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Proposal for the stratification of the Baltic Sea for the Baltic International Trawl Survey

by

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Abstract

Different national demersal trawl surveys are carried out in different parts of the Baltic Sea since 1962. These national surveys of the different countries were planned regarding the special scientific interests of the institutes.
The results of these surveys were used to calculate indices of the year class strength of cod and other species. The estimated indices were used as tuning variables in the VPA, to assess the discards in the commercial fishery and the total mortality. Furthermore, these values were used as recruitment index, for estimating the food consumption of young cod,-for estimating the maturity ogive, and for quantifying the exchanges between both Baltic cod stocks.
The first attempts to co-ordinate the different national surveys were carried out 1985 and were continued in the following years with different intensity in the following years.
Besides the standardization of the gears used and the inter-calibrations between the national and the new standard gear a common survey design is necessary.
The development of the standard gears and the inter-calibrations of the gears were carried out by an EU funded study project.
The goal of the analyses presented is the optimization of the relationship between the possible amount for the surveys (vessel days, man power, . ..) and the accuracy of the estimated indices. Using the available data from the BITS database the variance structures of the CPUE (catch per hour) were analysed in the different sub-divisions. The aim of the analyses was to find parameters which are correlated with the species density and the variance structure of the CPUE. These results are the basis for the development of the stratified survey design with the goal: the optimization of the relationship between the possible amount for the surveys (vessel days, man power, . ..) and the accuracy of the estimated indices.

Key words: Baltic Sea, demersal trawl survey, survey design

Introduction

Different national demersal trawl surveys are carried out in different parts of the Baltic Sea since 1962 (Schulz 1978, Netzel 1979, 1992, Bagge & Steffensen 1984). These national surveys of the different countries were planed regarding the special scientific interests of the institutes.
Hovgård (1997) presented a summary of the status of the national bottom trawl surveys in the central Baltic (ICES Subdivision 25 – 32) for the periods January to April and October to December as well as for the western Baltic Sea. The different national surveys are heterogeneously distributed in space and time.
The results of these surveys were used for calculating indices of the year class strength of cod and other species. The estimated indices were used as tuning variables in the VPA (ICES assessment working group, Schulz & Vaske 1984), to estimate the discards in the commercial fishery (Schulz & Berner 1981, Bagge 1989), the total mortality (Bagge & Steffensen 1984), as recruitment index (Munch-Petersen & Bay 1991, Anon. 1998, Köster et al. 1999, Oeberst & Bleil 1999, 2000), to estimate the food consumption of young cod (Kowalewska-Pahlke 1994), to estimate the maturity ogive (Tomkiewicz et al 1997), and to quantify the exchanges between both Baltic cod stocks (Oeberst 1999, 2000).
Since the national surveys have a very heterogeneous distribution in space, time and gears used Sparholt & Tomkiewicz (1998) developed a robust method of compiling trawl survey data for the use in the central Baltic cod stock assessment. Pennington & Strømme (1998) compared the estimates from surveys and from the VPA for different stocks and pointed out that the surveys produce more robust estimations of the present status of the stock than complex structural models. For this method they estimated the fishing power of the different combinations of vessel and gear and used these values as correction factors.
The first attempts to co-ordinate the different national surveys were carried out 1985 (ICES 1985) and were continued in the following years with different intensity (ICES 1986, ICES 1988, ICES 1991, ICES 1992, ICES 1993).
A working group for the Baltic International Fisheries Survey was established by the ICES in 1996. The aim of this group was to develop an international co-ordinated bottom trawl survey in the Baltic Sea (ICES 1996). As most suitable periods for estimating unbiased VPA independent year class indices the periods from 15 February to 25 March and from 1 November to 30 November were laid down during the WGBIFS meeting in Tallinn 1999 (ICES 1999b). During the WGBIFS meeting in Copenhagen 2000 it was furthermore laid down that the main goal of the demersal trawl surveys is the estimation of the total cod stock (all age groups). The flatfishes should also be include in the analyses but with a lower priority.
Since the density structures of both periods can be different it seems to be necessary to develop for each survey time a special design. During the spring survey the variability of the CPUE-values is essentially influenced by the age group 1 of the Belt Sea cod and the age group 2 of the central Baltic cod stock. The distribution pattern of the Belt Sea cod especially is very variable. A larger part of this stock emigrate during the autumn and winter in the eastern direction and enter the Bornholm Sea. The situation during the autumn is different. The largest portion of the age group 0 of the Belt Sea cod stay in ICES Subdivision 22 and 24.
Besides these differences in the density distribution the hydrographical conditions of both periods are different.
As part of the preparation of the international trawl survey new standard gears were designed (ICES 1997b). In the previous years inter-calibrations were carried out between the standard gears and the former used national gears.
In a further step a common design of the international survey is to be developed. The survey is planned as a stratified random survey of the whole Baltic Sea. It was agreed that the ICES sub-

divisions should be used as sample unit because these sub-divisions are used as a basis for different estimations and the stock structure is different in the sub-divisions. Furthermore, the hydrographical conditions of the sub-divisions, an essential factor which influences the distribution pattern of the cods, are different in most years.

