,216
TOTAL														
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
0	22.34	11	36.01	19	44.85	16	202.58	13	490.99	9	5.30	12	350.83	30.7
1	787.65	31	210.71	23	159.21	24	96.29	28	1358.17	16	413.09	23	595.19	25.1
2	179.89	58	280.77	45	180.13	44	103.84	54	233.95	43	85.05	45	130.62	58.6
3	184.82	79	190.84	77	196.06	74	161.01	76	128.88	68	124.32	74	96.86	101.1
4	114.88	99	179.52	99	166.87	94	136.06	95	104.01	89	104.76	91	45.13	121.0
5	67.59	121	104.87	123	151.07	123	90.84	118	53.57	125	99.78	115	28.96	155.5
6	25.97	139	84.01	153	61.80	149	74.02	134	38.82	150	53.24	119	35.15	181.2
7	6.14	152	34.75	166	42.21	169	35.11	154	20.87	193	24.16	138	19.46	197.4
8+	1.81	155	14.04	184	16.31	182	24.47	174	13.22	202	19.61	181	21.82	208.8
TOTAL	1,391.10		1,135.52		1,018.51		924.22		2,442.48		929.31		1,324.02	
Land. (SOP)(t)		74,453		84,888		80,642		66,425		74,057		56,822		67,899

Table 4.1 Survey data available as abundance indices during the HAWG meetings in 1991–1998.

1991
Separate assessments for herring in Division IIIa and in SD 22-24

1992
Index 1: Acoustic. survey in Div IIIa, July 1989-91, 2-8+ ringers
Index 2: Acoustic. survey in SD 22+24, Oct. 1989-91, 0-8+ ringers
Index 3: IBTS in Div. IIIa, Feb. 1977-1992, 3+ ringers

1994
Index 1: Acoustic. survey in Div IIIa+IVaE, July 1989-93, 2-8+ ringers
Index 2: Acoustic. survey in SD 22+24, Oct. 1989-93, 0-8+ ringers
Index 3: IBTS in Div. IIIa, Feb. 1980-1994, 1, 2 and 3+ ringers
Index 4: German bottom trawl survey (GBTS) in SD 22, Nov. 1979-93, 0-3+ ringers
Index 5: German bottom trawl survey (GBTS) in SD 24, Nov. 1978-93, 0-3+ ringers

1995
Index 1: IBTS in Div. IIIa, Feb. 1980-1994, 2 and 3+ ringers
Index 2: German bottom trawl survey (GBTS) in SD 22, Nov. 1979-94, 0-3+ ringers
Index 3: German bottom trawl survey (GBTS) in SD 24, Nov. 1978-94, 0-3+ ringers
Index 3a: German bottom trawl survey (GBTS) combined for SD 22+24, 1979-94, 0-3+ ringers
Index 4: Acoustic. survey in Div IIIa+IVaE, July 1989-94, 2-8+ ringers
Index 4a: Acoustic. survey in Div IIIa+IVaE using only data from IVaE, 1989-94, 2-8+ ringers
Index 5: Acoustic. survey in SD 22+24, Oct. 1989-94, 0-8+ ringers

1996
Index 1: IBTS in Div. IIIa, Feb. 1980-1995, 2 and 3+ ringers
Index 2: German bottom trawl survey (GBTS) in SD 22, Nov. 1979-95, 0-3+ ringers
Index 3: German bottom trawl survey (GBTS) in SD 24, Nov. 1978-95, 0-3+ ringers
Index 4: Acoustic. survey in Div IIIa, July 1989-95, 2-8+ ringers
Index 5: Acoustic. survey in SD 22+24, Oct. 1989-95, 0-8+ ringers
Index 6: Larvae survey in SD 24 (Greifswalder Bodden), March-June 1977-1994
Additional indices:
Index 1a: IBTS in Division IIIa, all quarters, 1991-1995, 2 and 3+ ringers- ringers
Index 2a: German bottom trawl survey (GBTS) in SD 22+24, Nov. 1979-95, 0-3+ ringers

1997
Index 1: IBTS in Div. IIIa, Feb. 1980-1996, 2 and 3+ ringers
Index 2: German bottom trawl survey (GBTS) in SD 22, Nov. 1979-96, 0-3+ ringers
Index 3: German bottom trawl survey (GBTS) in SD 24, Nov. 1978-96, 0-3+ ringers
Index 4: Acoustic. survey in Div IIIa, July 1989-96, 0-8+ ringers
Index 5: Acoustic. survey in SD 22+24, Oct. 1989-96, 0-8+ ringers
Index 6: Larvae survey in SD 24 (Greifswalder Bodden), March-June 1977-95, 0-group
Index 7: German bottom trawl survey (GBTS) in SD 24, February 1979-96, 1-8+ ringers

