Improved advice for the mixed herring stocks in the Skagerrak and Kattegat

EU Rolling Programme; FISH/2004/03

Worsøe Clausen, Lotte; Ulrich, Clara; van Deurs, Mikael; Skagen, D.

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IMPROVED ADVICE FOR THE MIXED HERRING STOCKS IN THE SKAGERRAK AND KATTEGAT

EU ROLLING PROGRAMME; FISH/2004/03

Final report

Reporting period: January 1st 2005 – January 1st 2007

By
Clausen[1], L.A.W, C. Ulrich-Rescan[1], M. van Deurs[1], and D. Skagen[2]

[1]Danish Institute for Fisheries Research, Ministry of Agriculture and Fisheries, Copenhagen, Denmark

[2]Institute for Marine Research, Bergen, Norway

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1. Preface

The ICES working group on Herring Assessment for the Area South of 62ºN (HAWG) has faced problems when providing an advice applicable for the stock components in area IIIa as the fishery for herring in Division IIIa exploits a mixture of stocks. In previous years, the TAC for the fleets fishing herring in Division IIIa have been decided by managers according to recommendations for the North Sea Autumn Spawners (NSAS), raised according to the historical fraction of NSAS in the catches by these fleets. The recommendation for the NSAS was guided by the need to rebuild that stock. However, the dynamics of the stocks and the variation in size and mixing makes a revisiting of the existing method for advice in the IIIa area appropriate. The present project seeks to improve the assessment and advice of the mixed stock in IIIa by elaborating fleet- and stock-based disaggregation on the existing projection method. The advice would so take into account both stocks and all fleet components in IIIa.

The present report provides an overview of the problems that the project identified in its application to the EU and document the work done within each of the 3 tasks. Since the tasks aim at the overall goal of improving the assessment and advice of the mixed stock in IIIa and the work schedule was structured to provide answers to each of the deliverables described within each task, the report focuses on describing all processes within each task. This has resulted in an extensive narrative report providing the development of all work processes in a chronological form. The deliverables are listed in headers as they have been finished and in addition are given the technical detailed documentation from relevant deliverables as annexes to this report (as working documents presented to HAWG). Below is a table displaying the meeting calendar and deliverable plan for the project.

Meeting	Dates	Participants	Deliverables
Constitutional meeting	October 17th 2005	Lotte Worsøe Clausen Mikael van Deurs Henrik Mosegaard Jørgen Dalskov Clara Ulrich-Rescan	
1st Progress meeting	December 8th 2005	Lotte Worsøe Clausen Mikael van Deurs Henrik Mosegaard Jørgen Dalskov Clara Ulrich-Rescan Dankert Skagen Bjørn Vidar	Del. 1.1 – part I Del. 2.4 – part I Del. 3.2 – part I
HAWG 2006	March 14th to 23rd 2006	Lotte Worsøe Clausen Mikael van Deurs Henrik Mosegaard Jørgen Dalskov Clara Ulrich-Rescan Dankert Skagen	Del. 1.2 - final
2nd Progress meeting	December 13th 2006	Lotte Worsøe Clausen Mikael van Deurs Clara Ulrich-Rescan Dankert Skagen	Del. 1.1 – final Del. 2.1, 2.2, (2.3), 2.4 – final Del. 3.1, 3.2 (3.3) – final

2. Objectives

An ecosystem approach to fisheries management should consider conservation of intra-specific variation due to population structure and life history variation. Knowledge of stock integrity is of unequivocal importance for sustainable fisheries management, since variable compositions in mixed areas together with asynchronous population dynamics may lead to over-fishing of individual stocks if not all components are managed to ensure (or achieve) sustainable exploitation. Atlantic herring display large variations in migration and homing behaviour (McQuinn, 1997a;b; Slotte, 1998; Husebø et al., 2005), and genetic studies have identified population structure across both small and large geographic scales (e.g., Bekkevold et al., 2005; Mariani et al. 2005). To ensure conservation of herring population diversity of the herring population in IIIa considering their natural migration patterns the major stock components must be addressed in the advice on the fishery. The primary goal of the project is to improve the assessment and advice of the mixed stock in IIIa by elaborating fleet- and stock-based disaggregation on the existing projection method taking the two major stock components and all fleet components in IIIa into consideration.

The fishery for herring in Division IIIa exploits both the North Sea Autumn Spawning (NSAS) and the Western Baltic Spring Spawning (WBSS) stocks. The HAWG used a simple procedure in 2004 to find the highest total catch by fleet in Division IIIa that would be compatible with a precautionary exploitation of WBSS. This procedure used two kinds of information about the fishery, the fraction of WBSS that is caught in IIIa, and the fraction of the catches by the IIIa fleets that consist of WBSS based on recent historic data. This very crude procedure can be refined with more detailed information on how the stocks on one hand and the fisheries on the other hand are distributed geographically and seasonally. Furthermore, the differences in both distribution and fishing pattern both in terms of season and stock components suggest a scope for a fishery management that is more fishery and stock oriented, allowing for more directed stock-wise exploitation.

Temporal and spatial distribution of the different stock components and fleet exploitation patterns form the basis for the elaboration of the existing projection method in the present project. Extensive data explorations are a prerequisite for this and the project was thus developed along three lines:

- Mapping of stock components: The migration patterns of the different stock components will be evaluated using existing data in the institute databases and other published material. Based on historical material the spatial and temporal distribution of the NSAS and WBSS in IIIa will be mapped. The current assumption of equal distribution of all stock components in the area with no differentiation regarding geographical and seasonal information will be revised.
- Exploitation by fleets: The exploitation pattern and fleet behaviour will be described the fishery pattern on all stock components. This will allow investigating and simulating how changes in fleet effort would affect the various herring stocks. This in turn will be employed in the model developed in Task 3.
- Improvement of assessment and advice procedures: The assumptions in the current approach for advice will be replaced by more consolidated fractions of the stock components based on the results from Task 1. The calculations will then be combined with multi-fleet short term prediction programs for each stock (Task 2), to outline combinations of total quotas by fleet that are compatible with proposed harvest rules and/or precautionary criteria.

3. Activities

Based on the objectives above the present project will include the following programmes and activities by work package:

Task 1. Mapping of the stock components.
Work package 1. Data mapping. The collated information on stock components from the updated institute databases including Norwegian survey data from IIIa will be assigned to ICES squares and for each stock component a map of quarterly distributions of age and length be produced and the degree of mixing in each square will be quantified.

Work package 2. Splitting of recent catches. Based on the sampling and routine laboratory work the catches from 2004 and 2005 will be separated into the stock components and raised to total catch in the area. Norwegian historic catch data previously used for separating catches by stock will be revised. The data and the split of catches will be implemented and revised during the ICES working group on Herring Assessment for the Area South of 62ºN.

Task 2. Exploitation by fleets.
This task will be mainly conducted on Danish data, given the pre-eminence of Danish catches and the greater diversity in terms of Danish fleets and fisheries exploiting herring in IIIa.

Work package 3. Effort and catches by fishery. All herring catches in division IIIa in the Danish log-books database will be allocated to one of the stocks, on the basis of the results from WP 1. Landings and effort by fishery for the various stock components will be estimated to clarify whether one stock is targeted by a certain fishery and other possible patterns.

Work package 4. Description of fleets activity and behaviour. The analysis by fishery will be further developed into an analysis by fleet. The activity of the various herring fleet components will be described through their participation in the different fisheries, which in turn will describe the allocation of fleet(s) effort on the various stock component using the model from WP 3. This will come to a general description of the activity and behaviours of herring fleets in division IIIa.

Task 3. Improvement of assessment and advice procedures.
Creation of a multi-fleet, multi-stock stochastic prediction program, where a common TAC for Division IIIa is translated into catches and partial fishing mortalities by stock, either as deterministic values or as probability distributions.

Work package 5. Set up of simulation parameters for prognoses. The results of WP3 and WP4 will be summarised as sets of input parameters (e.g. effort by fleet and fishery) to be included in WP 6 and WP 7.

Work package 6. Designing and producing software. One alternative may be to extend the existing multi-fleet prediction program developed for NSAS, but if it turns out to be more practical a new programme will be made.

Work package 7. Testing the improvement in management advice by this increase in complexity. Tests of performance of the new prediction procedure will be made using historical data, comparing predicted with real outcome for the new development and the current and similar simplistic procedures.

4. Narrative

4.1 Constitutional meeting

After confirmation of the project funding, the group met **October 17th 2005** at the Danish Institute for Fisheries Research, Charlottenlund Castle in order to set up an activity plan for the entire programme years 2005-2006. Agreements were made on effort allocation within the group with respect to the responsibilities on the work packages. Further status for each WP was summarised with respect to available data, tasks to be conducted and coordination of work with the external partner not present at the meeting (Norway).

4.2 1st work progress meeting

At **December 8th 2005** the group met at the Danish Institute for Fisheries Research, Charlottenlund Castle for an evaluation of the work progress and main points were as follows:

4.2.2 Task 1 – deliverable 1.1, part I

The purpose of task 1 is to split the herring in IIIa into two stock components (North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS)) and identify differences in their spatial and temporal distribution. Herring larvae otolith microstructure has been demonstrated to identify larvae from NSAS and NSS stocks (Moksness and Fossum, 1991) and differences in the larval otolith microstructure have been identified in adult herring (Zhang and Moksness, 1993) and successfully used to separate adult herring from NSAS, Downs and WBSS spawning stocks at the individual level (Mosegaard and Madsen, 1996; Clausen et al., 2007). For Division IIIa the ICES working group on Herring Assessment for the Area South of 62ºN (HAWG) has applied splitting keys to the catches of herring in the area to separate North Sea autumn spawners (NSAS) and Downs herring from Western Baltic spring spawners (WBSS). Prior to 1996, the splitting key used in the HAWG was calculated from a sample-based mean vertebral count. In the period from 1996 to 2001 splitting keys were constructed using information from a combination of vertebral count and otolith microstructure methods (ICES, 2001). From 2001 and onwards, the splitting keys have been constructed solely using the otolith microstructure method (ICES, 2004).

4.2.2.1 Material and method description

A combination of samples from collected from the Danish fishery, sampled by DIFRES, and the Norwegian fishery sampled by IMR, were used to achieve information on the length distribution for each combination of Y, Q, SR and metier. These samples are assumed to random both with respect to the catch they represent and the total landings, and will henceforth be referred to as spot samples. The spot samples are sub-samples of a random subset of the landings. The length-distribution in the sub-sample was assumed to be representative of the length distribution in the landings. The sub-samples were weighted according to the size of the landing. Annex 1 summarizes how well the spot samples cover the actual landings. Data from a total of 60410 herring collected from IIIa (plus a section of the North Sea and the western Baltic Sea, Figure 4.4.2.1) in the period 1992 - 2004, are included in the work. Out of this 51611 herring were collected by the Danish Institute for Fisheries Research (DIFRES), and consists of both scientific samples and samples taken from the fishery. The remaining 8799 herring are collected by the Norwegian Institute for Marine Research (IMR) from the fishery. Overview of the data is presented in figure 4.2.2.1 and figure 4.2.2.2.

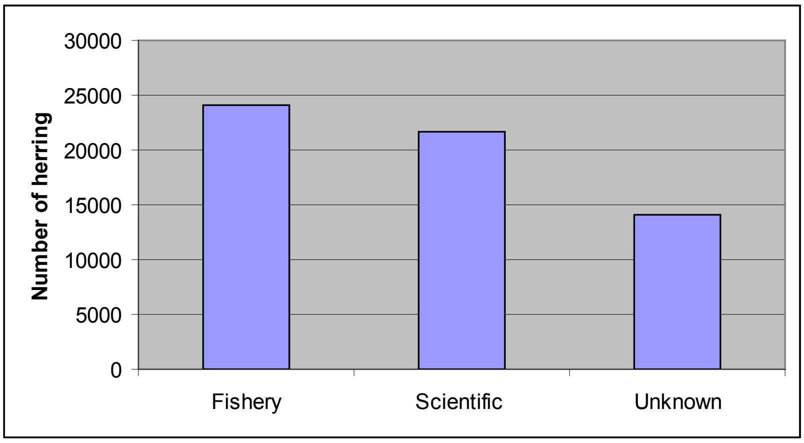


Figure 4.2.2.1: The sources of herring-data. Data collected from the fishery are sub-samples of catches either taken directly on board or from the fish auctions. Scientific data refers to samples from the acoustic surveys, International Bottom Trawl Survey (IBTS), or specific research projects. Unknown data-source mainly refers to data collected in the period before 1996, where no information on data-source was available from the DIFRES-database (The information exists in archives and can be recovered if needed).

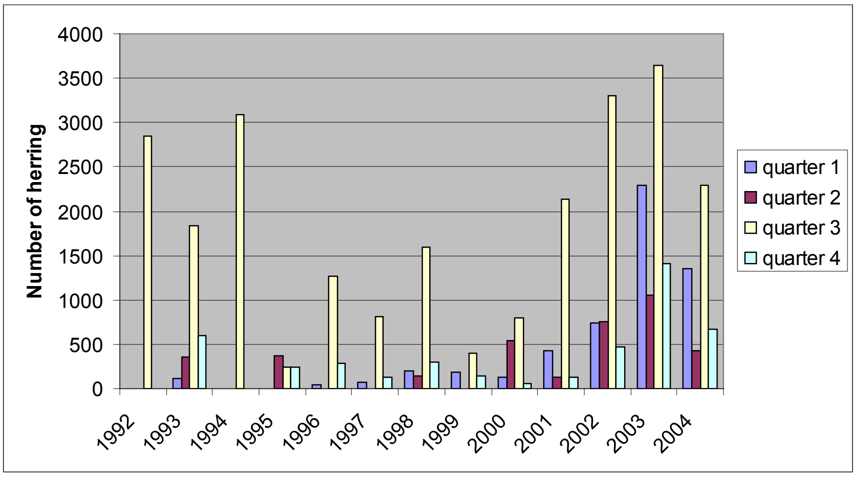


Figure 4.2.2.2: Number of herring included in the analysis distributed by year and quarter. This figure only includes data from DIFRES and it does not include samples from the western Baltic Sea.

In addition individual herring data from commercial sampling and containing information on either vertebrae count (VC) or spawning type were compiled from both DIFRES and IMR databases. Spawning type was achieved from visual analysis of otolith microstructure according to Mosegaard and Madsen, 1996 and Clausen et al., 2007. FSP was calculated for each combination of Y, Q, SR, and L, either directly from the proportion of WBSS based on otolith readings or from the equation formulated by Mosegaard and Madsen (1996):

FSP = (56.50-observed mean vc)/(56.50-55.80)

where 56.5 is the mean VC of North Sea Autumn Spawners, and 55.8 is the mean VC of Western Baltic Springspawners (WBSS). If FSP was > 1 it was given the value 1 and if < 0 it given the value 0. Norwegian samples and Danish samples up to 1999 mainly included VC only, whereas Danish data after 1999 mainly used OM readings. In cases where information on both VC and OM were available, OM were preferred, since OM are likely to be less sensitive to small sample sizes and the natural variability in the morphology of individual herring. The ability of OM to distinguish between WBSS and NSAS on an individual basis is

basically un-biased (Mosegaard and Madsen, 1996; Clausen et al., 2007). FSP-values based on less than 10 observations were excluded in the subsequent analysis.
FAUS was simply calculated as (1-FSP). This means that no attempt was made to distinguish between NSAS and winter spawners. Table 4.2.2.1 summarizes the number of fish used in the estimations of FSP, distributed on Y, Q, and SR.

number of observations distributed on year, quarter and sub region

		Sub region					
Year	Quarter	0	1	2	3	4	5
1992	2						
1992	3		343	137	501	1426	439
1993	1						107
1993	2						234
1993	3		313	233	145	607	527
1993	4			125	109	365	
1994	1						47
1994	2						257
1994	3		369	148	1187	573	805
1994	4						99
1995	1						
1995	2			116		119	619
1995	3					118	570
1995	4	229	122		115		415
1996	1	386	49				
1996	2	51					100
1996	3				102		364
1996	4	289	28			25	
1997	1	257	29				30
1997	2	139					785
1997	3		26		31	30	147
1997	4	323	31				99
1998	1	38	97				99
1998	2	110	49				719
1998	3	47	99		52	50	
1998	4	126	199			52	45
1999	1	62	27	79			
1999	2	46					683
1999	3		151	47	99	99	
1999	4	48	95		48		
2000	1	50	43		37		
2000	2		112				973
2000	3		100		115	56	389
2000	4	50	50				
2001	1		107	97	76		75
2001	2	24		54	72		441
2001	3		349	198	246	68	138
2001	4		41		58	36	
2002	1		281	95	192		49
2002	2		50	100		96	811
2002	3		643	93	97	194	195
2002	4	28	89	95	90	92	123
2003	1		1100	244	752		191
2003	2		359			282	417
2003	3		427		195	300	26
2003	4	88	632	300	173	98	24
2004	1		382	133	486	241	
2004	2		179	9	9	46	470
2004	3	48			274	411	31
2004	4		300	72	186	95	21

Table 4.2.2.1. Number of observations (1 observation=1 herring) used in the estimations of Fraction of Spring Spawners, distributed by year, quarter, and sub region. Each number of observations presented in the table are sampled from one or more stations within the sub region.

4.2.2.2 Data treatment

In the context of this study, all autumn- and winter-spawners were regarded as North Sea Autumn Spawners (NSAS) and all spring spawners as Western Baltic Spring Spawners (WBSS). The landings (in kg) of herring by metier, spawning type, year (Y), quarter (Q), length-group (L) and sub region (SR), were estimated for the period running from 1992 to 2004. The length groups L1 to L3 were defined as: L1 = 3 -11 cm, L2 = 12-19 cm and L3 = 20+ cm. The intention for these criterions was to divide the herring into juveniles (L1), a middle group (L2) and the spawning part of the population (L3). Only 3 groups were chosen to create groups with individuals enough for any analysis. The area studied was initially divided into 6 sub regions, because the sampling coverage was not sufficient to work at the level ICES rectangle (Figure 4.4.2.1), however later in the analysis, two of these sub regions were combined to get a better coverage of the data (Figure 4.4.2.2).

The landings of herring by metier, Y, Q, L, and SR were estimated by merging three separate data-files (data-file 1 through data-file 3), each containing a set of aggregated data. Data-file 1 contained information on the fraction of spring spawners (FSP) and autumn spawners (FAUS) respectively, data-file 2 contained information on the length-distribution, and data-file 3 contained information on total herring landings.

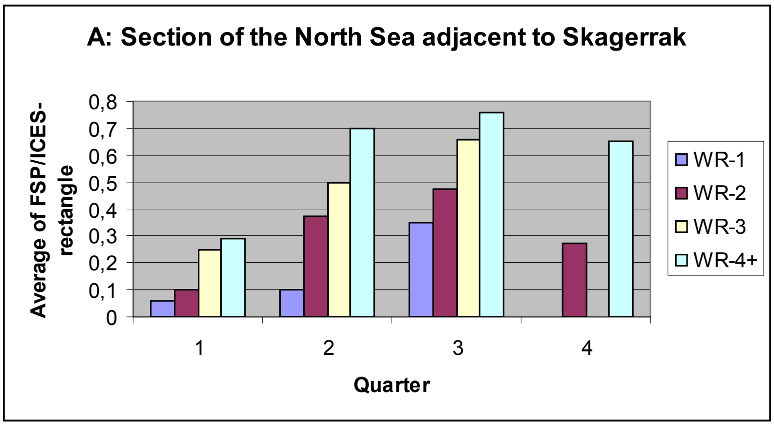
No raising procedures were used in the merging of the datafiles. This means that no decision was made to fill the gaps of missing sampling coverage using samples from other areas or other quarter.
Creation of the data-base, data quality insurance, data aggregations was conducted in the programming environment R (www.R-project.org). Individual programs were designed to carry out the desired data aggregations and quality insurance, allowing for quick subsequent adjustments and corrections.

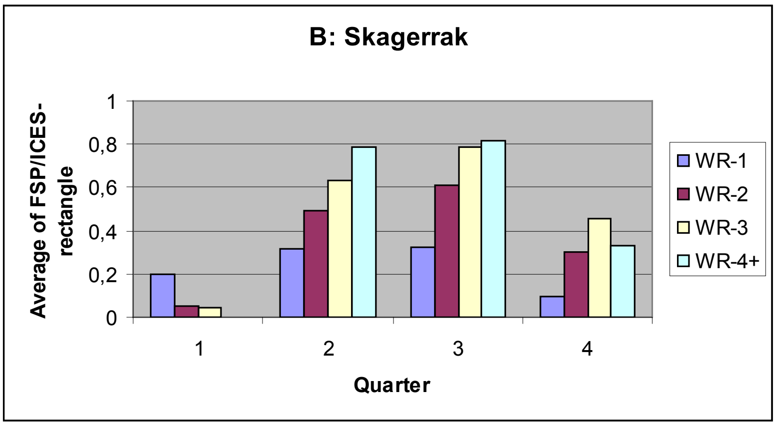
The Geographical Information System (GIS) was applied to visualize the estimated fractions of WBSS in various ways and an example of such GIS-maps is presented in figure 4.2.2.4.

4.2.2.3 Preliminary results and identifications of pit-falls

The data analysis revealed several general patterns and potential pit-falls and sources of bias:

- Seasonally and age related variation in FSP was evident (figure 4.2.2.3 A-B). In general FSP increased with age and from quarter 1 to 3 and decreased again in quarter 4. However, some variation existed between the three main regions (Kattegat, Skagerrak and section of the North Sea adjacent to Skagerrak).
- A pattern of spatial variation, in FSP on ICES-rectangle level, was present. General trends in the variation are presented in figure 4.2.2.4. Nonsystematic variation existed inter-annually, possibly due to variation in the demography of the two stock components and the hydrology.
- The presence of local Norwegian spring spawners along the Norwegian coast may bias the VC-based estimations of FSP. This is due to a mean VC of the local Norwegian spring spawners above the NSAS VC mean.
- The estimated FSP showed some dependence of the source of data and thus consideration will be made to allocate different weight to scientific- and fishery-data respectively.





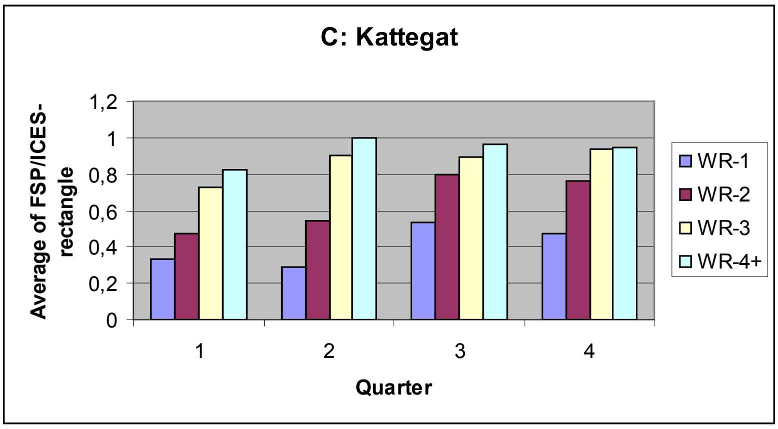
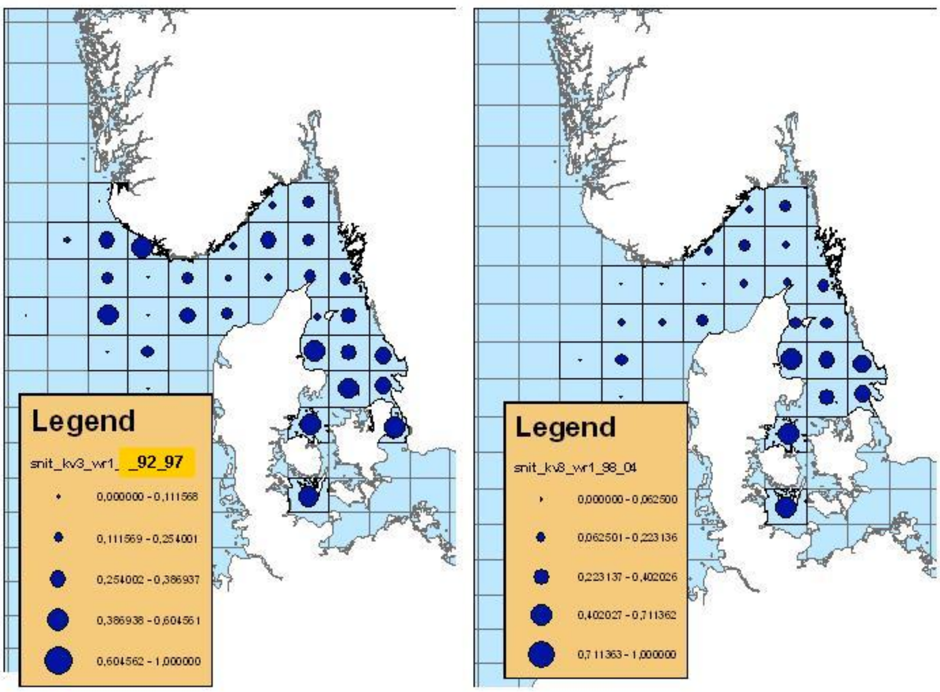


Figure 4.2.2.3 A-B: Averages of estimated FSP per ICES-rectangle for a section of the North adjacent to Skagerrak (A), Skagerrak (B), and Kattegat (C) respectively, and distributed on quarter and age-group.