During the meeting of the BITS working group (ICES 1998a) it was proposed as a first suggestion that the number of haul per sub-division should be calculated as the first approach by the product of 4 and number of rectangles. For the different sub-divisions the proposed data are presented in Table 1. In this case the number of stations in each sub-division was chosen proportional to the area of the sub-divisions. Furthermore, it was agreed that the international demersal trawl survey should cover the ICES Subdivisions 2 l – 28 to get indices of all cod age groups and additionally estimates of the flatfishes.

Different analyses were carried out regarding the optimization of a stratified random sample. Cochran (1977) pointed out that any stratification of samples is useful if a heterogeneous population can be separated into different homogeneous strata. The aim is to increase the accuracy of the means of the population. If the strata are homogeneous, that means that the values within the strata vary only in a small range, the mean of the strata can be estimated using a small sample.

The aim of the stratification is not the estimation of another mean. This value is independent of the stratification. The aim is the increase of the accuracy by the decrease in the standard deviation and the confidence interval.

From the equations of stratified samples it follows that it is not useful to stratify areas with low changes of the variance. If the distribution of the targets is nearly homogeneous in the whole area a stratification of the area in different parts produces a small increase of the variance and of the confidence interval.

Cochran (1977) showed that only a slight increase in precision can be achieved if the number of strata is essential larger than 6. Pennington & Grosslein (1978) analysed the accuracy of abundance indices based on stratified random trawl surveys. Pennigton (1996) showed furthermore, that a stratification scheme for a survey should have at least 30-40 stations in each stratum. Pennigton & Vølstad (199 1) analysed the optimum size of sampling units for trawl surveys. Pennigton & Strømme (1998) pointed out that: “It has been frequently observed that predictions and short-term forecasts based on complicated structural models are generally less accurate than those generated by simpler models . ..“. Comparable results were found by Korsbrekke et al. (1999) for acoustic and bottom trawl surveys.

For the German surveys in the ICES Subdivisions 22, 24 and 25 extensive statistical analyses were carried out (Schulz & Vaske 1988, Hinrichs et al. 1991). They found a correlation between the water depth and the density of cod and herring in the Arkona Sea and suggested stratification of this area by 10 m depth layers. The highest densities of cod were observed in areas with a water depth of more than 30 m in the Arkona Basin. They showed that the estimations, based on the 10 m depth layers, produced a higher accuracy of the year class indices. Schulz & Vaske (1988) proposed that a large portion of the possible stations (about 50%) must be carried out in the areas with a water depth of more than 40 m, if the log normal transformed catch in number is used as a database.

Using the method of Taylor (196 1) it was further analysed if the log normal transformation of the data is suited to reduce the influence of single extreme values.

The log normal transformation of the non zero survey data and the delta-distribution are very useful models to get more effective estimates for marine highly skewed data (Aitchison & Brown 1957, Smith 1988, McConnaughey & Conquest 1993, Pennigton 1996).

All these analyses show the necessity of a common survey design for the different sub-divisions of the planned international co-ordinated trawl survey for optimizing the relationship between the necessary effort of vessel time and the accuracy of the estimations.

During several meetings of the WGBIFS (ICES 2000) the following methods of stratification were discussed. The use of a random sample was rejected since the depth structure, as well as the hydrographical conditions are very different in the western and eastern parts of the Baltic Sea. The use of ICES rectangles or depth layers was proposed. In these cases the ICES subdivisions should be the first level of stratification. Also discussed was the method of an adaptive survey design. However, because the international co-ordinated survey is to install in the future and many problems of its organization are to solve in the next time, too, this method was not preferred. Such a method can be used later if the surveys are established as routine. Using the available data from the BITS database the variance structures of the CPUE (catch per hour) were analysed in the different sub-divisions. The aim of the analyses was to find parameters which are correlated with the species density and the variance structure of the CPUE. These results are the basis for the development of the stratified survey design with the goal: the optimization of the relationship between the possible amount for the surveys (vessel days, man power, . . .) and the accuracy of the estimated indices.