1998
Index 1: IBTS in Div. IIIa, Feb. 1980-1996, 2 and 3+ ringers
Index 2: German bottom trawl survey (GBTS) in SD 22, Nov. 1979-97, 0-3+ ringers
Index 3: German bottom trawl survey (GBTS) in SD 24, Nov. 1978-97, 0-3+ ringers
Index 4: Acoustic. survey in Div IIIa, July 1989-97, 0-8+ ringers
Index 5: Acoustic. survey in SD 22+24, Oct. 1989-97, 0-8+ ringers
Index 6: Larvae survey in SD 24 (Greifswalder Bodden), March-June 1977-1997, biomass
Index 7: German bottom trawl survey (GBTS) in SD 24, February 1979-97, 1-8+ ringers
Index 8: IBTS in Div. IIIa, Sept. 1991-1995, 1-5 ringers

Table 4.2.1 **German Bottom Trawl Survey in January/February in Sub-Div. 24. Mean catch at age in numbers per haul.**

Year	Winter rings							
	1	2	3	4	5	6	7	8+
1991	1961.0	636.2	261.4	87.1	34.5	8.8	2.0	2.1
1992	2778.1	820.6	251.2	79.7	26.8	9.7	3.1	1.1
1993	959.9	371.2	94.8	61.3	44.4	13.9	5.6	1.0
1994	996.3	214.9	201.9	329.5	130.6	75.8	30.3	21.0
1995	1949.0	91.7	328.7	131.1	83.6	24.4	27.9	11.3
1996	1221.7	188.9	83.3	87.9	86.7	41.4	33.3	35.2
1997	1163.1	206.0	395.8	163.5	61.2	32.6	23.2	28.4

Table 4.2.2 **International Bottom Trawl Survey in Division IIIa in quarter 1. Mean catch of spring spawning herring at age in numbers per haul**

Year	Winter rings	
	2	3+
1991	480	3392
1992	771	1268
1993	203	264
1994	0	1148
1995	0	344
1996	1870	0
1997	n.a.	n.a.

Table 4.2.3 **International Bottom Trawl Survey in Division IIIa in quarter 3. Mean catch of spring spawning herring at age in numbers per haul**

Year	Winter rings				
	1	2	3	4	5
1991	214	214	234	80	88
1992	0	333	199	156	52
1993	0	333	44	44	61
1994	0	190	213	83	66
1995	1198	234	168	172	69
1996	n.a.	n.a.	n.a.	n.a.	n.a.
1997	n.a.	n.a.	n.a.	n.a.	n.a.

* not available

Table 4.2.4 German Bottom Trawl Survey in Sub-Div. 24.
Young Fish survey in November/December
Mean Herring catch at age in numbers per haul.

Year	Month	Winter rings 0	1	2	3+	Total numbers	Mean catch (kg)
1991	Nov.	117.38	134.20	103.14	144.63	499.35	27.16
1992	Nov.	233.85	88.05	57.15	113.58	492.63	19.86
1993	Nov.	1,744.19	37.10	63.87	544.65	2,389.81	66.46
1994	Nov.	1,020.49	13.21	73.47	583.23	1,690.40	79.34
1995	Nov.	635.09	33.22	47.97	324.98	1,041.27	47.53
1996	Nov.	514.52	36.12	49.04	349.44	949.12	25.82
1997	Nov.	627.20	66.33	93.57	126.50	913.60	18.30

Table 4.2.5 German Bottom Trawl Survey in Sub-Div. 22.
Young Fish survey in November/December
Mean Herring catch at age in numbers per haul.

Year	Month	Winter rings 0	1	2	3+	Total numbers	Mean catch (kg)
1991	*						
1992	Nov.	572.68	87.68	19.16	17.26	696.78	13.13
1993	Nov.	8,419.70	1,644.05	1,293.70	898.10	12,255.55	301.71
1994	Nov.	2,158.10	317.35	1,588.45	326.35	4,390.25	135.65
1995	Nov.	1,226.63	158.75	29.00	123.31	1,537.69	31.17
1996	Nov.	8.76	193.71	101.24	57.76	361.47	15.23
1997	Nov.	11,289.45	2,196.45	257.75	159.90	13,903.55	209.24

Table 4.2.6 German Bottom Trawl Survey in Sub-Div. 22 and 24.
Young Fish survey in November/December
Mean Herring catch at age in numbers per haul.