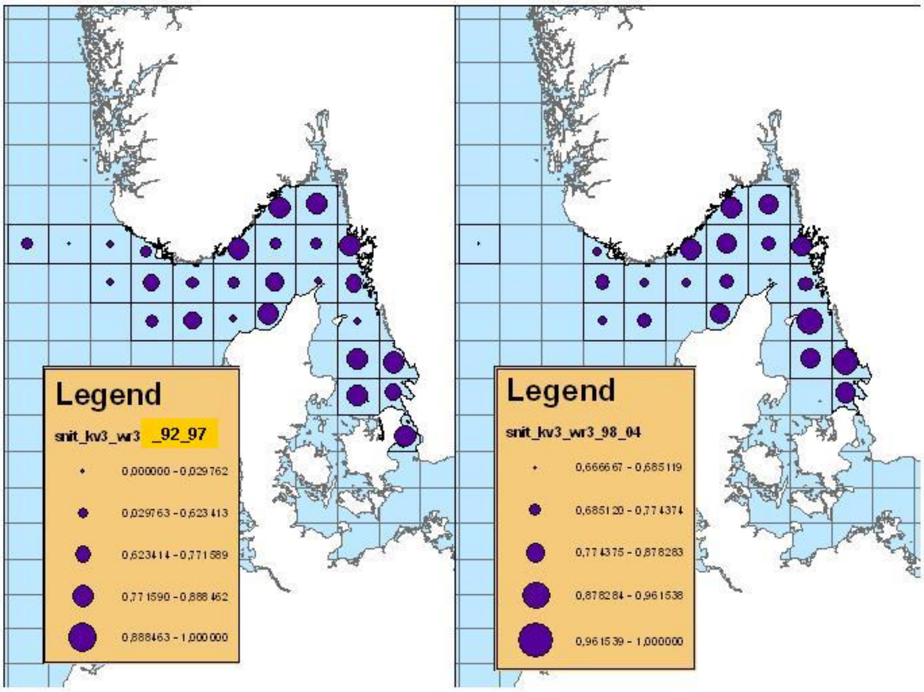


Figure 4.2.2.4: The spatial variation of FSP. The figure in the upper left corner show the 1992 – 1997 average of estimated FSPs for 1-ringers in quarter 3. The figure in the upper right corner show the 1998 – 2004 average of estimated FSPs for 1-ringers in quarter 3. The figure in the lower left corner show the 1992 – 1997 average of estimated FSPs for 3-ringers in quarter 3. The figure in the lower right corner show the 1998 – 2004 average of estimated FSPs for 3-ringers in quarter 3.

4.2.3 Task 2 – deliverable 2.4, part I

The analysis is based on the results from a previous study, aiming at identifying and describing Danish fisheries, fleets and fishing strategies based on usual catch and effort data (Ulrich and Andersen, 2004). Different concepts are used, as it is known that individual vessels can change activities (gear and mesh size, fishing area etc) throughout the year. Definitions are those used in ICES (2006).

The term fishery refers to the description of a fishing trip. The aim of this is to reduce the description of a variety of fishing trips to a single categorical variable that summarizes its main characteristics (e.g. gear and mesh size used, fishing ground, target species).. We use the terminology –ing to refer to a fishery (e.g. Kattegat herring midwater trawling).
The term fleet refers to the description of a physical fishing unit, i.e. a vessel. This term allows also to group individual vessels based on their physical characteristics, such as vessel size, official registered rigging, homeport etc.
A fishery describes thus an activity type regardless of the vessel type, whereas a fleet describes a vessel type regardless of its activity. Within a fleet, the various fisheries a vessel can engage in are referred to as a metier.
Finally, the term strategy refers to what was called vessel groups by Ulrich and Andersen (2004). It describes the main type of metiers fleets are engaging in. As for the fishery, it reduces the description of individual activity patterns to a categorical variable summarizing the main fisheries a vessel engaged in during a calendar year. We use the terminology –ers to refer to strategies and fleets. (e.g. Kattegat trawlers).

4.2.3.1 Fisheries analysis

The method used to identify fisheries was performed in 3 steps, individually for each Danish area and gear type, and based on 1999 log-books and sale slips data, (1) A multivariate analysis of landings value by trip (principal component analysis - PCA - and hierarchical ascending classification – HAC) allowed to categorise landings in main patterns, often referring to a main target species. These patterns are called landings profiles. (2) Another trial and error multivariate analysis (multiple component analysis – MCA – and HAC) linked these landings profiles to various effort descriptors. In the final analysis, only the mesh size was retained. (3) These results obtained from statistical analyses were compared and sometimes adjusted to existing empirical knowledge and expert opinion, in order to come up with a meaningful typology.

Some North Sea and Skagerrak fisheries had to be pooled together, because both areas were often visited during one single trip. A total of 54 fisheries were identified, covering the whole activity of all Danish vessels. Among these, three fisheries refer explicitly to the herring fishery in IIIa:

- The Kattegat Herring midwater trawling (283 trips in 1999), where herring represented in average 97% of the value
- The North Sea and Skagerrak Herring midwater trawling (668 trips in 1999), where herring represented in average 69% of the value
- The North Sea and Skagerrak Herring purse seining (105 trips in 1999), where herring represented 100% of the value

The distribution of Danish herring catches in 2003 in the different areas and fisheries is illustrated in figure 4.2.3.1.:

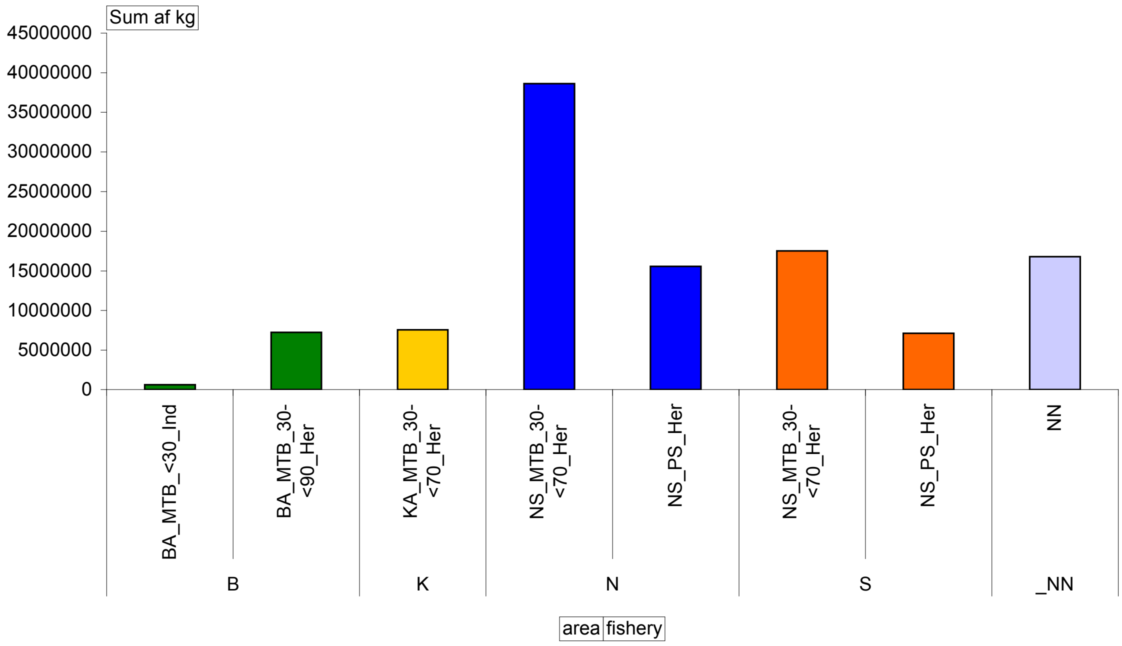


Figure 4.2.3.1: herring catches by area and fishery in 2003.

It is to be noted that the usual catch and effort database used to perform the analysis of fisheries from Ulrich and Andersen (2004) does not include the specific samplings from industrial fleets, which allow estimating the amount of herring by-catches in the industrial fisheries. For this reason, these fisheries do not appear on the previous graph, but these data will have to be included in the future analyses.

The distribution of all commercial catches in IIIa was mapped for all years and months since 1999, see example for 2003 on figure 4.2.3.2. The plots show a strong seasonal pattern, with very little fishery between

April and July, and two distinct major fishing grounds: one in the centre Skagerrak, and one in the Kattegat along the Swedish coast.

4.2.3.2 Fleet analysis

The individual patterns of fishing vessels can be tracked throughout the database with a unique personal coding number attached to every single vessel. Further information such as homeport and vessel size is also available, and can be used into a description of herring fleets characteristics. A number of fleets were previously defined, gathering the fishing vessels into a finite number of groups, which could further be further aggregated or disaggregated for modelling needs. The criteria used are

- The official registered vessel type (e.g. trawler, gillnetter, purse-seiner etc)
- The vessel length class (classes are based on the official length categories used by the Ministry and the Food and Resource Economic Institute FØI)
- The homeport, aggregated at the level of larger terrestrial area (e.g. Sjælland+Fyn, Vest Jylland, North Jylland etc) and immediate official fishing waters (e.g. North Sea, Kattegat, Skagerrak etc).

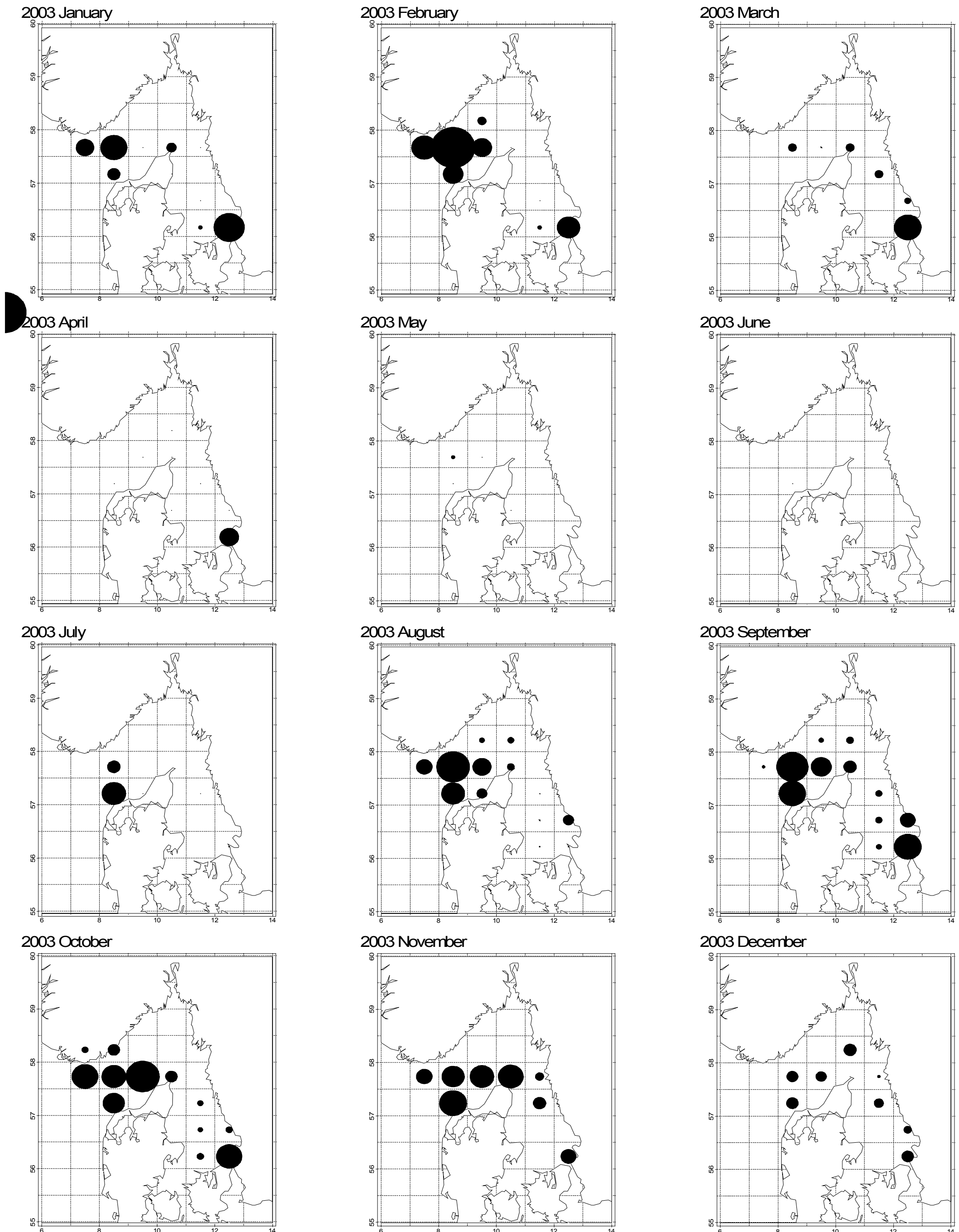


Figure 4.2.3.2: distribution of Danish herring catches by month in 2003.

The distribution of herring catches in 2003 by fleet and area is shown on table 4.2.3.1. Most ´catches in Kattegat are taken by the medium (24-40m) midwater trawlers from Sjælland (e.g Gilleleje harbour), while in the North Sea and Skagerrak they are taken by three major fleets : the large (>40m) purse seiners from Northern Jylland, the medium midwater trawlers from Northern Jylland, and the large midwater trawlers from Western Jylland. It is worth noticing that the fleets are clearly separated between the two geographical components of the catches: the fishermen from Kattegat do not fish in the Skagerrak, and the fishermen from Northern and Western Jylland do not fish in the Kattegat.

Sum af KG_her

AREA	FLEET	Total catch (kg)
Kattegat	OTB_15-<18_KA_SJæ	22.47%
	OTB_18-<24_KA_SJæ	11.34%
	OTB_24-<40_KA_SJæ	62.89%
	ROW_00-<12_KA_EJy	2.86%
Skagerrak	OTB_24-<40_NS_VJy	4.08%
	OTB_24-<40_SK_NJy	24.90%
	OTB_40- _NS_VJy	31.35%
	OTB_40- _SK_NJy	8.26%
	PSB_40- _SK_NJy	31.01%
North Sea	OTB_24-<40_NS_VJy	4.92%
	OTB_24-<40_SK_NJy	18.56%
	OTB_40- _NS_VJy	36.86%
	OTB_40- _SK_NJy	8.63%
	PSB_40- _SK_NJy	30.98%

Table 4.2.3.1: distribution of herring catches by fleet and area in 2003. OTB : trawler; PSB : purse_seiners; ROW : rowing boats; KA_SJæ : Kattegat Sjælland+Fyn harbours; NS_VJy : North Sea Western Jylland harbours; SK_NJy : Skagerrak Northern Jylland harbours .

4.2.3.3 Strategies analysis

The strategies (=vessel groups) described in Ulrich and Andersen (2004) were constructed as homogeneous groups of fishing vessels having similar activities, regardless of their physical characteristics and homeport. They were identified using the same multivariate procedure as used for the identification of landings profile. A normalised PCA and a HAC were applied on the percentage of trips spent in each fishery for individual vessels, and the strategies were named after the main fishery, i.e. the fishery with the highest percentage of trips within a cluster. A number of descriptive indices were also calculated, to characterise the flexibility of the activity.

The strategies identified for the herring activities in IIIa in 1999 were the following:

- KB_He: Kattegat-Baltic herring midwater trawlers. They spent in average 51% of their trips in the Baltic, and only 15% in the Kattegat midwater trawling activity. Their activity was seasonal.
- NS_In: North Sea / Skagerrak industrial trawlers. They spent in average 71% of their trips in the industrial fishery, and only 10% in herring midwater trawling. Their activity was not seasonal.
- NS_Ps: North Sea / Skagerrak purse seiners, They spent in average equal number of trips fishing for herring and for mackerel

The analysis gives an interesting insight, as it allows qualitatively anticipating in which way the fishermen might change their activity if the regulation, resource or market conditions change. As for the fleet analysis, we see that two different types of fishermen are operating with two distinct origins, fishing areas, and side activities. This clear distinction should be taken into account in any further modelling and assessment of herring in IIIa.

The results presented are only preliminary results from a previous analysis, undertaken for a different purpose and at a different scale. Some more work is thus required for achieving the specific purpose of the present project. First, the immediate task is to check and update the database used in the Ulrich and Andersen work, in order to (1) integrate the estimated herring by-catches of industrial fisheries from harbour samples

and (2) update the strategies identified, as major changes in strategies have likely taken place since the introduction of the ITQ system in 2003.
The second task is to produce a detailed description of the dynamics of all the fisheries, fleets and strategies in the recent years, for a better understanding of the behaviour and interactions occurring with regards to herring in IIIa.
Finally, the updated database will be merged with the results from the WP1 and 2, where the herring catches can be aged and split between the two stocks components. The ultimate goal of this task is to estimate the relative fishing pressure of the various fleet components over the different age groups of the two stocks.

4.2.4 Task 3 – deliverable 3.2, part I

The assumptions in the current approach for advice will be replaced by more consolidated fractions of the stock components based on the results from Task 1. The calculations will then be combined with multi-fleet short term prediction programs for each stock (Task 2), to outline combinations of total quotas by fleet that are compatible with proposed harvest rules and/or precautionary criteria.

So far, the following design of a prediction procedure seems most promising under a management strategy with a common quota or a fleet disaggregated management. This design is preliminary, however, and may have to be modified as analysis of the data progresses, thus further development of software is postponed until more complete analyses of the data are available. We will use a 'two-step' approach:

1. Translate a common herring quota for IIIa into removal from each stock, preferably by age. This elucidates the consequence of the fishery for each stock. The result will depend on which fleet fish when and where.
2. Disaggregate the fishery by fleet, area and season. For each disaggregation cell, there is a selection at age and a mortality factor ("effort"). By allocating quotas in a disaggregated form, derive the consequence for each stock at age, as well a total quota for the area.

Alternative 1 is probably more straight-forward, and closer to managers thinking: Given a quota, what will be the consequence?

The local/seasonal effects can be derived in two ways:

1. By local partial Fs, taking into account the local availability of fish of each stock.
2. By overall partial fleetwise mortalities, that applies to the whole abundance of herring of each stock.

Alternative 1 was tried previously, but never worked properly, because the prediction of the local abundance in IIIa was too uncertain. Alternative 2 avoids that problem, but the effect of biological variation on the fishing opportunities of each fleet will to some extent be concealed.

Depending on how specifically fleet units can be characterised, the most promising lay-out seems to be alternative 2 (see section 4.2.4), which may be implemented as follows:
Distribute an assumed total quota for IIIa on seasons, areas and fleets, according to specified probabilities. To each of these combinations, allocate a probability distribution of catch numbers by stock and age, i.e. the likelihood that a herring caught will be by a given stock and at a given age. These likelihoods will be largely derived from the area and seasonal distribution of biological information. They may also possibly be related to abundance of incoming year classes for each stock.
Procedure for stochastic prediction:

1. Assume a total quota of herring in IIIa.
2. Draw catch by season-area-fleet combinations according to their likelihoods
3. Draw according for each season-area-fleet combination the fractional distribution by stock and age from that combination.
4. Adjust catches proportionally so that the total amount becomes the given total quota.
5. Apply these catches at age and stock to the total estimates of stock abundance, to get partial fishing mortalities and consequences by stock.

Where the stochastic elements are:

a. Proportion of total catch that is taken be fleet x in season y and area z
b. Proportion of herring by stock and age for each xyz combination
c. Numbers at age of each stock. In particular, this goes for the recruitment, but also to some extent on older ages.
d. Weights and maturities at age – probably of minor importance but should be there.

From the material we then need:

1. If relevant, a small number of distinct fisheries (or perhaps only one) (task 2).
2. For each fishery, the distribution by area and season of its catch (task 2).
3. For each area, season, (fleet) combination, the probability distribution of catch by stock and age (task 2).
4. For each area, season, (fleet) combination, the probability distribution of catch weights by stock and age.

4.3 HAWG meeting 2006

The majority of the group participated in ICES HAWG (Herring Assessment Working Group for the Area South of 62ºN) **14th to 23rd of March 2006** at ICES Headquarters in Copenhagen to present data on stock affiliation of catches in IIIa in 2005 and the working documents produced within Task 1 and Task 2, and to compile a final assessment of herring in IIIa.

4.3.2 Deliverable 1.2

Analyses of individual otolith microstructure for determination of spawning type in age-class stratified random sub-samples of herring were applied to give the stock affiliation of catches from IIIa and IVa. The split between WBSS and NSAS in the eastern North Sea is limited to an area also referred to as the transfer area (the transfer area is defined by the following ICES rectangles: 43F3 to 43F7, 44F3 to 44F6, 45F3 to 45F6, 46F3 to 46F6, and 47F3 to 47F6, under the assumption that the geographical distribution of WBSS into the North Sea is within the boarders of the transfer area).
For 2005 the otolith-based method were exclusively applied for the Division IIIa split. For Subdivisions 22, 23 and 24 it was assumed that all individuals caught belong to the WBSS stock, even when otolith microstructure indicate occurrence of autumn spawners in the surveys or in samples of commercial catches. Catches from the transfer area in the eastern North Sea in 2005 were split by analyses of Norwegian and Danish samples from landings. Mean vertebral counts from the Norwegian samples and otolith microstructure readings from the Danish samples were used to estimate the proportion of WBSS. Samples were missing in the 1st quarter for all ages and in 2nd quarter for 1-ringers, and proportions were assumed to 0%. The sources of data for splitting between NSAS and WBSS in the transfer area are:

	1-ringers	**2-ringers**	**3-ringers**	**4+-ringers**
1st quarter	Assumed to be 0% WBSS	Assumed to be 0% WBSS	Assumed to be 0% WBSS	Assumed to be 0% WBSS
2nd quarter	Assumed to be 0% WBSS	Norwegian samples (landings)	Norwegian samples (landings)	Norwegian samples (landings)
3rd quarter	Danish samples (acoustic + landings)	Danish samples (acoustic + landings)	Danish samples (acoustic + landings)	Danish samples (acoustic + landings)
4th quarter	Danish samples (landings)	Danish samples (landings)	Danish samples (landings)	Danish samples (landings)

For commercial landings in 2005 the split of the Swedish and Danish landings was conducted using the proportion by age in the combined samples of Swedish and Danish microstructure analyses. The estimation of the proportion of spring- and autumn-spawners in the landings from Division IIIa was performed on the basis of totally 2411 (869 Danish and 1542 Swedish) otolith microstructure analyses in 2005. Data were disaggregated by area (Kattegat and Skagerrak), age group (1-8+ in 1st and 2nd quarter and 0-8+ in 3rd and 4th quarter) and quarter (1–4).

Sampling levels in 2005 were high enough in age groups 1-3 to allow the split to be applied to their respective spatial and temporal origin without reallocating between landings and surveys or between areas or quarters. Sampling of individual older age classes, and age group 0 in the Kattegat in 3rd quarter was scarce. Individual microstructure estimates were reallocated from the Swedish IBTS surveys, if less than 12 individual microstructure estimates per age group were available. In cases where reallocation of individual microstructure estimates was not enough, then analyses were pooled in combined age groups to achieve at least 12 individual otolith microstructure estimates per age group. Table 4.3.1 gives the proportion of North Sea autumn spawners and Baltic spring spawners given in % in Skagerrak and Kattegat by age and quarter in 2005.

		Skagerrak				Kattegat			
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP	n	source	North Sea autumn SP	Baltic Spring SP	n	source
1	1	97.50%	2.50%	40		69.72%	30.28%	109	
	2	84.78%	15.22%	46		29.19%	70.81%	185	
	3	53.33%	46.67%	45		16.67%	83.33%	72	
	4	7.69%	92.31%	39		3.57%	96.43%	56	
	5	50.00%	50.00%	10		**0.00%**	**100.00%**		
	6	**42.11%**	**57.89%**		IBTS	**0.00%**	**100.00%**		IBTS
	7	**42.11%**	**57.89%**		age5-7	**0.00%**	**100.00%**		age5-7
	8+	**42.11%**	**57.89%**	**19**	(6-8+)	**0.00%**	**100.00%**	**21**	(5-8+)
2	1	97.67%	2.33%	43		60.42%	39.58%	96	
	2	57.14%	42.86%	49		38.78%	61.22%	49	
	3	37.50%	62.50%	24		30.95%	69.05%	42	
	4	**3.33%**	**96.67%**			16.67%	83.33%	18	
	5	**3.33%**	**96.67%**		Acoust	25.00%	75.00%	4	
	6	**3.33%**	**96.67%**		IBTS	**7.69%**	**92.31%**		
	7	**3.33%**	**96.67%**		age4-6	**7.69%**	**92.31%**		
	8+	**3.33%**	**96.67%**	**30**	(4-8+)	**7.69%**	**92.31%**	**26**	(6-8+)
3	0	14.29%	85.71%	35		92.59%	7.41%	54	
	1	88.24%	11.76%	51		60.42%	39.58%	48	
	2	13.89%	86.11%	108		4.00%	96.00%	50	
	3	9.09%	90.91%	99		2.04%	97.96%	49	
	4	13.04%	86.96%	92		2.04%	97.96%	49	Acoust
	5	18.18%	81.82%	22	Acoust	4.00%	96.00%	25	IBTS
	6	4.76%	95.24%	21	IBTS	**0.00%**	**100.00%**		age0&
	7	**0.00%**	**100.00%**		age7-8	**0.00%**	**100.00%**		age4-8
	8+	**0.00%**	**100.00%**	**19**	(7-8+)	**0.00%**	**100.00%**	**32**	(6-8+)
4	0	100%*	0%*	5		94.06%	5.94%	101	
	1	60.77%	39.23%	130		38.89%	61.11%	90	
	2	17.86%	82.14%	56		2.08%	97.92%	96	
	3	11.11%	88.89%	45		0.00%	100.00%	36	
	4	41.18%	58.82%	34		**0.00%**	**100.00%**		
	5	**78.95%**	**21.05%**			**0.00%**	**100.00%**		
	6	**78.95%**	**21.05%**			**0.00%**	**100.00%**		
	7	**78.95%**	**21.05%**			**0.00%**	**100.00%**		
	8+	**78.95%**	**21.05%**	**19**	(5-8+)	**0.00%**	**100.00%**	**22**	(4-8+)

Table 4.3.1. Proportion of NSAS and WBSS in Subdivision IIIa in 2005 based on samples from commercial catches and scientific samples. Figures marked with * are based on less than 12 observations. If data was reallocated from IBTS or acoustic surveys it is noted under `source`. If age-classes were pooled it is noted under `source` in ( ), and the estimated percentages are in bold.

Working documents were presented within Task 1 and Task 2 and are included in the present report as annex 2 and 3 respectively:
Task 1: van Deurs, M. and L.A.W. Clausen: Catches of Spring- and Autumn spawners in Division IIIa distributed by metier, sub region, and length group - Perspectives for metier and area specific management. Working doc. 2, HAWG meeting March 2005.
Task 2: Ulrich-Rescan, C. and B.S. Andersen: Identification and description of the Danish herring fleets in IIIa. Working doc. 1, HAWG meeting March 2005.

Both working documents were well received by the working group and selected results and sections from the working documents were included in the final working group report.
As a part of Task 3, the methodology of the projection method was discussed within the HAWG and the HAWG encouraged further development of the method.

4.4 Final work progress meeting

At **13th of December 2006** the group met at Charlottenlund Castle for an evaluation of the finalising work with respect to the forthcoming HAWG and final report.