Material and Methods

Data from the BITS database were used for the analyses. The data were used as CPUE-values. For the German data the catch per half hour was used. For the catch of all other countries the catch per hour was used. The CPUE-values are available for 1 cm length intervals. The database includes values from the countries Denmark, Germany, Latvia, Poland, Russia and Sweden. All these countries used different vessels and gears
Figure 1 shows the southern part of the Baltic Sea with the 40 m depth line and the stations of the 1th quarter (mostly March) in 1997. Figure 2 presents the stations of the 4th quarter in 1997. Comparable densities of stations were realized in the 1th as well as in the 4th quarter between 1995 and 1998. The figures illustrate the very different number of trawl stations in both periods in the past.
The numbers of stations for ICES sub-divisions, years and countries are given in Table 2 for the period from 1995 to 1999, for ICES subdivisions and countries. This period was used since for this time interval a relative constant distribution structure of the stations exists.
For combining the values of the different vessels and gears correction factors are necessary. The CPUE values of the central Baltic Sea were already used by Sparholt & Tomkiewicz (1988) to estimate the fishing power of the different research vessels and furthermore, for estimating the year class indices. For this procedure the data were stratified for 20 m depth layers in the area of the eastern Baltic cod stock (SD 25 – 32). The fishing power as used in this analysis is given in ICES (1998b). The values are also presented in Table 3.
For many stations the water depth was available. Additionally, hydrographical data (salinity and temperature close to the bottom) from the same position as the trawl station were available for some German surveys. Additional data were available from the ICES hydrographical database. Besides these point data the reports of the Institute of Baltic Research, in Warnemünde were used. These reports of the routine cruises describe the vertical stratification of the temperature, of the salinity and of the oxygen content.
Besides the variance of the CPUE values the areas of the different strata used are necessary for estimating the optimal number of stations per strata. For this estimation the data of the Manual for the Baltic International Demersal Trawl Survey (Version 2.0, ICES 1999b) were used.
For the analyses the frequencies for 5 cm length intervals were used (10 – 14 cm, 15 – 19 cm,) for evaluating possible differences of the distribution patterns of cod regarding the hydrographical parameters. These length ranges were also chosen because it can be expected

the variability of the CPUE-values can be different for smaller and larger cods. The consideration of the length is therefore important, too, because the year class strengths of the cod stocks varied considerably in the previous years.

During the analyses the following steps were carried out:

a) Analyses of the distribution pattern of the CPUE-values with different methods
b) Analyses of possible correlations between the CPUE-values and different hydrographical parameters
c) Analyses of the structure of the variance of the CPUE-values
d) Comparison of different stratification schemes
e) Estimation of the optimal distribution pattern of the available number of stations

The analyses were carried out with the software Statgraphics (1996). Furthermore, special EXCEL spreadsheets were developed.

Results

Since the depth structure of the Baltic Sea is very different as shown in Figure 1 and the hydrographical conditions are very different the ICES subdivisions are used as a first level of stratification of the Baltic Sea. For these subdivisions it is to analyse if further stratification is necessary as used in the past. Therefore, the analyses were carried out for the subdivisions separately. Furthermore, the analyses are concentrated on the German data from the ICES Subdivisions 22 and 24 because these surveys covered the subdivisions investigated intensively and additional to the CPUE-values some hydrographical data were available which were sampled close to the position of the hauls.

Analysis of the distributions structure of the CPUE-values

Schulz & Vaske (1988) analysed the distribution pattern of the CPUE-values, the catch per half hour, which were observed in the Arkona Sea, using the method of Taylor (1961). This method estimates the regression

$$S^2 = a\,\overline{X}^b$$

The parameter b is then used for evaluating the distribution pattern of the stochastic variable. If the b-value estimated is close to 2 it would be assumed that the variable is log normal distributed. For the catch in number of cod Schulz & Vaske (1988) assessed a b-value of 1.74 and concluded that the log-transformation of the CPUE-values can be used for reducing the influence of extreme high catches.
Using the data from 1995 to 1999 a b-value of 1.76 was estimated for the November surveys. For the February surveys from 1996 to 1999 the b-value of the Taylor regression was 1.8. In both cases the CPUE-values for the total length range and all stations were used. However, if the analysis is carried out for different length ranges the b-values varied considerably. Table 4 presents the b-values of Taylor's analysis for the length ranges from 10 cm to 29 cm, as well as from 30 cm to 60 cm for the November and February surveys in the Arkona Sea. The values varied between 1.4 and 1.8 and suggest that the density distributions of the CPUE-values are not equal for the length ranges and the different survey periods. It can be concluded that the log normal distribution is not suitable for the description of the CPUE-values in all cases. Comparisons between the distribution of the CPUE-values and different theoretical distribution functions suggested that

a) either the CPU&values of the different length ranges and depth strata are influenced by patchiness or

b) the CPUE-values are correlated with co-variables.