Sum weighted by area of Sub-division:	
Area of 24:	2325 sq.nm
Area of 22:	485 sq.nm
Total	**2810 sq.nm**

Year	Month	Winter rings 0	1	2	3+	Total numbers	Mean catch (kg)
1991	*						
1992	Nov.	292.3	88.0	50.6	97.0	527.9	18.7
1993	Nov.	2896.4	314.5	276.1	605.7	4092.6	107.1
1994	Nov.	1216.8	65.7	335.0	538.9	2156.4	89.1
1995	Nov.	737.2	54.9	44.7	290.2	1126.9	44.7
1996	Nov.	427.2	63.3	58.0	299.1	847.7	24.0
1997	Nov.	2467.5	434.0	121.9	132.3	3155.6	51.3

* no data

Table 4.2.7 Acoustic surveys on the Spring Spawning Herring in the North Sea / Div. IIIa in 1991-1997*. (July)

Year	1991	1992	1993	1994	1995	1996	1997
	Numbers in millions						
W-rings							
0		3,853	372	964			
1		277	103	5	2,199	1,091	128
2	1,864	2,092	2,768	413	1,887	1,005	715
3	1,927	1,799	1,274	935	1,022	247	787
4	866	1,593	598	501	1,270	141	166
5	350	556	434	239	255	119	67
6	88	197	154	186	174	37	69
7	72	122	63	62	39	20	80
8+	10	20	13	34	21	13	77
Total	5,177	10,509	5,779	3,339	6,867	2,673	2,088
3+ group	3,313	4,287	2,536	1,957	2,781	577	1,245
	Biomass ('000 tonnes)						
W-rings							
0	0.0	34.3	1	8.7			
1	0.0	26.8	7	0.4	77.4	52.9	4.7
2	177.1	169.0	139	33.2	108.9	87.0	52.2
3	219.7	206.3	112	114.7	102.6	27.6	81.0
4	116.0	204.7	69	76.7	145.5	17.9	21.5
5	51.1	83.3	65	41.8	33.9	17.8	9.8
6	19.0	36.6	26	38.1	27.4	5.8	9.8
7	13.0	24.4	16	13.1	6.7	3.3	14.9
8+	2.0	5.0	2	7.8	3.8	2.7	13.6
Total	597.9	790.4	438.0	334.5	506.2	215.1	207.5
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6
	Mean weight (g)						
W-rings							
0		8.9	4.0	9.0			
1		96.8	66.3	80.0	35.2	48.5	36.9
2	95	80.8	50.1	80.3	57.7	86.6	73.0
3	114	114.7	87.9	122.7	100.4	111.9	103.0
4	134	128.5	116.2	153.0	114.6	126.8	129.6
5	146	149.8	149.9	175.1	132.9	149.4	145.0
6	216	185.7	169.6	205.0	157.2	157.3	143.1
7	181	199.7	256.9	212.0	172.9	166.8	185.6
8+	200	252.0	164.2	230.3	183.1	212.9	178.0
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4

* The data from 1992-1996 were revised in 1997.

Table 4.2.8 **Acoustic survey on the Spring Spawning Herring in Sub-Div. 22-24 in 1991-1997 (September/October).**