4.4.2 Task 1 – deliverable 1.1, final output

All available data has been compiled including Norwegian data, which mainly are represented in the biological data applied to split total catches into WBSS and NSAS. A GIS database has been created and the group decided to analyse the stock distribution by both age and length as all worked performed on the data in relation to assessment and predictions are made on age aggregated data.
The sampling coverage was found insufficient for a spatial analysis on rectangle level (figure 4.4.2.1) instead two scenarios with respectively 5 and 6 subdivisions were defined (figure 4.4.2.2) based on current knowledge of herring migration patterns as well as fishery patterns. The data were grouped into length groups (L1 to L3) and the relative contribution of NSAS and WBSS was calculated for each combination of year, quarter, subdivision and length group (figure 4.4.2.3 to 4.4.2.5).

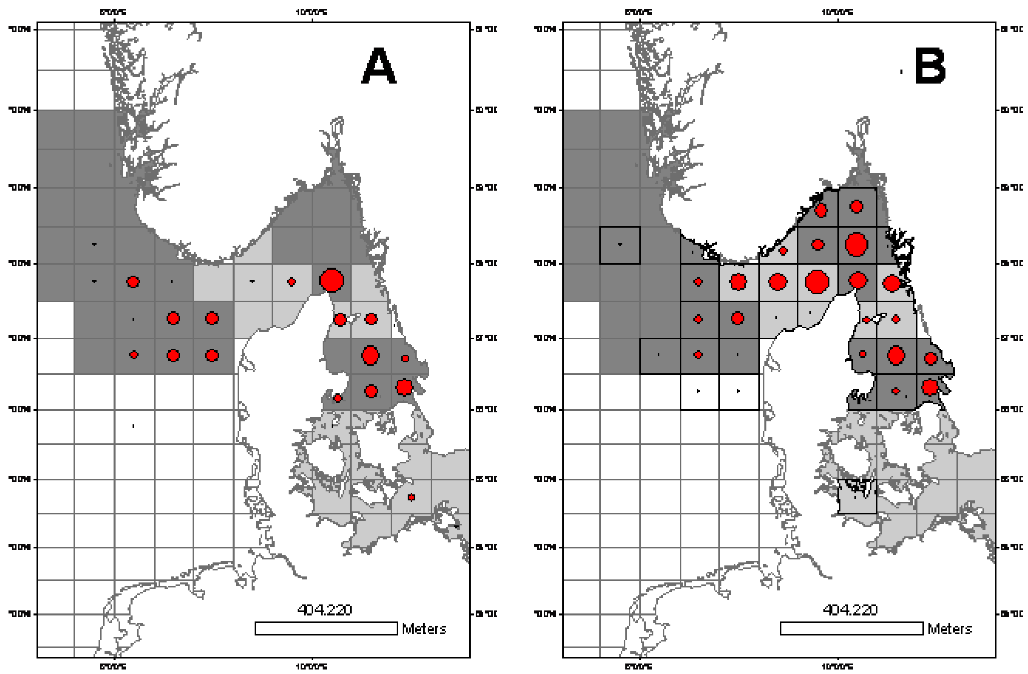


Figure 4.4.2.1. The maps A to B show the relative sampling frequency (red symbols) for each ICES rectangle over the period from 1999 to 2004. A: quarter 1, B: quarter 3.

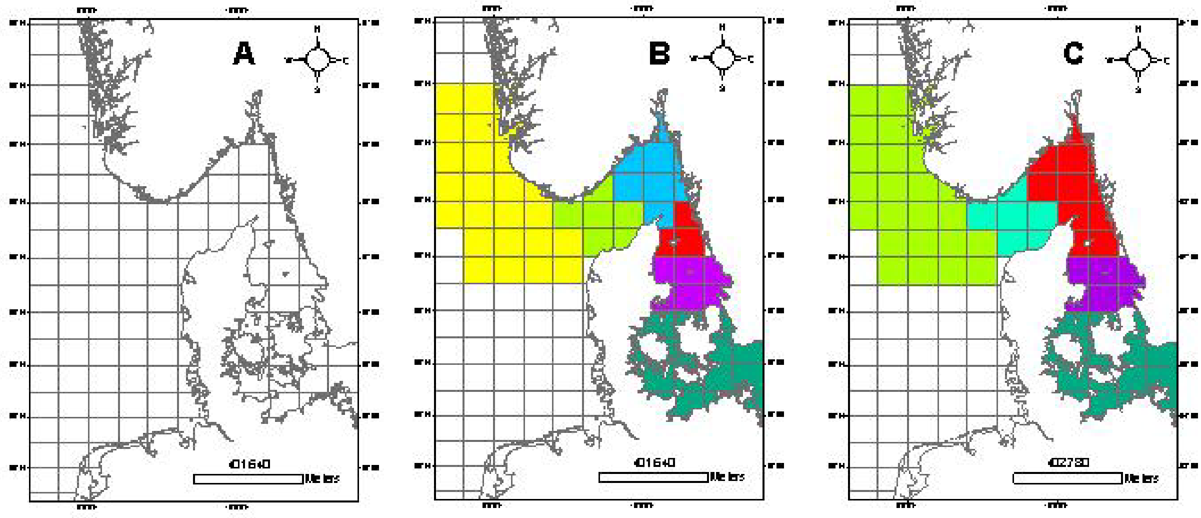


Figure 4.4.2.2. The map shows three different scenarios of subdivisions. A: Ices rectangles, B: 6 subdivisions, C: 4 subdivisions.

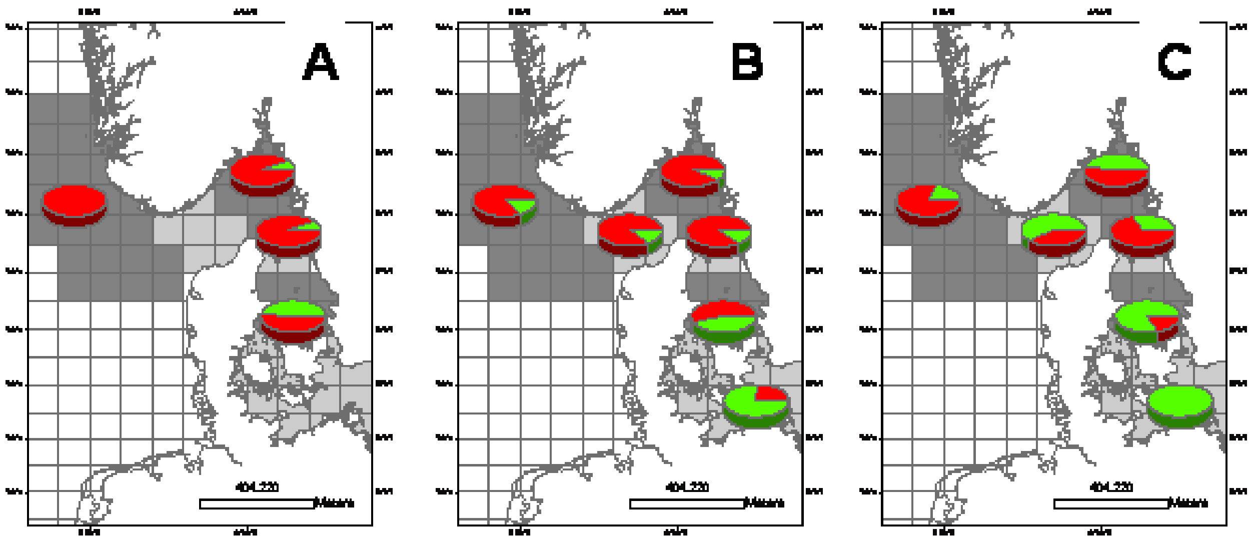


Figure 4.4.2.3. The maps A to C show the relative contribution of the two main stocks, NSAS and WBSS, to each area subdivision, averaged over the period from 1999 to 2004. A: L1, B: L2, C: L3. Possible variability related to season was not accounted for. Green: WBSS, Red: NSAS.

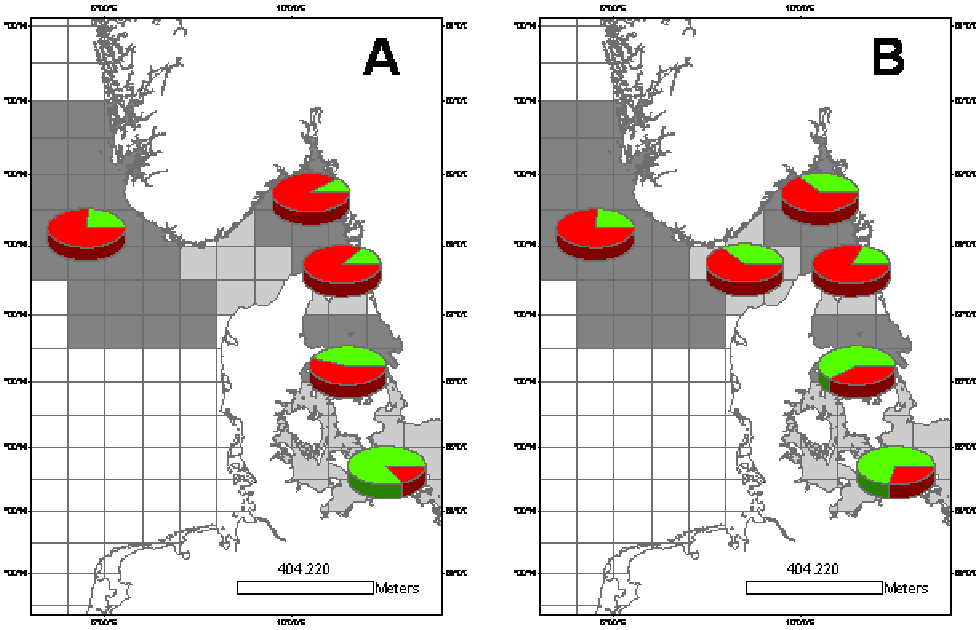


Figure 4.4.2.4. The maps A to B show the relative contribution of the two main stocks, NSAS and WBSS, to each area subdivision, averaged over the period from 1999 to 2004. A: quarter 1, B: quarter 3. Possible size related variability was not accounted for. Green: WBSS, Red: NSAS.

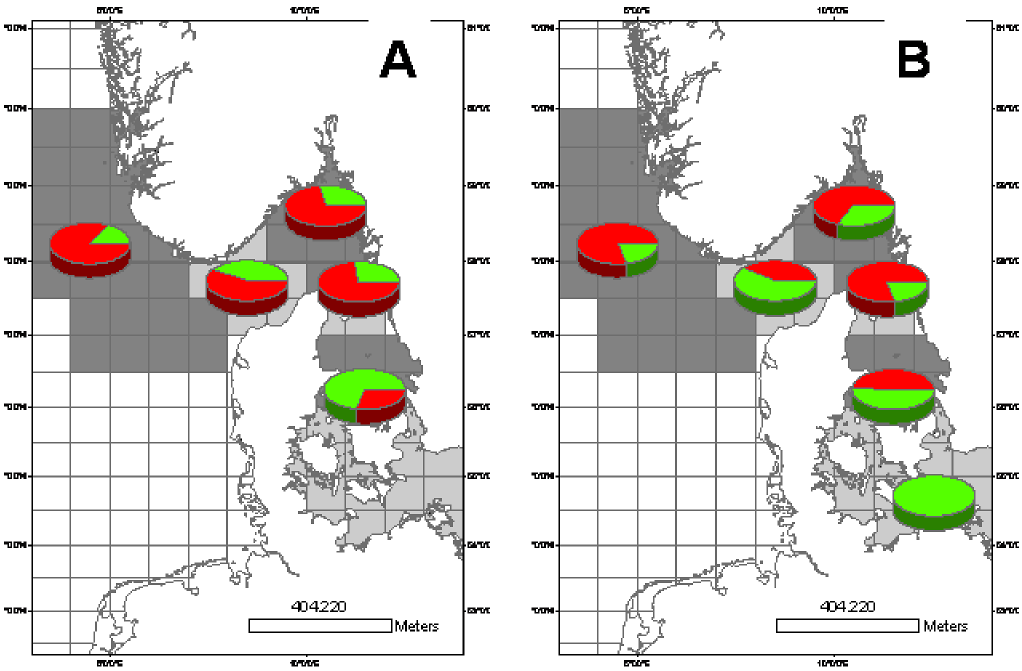


Figure 4.4.2.5. The maps A to B show the relative contribution of the two main stocks, NSAS and WBSS, to each area subdivision (1 to 6). A: 2002, B: 2004. Possible variability related to season or size was not accounted for. Green: WBSS, Red: NSAS.

Biological information on spawning type was subsequently combined with sub sample information of length distributions in commercial landings by year, quarter and subdivision. Sampling was found insufficient for a spatial resolution of 6 subdivisions, thus the scenario with 4 subdivisions was applied. Data was disaggregated into age groups (0-ringer to 4-ringer) applying an ALK to make the data suitable for cohort based projection models. Biological information on spawning types for 0-ringers was insufficient instead relative contribution of the two main stocks as calculated for 1-ringers was applied and thus the distribution of these two age-classes is identical (figure 4.4.2.6).

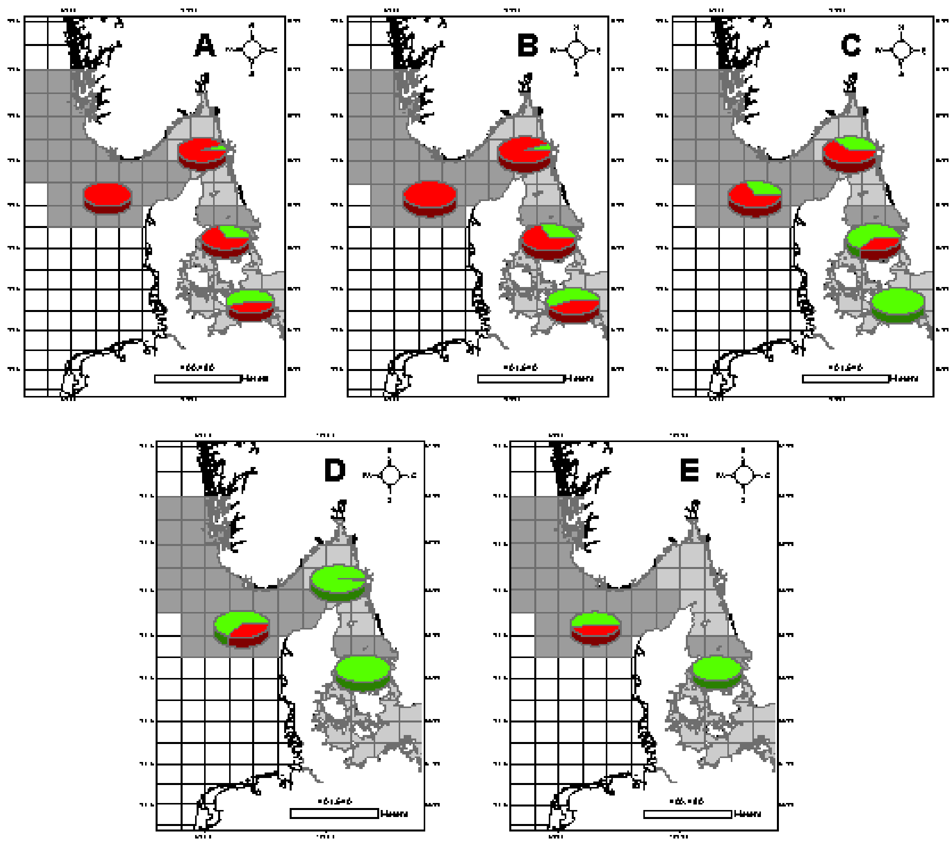


Fig 4.4.2.6. The maps A to E show the relative contribution of the two main stocks, NSAS and WBSS, to each area subdivision (1 to 4), averaged over quarters for the period from 1999 to 2004. A: age 0, B: age 1, C: age 2, D: age 3, E: age 4+.

4.4.3 Task 2 – deliverables 2.1, 2.2, (2.3), and 2.4, final output

4.4.3.1 Landing composition by metier – deliverable 2.1, final output

Total herring landings (in kg) by Y, Q, SR, and metier were calculated using information from the Danish official landing statistics on all herring related landings.

Eight different metiers were initially defined by Ulrich and Andersen (2006), as a combination of gear used and geographical origin of the vessels. The analysis showed a clear distinction between the activity of a “Northern fleet” from North Sea and Skagerrak harbours, and a “Southern fleet” from Kattegat and Western Baltic harbours. Industrial trawling and trawling targeting herring for human consumption were also segregated into different metiers, since both landings composition (Ulrich and Andersen, 2004) and herring sizes differ across both fisheries. The purse seiners only used one type of gear throughout the year. The resulting typology was a compromise between keeping the number of metiers relatively low and defining homogeneous groups.

However, it was decided subsequently to pool both Baltic metiers into one single metier, as the activity of both fleets in this area could not be clearly separated. This gave also more consistency with the categories traditionally used in HAWG.

The seven metiers were:

PSB_NSSK (Purse seiners from North Sea and Skagerrak harbours)
OTB_NSSK/MTB_Ind (Industrial midwater trawling in Skagerrak and Kattegat, trawler vessels from North Sea and Skagerrak harbours)
OTB_NSSK/MTB_Her (Herring midwater trawling for human consumption in Skagerrak and Kattegat, trawler vessels from North Sea and Skagerrak harbours)
OTB_KAWB/MTB_Ind (Industrial midwater trawling in Skagerrak and Kattegat, trawler vessels from Kattegat and Western Baltic harbours)
OTB_KAWB/MTB_Her (Herring midwater trawling for human consumption in Skagerrak and Kattegat, trawler vessels from Kattegat and Western Baltic harbours)
WB_all (All herring landings in Western Baltic)
OTH (Others)

The total landings by metier, year, quarter, area and stock, as well as sampling coverage are illustrated in Figures 4.4.3.1 (by metier (A) and area (B), 4.4.3.2 (by area for some selected metiers), and 4.4.3.3 (metiers aggregated across gear, approximate for the traditional C fleet (without purse seiners) and D fleet). Length distribution is not presented, as this is not considered a key factor for segregating stock components.

It is to be noted that the areas were defined by rectangles, whereas the official boundaries between divisions (Skagerrak/Kattegat/Western Baltic) are straight lines, resulting in some areas not covering adequately the divisions. For example, the most northern rectangles in area 0 include a part of southern Kattegat. Although small, this area is a main fishing ground for herring. This explains some mismatches between the area 0 and the Baltic metier WB_all.

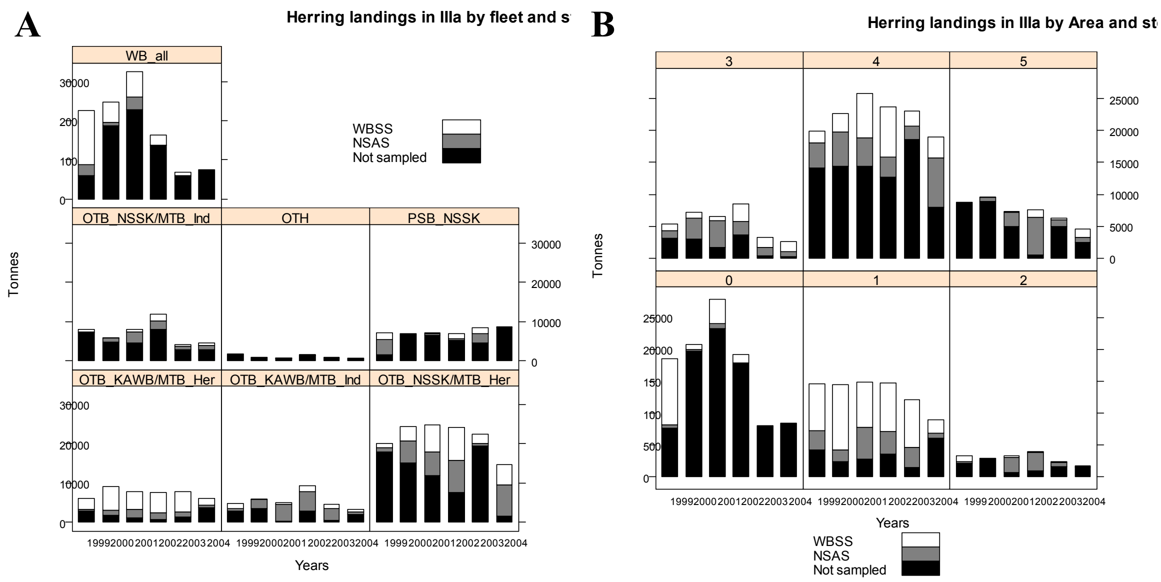


Figure 4.4.3.1. (A) Total herring landings in IIIa by fleet and stock component; (B) Total herring landings in IIIa by areas (0 to 5) and stock component.

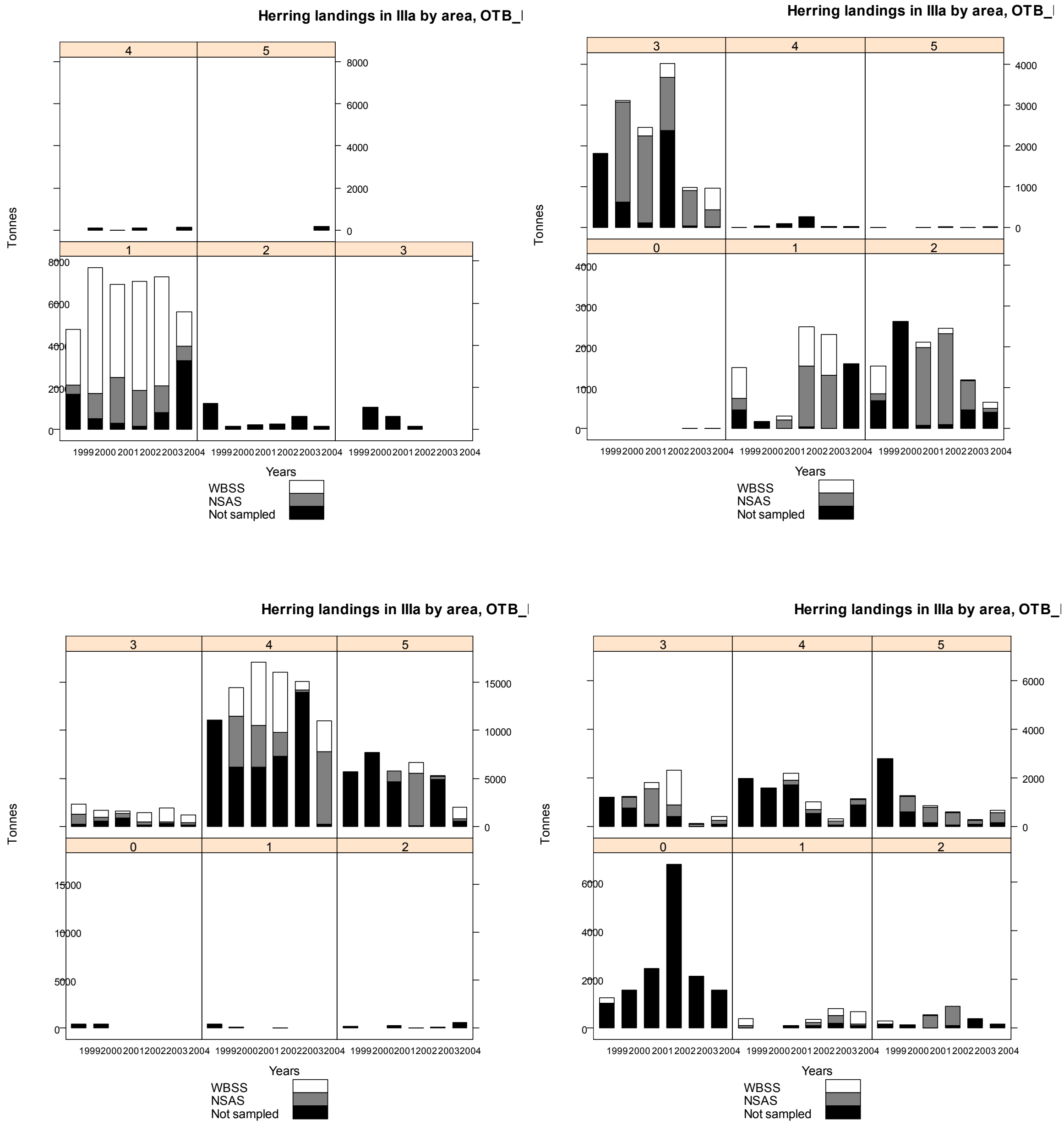


Figure 4.4.3.2. Total herring landings in IIIa by fleet, area and stock component.

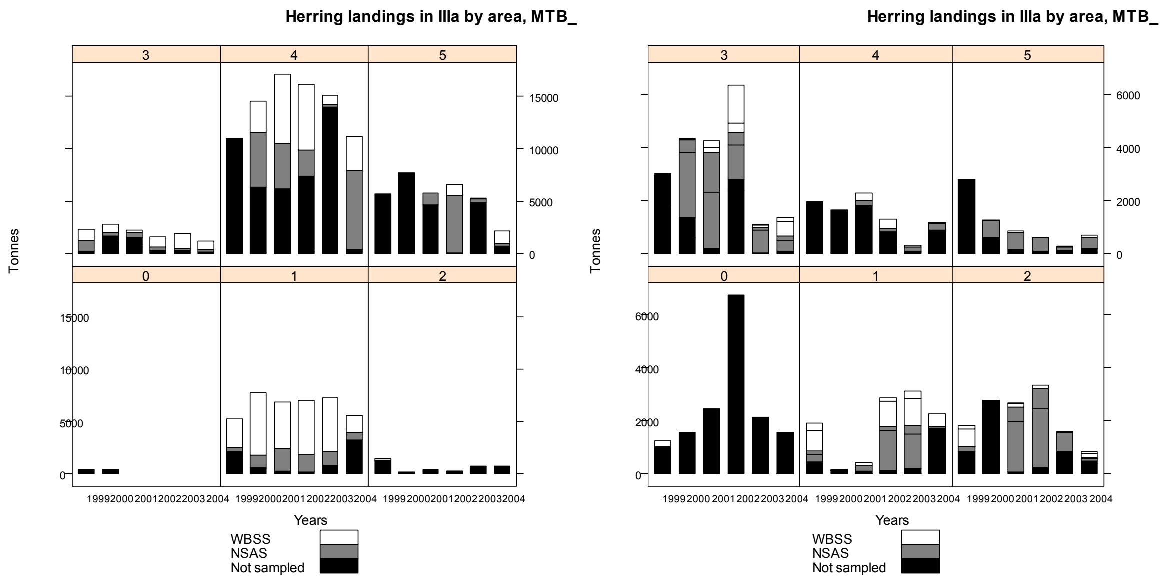


Figure 4.4.3.3. Total herring landings by sub-region and gear type, summed over the Northern fleet and the Southern fleet, as a proxy of the traditional C and D fleets.