Since the difference from the log-normal distribution and the normal distribution were significant regression analyses were carried out for evaluating possible influences of the parameters depth, the temperature and the salinity.

Spring surveys

During the demersal trawl surveys in the Arkona Sea and Bornholm Sea in February 1996 and 1999 hydrographical stations were carried out using a CTD-memory probe. After most hauls a TS-profile was sampled with one data set per meter. Some data were also sampled during the November surveys. The analyses of possible relationships between the CPUE-values and hydrographical parameters showed that the influence of the salinity was not significant. The major factor which determines the distribution pattern of the cods is the temperature. The highest concentrations of cod were observed in the warmest water.

Figure 3 presents the hydrographical observations for the February surveys in the Arkona Sea in 1996 (*) and in 1999 (0) together. The figure illustrates the significant influence of the temperature. Table 5 shows the parameters of the non linear regression analyses. The square-root-y model was determined as the most suitable model. The figure illustrates that the temperature distribution was very different in both years. In 1996 the temperature varied between –0.5°C and 3.5°C. Warmer conditions with a temperature range from 1.7°C to 4.1°C could be observed in 1999. The analyses showed that in both years the same regression model was the most suitable description of the relationship. The slopes of both years were comparable. The intercepts of both regressions were different.

The figure additionally shows that the fish density distribution was different in the years analysed. In 1996, the year with the lower temperature, the higher densities were found. This result is significantly influenced by a single value.

A multiple regression model which includes besides the temperature also the year as an indirect description of the different density distributions produced the following results for the CPUE-values of the length range from 20 cm to 49 cm.

$$CPUE = 164814 - 82.541 * Year + 101.24 * Temperature$$

Based on 54 data sets a coefficient of determination of B = 69.2% was estimated. The inclusion of the length range from 10 cm to 19 cm did not modify the result significantly.

The results of these analyses led assume that also in the other years the distribution of the cod is influenced by the temperature significantly.

The relationship between the CPUE-values and the water depth varies, too, since the vertical distribution of the temperature varies from year to year during the demersal trawl surveys, and since these profiles are mostly influenced by a thermocline. Figure 4 and 5 present the observations for the February surveys in 1996 and 1999. The figures illustrate that the distribution of the temperature can be different in several years.

Figure 6 and 7 combine the CPUE-values with the water depth for the February surveys in 1996 and 1999. The highest concentrations of cod were observed in the deepest area of the Arkona Sea. In this area the temperature was significantly higher than in the area with a water depth of less than about 40 m. In contrast to this the highest concentrations of cod were observed in the area with a depth between 40 m and 48 m. The density decreased again in the deeper area. This structure corresponds with the changes of the temperature in Figure 5.

The presented analyses illustrate the significant influence of the temperature regarding the distribution pattern of the cod density in the Arkona Sea during the February surveys.

Figure 8 and 9 additionally show the relationship between the CPUE-values and the depth during the February surveys in 1997 and 1998. For these surveys only a low number of hydrographical data could be sampled. These figures demonstrate, too, that the depth with the highest cod density can vary considerably between the depth of 30 m and the deepest area of the Arkona Sea.

The observations regarding the different distributions of the temperature are supported by the results of the routine cruises of the Institute of Baltic Research in Warnemünde. Beginning of February and end of March monitoring cruises are carried out by this institute in most parts of the Baltic Sea. (Nehring et al. 1995, 1996, Matthaus et al 1997, 1998, 1999, 2000). The reports show the high variability of the hydrographical situations during spring. However, in contrast to variability of temperature distribution in the deeper water a relative homogeneous and could surface layer was observed until a water depth of more than 30 m every year.