Year	1991	1992	1993*	1994*	1995*	1996*	1997*
	Numbers in millions						
W-rings							
0	7,359	3,412	1,079	5,613	4,968	1,797	3,276
1	3,224	1,658	452	419	1,372	1,188	1,769
2	1,764	657	409	760	365	516	551
3	1,437	282	536	495	387	410	395
4	461	156	417	413	429	287	162
5	174	37	133	180	306	273	118
6	44	25	56	61	149	115	97
7	24	4	32	25	53	46	30
8+	21		14	3	36	16	40
Total	14,508	6,231	3,129	7,967	8,066	4,649	6,436
3+ group	2,161	504	1,189	1,176	1,360	1,147	841
	Biomass ('000 tonnes)						
W-rings							
0	**	53.2	15.8	62.3	52.6	14.6	34.8
1	**	61.3	16.1	14.6	46.9	35.8	47.2
2	**	39.6	18.2	35.1	24.5	29.7	32.8
3	**	20.6	33.5	37.2	35.4	32.2	36.9
4	**	14.4	26.5	40.2	51.5	22.5	22.4
5	**	4.6	14.1	22.9	37.2	34.7	16.4
6	**	3.3	8.0	12.9	18.6	16.4	14.0
7	**	0.7	3.2	5.7	11.5	6.7	4.9
8+	**		2.4	0.7	8.5	2.5	8.8
Total	**	197.7	137.9	231.7	286.7	195.1	218.3
3+ group	**	43.6	87.8	119.7	162.7	115.1	103.5
	Mean weight (g)						
W-rings							
0	**	15.6	14.7	11.1	10.6	8.1	10.6
1	**	37.0	35.7	34.8	34.2	30.1	26.7
2	**	60.2	44.5	46.2	67.2	57.5	59.7
3	**	73.0	62.6	75.3	91.4	78.7	93.5
4	**	92.1	63.4	97.3	120.1	78.5	138.7
5	**	125.6	106.2	127.8	121.4	127.1	139.6
6	**	132.0	142.6	209.8	125.0	142.3	144.6
7	**	168.1	101.1	230.9	217.2	145.4	165.6
8+	**		164.1	269.4	234.4	158.5	219.7
Total	**	31.7	44.1	29.1	35.5	42.0	33.9

* revised in 1999 according to the "Hydroacoustic" manual (ICES CM 1998/H:4)

** no data available

Table 4.2.9 Environmental Impact Monitoring: Biomass and abundance estimates of herring in the Sound (SD 23) during the period Sept. 1993 to May 1998 (Nielsen *et al.* 1998).

Year*	Month	Biomass (t)	Abundance (N in millions)
1993	Sept.	118 832	1151.44
	Oct.	87 794	792.08
	Dec.	65 462	680.47
1994	Jan.	77 421	674.29
	Febr.	91 061	835.97
	Mar.	15 933	132.02
	Apr.	5 609	51.30
	Oct.	83 609	513.32
	Nov.	50 049	320.07
	Dec.	50 795	314.88
1995	Jan.	31 395	205.17
	Febr.	8 270	61.42
	Mar.	17 703	127.22
	Apr.	11 511	86.91
	May	10 759	82.67
	Jul.	1 548	24.80
	Aug.	65 075	370.40
	Oct.	45,690	284.93
1996	Mar.	34 989	207.56
	Apr.	19 069	113.07
	Oct.	90 595	839.50
	Nov.	88 404	857.73
1997	Mar.	58 406	553.13
	Apr.	56 554	537.45
	Nov.	163 184	1125.67
1998	Mar.	62 144	608.93
	May	7 089	116.48

* 1993-1997 revised in 1998

Table 4.2.10 **Estimation of the herring O-Group (TL⑨30 mm)**
Greifswalder Bodden and adjacent waters (March/April to June)

Year	Number in Millions
1977	2000[1]
1978	100[1]
1979	2200[1]
1980	360[1]
1981	200[1]
1982	180[1]
1983	1760[1]
1984	290[1]
1985	1670[1]
1986	1500[1]
1987	1370[1]
1988	1223[2]
1989	63[2]
1990	57[2]
1991	236[3]
1992	18[3]
1993	199[3]
1994	788[2]
1995	171[2]
1996	31[2]
1997	61[2]