4.4.3.2 Analysis of inter-stock selectivity by metier – deliverable 2.2, final output

Information on spawning types and age distributions in landings by year, quarter, subdivision was applied to raise log book information on all Danish commercial landings to landings in kilo by metier, year, quarter, subdivision, age (or length) group, and spawning type (NSAS or WBSS).

Throughout the data exploration the sampling of biological information from the catches of herring has shown to be varying in coverage, in particular concerning the small meshed fleet in sub region 1. This may be due to several reasons one important being potential misreporting in the whole Division IIIa. Misreporting of fishing area do occur (ICES 2006), and there is uncertainty about where the Danish landings for human consumption, reported from Division IIIa were actually taken in the area and there is a high probability that these catches have been taken in the North Sea. The same problem of mis-reporting is likely to have existed also for the Norwegian landings between 1995 and 2005 (except for 2004 where the Norwegian fleet had full area flexibility). Some landings, reported as taken in the Triangle (Gilleleje, DK - Kullen, S - Helsingborg, S - Helsingør, DK), may have been taken outside this area and listed under the Kattegat. However, though the sampling level in all years examined in the present project meets the by EC recommended level of one sample per 1000 t landed per quarter, there is an unequal coverage of some areas, times of the year and gear (meshsize) as illustrated by figures 4.4.3.2 to 3. The Southern fleet OTB_KAWB is generally well sampled, and its landings can be fairly well allocated to the two stocks whereas the sampling coverage of the Northern fleet is more variable. Particularly is the industrial activity by the Northern Fleet largely unsampled, which mainly is due to the assumption by the Danish Fishery Inspectorate (who is responsible for the sampling) that this fishery is “clean” without by-catches. However, as this small meshed fishery in general appears to catch mainly NSAS herring, unsampled catches were allocated to the stocks using the existing samples as described below.

In order to create the necessary input to the prediction of herring catches in the sub regions disaggregated by stock and metier the unsampled catches were allocated to stock using a GLM procedure. Two generalized linear models were fitted to the available biological data:
Model 1: fraction of WBSS ~ factor(quarter) + factor(age) + factor(area) + factor(year) + factor(year):factor(quarter)+ factor(year):factor(age)+ factor(year):factor(area)

Model 2: proportion of a given age group ~ factor(fleet) + factor(quarter) + factor(age) + factor(area) + factor(year) + factor(year):factor(area) + factor(year):factor(quarter)
The overall model fit was around 0.6, highest for the youngest age classes and figure 4.4.3.4 shows the fit of the modelled data to actual compositions of samples from a given year, quarter, area, metier and age.

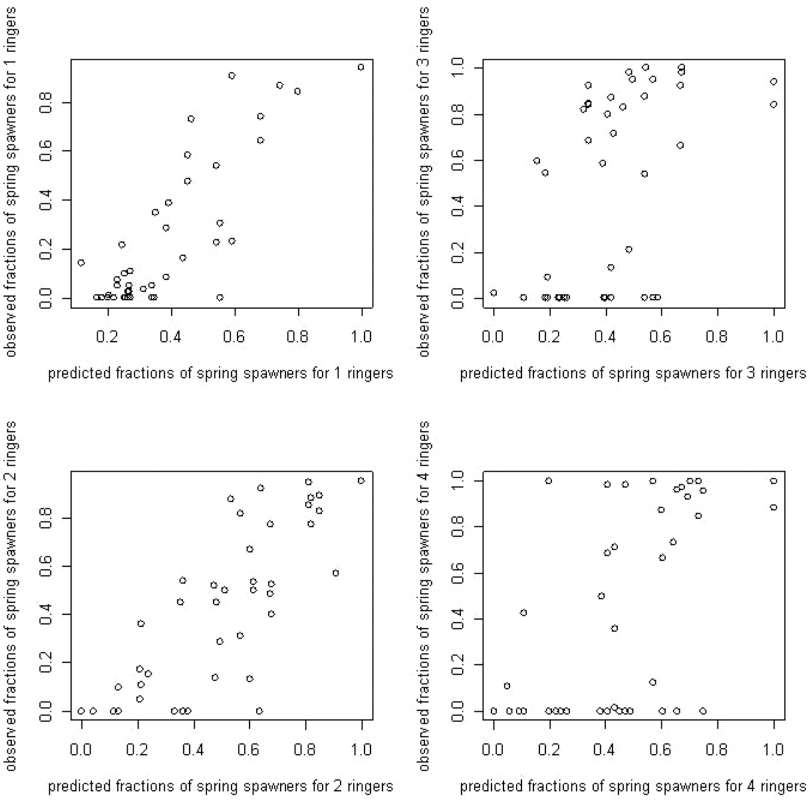


Figure 4.4.3.4. The overall fit of the modelled fraction of WBSS by age to the actual proportions of WBSS in the catch.

In those cases where the biological information on either age distribution or stock composition was missing, predicted values based on model 1 and model 2 respectively was applied to disaggregate the log book total landings by metier, year, quarter and area into stock and age groups, for a given combination of year, quarter, and area. The allocation of predicted data to unsampled combinations of year, quarter, area, metier and age was performed on average in 100 cases by year. Area 1, however, showed to be particularly represented in terms of missing biological samples, which made it impossible to fit any combination of the models, thus the fraction of WBSS was assumed to be 1 and proportions of age groups were taken from the historical stock information from the HAWG. The actual samples available from the area did confirm this method and in addition it concurs with the method applied in the HAWG and biology and migration patterns of the WBSS do certainly suggest the stock to be dominating the herring population in the Western Baltic.

Though the sampling at times were sporadic and did not cover the combination of year, quarter, area and metier, the raising to catch from the existing samples using the procedure described further below seemed solid. This gave a unique dataset made it possible to screen for patterns in selectivity by fleet, year, quarter and area on the stocks examined.

A screening for selective metiers was conducted for every sub region (1 to 4), quarter (1 to 4) and year (1999 to 2004) and some combinations of area and metier show clear predominance for one or the other stock component (figures 4.4.3.5 to 4.4.3.9). Metiers having more than 80% of one stock in their landings were defined as being selective for this particular stock in that particular area, quarter and year (the stipulated line in all figures mark this boundary). The results obtained were:

- In the more southern areas 1 and 2:
  - The WB_all was highly selective for WBSS in all years and quarters and though these results are partly based on few samples, these samples all showed a dominance of WBSS in the area.
  - More surprisingly were the purse seines with homeports in Skagerrak and North Sea harbors also selective on the WBSS in area 1 and 2 in quarter 2 in 2001-2004.
  - This pattern is even more pronounced for the Industrial midwater trawlers from North Sea and Skagerrak harbours, which have more than 80% WBSS in their catch in quarter 2 in all years, except 1999.
- Moving further north to area 3:
  - The trawlers with homeport in the Western Baltic and Kattegat show a more or less consistent pattern in being selective for WBSS during quarter 3 and sometimes quarter 4 in all years;
  - The WB_all metier is absent in area 3
  - The midwater trawler metiers show a somewhat inconsistent pattern being selective for WBSS only in some years and predominantly the later quarters 3 and 4.
  - The purse seines are not being selective on the WBSS at all in this area in any years.
- In the more northern area (area 4), no metiers appear to be selective for WBSS and thus the NSAS appear to be targeted by several metiers especially by the NSSK metiers in this area during most quarters.
- In area 5 (the North Sea) no metiers were selective for WBSS and no pattern in selectivity could be defined as the catches of pure WBSS herring was minimal
- Overall, the predominant NSAS targeting metier is the purse seines, which only display the selectivity for WBSS in area 1, quarter 2 in 2002-2004. However, it is worth noticing that the NSSK metiers including the purse seines do target WBSS to an extent as the catches in quarters 3 and 4 in most years contain up to 50 % WBSS.

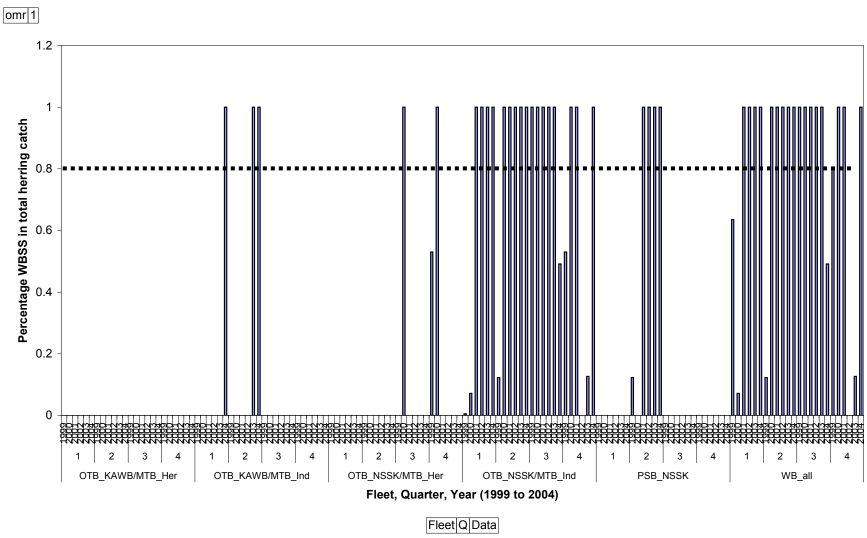


Figure 4.4.3.5. The proportion of WBSS in the total catch by fleet, quarter and year in Area 1.

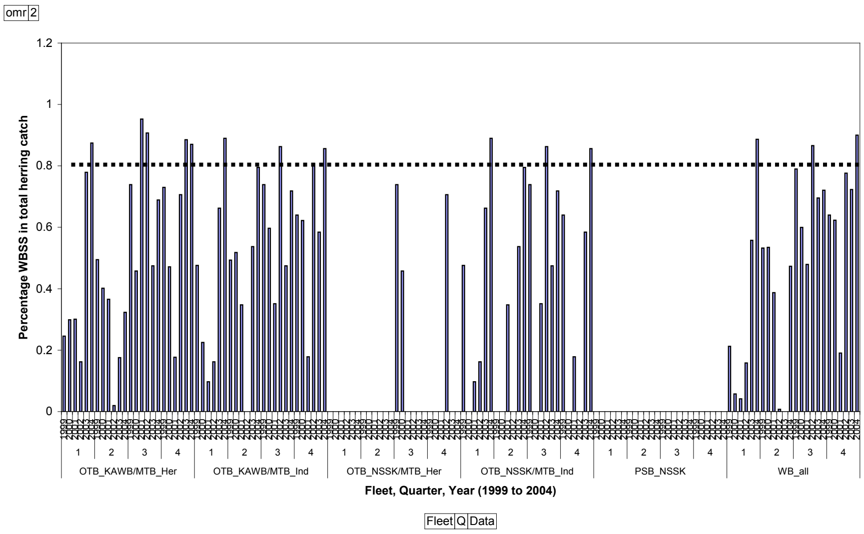


Figure 4.4.3.6. The proportion of WBSS in the total catch by fleet, quarter and year in Area 2.

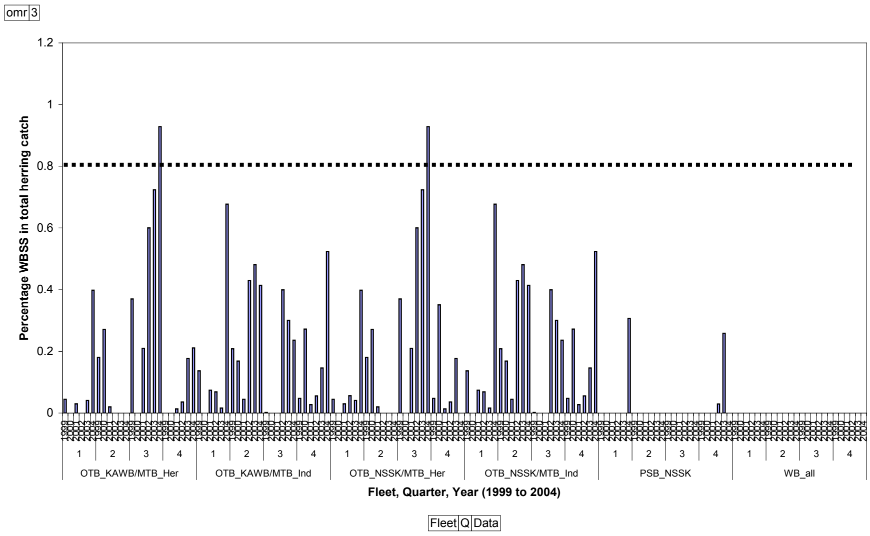


Figure 4.4.3.7. The proportion of WBSS in the total catch by fleet, quarter and year in Area 3.

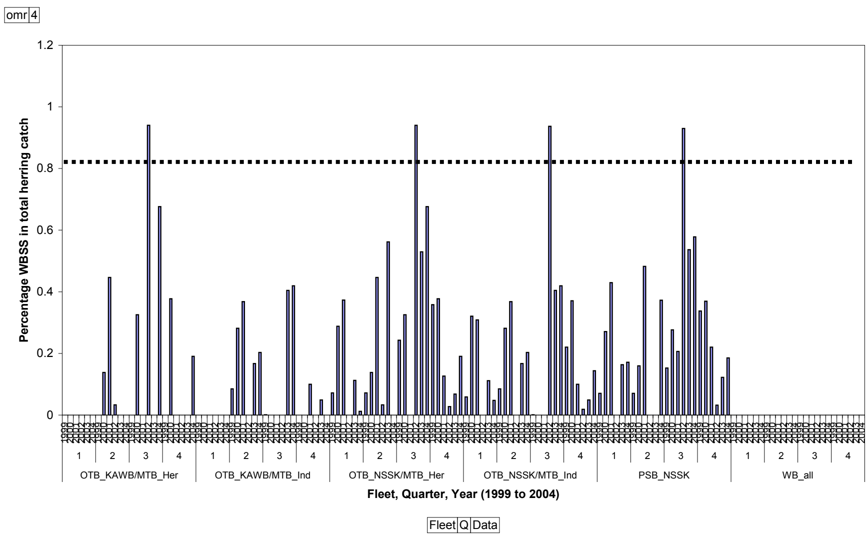


Figure 4.4.3.8. The proportion of WBSS in the total catch by fleet, quarter and year in Area 4.

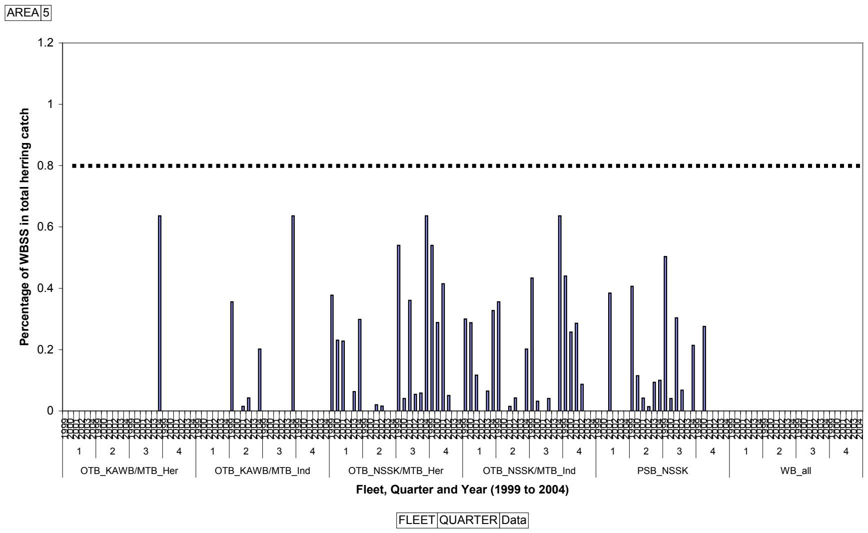


Figure 4.4.3.9. The proportion of WBSS in the total catch by fleet, quarter and year in Area 5.

4.4.3.3 Description of fleet activity – deliverables (2.3 and) 2.4, final output

The above general description of the activity and behaviors, of herring fleets in the sub regions and the allocation of all herring catches to one of the stocks gives the appropriate input to the prediction model developed in the present project. A complete fishery based analysis giving effort, CPUE and catchability for both stock components is not necessary for the performance of the program and thus is not included in the project. The program itself calculates relative F's by age and stock as described in section 4.4.4. Furthermore, it was advocated that CPUE may not be relevant indices in the case of schooling pelagic species, because effort includes variable searching time, while catches occur at once during short periods of time. In consequence, the analyses planned for deliverable 2.3 were not considered necessary for conducting the subsequent work tasks. They were thus not performed, and no results are presented for this deliverable.

However, a general description of the fleets behavior in terms of effort allocation was conducted from log-books data, and presented to HAWG 2006 as WD2 (Ulrich and Andersen, 2006, annex 3). Although this has no direct implications for the assessment of herring stocks in IIIa, this description was a step further in the global understanding of fleet dynamics. In particular, it is worth investigating how dependent these fleets are on herring stocks, and what would be their potential changes in activity if conditions in herring resources, market or regulation were changing. We described the full activity of the vessels recorded as having fished herring in IIIa at least once, and investigated what was their yearly activity. The description of metiers was extended to all metiers exerted by the recorded vessels, and not only the ones happening in IIIa.

For both the Northern and Southern pelagic trawler fleets, the herring-directed fishery for human consumption is a relatively minor activity, representing 10 to 20% of the total effort (Figure 4.4.3.9). The industrial activities are the major activities. The Northern fleet spends around 70% of its effort in the industrial activities, both in the North Sea and in IIIa. The Southern fleet has worked primarily as industrial trawling in IIIa and in the Western Baltic. The activity of purse seiners in IIIa has been constant around 10-15%.

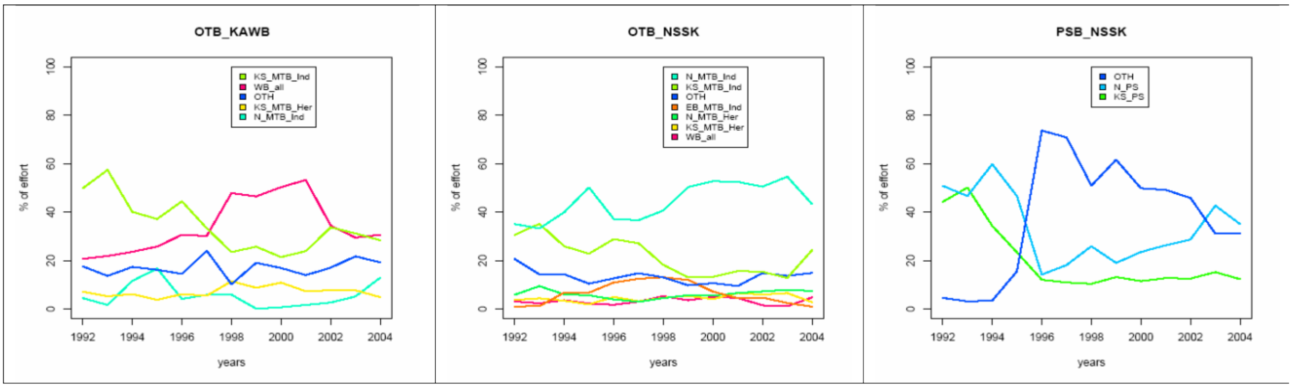


Figure 4.4.3.9. Effort distribution by fleet and metier from 1992 to 2004. (N_:North Sea, KS_:Kattegat/Skagerak, WB_:western Baltic, EB_:Eastern Baltic).

For all fleets, we have shown the same general dynamic:

- During the first half of the nineties, the activity was relatively local. The fleets were mostly fishing in their immediate waters. The pelagic trawling targeting herring for the human consumption was a minor but stable activity for the industrial fleets, and the industrial by-catches of herring were important
- The second half of the nineties was a period of extension. Both the Southern and Northern trawling fleets extended their activity to the Baltic, and decreased meanwhile their industrial activities in the Kattegat and Skagerrak, which induced reduced bycatches of herring. In the same period, the large purse seiners increased significantly their geographical mobility, with a majority of their effort being spent outside the traditional Danish fishing grounds in the North Sea and IIIa.
- Finally, since 2002 the patterns have shifted back to schemes comparable to the early nineties, with slightly increasing industrial activities and decreasing activities in the Baltic for the trawlers, and reduced remote activities for the purse seiners.

Some reasons could be a priori advocated for these observed dynamics. The expansion phase in the mid-nineties has been a general trend observed for most Danish towing fleets (Ulrich and Andersen, 2004), with considerable mobility between the North Sea and the Baltic Sea. This could be linked to both increasing restrictions of North Sea fishing activities and improved technology and communication tools, which gave fishermen higher information about local resource and market conditions. On the contrary, the reduced flexibility and mobility observed since 2002 could be due primarily to the new management system, where ITQ have been introduced since the 1st of January 2003. The first evaluations of this new regulation showed a significant adaptation of the pelagic fleet, with primarily a concentration of the herring fishery within fewer and larger vessels, and an increasing specialization of the fleet, where some vessels exited from the herring fishery to become more exclusive industrial trawlers (Anon, 2005). Increasing fuel price since 2003 could also explain partly the reduced mobility of the large purse seiner fleet.

4.4.4 Task 3 – deliverables 3.1, 3.2 and 3.3

The purpose of predictions is to estimate the consequences for the stock and the fisheries of future management proposals. Based on the fleet behaviour analysis giving the selective nature of the metiers targeting herring in Division IIIa and adjacent areas in section 4.4.3, a more precise estimate of the impact of each metiers fishery on each main stock is possible.

Management measures are at present agreed as TACs for the fleets A, B, C, D and Western Baltic. The task to incorporate detailed fleet information into a prediction can be split in two; one is how quotas for these fleets will be allocated to the various metiers, the other how each metier exploits herring with respect to stock and age. A prediction program that can take this information into account will have to be multistock and multifleet disaggregated.

The procedure that has been outlined is the following:
1. Assume a certain total catch for each aggregate fleet (the 'manager's fleets'). This assumption represents one management option that is to be evaluated in terms of consequence for the stock.
2. Allocate these catches to the metiers operating in the area, based on historical experience.
3. Translate the catch by each metier to catch in numbers at age by stock, using historical data for each fleet's preference.
4. Project the stocks forward with these catches.

This procedure does not take local abundance into account; it just assumes that there is enough fish locally to satisfy each of the fleets. Alternatively, one could split the abundance by area, and evaluate the local impact on the stocks. Then, one may use that information to calculate the effect on the stocks by fleet assuming that their preferences are constant, or one may adjust the fractional outtake by stock assuming that the relative partial fishing mortalities are constant for each fleet. To be meaningful, such area disaggregation requires quite precise insight in the area distribution for each stock. Previous attempts to do it this way have not been encouraging (ICES, 2001), and for the time being, we maintain the view that including migration and area distribution of the stock in the calculation creates more problems than it solves. Hence, the program that is made does not include area disaggregation of the stock. Then, the area information just is reflected in the definitions of the fleets, and in the mixture of stocks in their catches.

To incorporate a detailed metier structure in the prediction, each metier has to be characterized in terms of how it exploits each stock and each age. The choice in this project was to express the exploitation practise by each fleet as the harvest rates applied by the fleet to each stock and age, by metier, year and quarter. Such harvest rates (fraction of the initial stock taken in the time step, which is almost equivalent to partial fishing mortalities) can be expressed primarily as relative rates and scaled to give the right total catch by the metier in the year and quarter.

The basis for obtaining the harvest rates for prediction purposes will be the historical experience. Hence, harvest rates for each metier and quarter were derived from historical catches by metier, year, quarter, age and stock for the years 1999 – 2005. Several complicating factors became apparent when doing so: First, at this level of disaggregation, the behaviour of the metiers was quite variable from year to year. Secondly, some of the metiers operate in several areas, i.e. are allocated to more than one of the standard fleets used by managers. Finally, at this level of disaggregation, sampling is not sufficient.

Some kind of aggregation, either of metiers, but more likely on areas and/or seasons will therefore be necessary. Further analysis of the material will be required to find the most adequate way of doing so. Furthermore, incorporating more detail in the fleet structure in the prediction leads to greater uncertainty in the prediction of future behaviour of the fleets, and hence in the prediction of the consequences for the stock.

5. Final output of project – the prediction programme

It became clear that no prediction programme having the properties outlined above is readily available. It was therefore decided to write a new programme, which incorporated the need for the herring prediction, but is designed to be used for other stocks as well. At present, most of the program is written, but it is not extensively tested yet.

This program (called HERPRED) is a prediction program for multiple stocks fished by multiple fleets (metiers), to evaluate the effects of quotas allocated to aggregate groups of metiers. The program has options to screen over combinations of catches by aggregate fleet groups. It is designed as a stochastic projection, where uncertainty in the input data is translated to distribution of the output variables by parametric bootstrap.

Outline of the program HERPRED

Information basis:

- The starting point is the catch in tonnes for each aggregate fleet (in this case fleets A, B etc). An outer loop allows for screening over a range management options in terms of values for these catches.
- The allocation to metiers of catches by aggregate fleets is input in allocation tables. These tables express the percentage contribution of each metier to the catch by the aggregate fleet.
- For each metier we need the following information for the intermediate year and the prediction year(s), as tables with the form below (fleet tables), for each quarter and metier:
    - Relative harvest rates by age and stock. These show the preference for each age for each stock, and must be internally consistent between stocks. The harvest rate by definition is the fraction of the initial stock at age that is caught in a time step; hence the catch in the time step is the stock number at the start of the time step multiplied with the harvest rate. These harvest rates are relative in the sense that they have a common scaling factor.
    - Weights of individual fish in the catch by age and stock.

	0	*1*	*2*	*....*	*Plus group*
Stock 1 (NSAS)					
....					
Stock n (WBSS)					

- Finally, we need biological data for each stock:
    - Stock numbers at age for each stock (NSAS and WBSS) at the start of the intermediate year
    - Annual recruitments for each stock
    - Stock weights and maturities for calculating SSB for each stock

Uncertainties:
The program is designed to evaluate uncertainties in the prediction by parametric bootstrap on the input information. The variables that can be considered as stochastic are:
Initial stock numbers at age

- Allocation of total catch by aggregate fleets to metiers.
- Relative harvest rates for the metiers (fleet tables)
- Weights at age in the catch
- Annual recruitments

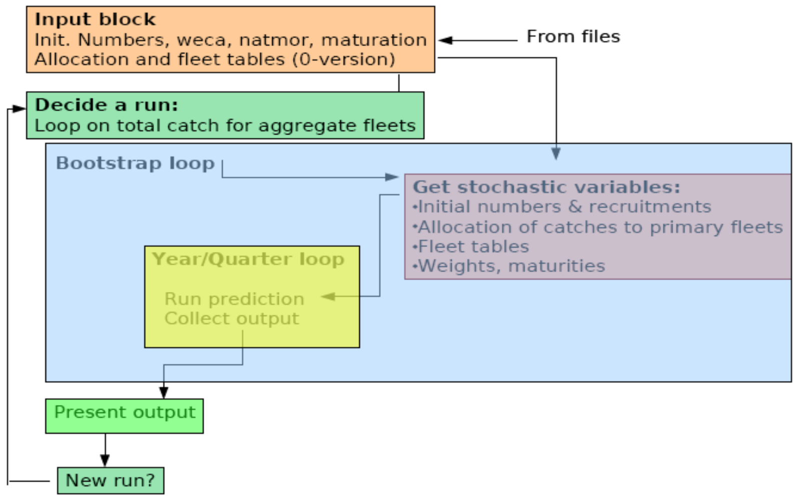
The routines to generate bootstrap data are self-contained and can be supplemented and exchanged without much other change in the program. Three alternatives are implemented for the time being.
1. Nonparametric bootstrap: Draw randomly in a collection of values, typically from historical values. This applies to all stochastic variables except the initial numbers, and requires that such a collection exists as input data.
2. Parametric bootstrap with variance-covariance. A set of variables, e.g. the initial stock numbers, are drawn from a multinormal distribution. The variance-covariance matrix, or in practice, standard deviations and correlation coefficients have to be specified. In the case of initial numbers for the herring, these are generated

by the ICA program. In some cases, where only variances are assumed, a correlation table with zero entries except on the diagonal implies uncorrelated, normally distributed noise.
3. In the cases where a total is distributed on several categories, i.e. the initial numbers and the allocation of a total catch to fleets, a multinomial distribution may be considered. In that case, the parameter is the effective sample size, which has to be assumed. There are theoretical arguments favouring this choice, but it may in practice lead to distributions that hardly are realistic. The program gives the opportunity, without claiming that it is appropriate.

Program overview:
The main building blocks are:

- Input
- Specification of the run in a loop with varying catches by aggregate fleets.
- A bootstrap loop that is a repetition of model runs with randomly drawn parameters and collection of output
- Output presentation

Schematically, the outline is like this:



The projection itself (the single model run) is performed as follows:
For each quarter:
1. Split aggregate catches on metiers according to allocation tables.
2. Apply fleet tables to translate catches to catch numbers at age by fleet and stock.
3. Project the stock forwards with these catches, calculate SSB and Fs.

The run starts at the start of the intermediate year, with initial numbers. The projection goes trough the intermediate year and the projection year, and into the year after, to get the SSB. The outer loop, with specification of catches for each aggregate fleet applies to the projection year only, the quotas for the intermediate year remains fixed. An option to prime the prediction with quotas for the intermediate year that correspond to the specified F-constraints may be considered, but not at the first stage. The allocation to metiers and the fleet tables (of Fs by stock) are specified for both the intermediate and the prediction years. For the last year, the stocks are just projected forwards with the same overall Fs as in the prediction year, to get the SSB.

This single run is repeated a large number of times in a bootstrap run, each time with randomly drawn specifications. The outcome of a bootstrap run is a distribution of fishing mortalities by stock, a distribution of spawning biomasses and a distribution of allocations to the metiers in the cases where there is more than one metier for each aggregate fleet.

An outer loop runs a number of bootstrap runs, each with specified catches by aggregate fleets,
The detail within the bootstrap loop is shown below:

Input data.
The input is from ascii-files that have to be set up in advance. Two kinds of files are needed:
1. An options file, indicating options for the run, including the quotas to screen over for the aggregate fleets, choice of distributions for bootstrap, and names of data files.
2. A set of data files, containing all data that go into the prediction.

The data files are the following:

- Initial numbers at age, optionally with a matrix with standard deviations on the diagonal and correlations in the other entries, and as another option, the effective sampling size.
- Weights at age in the catch by metier, at least for the intermediate and prediction years, optionally for historical years.
- Maturities at age, at least for the intermediate and prediction years, optionally for historical years.
- Weight at age in the stock, at least for the intermediate and prediction years, optionally for historical years.
- Allocation tables: Fractional distribution of catch by aggregate fleet on primary fleets.
- Fleet tables with relative fishing mortalities by age and stock, for each metier, year and season.

At present, most of the program code is written, but it is not extensively tested yet. Therefore, comparisons with previous methods for predictions (Task 3.3) have not been carried out yet, however, test runs will be performed prior to the HAWG 2007 and the results will be presented in HAWG.

6. Conclusions

- The spatial and temporal distribution of the two main stocks (NSAS and WBSS respectively) in the areas IVaE, IIIaN, IIIaS and subdivisions 22-24 based on analysis of herring catch compositions from both commercial and scientific sampling in the period from 1999 to 2004 appear to be following certain patterns in terms of seasonality which in turn allow predictions of the mix of herring in the area. The WBSS constitutes the highest percentage of the stock mix in the more southern parts of the area, whereas the NSAS are more abundant in the mix in the more northern part and out into the North Sea. When disaggregating the distributions into age, the NSAS present in the southern areas (subdivision 22 and even 24) are comprised of younger NSAS (0-1 ringers), whereas the observed WBSS in the more northern part of the area (IVaE and IIIaN) are 3-4 ringers. This pattern corresponds to a high degree to what could be expected from current knowledge of the migration patterns of the two stocks, where mature individuals in the WBSS stock perform feeding migrations into the IVaE and IIIa during summer and return to the southern Kattegat and the sound where they over-winter before they, from Marts to May, move into the spawning areas at Rügen on the German Baltic coast (Bekkevold et al, *in press*, Nielsen et al, 2001). The NSAS drift as larvae across the North Sea into IIIaN and IIIaS and use these as nursery grounds (Burd, 1978; Heath et al, 1997). Thus; the seasonality in the mixture of WBSS and NSAS life stages in the area appear to be predictable to some extent, though variations definitely occur and the factors driving these patterns are not well-known, which to a high necessitates sampling of the herring stocks in the area. To ensure conservation of herring population diversity in the North Atlantic, all stock components and their natural migration patterns must be considered in the compilation of scientific advice on the fishery (Stephenson 2001). Thus, obtaining high levels of precision in the input data to the assessment of mixed stocks is highly warranted.

- The detailed analysis of log-books data has allowed a finer comprehension of the herring fleets dynamics in IIIa. While the previous C and D fleets traditionally used in HAWG were rough aggregations of trips based on mesh size (and should be therefore referred to as fisheries and not fleets), we have shown the existence of two major groups of trawler vessels (fleets), one in the North and one in the South. These fleets shift between mesh sizes (industrial trawling and human consumption trawling) throughout the year, and have to some extent distinct fishing patterns and fishing grounds. We have thus proposed a newer typology including 6 metiers (plus an "others" one), more representative of the actual fishing activities. The traditional typology was simple and useful enough for stock-based management. But it was too aggregated to address fleet-based management, as the C- and D-fleets were covering heterogeneous activities, and the linkages between them were unclear. The new typology is a compromise between defining more homogeneous and realistic groups, while keeping the number of segments low and tractable. The six metiers can be eventually aggregated either by fishery into the traditional C- and D-fleets, for insuring consistency with previous practices, or by vessel, for understanding the dynamics of effort and the drivers of interactions among fisheries. It is thus a more flexible and more process-based typology, in line with ICES approach to mixed-fisheries issues (ICES, 2006). Further work should be conducted in the future for a finer testing of the typology through analysis of the fishing patterns, and for a better understanding of the fleet behaviour and their reaction to management. However, we consider the new typology as more appropriate and one step further towards operational fleet-based management.

- The share of landings across stocks for each metier was analysed, in order to point out some regular patterns of inter-stock selectivity, i.e. some metiers catching consistently one particular stock in some particular areas and quarters. The screening for such selectivity by metier on the two main herring stocks in IIIa and adjacent areas did demonstrate some degree of selectivity on either stock by defined metiers. These patterns from the fisheries based analysis of landings and fishery for the stock components by metier are consistent with the expected behaviour bearing the geography in mind and it is also worth noticing is that results agreed with the existing knowledge on migration behaviours of the respective stocks.

- Identifying such patterns, both in terms of the life-stage spatiality of WBSS and NSAS in division IIIa and adjacent areas, and in terms of fleets activity and inter-stock selectivity was a necessary prerequisite for any use of improved fleet- and stock-based management objectives. We have thus demonstrated that a more precise advice for the mixed stock in IIIa using elaborate fleet- and stock-based disaggregation could be implemented. A specific projection method is being developed accordingly.

- The results of the project, both the analysis of the fleet behaviour and the new prediction programme, should enable management an advice that accounts better for the way the fishery is conducted. The gain by this is two-fold. The predictions may become more realistic, and there will be information that should enable a direct fishery management rather than just setting overall quotas. The main obstacles are the lack of sufficiently detailed information about how the fisheries have exploited the stocks in the past, and the ability to predict the expected preferences of each metier with respect to where and when it will conduct its fishery. The former problem may to some extent be amended by models of the behaviour, as described in Section 4.4.3. The latter problem ranges outside the remits of this project. However, as hypotheses about future fleet behaviour emerge, the tool to make use of such information in predicting the consequences for the stock is now becoming available.

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8. Annexes

8.1 Annex 1

Landings data (tonnes), stock components and sampling coverage (ratio of landings allocated to a stock component through sampling) by métier, year (1999-2004), area (sub-region) and quarter.

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
OTB_KAWB/MTB_Her	1999	1	1	1084.35	0	0	0
	1999	1	2	381.66	0	0	0
	1999	1	3	3300.19	2659.18	446.88	0.94
	1999	2	1	8	0	0	0
	1999	2	2	592.2	0	0	0
	1999	2	3	633.93	0	0	0
	2000	1	1	536.09	0	0	0
	2000	1	2	764.91	596.88	168.03	1
	2000	1	3	6194.21	5215.8	978.41	1
	2000	1	4	191.7	154.13	37.57	1
	2000	2	1	15.3	0	0	0
	2000	2	2	136.4	0	0	0
	2000	3	1	32.9	0	0	0
	2000	3	2	1036.02	0	0	0
	2000	4	2	84.18	0	0	0
	2000	4	4	7.12	0	0	0
	2001	1	1	2225.52	1215.99	1009.53	1
	2001	1	2	252.54	0	0	0
	2001	1	3	4352.94	3174.56	1178.39	1
	2001	1	4	37.9	0	0	0
	2001	2	2	230.81	0	0	0
	2001	3	1	58.9	0	0	0
	2001	3	2	534.93	0	0	0
	2001	3	3	45	0	0	0
	2001	4	2	12.66	0	0	0
	2002	1	1	2581.88	1267.25	1314.62	1
	2002	1	2	162.38	0	0	0
	2002	1	3	4274.75	3894.88	379.87	1
	2002	2	2	2.39	0	0	0
	2002	2	3	272.4	0	0	0
	2002	3	2	67.4	0	0	0
	2002	3	3	89.64	0	0	0
	2002	4	2	114.71	0	0	0
	2003	1	1	3335.36	2461.76	873.6	1
	2003	1	2	529.47	0	0	0
	2003	1	3	3113.95	2709.39	404.57	1
	2003	1	4	276.24	0	0	0
	2003	2	1	90.42	0	0	0
	2003	2	3	418.94	0	0	0
	2003	2	4	125.81	0	0	0
	2004	1	1	2324.1	1655.08	669.02	1
	2004	1	2	54.22	0	0	0
	2004	1	3	2834.08	0	0	0
	2004	1	4	389.42	0	0	0
	2004	2	1	61.34	0	0	0
	2004	2	2	0.08	0	0	0
	2004	2	3	26.98	0	0	0
	2004	2	4	70.38	0	0	0
	2004	4	3	143.69	0	0	0
	2004	5	3	141.41	0	0	0
	2004	5	4	48.74	0	0	0

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
OTB_KAWB/MTB_Ind	1999	1	1	705.6	459.29	240.39	0.99
	1999	1	2	49.22	0	0	0
	1999	1	3	746.73	293.14	46.28	0.45
	1999	2	1	323.05	50	170.61	0.68
	1999	2	2	53.3	0	0	0
	1999	2	3	1040.56	629.12	0.73	0.61
	1999	2	4	118.55	0	0	0
	1999	3	1	379.09	0	0	0
	1999	3	2	66.74	0	0	0
	1999	3	3	1106.71	7.32	8.1	0.01
	1999	3	4	263.29	4.01	4.01	0.03
	1999	4	2	0.02	0	0	0
	1999	5	2	0.82	0	0	0
	2000	1	1	83.96	0	0	0
	2000	1	2	15.08	9.14	5.93	1
	2000	1	3	27.36	21.07	6.3	1
	2000	1	4	55.85	0	0	0
	2000	2	1	1562.2	0	0	0
	2000	2	2	3.03	0	0	0
	2000	2	3	856.73	0	0	0
	2000	2	4	206.05	0	0	0
	2000	3	1	1557.33	0	1557.33	1
	2000	3	2	81.9	0	0	0
	2000	3	3	932.4	29.58	902.82	1
	2000	3	4	529.18	0	0	0
	2000	4	2	37.07	0	0	0
	2000	4	3	4.24	0	0	0
	2001	1	1	34.88	6.18	28.7	1
	2001	1	2	10.39	0	0	0
	2001	1	3	269.69	89.78	179.91	1
	2001	2	1	687.85	43.59	644.26	1
	2001	2	2	145.03	8.44	136.59	1
	2001	2	3	1285.3	72.23	1132.22	0.94
	2001	3	1	723.67	49.85	578.7	0.87
	2001	3	2	307.73	36.5	259.23	0.96
	2001	3	3	1413.56	111.52	1302.03	1
	2001	4	2	49.86	0	0	0
	2001	4	3	45.64	0	0	0
	2001	5	2	0.18	0	0	0

Annex 1 (Ctd)

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
OTB_KAWB/MTB_Ind	2002	1	1	923.42	169.01	754.41	1
	2002	1	2	489.91	272.17	217.74	1
	2002	1	3	1033.13	520.83	512.3	1
	2002	1	4	48.42	0	0	0
	2002	2	1	793.01	15.06	777.95	1
	2002	2	2	289.11	107.87	151.3	0.9
	2002	2	3	1296.21	0	1296.21	1
	2002	2	4	71.69	0	0	0
	2002	3	1	1476.64	187	1289.64	1
	2002	3	2	170.18	0	0	0
	2002	3	3	2003.26	148.21	11.53	0.08
	2002	3	4	353.87	0	0	0
	2002	4	2	265.79	0	0	0
	2002	5	2	13.39	0	0	0
	2003	0	2	0.29	0	0	0
	2003	1	1	1145.38	393.98	751.4	1
	2003	1	2	596.59	153.38	443.21	1
	2003	1	3	540.3	429.18	111.12	1
	2003	1	4	20.8	19.48	1.32	1
	2003	2	1	700.8	12.04	688.76	1
	2003	2	2	192.47	0	0	0
	2003	2	3	259.09	0	0	0
	2003	2	4	41.34	14.64	26.71	1
	2003	3	1	708.3	14.01	694.28	1
	2003	3	2	32.54	0	0	0
	2003	3	3	188.83	68.08	117.6	0.98
	2003	3	4	56.77	9.13	47.64	1
	2003	4	2	4.07	2.43	1.65	1
	2003	4	3	21.59	0	0	0
	2003	5	2	2.34	0.45	1.89	1
	2003	5	3	3.29	0	0	0
	2004	0	1	14.46	0	0	0
	2004	0	2	0.93	0	0	0
	2004	1	1	881.29	0	0	0
	2004	1	2	173.51	0	0	0
	2004	1	3	491.53	0	0	0
	2004	1	4	48.14	0	0	0
	2004	2	1	165.31	92.2	73.05	1
	2004	2	2	25.05	0.4	1.39	0.07
	2004	2	3	368.7	0	0	0
	2004	2	4	97.7	68.86	19.28	0.9
	2004	3	1	287.21	230.53	56.68	1
	2004	3	2	75.99	32.15	43.85	1
	2004	3	3	506	245.44	238.91	0.96
	2004	3	4	90.17	25.74	64.43	1
	2004	4	2	19.32	3.92	15.4	1
	2004	5	2	21.98	0	0	0
	2004	5	3	3.32	0	0	0

Annex 1 (Ctd)

Metier	Year	Area	Quarter	Tot_land	VBSS	NSAS	ampl_cover
OTB_NSSK/MTB_Her	1999	0	3	428.27	0	0	0
	1999	1	3	449.98	0	0	0
	1999	2	1	73.41	0	0	0
	1999	2	3	143.25	124.56	18.68	1
	1999	3	1	67.48	0	0	0
	1999	3	2	106.75	0	0	0
	1999	3	3	2049.66	973.07	1076.6	1
	1999	3	4	64.11	0	0	0
	1999	4	1	862.8	0	0	0
	1999	4	2	548.55	0	0	0
	1999	4	3	9369.44	0	0	0
	1999	4	4	258.81	0	0	0
	1999	5	1	434.42	0	0	0
	1999	5	3	4762.87	0	0	0
	1999	5	4	490.23	0	0	0
	2000	0	3	453.56	0	0	0
	2000	1	3	81.99	0	0	0
	2000	3	1	63.1	0	0	0
	2000	3	2	314.28	0	0	0
	2000	3	3	1142.14	769.2	372.94	1
	2000	3	4	198.91	0	0	0
	2000	4	1	2558.37	0	0	0
	2000	4	2	2636.12	0	0	0
	2000	4	3	8242.24	2943.7	5298.6	1
	2000	4	4	1017.78	0	0	0
	2000	5	1	921.38	0	0	0
	2000	5	2	1701.8	0	0	0
	2000	5	3	3858.21	0	0	0
	2000	5	4	1234.48	0	0	0
	2001	2	1	233.1	0	0	0
	2001	2	3	5.51	0	0	0
	2001	3	1	313.28	0	0	0
	2001	3	2	552.25	0	0	0
	2001	3	3	748.68	259.96	488.72	1
	2001	4	1	3782.19	0	0	0
	2001	4	2	2366.11	0	0	0
	2001	4	3	10918.4	6583.2	4335.3	1
	2001	5	1	2239.43	0	0	0
	2001	5	2	1140.74	0	1140.7	1
	2001	5	3	2414.05	0	0	0
	2002	1	4	29.07	0	0	0
	2002	2	4	4.27	0	0	0
	2002	3	1	238.47	14.45	224.02	1
	2002	3	2	54.31	0	0	0
	2002	3	3	1137.38	967.38	75.24	0.92
	2002	4	1	5637.07	0	0	0
	2002	4	2	1096.08	0	0	0
	2002	4	3	8788.22	6296.7	2491.5	1
	2002	4	4	530.42	0	0	0
	2002	5	1	3068.94	375.79	2693.2	1
	2002	5	2	1022.07	566.45	455.62	1
	2002	5	3	2489.08	173.23	2315.9	1
	2002	5	4	42.69	0	0	0
	2003	2	3	117.66	0	0	0
	2003	2	4	7.6	0	0	0
	2003	3	1	326.27	0	0	0
	2003	3	3	1609.62	1427.1	182.53	1
	2003	4	1	2269.02	0	0	0
	2003	4	2	1099.55	868.93	230.62	1
	2003	4	3	11170.17	0	0	0
	2003	4	4	567.26	0	0	0
	2003	5	1	197.04	0	0	0
	2003	5	2	41.19	0	0	0
	2003	5	3	4635.6	0	0	0
	2003	5	4	389.4	16.22	373.17	1
	2004	2	3	580.77	0	0	0
	2004	3	1	77.41	0	0	0
	2004	3	2	66.96	0	0	0
	2004	3	3	1053.57	771.5	282.07	1
	2004	4	1	3707.32	100.88	3606.4	1
	2004	4	2	112.09	0	0	0
	2004	4	3	7058.3	3122.3	3936	1
	2004	4	4	136.18	0	0	0
	2004	5	1	306	0	0	0
	2004	5	3	1423.94	1218.1	205.84	1
	2004	5	4	246.28	0	0	0

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
OTB_NSSK/MTB_Ind	1999	0	1	288.04	230.44	0	0.8
	1999	0	2	92.3	0	0	0
	1999	0	3	864.09	0	0	0
	1999	0	4	15.5	0	0	0
	1999	1	1	379.78	267.02	112.77	1
	1999	1	3	24.29	16.48	2.6	0.79
	1999	2	1	77.75	0	0	0
	1999	2	3	213.66	128.14	0.97	0.6
	1999	3	1	211.63	0	0	0
	1999	3	2	44.75	0	0	0
	1999	3	3	927.53	33.53	37.1	0.08
	1999	3	4	20.82	0	0	0
	1999	4	1	24.23	0	0	0
	1999	4	2	125.3	0	0	0
	1999	4	3	1816.33	8.46	17.71	0.01
	1999	5	1	30.79	0	0	0
	1999	5	2	1062.11	0	0	0
	1999	5	3	1700.68	0	0	0
	1999	5	4	2.63	0	0	0
	2000	0	1	42.92	0	0	0
	2000	0	2	8.65	0	0	0
	2000	0	3	1500.23	0	0	0
	2000	0	4	29.67	0	0	0
	2000	2	1	72.51	0	0	0
	2000	2	2	8.84	0	0	0
	2000	2	3	64.78	0	0	0
	2000	3	1	556.96	0	0	0
	2000	3	2	2.15	0	0	0
	2000	3	3	501.95	33.71	468.25	1
	2000	3	4	188.99	0	0	0
	2000	4	2	269.32	0	0	0
	2000	4	3	1312.83	0	0	0
	2000	4	4	13.7	0	0	0
	2000	5	1	99.76	0	0	0
	2000	5	2	651.66	20.31	631.35	1
	2000	5	3	502.5	0	0	0
	2000	5	4	0.5	0	0	0
	2001	0	1	236.01	0	0	0
	2001	0	2	67.06	0	0	0
	2001	0	3	876.93	0	0	0
	2001	0	4	1279.48	0	0	0
	2001	1	1	2.39	0	0	0
	2001	1	2	14.52	0	0	0
	2001	1	3	85.59	0	0	0
	2001	2	2	93.84	4.5	89.34	1
	2001	2	3	468.23	25.85	442.38	1
	2001	3	1	39.08	0	0	0
	2001	3	2	160.49	94.78	65.71	1
	2001	3	3	1559.39	143.18	1416.2	1
	2001	3	4	37.82	0	0	0
	2001	4	1	53.39	0	0	0
	2001	4	2	270.91	0	0	0
	2001	4	3	1288.48	302.14	198.97	0.39
	2001	4	4	586.59	0	0	0
	2001	5	1	57.7	4.23	10.19	0.25
	2001	5	2	78.53	0	0	0
	2001	5	3	691.76	57.65	634.11	1
	2001	5	4	38.69	0	0	0

Annex 1 (Ctd)

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
OTB_NSSK/MTB_Ind	2002	0	1	4577.32	0	0	0
	2002	0	2	255.12	0	0	0
	2002	0	3	1630.23	0	0	0
	2002	0	4	280.7	0	0	0
	2002	1	1	101.01	0	0	0
	2002	1	3	266.24	119.32	146.92	1
	2002	2	1	73.29	0	0	0
	2002	2	2	47.71	0	0	0
	2002	2	3	770.47	0	770.47	1
	2002	3	1	429.32	56	373.32	1
	2002	3	2	184.07	0	0	0
	2002	3	3	1703.38	1372.3	106.73	0.87
	2002	3	4	10.4	0	0	0
	2002	4	1	55.31	0	0	0
	2002	4	2	380.69	0.47	14.6	0.04
	2002	4	3	573	329.78	130.49	0.8
	2002	4	4	9.95	0	0	0
	2002	5	1	4.78	0	0	0
	2002	5	2	245.76	0	185.31	0.75
	2002	5	3	345.74	24.06	321.68	1
	2002	5	4	0.48	0	0	0
	2003	0	1	5.7	0	0	0
	2003	0	2	55.44	0	0	0
	2003	0	3	2011.99	0	0	0
	2003	0	4	67.83	0	0	0
	2003	1	1	618.53	283.34	335.18	1
	2003	1	2	67.77	0	0	0
	2003	1	3	120.81	0	0	0
	2003	1	4	11.71	11.3	0.41	1
	2003	2	1	201.17	0	0	0
	2003	2	2	24.93	0	0	0
	2003	2	3	165.67	0	0	0
	2003	2	4	7.45	0	0	0
	2003	3	1	45.68	1.48	44.19	1
	2003	3	2	6.27	0	0	0
	2003	3	3	58.13	14.89	43.24	1
	2003	3	4	8.46	1.17	7.29	1
	2003	4	1	66.76	0	0	0
	2003	4	2	26.37	3.52	22.86	1
	2003	4	3	206.14	79.2	122.7	0.98
	2003	4	4	3.7	0	0	0
	2003	5	1	10.62	0	0	0
	2003	5	2	60.38	11.04	46.55	0.95
	2003	5	3	201.21	17.03	93.65	0.55
	2004	0	1	0.44	0	0	0
	2004	0	2	74.63	0	0	0
	2004	0	3	1109.86	0	0	0
	2004	0	4	374.8	0	0	0
	2004	1	1	527.62	465.9	61.71	1
	2004	1	2	21.6	18.36	3.24	1
	2004	1	3	101.74	0	0	0
	2004	1	4	19.68	0	0	0
	2004	2	1	5.76	0	0	0
	2004	2	2	26.51	5.89	20.62	1
	2004	2	3	83.98	0	0	0
	2004	2	4	60.83	43.2	12.1	0.91
	2004	3	1	50.79	10.81	39.98	1
	2004	3	2	77.18	0	0	0
	2004	3	3	158.76	99.77	58.99	1
	2004	3	4	117.52	45.87	68.24	0.97
	2004	4	1	129.34	11.84	117.49	1
	2004	4	2	152.01	32.75	119.25	1
	2004	4	3	843.74	0	0	0
	2004	4	4	27.94	0	0	0
	2004	5	1	1.73	0	0	0
	2004	5	2	497.69	93.34	404.34	1
	2004	5	3	155.85	0	0	0