[1] Brielmann 1989
[2] not yet published
[3] Mueller & Klenz 1994

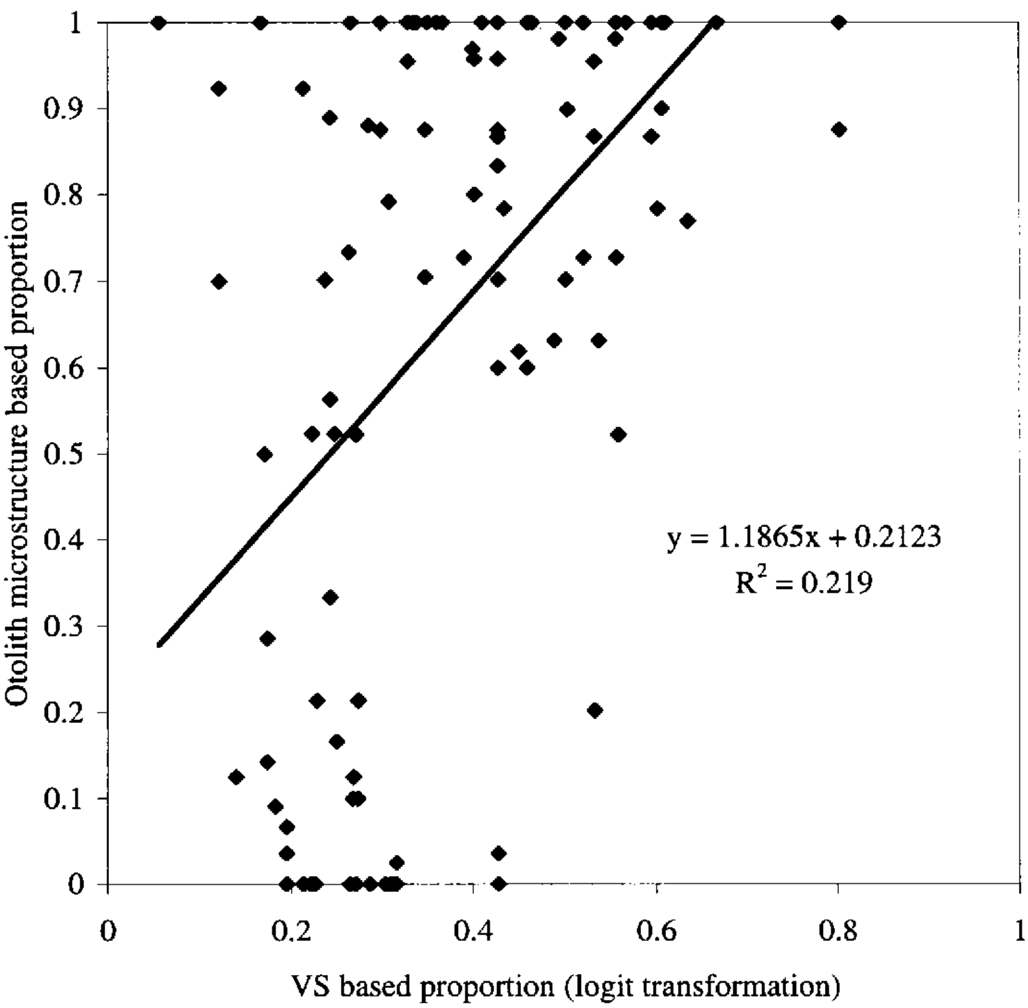
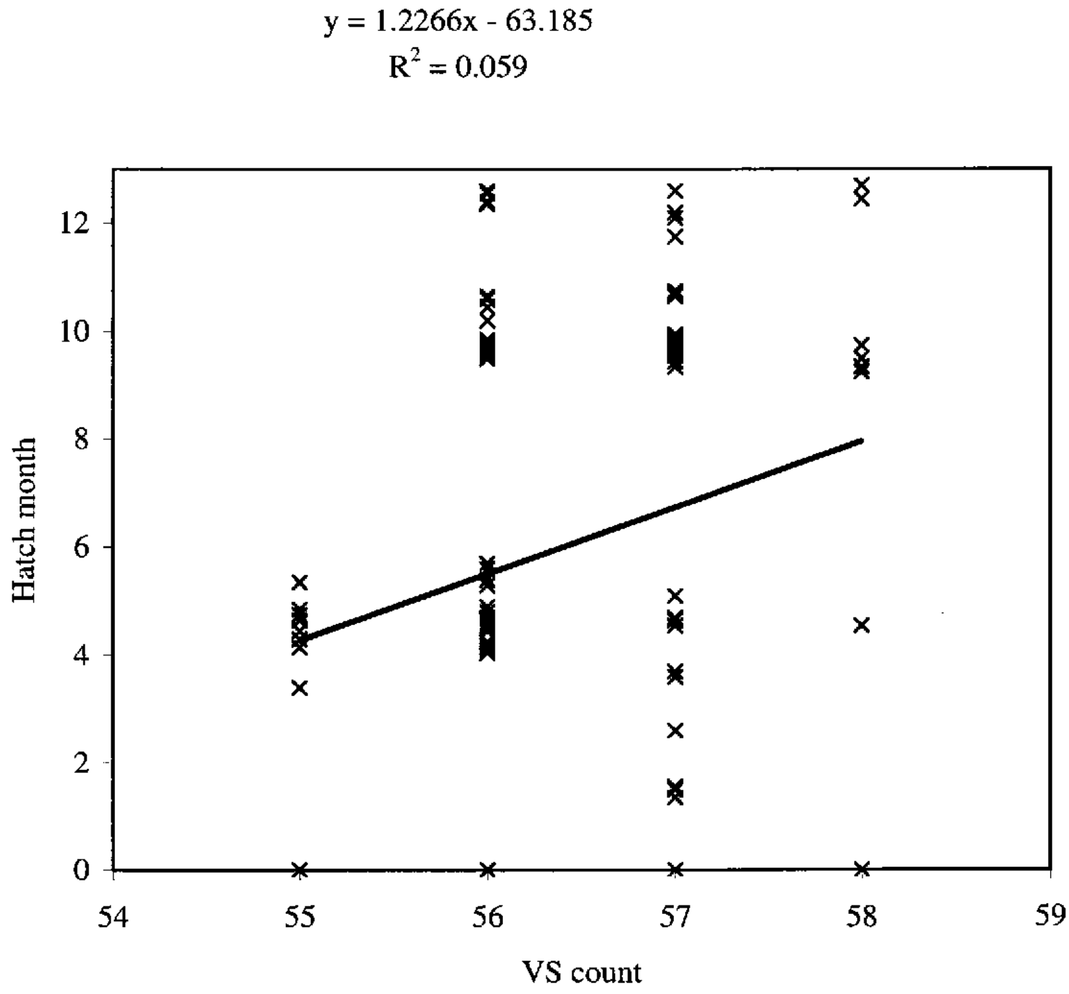