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
PSB_NSSK	1999	0	2	0.6	0	0	0
	1999	4	1	612.9	0	0	0
	1999	4	2	192.08	0	0	0
	1999	4	3	5702.38	1843.19	3859.19	1
	1999	4	4	379.04	0	0	0
	1999	5	2	199.76	0	0	0
	1999	5	3	119.85	0	0	0
	2000	4	1	2197.75	0	0	0
	2000	4	2	507.89	0	0	0
	2000	4	3	2574.76	0	0	0
	2000	4	4	1237.48	0	0	0
	2000	5	2	88.71	0	0	0
	2000	5	3	52.98	0	0	0
	2000	5	4	207.06	0	0	0
	2001	0	2	0.75	0	0	0
	2001	4	1	3804.81	0	0	0
	2001	4	2	486.6	0	0	0
	2001	4	3	1981.08	0	0	0
	2001	4	4	133.77	0	0	0
	2001	5	1	573.18	168.13	405.05	1
	2001	5	2	111.01	0	0	0
	2001	5	3	1.71	0	0	0
	2002	0	2	5.19	0	0	0
	2002	3	3	386.71	0	0	0
	2002	4	1	4524.31	0	0	0
	2002	4	3	1614.36	1156.68	457.68	1
	2002	5	1	217.39	0	0	0
	2002	5	2	96.79	0	0	0
	2002	5	3	4.41	0	0	0
	2003	0	2	0.45	0	0	0
	2003	3	4	223.61	9.09	214.52	1
	2003	4	1	4515.35	0	0	0
	2003	4	3	2998.19	1371.18	1627	1
	2003	5	2	665.22	127.5	537.72	1
	2003	5	3	1.65	0	0	0
	2004	0	2	0.64	0	0	0
	2004	2	1	211.54	0	0	0
	2004	4	1	5072.97	0	0	0
	2004	4	2	533.27	0	0	0
	2004	4	3	1018.39	0	0	0
	2004	4	4	52.5	0	0	0
	2004	5	2	282.2	16.28	265.92	1
	2004	5	3	1434.28	0	0	0

Annex 1 (Ctd)

Metier	Year	Area	Quarter	Tot_land	WBSS	NSAS	Sampl_cover
WB_all	1999	0	1	9128.88	7736.14	222.37	0.87
	1999	0	2	2207.42	1890.01	317.41	1
	1999	0	3	3539.03	0	0	0
	1999	0	4	599.7	542.58	26.91	0.95
	1999	1	1	5114.57	2939.72	2119.63	0.99
	1999	1	2	1280.65	0	0	0
	1999	1	3	808.78	690.92	117.86	1
	1999	1	4	6.64	0	0	0
	2000	0	1	8448.55	822.08	156.59	0.12
	2000	0	2	3133.86	0	0	0
	2000	0	3	4617.6	0	0	0
	2000	0	4	2096.74	0	0	0
	2000	1	1	4169.5	3695.33	474.18	1
	2000	1	2	1462.72	0	0	0
	2000	1	3	705.63	576.28	129.34	1
	2001	0	1	12721.63	0	0	0
	2001	0	2	4683.06	3804.23	739.02	0.97
	2001	0	3	5225.74	0	0	0
	2001	0	4	2251.59	0	0	0
	2001	1	1	2458.5	490.51	1967.99	1
	2001	1	2	804.41	0	0	0
	2001	1	3	2740.26	2066.94	673.32	1
	2001	1	4	1582.08	0	0	0
	2002	0	1	3100.64	0	0	0
	2002	0	2	2329.32	0	0	0
	2002	0	3	4738.37	0	0	0
	2002	0	4	1759.65	1267.32	0	0.72
	2002	1	1	443.3	0	0	0
	2002	1	2	565.3	0	0	0
	2002	1	3	2029.54	0	0	0
	2002	1	4	1366.66	1290.73	75.93	1
	2003	0	1	3607.33	0	0	0
	2003	0	2	379.03	0	0	0
	2003	0	3	1002.79	0	0	0
	2003	0	4	297.35	0	0	0
	2003	1	1	332.83	0	0	0
	2003	1	3	983.52	841.46	142.06	1
	2003	1	4	177.86	0	0	0
	2004	0	1	2644.48	0	0	0
	2004	0	2	1025.36	0	0	0
	2004	0	3	1826.69	0	0	0
	2004	0	4	859.57	0	0	0
	2004	1	1	220.52	0	0	0
	2004	1	2	73.78	0	0	0
	2004	1	3	555.83	0	0	0
	2004	1	4	226.67	0	0	0

Annex 1 (Ctd; end)

8.2 Annex 2

Working Document to the ICES Herring Assessment Working Group 2006

Catches of Spring- and Autumn spawners in Division IIIa distributed by metier, sub region, and length group

Perspectives for metier and area specific management

Mikael van Deurs & Lotte Worsøe Clausen, DIFRES, Denmark

Introduction

Atlantic herring (*Clupea harengus L*) population dynamics are complex and the various stocks display high variation in terms of life history (Jennings and Beverton, 1991; McQuinn, 1997a). Herring commonly perform extensive seasonal migrations between spawning, feeding, and wintering areas (see e.g. Slotte, 1998) and different stock components often mix on feeding and wintering grounds (Rosenberg and Palmén, 1981; Wheeler and Winters, 1984; Husebø et al., 2005).

In the Eastern North Sea, the Skagerrak and the Kattegat areas young North Sea Autumn Spawning herring (NSAS) mix with Western Baltic Spring Spawning herring (WBSS) during summer feeding migrations. In addition a number of local stocks have been identified that mix with the major stocks during their feeding migrations (Rosenberg and Palmén 1982). The expansion of the Norwegian Spring Spawning population (NSS) to the south may in the future add to the complexity.

Separation of these mixed stocks has become increasingly important for management purposes (ICES, 2005) as the preservation of such complex stock structures necessitates knowledge of how migratory components of various stocks overlap both spatially and seasonally.

In previous years, the TAC for the metiers fishing herring in Division IIIa have been decided by managers according to recommendations for the NSAS, raised according to the historical fraction of NSAS in the catches by these metiers. The recommendation for the NSAS was guided by the need to rebuild that stock. By now, the NSAS stock has recovered and the main concern is for the WBSS stock.

The fishery for herring in Division IIIa exploits both stocks. The HAWG used a simple procedure in 2004 to find the highest total catch by metier in Division IIIa that would be compatible with a precautionary exploitation of WBSS. This procedure used two kinds of information about the fishery, the fraction of WBSS that is caught in IIIa, and the fraction of the catches by the IIIa metiers that consist of WBSS based on recent historic data. This very crude procedure can be refined with more detailed information on how the stocks on one hand and the fisheries on the other hand are distributed geographically and seasonally. Furthermore, the differences in both distribution and fishing pattern both in terms of season and stock components suggest a scope for a fishery management that is more fishery and stock oriented, allowing for more directed stock-wise exploitation. To ensure the preservation of the diversity of the herring population in IIIa and their natural migration patterns all stock components must be incorporated in advice on the fishery.

The present working document describes the temporal and spatial distribution of WBSS and NSAS in ICES Division IIIa and adjacent areas, in the catches of six different metiers. It is the first steps towards a more refined forecast method by elaborating metier- and stock-based disaggregation on the existing projection method.

Methods and materials

The landings (in kg) of herring by metier, spawning type (all autumn- and winter-spawners will, in the context of this study, be regarded as North Sea Autumn Spawners (NSAS) and all spring spawners as Western Baltic Spring Spawners (WBSS)), year (Y), quarter (Q), length-group (L) and sub region (SR), were estimated for the period running from 1992 to 2004. Length groups consist of: L1 = 3 -11 cm, L2 = 12-19 cm and L3 = 20+ cm. The region under the scope of this study was divided into 6 sub regions. For more information on SR see figure 1.
The catch of herring by metier, Y, Q, L, and SR were achieved by merging three separate data-files (data-file 1 through data-file 3), each containing a set of aggregated data. Data-file 1 contain information on the fraction of spring spawners (FSP) and autumn spawners (FAUS) respectively, data-file 2 contain information on the length-distribution, and data-file 3 contained information on total herring catches. Aggregation procedures used in the makings of data-file 1 through data-file 3 are presented below.
Creation of the data-base, data quality insurance, data aggregations was conducted in the programming environment R (www.R-project.org). Individual programs were designed to carry out the desired data aggregations and quality insurance, allowing for quick subsequent adjustments and corrections.

Data-file 1: Spawning types

Individual based herring data containing information on either vertebrae count (VC) or hatchmonth were subtracted from the data-bases of both the Danish Institute of Fisheries Research (DIFFRES) and the Norwegian Institute of marine research (IMR) and stored together in a new database dedicated this study. HM was achieved from visual analysis of otolith microstructure (OM) according to Mosegaard and Madsen, ICES C.M. 1996/H:17)
FSP was calculated for each combination of Y, Q, SR, and L. The data included both scientific data and commercial data. In this working document, however, only commercial data was included.
FSP was determined in two ways: 1) directly from the proportion of WBSS based on OM readings 2) from the equation formulated by Mosegaard and Madsen (ICES C.M. 1996/H:17), FSP = (56.50-observed mean vc)/(56.50-55.80), where 56.5 is the mean VC of North Sea Autumn Spawners, and 55.8 is the mean VC of Western Baltic Springspawners (WBSS) (If FSP was > 1 it was given the value 1 and if < 0 it given the value 0). Norwegian samples and Danish samples from before 1999 are mainly followed by VC only, whereas Danish data after 1999 mainly are followed by OM readings only. In cases where information on both VC and OM were available, OM were preferred, since OM are likely to be less sensitive to small sample sizes and the presence of WBSS different from WBSS. The ability of OM to distinguish between WBSS and NSAS on an individual basis is basically un-biased (Mosegaard and Madsen, ICES C.M. 1996/H:17; Evaluation of OM readings at DIFFRES). FSP-values based on less than 10 observations were excluded in the subsequent analysis.
FAUS was simply calculated by subtracting FSP from 1 (1-FSP). This also means that no attempt was made to distinguish between NSAS and winter spawners. Table 1 summarizes the number of observations (1 observation = 1 herring) used in the estimations of FSP, distributed on Y, Q, and SR.

Data-file 2: Metier and total catches

Total herring landings (in kg) by Y, Q, SR, and metier was calculated using information from the Danish official landing statistics on all herring related landings.
Six different metiers were defined by Ulrich-Rescan and Andersen (ICES WD, 2006) according to a compromise between keeping the number of metiers relatively low and minimizing the geographical overlap between the activities of the individual metiers. Furthermore, industrial trawling and trawling targeting herring for human consumption were segregated into different

metiers, since herring caught for industrial purposes are assumed in general to be smaller than herring for human consumption.

The six metiers defined by Ulrich-Rescan and Andersen (ICES WD, 2006) are presented below:

- PSB_NSSK
- OTB_NSSK/MTB_Ind
- OTB_NSSK/MTB_Her
- OTB_KAWB/MTB_Ind
- OTB_KAWB/MTB_Her
- WB_all
- OTH

OTH is an abbreviation for “other” and was not included in this study, since it was assumed to be quantitatively insignificant. Furthermore, it was not convenient to allocate the activities under OTH to any of the existing six metiers or a new seventh metier. PSB and OTB refer to vessel type, purse seining and trawling respectively. NSSK and KAWB refer to the geographical location of the harbor, North Sea-Skagerrak and Kattegat-Western Baltic respectively. Lastly, MTB is short for midwater trawling and “Ind” and “Her” is short for industrial purpose and human consumption herring respectively.

Data-file 3: Length groups
Samples collected from the Danish fishery, sampled by DIFFRES, were used to achieve information on the length distribution for each combination of Y, Q, SR and metier. These samples are assumed to random both with respect to the catch they represent and the total Danish landings (and therefore also the Danish Landing Statistics), and will be referred to as spot samples in this working document. The spot samples are sub-samples of a random subset of the landings. The length-distribution in the sub-sample was assumed to be representative of the length distribution in the landings. The sub-samples were weighted according to the size of the landing.
Table 2 summarizes how well the spot samples cover the actual landings.

Results

The data analysis and subsequent conclusions presented here is based only on the period from 1999 to 2003. This was a consequence of the relatively few spot samples available from most of the years before 1999. In addition FSP from years after 1999 are mainly based on OM and as described in section 2.1 OM based estimates of FSP are basically un-biased in contrast to VC-based estimates. One exception to this is SR 5, in which FSP are based almost entirely on VC, also after 1999, since almost all samples from this sub region are Norwegian samples.
Work presented in this working document did not include statistical treatments. All results presented are therefore calculated directly from the landing statistics, mainly OM based FSP (with a few exceptions e.g. in SR 5, as described earlier) and length measurements. In this way approximations were kept at a minimum. The only major approximation was when length information and FSP from spot samples were assumed to be representative of the given combination of Y, Q, SR, and metier. A consequence of this non-statistical approach is the missing values in cases of where spot-samples were missing.

To achieve an overview of the selectivity of the metier in terms of length groups, spawning types, a 1999to2003-average of total landings by Q, SR, metier, L, and spawning type was calculated. The next step was then to identify combinations of Q, SR, and metier that displayed an apparent high degree of selectivity. OTB_KAWB/MTB_Her stood out in Q3 and SR1 where mainly WBSS L2-3 were targeted. OTB_KAWB/MTB_Ind and OTB_NSSK/MTB_Ind targeted almost solely NSAS L1-2 in Q3 and SR2-3. Lastly, OTB_NSSK/MTB_Her displayed a high selectivity for NSAS L3 in Q1 and Q4 in SR5. The results are summarized in table 3. The Danish landings of WBSS L1 were minor and were not targeted by any specific metier.

One should keep in mind that these 1999to2003-average values should only be used for guidance purpose, since the number of values underlying each average was in some cases as low as one. Furthermore, the variation between values underlying each mean did in some cases display large variation.
Data from metiers displaying a degree of selectivity was further analyzed by plotting the values of the individual years (2000-2003) (see table 4) on a graph together with calculated total landings by Y, L, and spawning types. This allowed for an evaluation of the year to year variation and the quantitative importance of a landing by a given metier in a given SR and Q of a particular spawning type and L compared to the total yearly landing of that particular spawning type and L. The patterns accentuated from table 3 proved to be relatively consistent between years, and figure 2 confirm the high selectivity with respect to spawning type and L. However, for OTB_KAWB/MTB_Her and OTB_NSSK/MTB_Her several years were not represented in the data (due to lack of spot samples). This was especially a problem for OTB_NSSK/MTB_Her. OTB_KAWB/MTB_Her was represented in all years and the variation between years was small. The landings of WBSS L3 in Sr1 and Q3 by OTB_KAWB/MTB_Her represented in the order of 15-30% of the total Danish yearly landings of WBSS L3. OTB_NSSK/MTB_Her in Q1 and SR5 stands for roughly 10-30% of the Danish total landings of NSAS L3 . OTB_NSSK/MTB_Ind and OTB_KAWB/MTB_Ind in Q3 and SR2-3 as a whole represents in the order of 20 % of the total Danish landings of NSAS L1, but only an insignificant proportion of NSAS L2 landings. All percentages given above are roughly estimates based on figure 2.

Discussion

The mix of NSAS and WBSS in the catches from ICES Division IIIa and surrounding areas constitute a management problem. As it is today the two stocks are being managed as one stock based on management objectives set as a combination between the relative statuses of each stock.
The results presented in this working document indicate that several metiers are selective with respect to spawning type and fish sizes. It also indicates that these metiers in most years (2000-2003) stands for a significant (not in its statistical meaning) proportion of the total catch. This suggests that the two herring stocks that mix in the Western Baltic, Kattegat, Skagerrak, and the northeastern North Sea, to some extent, can be managed individually on a metier basis. Assuming a constant metier behavior, we suggest that fishing mortality induced by the Danish fisheries on

I. juvenile NSAS can be reduced by roughly 20% by closing or restricting the activities of OTB_NSSK/MTB_Ind and OTB_KAWB/MTB_Ind in the northern Kattegat and the eastern Skagerrak in quarter 3

II. the spawning stock of NSAS can be reduced by roughly 10-30% by closing or restricting the activities of OTB_NSSK/MTB_Her in northeastern North Sea in quarter 1 and 4

III. the spawning stock of WBSS can be reduced by roughly 15-30% by closing or restricting the activities of OTB_KAWB/MTB_Her in Kattegat in quarter 3

The percentage reduction will off cause vary between years.

The results that lead to the statement in point III are the most consistent.
Juvenile spring spawners can not be managed selectively by setting up restrictions for the Danish metiers.

The fraction of spring spawners used under point II was derived mainly from VC, this was assumed not to be a problem since spring-spawners different from WBSS (VC = 55,8) are not likely to occur in the northeastern North Sea during Q1 and Q4. Local spring spawning populations on the Norwegian Skagerrak coast are assumed to remain in Skagerrak, and the Norwegian Spring Spawners (NSS) (also referred to as the Atlanto Scandian Herring) over-winter north of 62^{o} N, by Q1 and Q4, and also the main feeding and nursery areas are located north of 62^{o} N (Saetre et al, 2002; Toresen and Oestvedt, 2000). However, the knowledge on the behavior and the quantitative importance of the local Skagerrak spring spawning population/populations are very scarce, and recent un-published work on A. simplex in herring (to be submitted, van Deurs) suggest that the mature individuals take on feeding migrations to the northeastern north sea.

Winter spawners are relatively easily distinguished from NSAS and WBSS by otolith microstructure readings. However, the proportion of winter-spawners in ICES Division IIIa and adjacent areas is assumable very small relative to the proportion of NSAS and WBSS, and was therefore pooled together with NSAS for simplifications.

Another potential source of bias is misreporting of catches. Ways to identify misreported catches should be developed in the future. The registered Landings of L3 spring-spawners in 3rd quarter from the southern Kattegat (SR1) may have been taken in the Triangle area (an area in the south-eastern corner of Kattegat, which is a part of the Baltic area: Gilleleje, DK - Kullen, S - Helsingborg, S - Helsingør, DK) which belong to Subdivision 23 (SR0).

Since this work does not include any statistical treatments, we suggest that this is done. Among the statistical challenges is the task of filling out the “wholes” not covered by the spot samples (see table 2). Furthermore, the spot samples ability to represent metiers, sub regions and quarters should also be statistically evaluated.

The next step of this study, will involve fitting a model to the data and attempt to produce projections. Some of the obstacles to overcome in this modeling process will be the relatively large inter-annual variation in landings and interactions between the variable factors (Metier, Y, Q, SR, L, and spawning type). Factors influencing the inter-annual variability in landings by spawning types and length group should be investigated.

The sub regions used in the analysis was not based on any biological fishing related argumentation. It may improve the results if the sub regions reflected the fishing areas or the different ecosystem types, topography, salinity, depth contours, or other biological factors. However, other than the spawning areas, only little is known about the relationship between these variables and the distribution of herring at different life stages. The spawning in general takes place in shallow areas (<40 m) of coarse gravel or eelgrass (e.g. Parrish, 1959; Scabell, 1988). It is not unlikely that juvenile herring prefer relatively shallow areas, whereas the mature herring migrate to feeding areas over deeper water or on the slopes into deep water. This trend is found for both the NSAS and WBSS (Burd, 1978; ICES 2006), but the biological reasoning for this largely unknown and the apparent relationships with depth may just be a coincidence whilst the true explanation could be another. E.g. young herring do not migrate, whereas adult herring exhibit feeding migrations towards areas of high bio-productivity in example given slopes into deep water associated with up-welling. Food availability is a factor recognized to regulate distribution of adult NSAS during the feeding season (Corten, 2001).

Whereas relatively little is known about the relationships between environmental variables and the distribution of herring at different life stages, much more is known about the migration routes and seasonality of both the WBSS and NSAS. The results presented at the beginning of this discussion are not at all unexpected. In fact they fit very well with what is known about the migrations of NSAS and WBSS, and support earlier results on this topic (e.g. ICES 1979a-c; Burd, 1978; Cushing and bridger, 1966; Nielsen et al., 2001). The reduction of WBSS L3 in the human consumption landings in quarter 1 and 4 in the northeastern North Sea and Skagerrak is most likely due to the gathering of mature WBSS in the southern Kattegat and the sound where they over-winter before they, from Marts to May, move into the spawning areas at Rügen on the German Baltic coast (Nielsen et al, 2001). Then in quarter 2 the adult WBSS will again migrate towards feeding areas in Skagerrak. However, landings of L3 WBSS in the order of 100 tons takes place in the northeastern North Sea in every quarter (see table 3), which rises the question whether spring spawners other than WBSS plays a quantitative role in the fishery. Alternative explanations includes that a fraction of the spawning stock skip spawning, or the largest juveniles of WBSS over-winter in the Norwegian Trench together with part of the NSAS stock (Cushing and bridger, 1966).
The reduction in NSAS L3 going from Q1 to Q2 may be explained by the migration of adult NSAS from over-wintering areas in the Norwegian Trench to the main feeding areas in the northwestern North Sea (Corten, 2001; Cushing and bridger, 1966).
That only NSAS L1, and no WBSS L1, is caught in SR 2-3 is in agreement with the theory that juvenile WBSS stay in the Western Baltic and the southern Kattegat until age-2 (ICES 1979; Jönsson and ICES 1979). It is, however, well known that juvenile NSAS, that drift into Kattegat and Skagerrak as larvae utilize these areas as nursery grounds (Burd, 1978; Heath et al, 1997). The fact that the industrial trawling on NSAS L1 mainly occurred in SR2-3 may indicate that the youngest NSAS stay out of the western Skagerrak and northeastern North Sea. On the other hand the explanation for this may also lie in the distribution of other industrial species such as the sprat.

Conclusion

There are good indications that the two herring spawning types or stocks, WBSS and NSAS, that mix in ICES Division IIIa and adjacent areas, to some degree can be managed individually by a metier-based approach.

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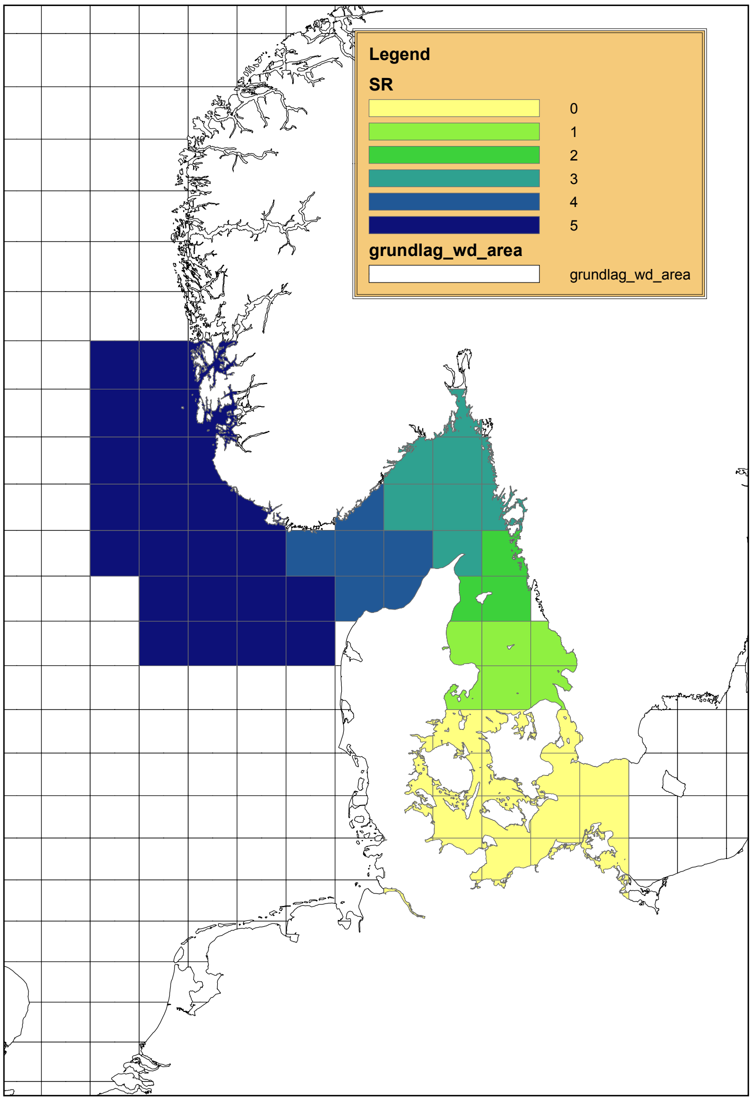
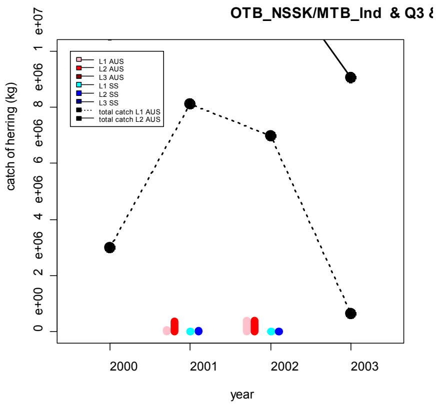


Figur 1: Six sub regions (SR) used in the study. The sub regions have been designated a number from 0 to 5, going from SR 0 in the Western Baltic to SR 5 in the eastern North Sea.

A:



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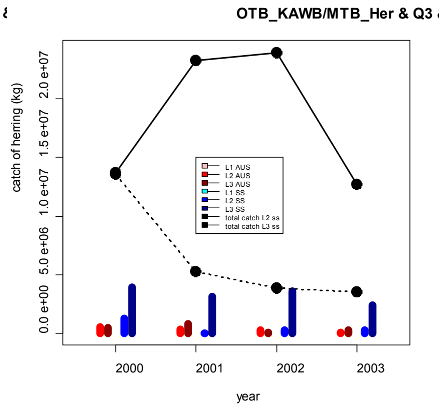
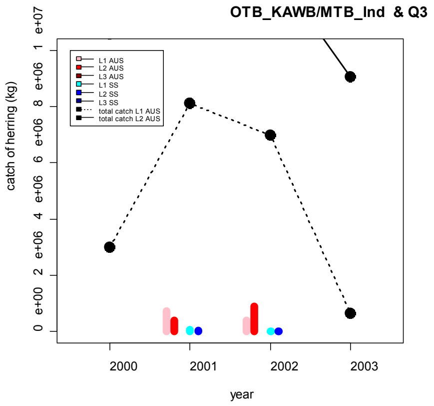


B:



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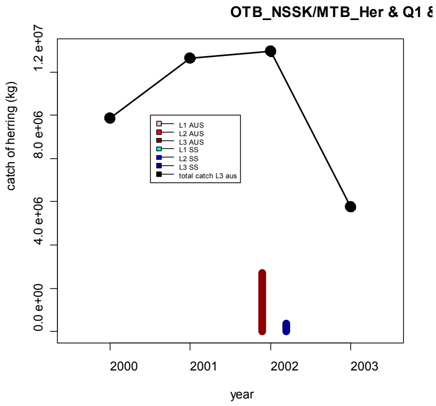

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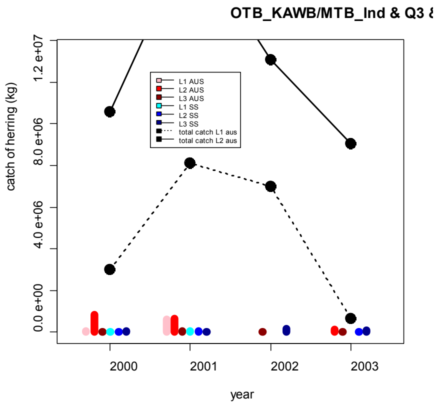

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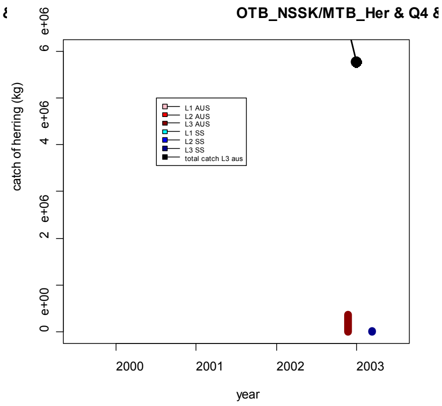


Figur 2 A-F: Visualisation of important patterns identified and highlighted in table 3 and comparison to the total landing of the spawning type and length group in focus. Landings of herring (in kg) by metier, year, quarter, sub region, spawning type, and length group, represented by vertical pillars. Red colours represent WBSS and blue colours represent NSAS. Metier, quarter and sub region varies between figures and is given in the heading of each figure. Dotted and solid line graphs represents total landings of herring by year, spawning type and length group (L) of the ones in focus (see the legends to know what spawning type and L the solid and dotted graphs represents in the respective figures, WBSS = ss, NSAS = aus and L1 to L3 are the three length groups). Figure A-C: Illustrates selective fishing on L1 and L2 NSAS. Figure D: Illustrates selective fishing on L3 WBSS. Figure E-F: Illustrates selective fishing on L3 NSAS. The complete lack of vertical pillars, as is the case in figure A year 2000 and 2003, it reflects lack of spot sample for that given combination of year, quarter, metier, and sub region. In figure A, B, C and E part of the solid black line graph is partly outside the frame of the figure, these values are therefore not available from the figure, but can instead be achieved from table 4.

number of observations distributed on year, quarter and sub region

Year	Quarter	Sub region 0	1	2	3	4	5
1992	2						
1992	3		343	137	501	1426	439
1993	1						107
1993	2						234
1993	3		313	233	145	607	527
1993	4			125	109	365	
1994	1						47
1994	2						257
1994	3		369	148	1187	573	805
1994	4						99
1995	1						
1995	2			116		119	619
1995	3					118	570
1995	4	229	122		115		415
1996	1	386	49				
1996	2	51					100
1996	3				102		364
1996	4	289	28			25	
1997	1	257	29				30
1997	2	139					785
1997	3		26		31	30	147
1997	4	323	31				99
1998	1	38	97				99
1998	2	110	49				719
1998	3	47	99		52	50	
1998	4	126	199			52	45
1999	1	62	27	79			
1999	2	46					683
1999	3		151	47	99	99	
1999	4	48	95		48		
2000	1	50	43		37		
2000	2		112				973
2000	3		100		115	56	389
2000	4	50	50				
2001	1		107	97	76		75
2001	2	24		54	72		441
2001	3		349	198	246	68	138
2001	4		41		58	36	
2002	1		281	95	192		49
2002	2		50	100		96	811
2002	3		643	93	97	194	195
2002	4	28	89	95	90	92	123
2003	1		1100	244	752		191
2003	2		359			282	417
2003	3		427		195	300	26
2003	4	88	632	300	173	98	24
2004	1		382	133	486	241	
2004	2		179	9	9	46	470
2004	3	48			274	411	31
2004	4		300	72	186	95	21

Table 1: Number of observations (1 observation = 1 herring) used in the estimations of FSP, distributed by year, quarter, and sub region. Each number of observations presented in the table is sampled from one or more stations within the sub region, this information is not provided here.

Y	Q	fleet / data	OTB_KAWB/MTB_Her SR 1	2	3	4	5	OTB_KAWB/MTB_Ind SR 0	1	2	3	4	5	OTB_NSSK/MTB_Her SR 0	1	2	3	4	5	OTB_NSSK/MTB_Ind SR 0	1	2	3	4	5	OTH SR 0	1	2	3	4	5	PSB_NSSK SR 0	2	3	4	5	WB_all SR 0	1
1999	1	fishing	x	x					x	x	x					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x		x	x
		spot sample							x	x										x	x																x	x
	2	fishing	x	x					x	x	x	x	x				x	x		x			x	x	x	x	x	x	x	x		x			x	x	x	x
		spot sample																																			x	
	3	fishing	x	x					x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x	x
		spot sample	x						x	x	x					x	x				x	x	x	x											x			x
	4	fishing								x	x						x	x	x	x			x		x	x			x	x					x		x	x
		spot sample									x																										x	
2000	1	fishing	x	x	x				x	x	x						x	x	x	x		x	x		x	x	x	x	x	x	x				x		x	x
		spot sample									x																										x	x
	2	fishing	x	x	x	x			x	x	x	x					x	x	x	x		x	x	x	x	x	x	x	x	x	x				x	x	x	x
		spot sample	x						x																x													
	3	fishing	x						x	x	x	x		x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x				x	x	x	x
		spot sample	x						x		x						x	x					x															x
	4	fishing	x			x			x	x	x						x	x	x	x			x	x	x	x	x		x	x					x	x	x	
		spot sample	x																																			
2001	1	fishing	x		x				x	x	x					x	x	x	x	x	x		x	x	x	x	x	x	x	x					x	x	x	x
		spot sample	x						x	x	x														x											x		x
	2	fishing	x	x	x	x			x	x	x	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x		x			x	x	x	x
		spot sample								x	x								x			x	x														x	
	3	fishing	x		x				x	x	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x
		spot sample	x						x	x	x						x	x				x	x	x	x				x									x
	4	fishing	x																	x			x	x	x	x	x	x	x	x	x				x		x	x
		spot sample																																				
2002	1	fishing	x						x	x	x						x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x	x
		spot sample	x						x	x	x						x		x				x				x											
	2	fishing	x	x	x	x			x	x	x	x	x				x	x	x	x		x	x	x	x	x	x	x	x	x	x	x				x	x	x
		spot sample							x	x									x					x	x													
	3	fishing	x	x	x				x	x	x						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x
		spot sample	x						x	x	x						x	x	x		x	x	x	x	x					x					x			
	4	fishing							x	x	x				x	x		x	x	x			x	x	x	x	x	x	x	x	x						x	x
		spot sample																																			x	x
2003	1	fishing	x	x					x	x	x						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x		x	x
		spot sample	x						x	x	x										x		x															
	2	fishing	x					x	x	x	x	x	x					x	x	x	x	x	x	x	x	x	x	x	x	x		x				x	x	
		spot sample							x			x	x					x						x	x											x		
	3	fishing	x	x					x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x		x				x	x	x	x
		spot sample	x						x		x						x						x	x	x		x								x			x
	4	fishing	x	x					x	x	x					x		x	x	x	x	x	x	x		x	x		x	x				x			x	x
		spot sample							x	x	x								x		x		x											x				
2004	1	fishing	x	x				x	x	x	x						x	x	x	x	x	x	x	x	x	x	x		x	x			x		x		x	x
		spot sample	x							x	x							x			x		x	x														
	2	fishing	x	x				x	x	x	x	x	x				x	x		x	x	x	x	x	x	x	x	x	x	x		x			x	x	x	x
		spot sample								x	x	x									x	x		x	x											x		
	3	fishing	x	x		x	x		x	x	x		x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x
		spot sample									x						x	x	x				x															
	4	fishing	x	x			x		x	x	x							x	x	x	x	x	x	x		x	x		x	x	x				x		x	x
		spot sample								x	x											x	x															

Table 2: Not all combinations of year, quarter, sub region, and fleet was represented in the spot-samples. This table provides an overview of how well the spot-samples cover the actual landings. X marks the presence of landing (fishing) and spot-sample (spot sample) respectively.

fleet	quarter	sub region	Data: mean yearly total landing of WBSS (kg), lenght group 1	2	3	mean yearly total landing of NSAS (kg) 1	2	3
OTB_KAWB/MTB_Her	1	1	0	115.211	1.533.121	0	489.340	576.578
	2	1	0	173.651	423.231	0	118.814	49.213
	3	1	0	532.552	2.998.208	0	285.381	392.243
	4	1	0	20.242	133.885	0	7.144	30.428
OTB_KAWB/MTB_Ind	1	1	41.452	199.627	52.801	59.813	372.980	51.775
		2	5.363	18.045	16.211	79.911	496.146	28.630
		3	10.659	54.341	505	151.194	888.155	37.915
	2	1	10.070	28.097	122.811	30.210	203.915	76.282
		2	0	58.157	0	33.619	124.984	4.294
		3	0	15.300	21.203	0	248.629	10.601
		4	0	161	2.266	0	1.046	601
		5	0	0	449	0	0	1.893
	3	1	71.086	203.944	30.253	50.036	140.126	1.293
		2	24.906	215.566	4.841	570.797	428.946	726
		3	31.135	10.521	54.177	328.006	536.709	15.188
	4	1	0	16.051	3.425	0	585	734
		2	0	14.417	219	0	26.088	618
		3	0	8.812	2.164	0	40.142	5.755
OTB_NSSK/MTB_Her	1	3	0	0	14.453	0	0	224.018
		5	0	0	375.789	0	0	2.693.155
	2	4	0	0	868.933	0	0	230.617
		5	0	0	283.223	0	107.041	744.660
	3	2	0	0	124.563	0	0	18.684
		3	0	0	879.338	0	0	439.206
		4	0	0	5.274.509	0	0	4.041.780
		5	0	0	173.233	0	0	2.315.846
	4	5	0	0	16.225	0	0	373.172
OTB_NSSK/MTB_Ind	1	0	0	230.436	0	0	0	0
		1	111.457	190.016	29.435	13.003	205.243	12.230
		3	2.138	25.244	1.361	25.639	166.356	16.762
		5	0	0	4.231	0	0	10.194
	2	2	0	4.505	0	0	70.571	18.769
		3	0	1.163	93.619	0	18.898	46.810
		4	0	3.516	471	0	22.856	14.600
		5	0	0	15.673	0	324.069	107.537
	3	1	0	67.901	0	19.017	65.251	0
		2	2.473	47.529	6.457	229.163	251.507	969
		3	51.321	5.746	295.546	509.421	282.266	41.177
		4	0	0	179.895	0	28.718	110.286
		5	0	57.647	20.545	345.879	288.233	207.665
	4	1	0	11.298	0	0	412	0
		3	0	1.067	103	0	4.861	2.425
PSB_NSSK	1	5	0	0	168.134	0	0	405.049
	2	5	0	0	127.500	0	0	537.719
	3	4	0	0	1.457.021	0	0	1.981.290
	4	3	0	0	9.090	0	0	214.520
WB_all	1	0	0	2.166.592	4.225.032	0	78.293	222.370
		1	0	1.582.305	792.879	234.143	805.012	637.538
	2	0	0	1.168.238	1.678.886	0	512.582	15.630
	3	1	0	116.154	927.746	0	77.188	188.460
	4	0	0	219.680	795.109	0	0	13.454
		1	0	273.332	1.017.402	0	0	75.925

Table 3: Mean (1999 to 2003) of estimated landings (kg) by quarter, sub region, fleet, spawning type, and length group. Cases in which a fleet is observed to practice relatively high selectivity on spawning type and length group is highlighted. Selectivity for WBSS L2 and L3 (gray); selectivity for NSAS L3 (light red); selectivity for NSAS L1 and L2 (light yellow).

Estimated total catches distributed on year, spawning type, and length group						
year	WBSS L1	WBSS L2	WBSS L3	NSAS L1	NSAS L2	NSAS L3
1999	0	21.547.922	22.567.472	0	3.333.332	13.263.871
2000	0	13.579.389	13.670.705	2.991.685	10.580.903	9.868.091
2001	799.538	5.288.862	23.254.878	8.109.862	19.053.098	12.640.886
2002	301.817	3.875.172	23.920.263	6.975.724	13.098.038	12.941.808
2003	3.861.234	3.517.154	12.712.838	650.172	9.049.700	5.764.244

Table 4: Total landings (in kg) by year, spawning type (WBSS or NSAS) and length group (L).

8.3 Annex 3

WORKING DOCUMENT: IDENTIFICATION AND DESCRIPTION OF THE DANISH HERRING FLEETS IN IIIA

Clara ULRICH-RESCAN, Bo SØLGAARD ANDERSEN, Danish Institute of Fisheries Research

Introduction

The fishery for herring in Division IIIa exploits both stocks of North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS), and the management objectives are set as a combination between the relative statuses of both stocks. However, first estimates in both distribution and fishing pattern both in terms of season and stock components suggest a scope for a fishery management that would be more fishery and stock oriented, allowing for more directed stock-wise exploitation.

An ongoing research project between DIFRES and IMR aims at improving the assessment and advice of the mixed stock in IIIa by elaborating fleet- and stock-based disaggregation of the catches. In this idea, a detailed analysis of the dynamics of herring fleets activity is necessary to investigate to which extent such a disaggregation can be implemented in terms of management. This working document is a descriptive analysis of the Danish fleet dynamics during the last decade, where we look both at the distribution of herring catches over fleets, and at the overall activity of the vessels targeting herring in IIIa.

Identification of fleets, fisheries, metiers and strategies

Terminology

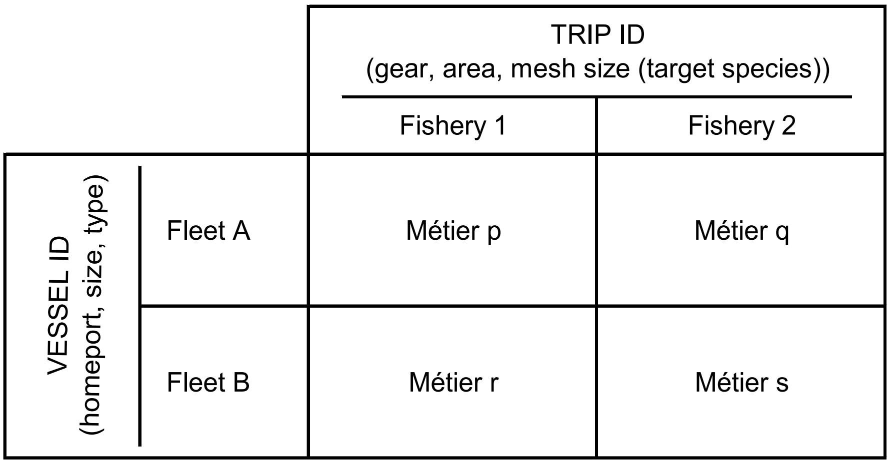
The definitions of these concepts have varied between institutes and research projects, but in the following document we will use the definitions adapted from ICES (2006), which clearly state that the terms refer to very different concepts which should not be confused:

* FLEET: **A physical group of vessels** sharing similar characteristics in terms of technical features (e.g. the Danish Trawlers >24m from Skagerrak harbours, regardless of which species activity they have).
* FISHERY: **Group of fishing trips** targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area (e.g. the Danish Industrial trawling with mesh size <32 mm in the North Sea).
* METIER: **Homogeneous sub-division of a fishery by fleet** (e.g. the Danish trawling with mesh size <32 mm in the North Sea, by vessels > 24m from Skagerrak harbours).
* STRATEGY: **Homogeneous sub-group of a fleet grouping vessels sharing similar annual activity patterns**, in terms of effort spent in the various metiers. Strategies are referred to as the main metier operated in (e.g. Danish Herring trawlers >24m from Skagerrak harbours).

The text table below should help to elaborate the distinction between fishery and metier. However, the two terms are sometimes used interchangeably (ICES, 2006).

The major advantage of using such terms is their ability to summarise high levels of information into single and simple categorical terms, which collate the main descriptors necessary to describe types of trips and vessels. Furthermore, the analysis of strategies allows qualitatively anticipating in

which way the fishermen might change their activity if the regulation, resource or market conditions change. However, the strategies cannot be used as stable management units as fleets do, because of the ability of fishermen to adapt their activity and to shift strategy if changes in resource, market or regulation occur.
We use the terminology *–ing* to refer to fisheries and metiers (trawl-*ing*), and the terminology *–ers* to refer to fleets and strategies (trawl-*ers*)



Relationships between fleets, fisheries and metiers. Variables in brackets are indicative of possible categorisation criteria (ICES, 2006).

Background

A previous study aimed at identifying and describing fisheries and strategies (also called vessel groups) at the whole Danish scale, based on usual catch and effort data from 1999 (Ulrich and Andersen, 2004). Fisheries were identified using a 3-steps method using multivariate analysis of landings profile (target species) and trips descriptors (mesh size, season, and area. A total of 54 fisheries were identified, covering the whole activity of all Danish vessels. Among these, three fisheries refer explicitly to the herring fishery in IIIa (not including the industrial by-catch, whose species distribution was not detailed in the catch and effort database):

- The Kattegat Herring midwater trawling (283 trips in 1999), where herring represented in average 97% of the value
- The North Sea and Skagerrak Herring midwater trawling (668 trips in 1999), where herring represented in average 69% of the value
- The North Sea and Skagerrak Herring purse seining (105 trips in 1999), where herring represented 100% of the value

Similarly, the strategies were constructed as homogeneous groups of fishing vessels having similar activities, regardless of their physical characteristics and homeport. They were also identified using multivariate procedures on the percentage of trips spent in each fishery for individual vessels. The strategies were named after the main fishery, i.e. the fishery with the highest percentage of trips within a cluster. A number of descriptive indices were also calculated, to characterise the flexibility of the activity.

The strategies identified for the herring activities in IIIa in 1999 were the following:

- KB_He : Kattegat-Baltic herring midwater trawlers. They spent in average 51% of their trips in the Baltic, and only 15% in the Kattegat midwater trawling activity. Their activity was seasonal.
- NS_In: North Sea / Skagerrak industrial trawlers. They spent in average 71% of their trips in the industrial fishery, and only 10% in herring midwater trawling. Their activity was not seasonal.
- NS_Ps : North Sea / Skagerrak purse seiners, They spent in average equal number of trips fishing for herring and for mackrel

The work presented here is a direct follow up of this analysis, with a unique focus of the herring fleets in IIIa.

Definition of fleets

The individual patterns of fishing vessels can be tracked throughout the database with a unique personal coding number attached to every single vessel. Further information such as homeport and vessel size is also available, and can be used into a description of herring fleets characteristics. A number of fleets were previously defined, gathering the fishing vessels into a finite number of groups, which could be further aggregated or disaggregated for modelling needs. The criteria used are

- The official registered vessel type (e.g. OTB, PSB, BTB, GN etc)
- The vessel length class (classes are based on the official length categories used by the Ministry and the Food and Resource Economic Institute FØI)
- The homeport, aggregated at the level of larger terrestrial area (e.g. Sjælland+Fyn, Vest Jylland, North Jylland etc) and immediate official fishing waters (e.g. North Sea, Kattegat, Skagerrak etc).

These criteria lead of course to a quite high number of fleet segments, which is neither very handy nor very useful. The first task of the analysis of the fleets activity was thus to get a global overview of main activity patterns for the single fleet segments, so as to aggregate them into a limited numbers of homogeneous fleets.

The landings share by fleet and water in 2004 was the following (see also figure 1):

AREA	FLEET	% landings
Skagerrak	OTB_24-<40_SK_NJy	18%
	OTB_40- _NS_VJy	34%
	OTB_40- _SK_NJy	7%
	PSB_40- _SK_NJy	36%
	Others	4%
Kattegat	**OTB_15-<18_KA_SJæ**	17%
	OTB_18-<24_KA_EJy	6%
	OTB_18-<24_KA_NJy	8%
	OTB_18-<24_KA_SJæ	10%
	OTB_24-<40_KA_SJæ	26%
	OTB_40- _NS_VJy	5%
	Others Kattegat fleets	10%
	Others	17%
22-24	**OTB_15-<18_KA_SJæ**	12%
	OTB_15-<18_WB_SJæ	29%
	OTB_18-<24_KA_SJæ	14%
	OTB_24-<40_KA_SJæ	21%
	OTB_15-<18_WB_EJy	5%
	Others	19%

Table 1: distribution of herring catches by fleet and area in 2004. OTB : trawler; PSB : purse_seiners; ROW : rowing boats; KA_SJæ : Kattegat Sjælland+Fyn harbours; NS_VJy : North Sea Western Jylland harbours; SK_NJy : Skagerrak Northern Jylland harbours .

In 2004, most catches in Kattegat and Western Baltic were taken by the medium (24-40m) midwater trawlers from Zealand, while in the Skagerrak (such as in the North Sea) they are taken by three major fleets : the large (>40m) purse seiners from Northern Jutland, the medium midwater trawlers from Northern Jutland, and the large midwater trawlers from Western Jutland. It appears quite clearly that the fleets are well separated between the two geographical components of the catches: the fishermen from Kattegat do not fish in the Skagerrak, and the fishermen from Northern and Western Jutland do not fish in the Kattegat. Given the importance it might play about the catch share by stock, we considered the fleets from the North and the fleets from the south as two independent components.

Conversely, little evident distinction could be made between the spatio-temporal patterns of the fleets coming from North Sea harbours or the ones coming from Skagerrak harbours (figure 1), nor between the 24-40 m and the >40m vessels. Consequently, these fleets were pooled into two larger groups, the purse seiners and the trawlers. In the Southern part, the distinction between Kattegat and Baltic vessels was not clear enough, and furthermore the importance of Baltic vessels to the overall catches in IIIa is minor, and these fleets were pooled as well.

This distinction between two trawling fleets has been observed since the beginning of the time series, regardless whether the landings were large or small (figure 2). Little overlap have been observed in the Skagen rectangle at the limit between Skagerrak and Kattegat, and in the division 24, but there is however a clear separation of the landings of the two fleets.

As a result, the fleets used in the analysis are the following:

1 – **OTB_NSSK**: trawlers from North Sea and Skagerrak harbours (Skagen included). This fleet is referred to as the Northern fleet.
2 – **PSB_NSSK**: purse-seiners from North Sea and Skagerrak harbours.
3 – **OTB_KAWB**: trawlers from North Zealand and Western Baltic (div 22-24) harbours. This fleet is referred to as the Southern fleet
4 – **OTH**: all other vessels recorded for having caught herring in IIIa at least once a year. Given its low importance, this fleet is not kept further in the analysis.

Definition of fisheries and metiers

The HAWG has used the following definitions since 1998:

- **Fleet C**: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.
- **Fleet D**: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as by-catch. Danish and Swedish by-catches of herring from the sprat fishery and the Norway pout and blue-whiting fisheries are listed under fleet D.
- **Fleet F**: Landings from Subdivisions 22–24. Most of the catches are taken in a directed fishery for herring and some as by-catch in a directed sprat fishery.

These are referred to as fleets, but are actually corresponding to metiers according to our terminology. They make the separation between the fishery for human consumption, the industrial by-catch and the landings from division 22-24.

Here again, in the purpose of keeping the number of categories as low and tractable as possible, the fisheries identified in Ulrich and Andersen (2004) were modified accordingly, to get as much consistency with the previous WG work.
The following fisheries were thus used:
1 – **MTB_Her**: midwater trawling with mesh size >=32mm, targeting herring for human comsumption
2 – **MTB_Ind**: midwater industrial trawling with mesh size <32mm, having herring as bycatch
3 – **WB_all**: all trips in division 22-24
4 – **PS**: purse seining

The combination of fleets and fisheries are referred to as metier.

Time trends in activity of herring fleets in IIIa

Catches by metier

Maximum landings in IIIa were observed at the beginning of the time series, in 1993 (figures 3 and 4). The landings decreased widely from 1993 to 1997, mostly because of a decrease in industrial by-catches. They increased again afterwards, because of increasing landings in the division 22-24 for both the Northern and the Southern fleets. Since 2002 the landings have been decreasing again, and this is similarly due to the decrease in 22-24 for these same fleets. This indicates that the fleets share observed in 2004 on the previous table was not representative of the whole period, especially with regards to the activity in the area 22-24. In 2004, no catches in western Baltic were due to the Northern fleet, whereas this fleet has historically been observed there during the nineties.

On the opposite, the more traditional activities for human consumption in Kattegat and Skagerrak (midwater trawling and purse seining) remained fairly constant during the last decade.

These landings share by fleet and metier will be used in complement to the stock identification by area and period (Van Deurs et al., WD). The final result of this cross-analysis is the estimation of distinct selectivity patterns by fleet, metier, stock and length class, for a better management of the two stock units.

Dynamics of fleets

The following chapter has no direct implications for the assessment of herring stocks in IIIa, but is rather a step further in the description of fleet patterns, for a global understanding of their activity. We describe here the full activity of the vessels recorded as having fished herring in IIIa at least once, and investigate what is their yearly activity. The purpose of this analysis is in particular to investigate how dependent these fleets are on herring stocks, and what would be their potential changes in activity if conditions in herring resources, market or regulation were changing.