Figure 2.5 Comparison by square stratified by year, quarter, Sub-division, and age class of otolith based spring spawning proportions from Danish samples with VS based proportions of Swedish samples.
All overlapping data from 1996 and 1997 are compared.



Individuals with estimated hatch months in December (12), January (1) and February (2) were considered winter spawned. Individuals with estimated hatch months in March (3), April (4) and May (5) were considered spring spawned and individuals from September to November (9-11) were assigned to the autumn spawners.

Figure 2.6.1 Otolith microstructure estimated hatch month versus vertebrae counts (VS) from the same individual herring taken from Swedish IBTS samples in the 1st and 3rd quarters in 1996 and in 1997 in Division IIIa.

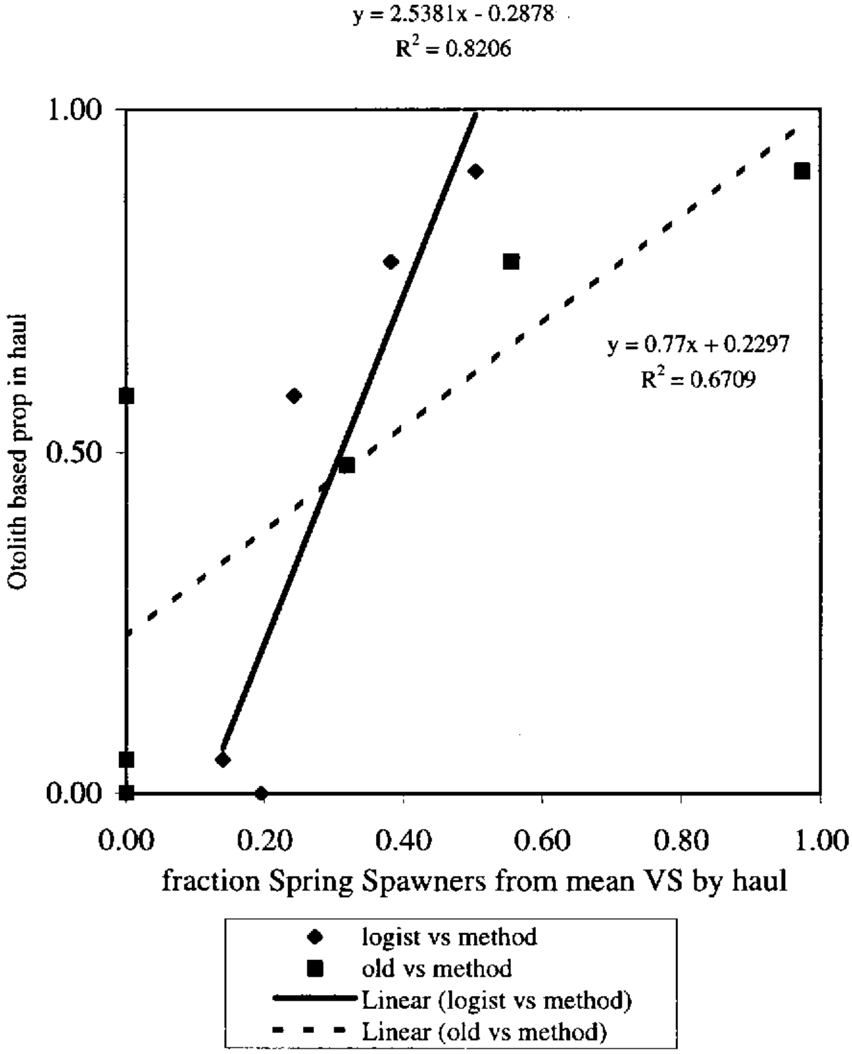


Figure 2.6.2 Proportions based on estimated sample mean values from the same individuals using VS based and otolith based methods.

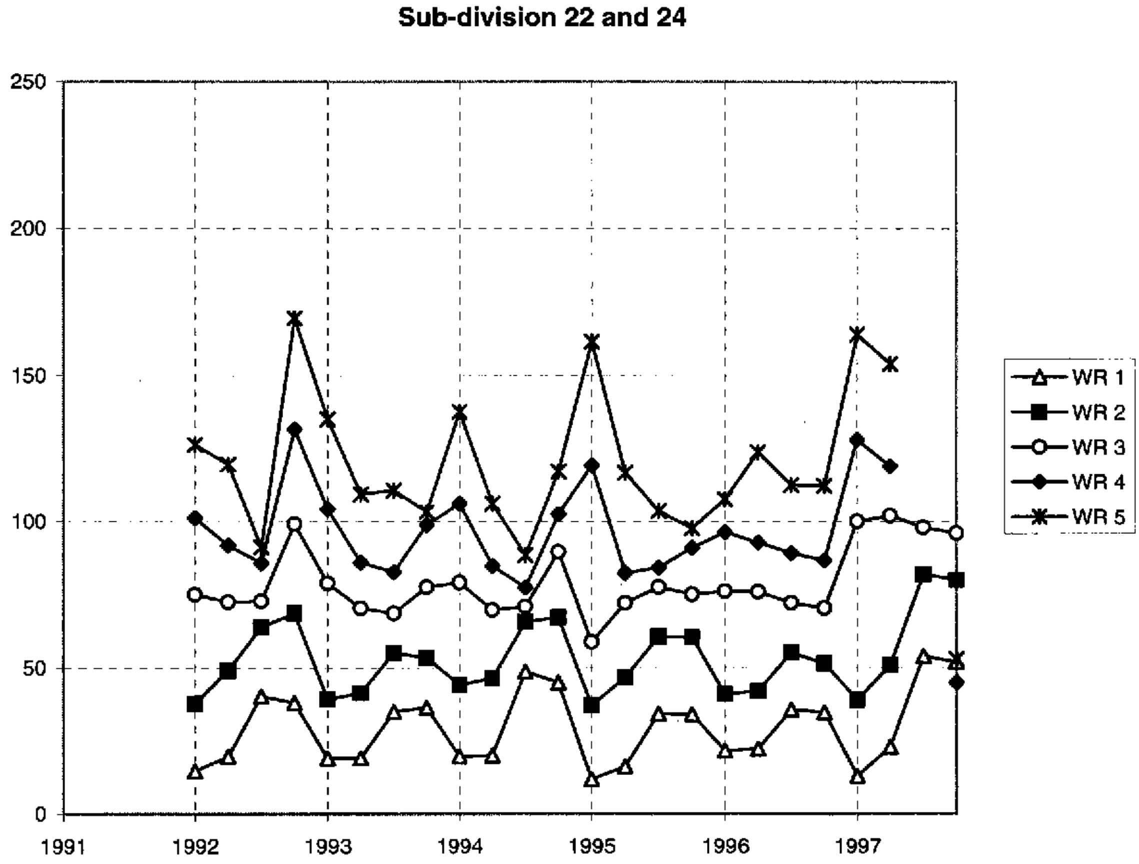


Figure 3.2 **Mean weights at age (g) in the catches of Baltic spring spawning herring by quarter 1991-1997 (from ICES CM 1998/ACFM:14).**