The figure 5 displays the time series of number of vessel by vessel length class, their average catches of herring in IIIa, and the proportion of effort they spent in the various metiers. The description of metiers was extended to all metiers exerced by the recorded vessels, and not only the ones happening in IIIa. The metiers were thus identified from the same gear description as above, plus the area code. Kattegat and Skagerrak were pooled in the IIIa metiers. The number of vessels by fleet has been slightly decreasing for the major pelagic fleets, while it has remained constant for the purse seiners. The Southern fleet is mostly composed by medium size vessels. However, most of the catches are taken by the relatively few large vessels (>=24m). Conversely, the Northern fleet includes a majority of large trawlers, but the difference of IIIa herring landings for the large vessel compared to the medium size vessel is minor. This difference in pattern can be explained by the fact that the incentives for having larger vessels in the Northern fleet are largely motived by other perspectives than the herring in IIIa, as most of their activity is about industrial trawling in the North Sea (see chapter 4.2). Similarly, the drop in average landings by vessel for the purse seiners after 1996 is likely related to the expansion of their activities to remote fishing waters beyond the North Sea (the “OTH” metier for this fleet corresponds mainly to remote activities).
For both the Northern and Southern pelagic trawler fleets, the herring-directed fishery for human consumption is a relatively minor activity, representing 10 to 20% of the total effort. The industrial activities are the major activities. The Northern fleet spends around 70% of its effort in the industrial activities, both in the North Sea and in IIIa. The Southern fleet has worked primarily as industrial trawling in IIIa and in the Western Baltic. It was not possible to identify “true” herring vessels, i.e. trawlers having herring trawling as main activity (strategy) over several years. This might be due to the seasonality of the herring fishery, as well as the restrictive management rules existing for this species.

Conclusion

All our analyses come to the same general dynamic of the Danish herring activities in IIIa:

- During the first half of the nineties, the activity was relatively local. The fleets were mostly fishing in their immediate waters. The pelagic trawling targeting herring for the human consumption was a minor but stable activity for the industrial fleets, and the industrial by-catches of herring were important

- The second half of the nineties was a period of extension. Both the Southern and Northern trawling fleets extended their activity to the Baltic, and decreased meanwhile their industrial activities in the Kattegat and Skagerrak, which induced reduced bycatches of herring. In the same period, the large purse seiners increased significantly their geographical mobility, with a majority of their effort being spent outside the traditional Danish fishing grounds in the North Sea and IIIa.
- Finally, since 2002 the patterns have shifted back to schemes comparable to the early nineties, with slightly increasing industrial activities and decreasing activities in the Baltic for the trawlers, and reduced remote activities for the purse seiners.

Some reasons could be a priori advocated for these observed dynamics. The expansion phase in the mid-nineties has been a general trend observed for most Danish towing fleets (Ulrich and Andersen, 2004), with considerable mobility between the North Sea and the Baltic Sea. This could be linked to both increasing restrictions of North Sea fishing activities and improved technology and communication tools, which gave fishermen higher information about local resource and market conditions. On the contrary, the reduced flexibility and mobility observed since 2002 could be due primarily to the new management system, where ITQ have been introduced since the 1st of January 2003. The first evaluations of this new regulation showed a significant adaptation of the pelagic fleet, with primarily a concentration of the herring fishery within fewer and larger vessels, and an increasing specialisation of the fleet, where some vessels exited from the herring fishery to become more exclusive industrial trawlers (Anon, 2005). We observed the same patterns in the analysis of strategies (figure not shown) Increasing fuel price since 2003 could also explain partly the reduced mobility of the large purse seiner fleet.

Further analysis should be necessary to investigate the significance of these effects, and the detailed processes of how ITQ have influenced the restructuring of the fleet. But we showed here, that beyond the interest of using fleet-disaggregated assessment models to encapture the major differences in selectivity and fishing pressure on the various sub-components of the herring stock in IIIa, an overall understanding of the main patterns driving the dynamics of the fleets is a useful information to anticipate, at least qualitatively, the expected effects of various management regulations.

Considerable misreporting is suspected to take place about herring catches in IIIa, and the HAWG usually apply some correction factors between IIIa and the North Sea. This issue could be advocated for preventing using fleet-based model, given the potential low reliability of log-books data. We acknowledge that some misreporting might exist, but we expect that this might only take place for the catches located at the edge between the North Sea and Skagerrak. Consequently, the patterns we observed for the different fleets might be wrong in terms of absolute quantities of catches, and should probably be modified to account for HAWG corrections. But we do not believe that the distinct geographical distributions between the Northern and Southern fleets might be biased due to misreporting, and we do not consider this issue as an obstacle for estimating relevant selectivity patterns by stock.

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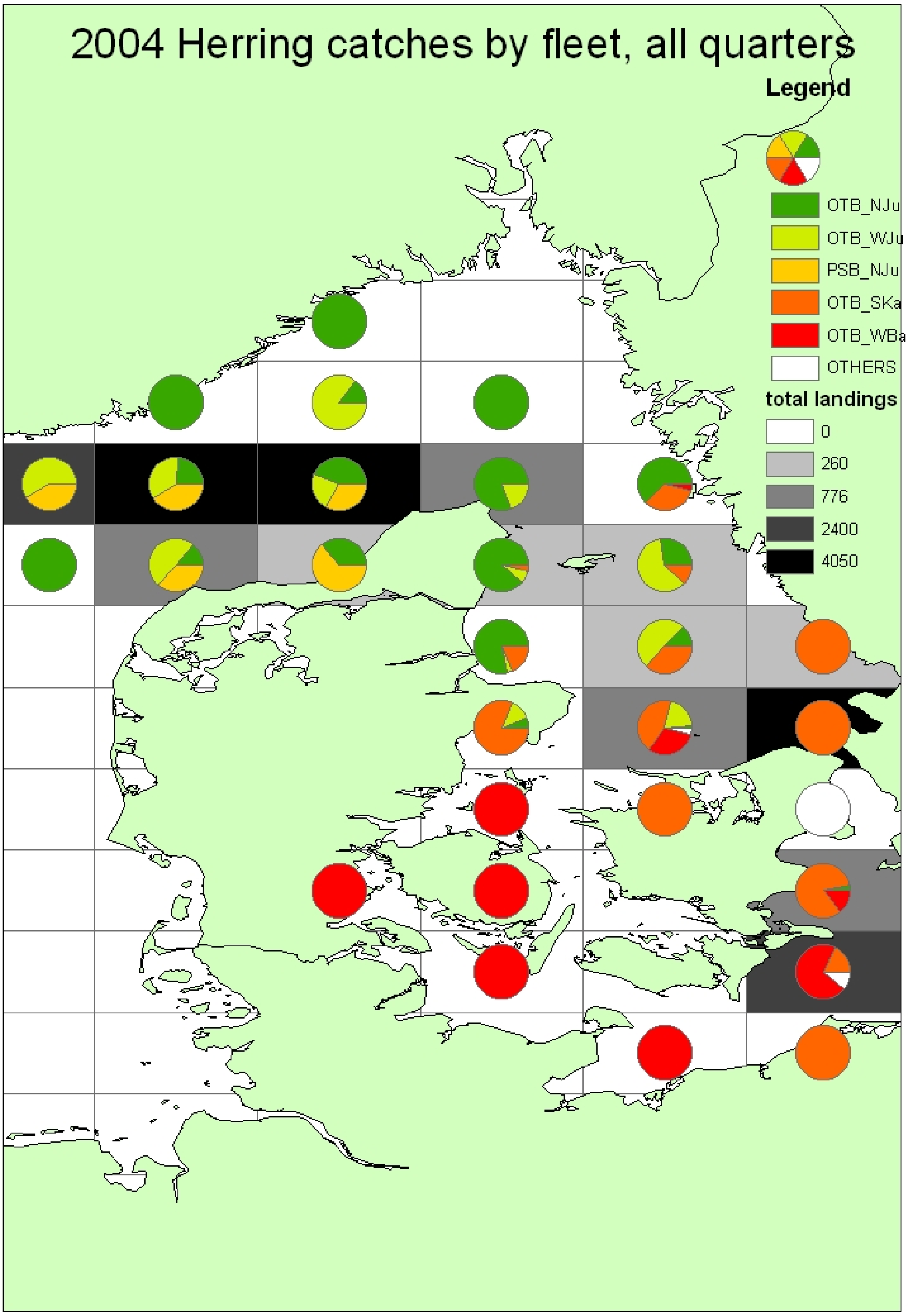

Figure 1 . Danish herring landings in IIIa by vessel type and homeport (fleet).

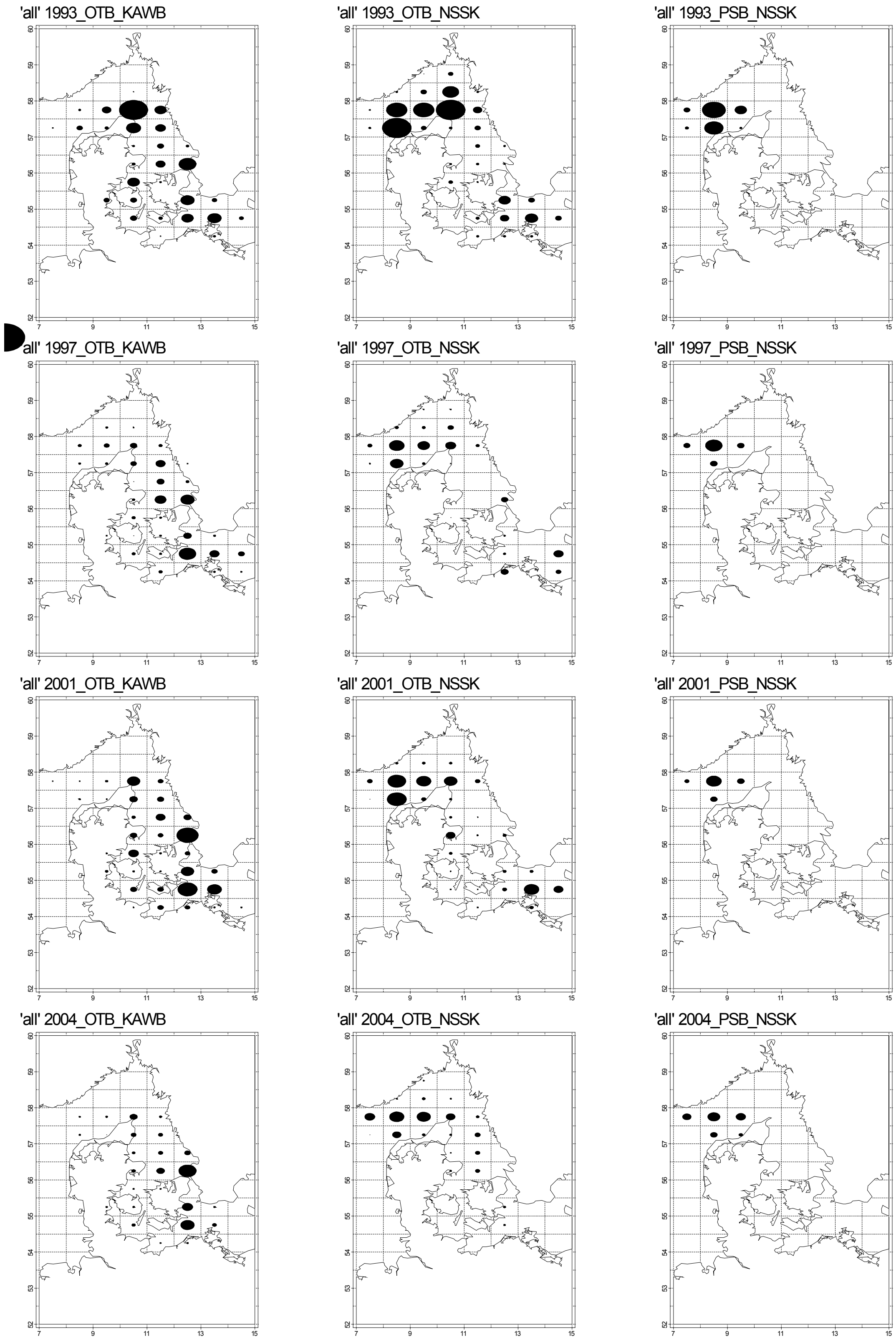

Figure 2 : Distribution of herring landings by fleet over selected years

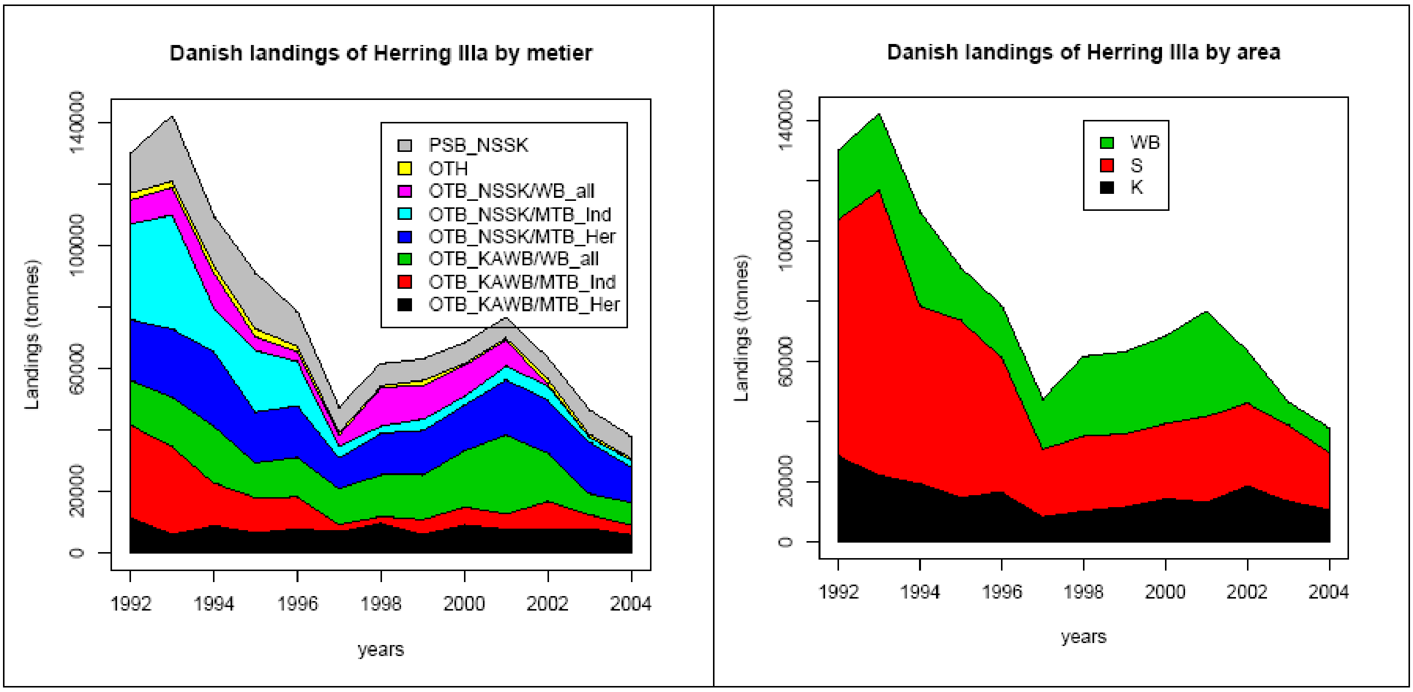

Figure 3. Distribution of Danish landings by fleet, metier and area, from 1992 to 2004.

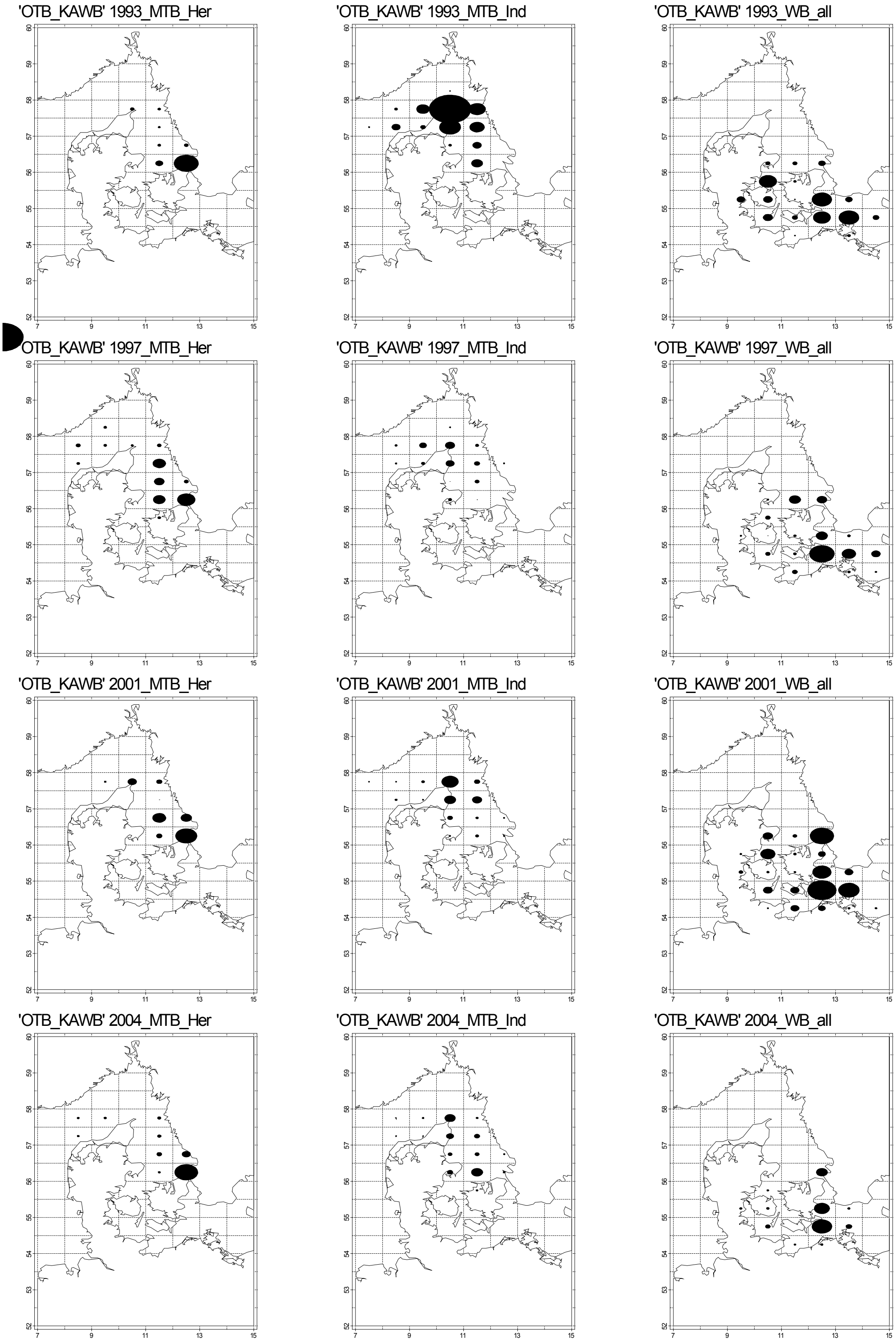

Figure 4a : Distribution of herring landings by metier for the Southern trawler fleet, over selected years

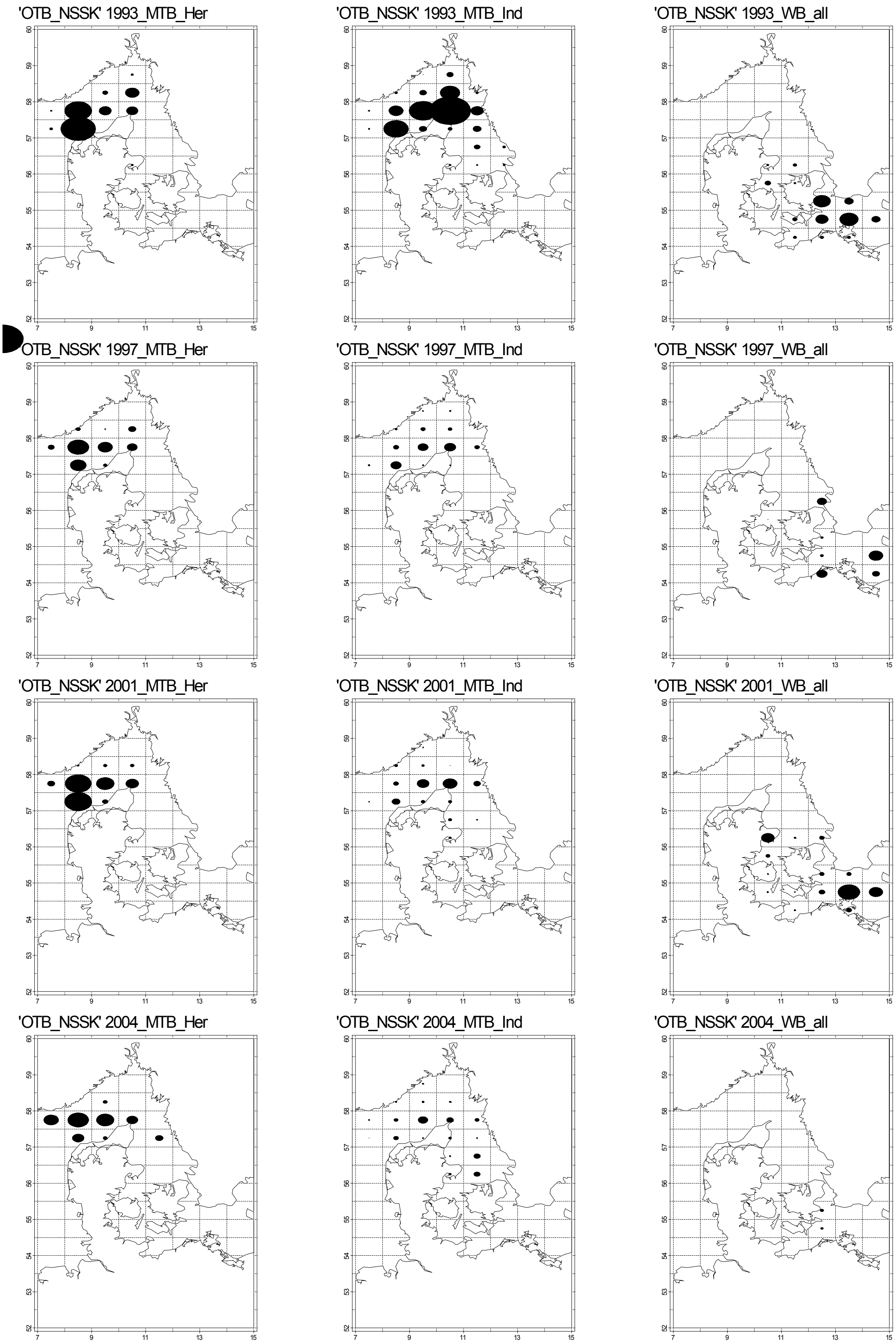

Figure 4b : Distribution of herring landings by metier for the Northern trawler fleet, over selected years. Figure 5a and 5b are at the same scale.

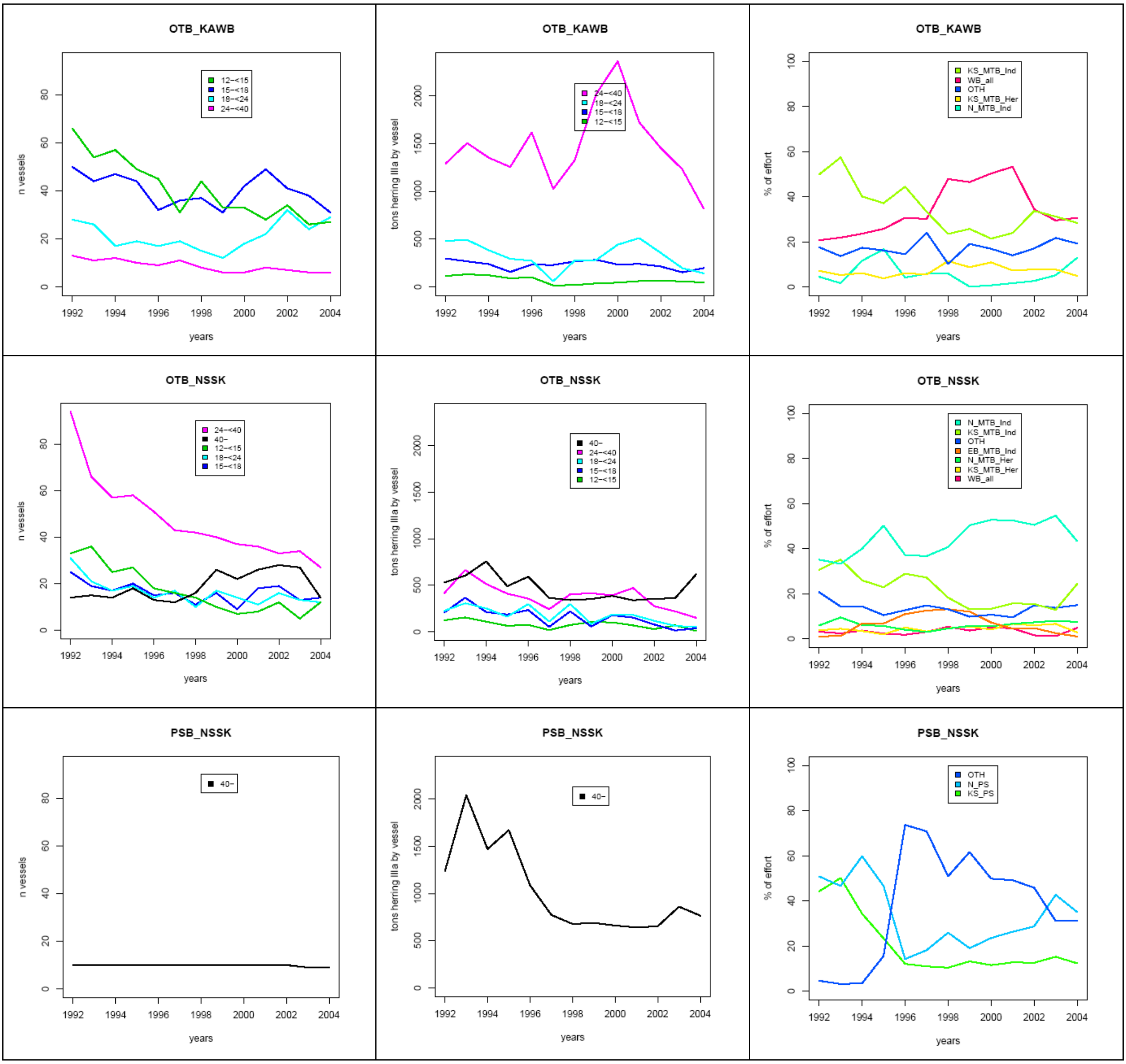

Figure 4. Number of vessels, average landings of IIIa herring by vessel and effort distribution by metier, by fleet between 1992 and 2004.