Since the standard deviation in combination with the area of the select strata is the basis for estimating the optimal distribution of the planed stations the distribution patterns of the CPUE-values for 10 m depth layers and 10 cm length intervals were assessed. The intervals of IO m depth layers were chosen because this stratification scheme was used in the past (Schulz & Vaske 1988). The parameters number of observations, the mean CPUE-values and the standard deviation were given. Additionally the parameters for the length ranges from 20 cm to 60 cm as well as from 10 cm to 60 cm are given. The parameters are shown in Table 6. I to 6.4 for the February surveys in the Arkona Sea between 1996 and 1998.

The tables illustrate that the variability of the CPU&values of the total length ranges is influenced by smaller cods significantly. The highest CPUE-values were observed in the length position between 30 cm and 49 cm in 1996. In the following two years the highest CPUE-values were found in the length range between 10 cm and 29 cm.

Large differences can be observed for the standard deviations, too. In most cases high standard deviations were combined with high densities. Furthermore, the tables illustrate that the depth of the largest densities as well as the largest standard deviations varied between the years considerably, as shown in Figures 5 to 8.

Using the estimates of the standard deviation in combination with the area of the depth stratums the optimal distribution of the stations planed was estimated for the different years. Table 7 presents the estimates of the optimal number of stations for 10 m depth layers based on the German surveys. The table summarizes for the depth layers the area of the strata in nm^2, as well as the standard deviation of the CPUE-values and the portions of the optimal number of stations in percentage, n*(h). As a basis the CPUE-values of the length range from 10 cm to 69 cm were used. Additionally the means of the optimal number of stations, E(n*(h)) are given for depth layers. For the area of the depth layers the estimates of the Manual for the Baltic Fishery Survey (ICES 2000) were used.

For comparing the effects of the different optimal distributions of the stations planned the standard deviations of the stratified estimates were given, too, using the data of n*(h) of the actual year, S_a and using the mean estimates E(n*(h) for S_m. The difference between S_a and S_m was large in 1997 determined by the large densities of the small cods in the depth layer between 30 m and 40 m (Table 6.2)

Two variants exist for solving the problem of this high variability of the hydrographical conditions. The best way is the use of an adaptive survey design which use the actual hydrographical conditions for the planning. Another possibility is the use of any different stratification of the Arkona Sea. In Table 8 this proposal is presented. As strata the areas with a water depth of less than 30 m and with a water depth of more than 30 m were chosen. In all years the CPUE-values were low in the area with a water depth of less than 30 m. This is the reason that only a low portion of the planed stations is necessary in these strata. The highest portion of the planed station must be realized in the area with a water depth of more than 30

m. The small differences between the standard deviations S_a and S_m show that this stratification produces comparable distribution patterns of the portions of stations in all years. As it was expected the standard deviations of this stratification were higher in some years in comparison to the results of Table 7. However, the second proposal is more suitable for the first phase of the international co-ordinated survey. These results demonstrate again that an adaptive design is a more suitable version of the survey design for taking into account the high variability of the hydrographical situation.

German Spring surveys in the Bornholm Sea

Hydrographical data were sampled during the spring surveys in the Bornholm Sea in 1996 and in 1999. In both years strong stratification of the water column could be observed. Figure IO presents the relationship between temperature and salinity for both years. The figure documents the thermocline in the water depth of about 60 meters. Within a very small depth range the temperature increased from about 2°C to more than 6.6 °C in 1996 and from about 2°C to more than 6°C in 1999.

Figure 11 presents the relation ships between the temperature and the depth during the spring surveys in the Bomholm Sea in 1996 (*) and in 1999 (□). In both years the thermocline was observed in water depth of about 60 m. The description of the temperature pattern corresponds with the reports of the routine cruises of the Institute of Baltic Research in Warnemünde. In the Bomholm Sea the relative homogeneous and cold surface layer was observed until a water depth of more than 50 m. Then the depth of thermocline follows. Comparable vertical distribution patterns were observed in the more eastern regions of the Baltic Sea, too.

The influence of the temperature regarding the distribution pattern of cod is different in the Bornholm Sea and probably in the more eastern areas of the Baltic Sea, too since the Bornholm Sea with a water depth of more than 60 m is significantly larger in comparison to the area with more the 45 m in the Arkona Sea.

The relationship between the CPUE-values and the water depth is described in Figure 12 for 10 cm length intervals of the years 1996 and 1999.

The figure illustrates two things. The highest CPUE values and the highest variability of the CPUE-values were observed for cods of the length range from 20 cm to 39 cm. These cods are concentrated in the depth range from 40 m to 70 m. These cods were concentrated in the area above and close to the thermocline. The highest concentrations of cod with a total length of more than 50 cm were found in the areas with a water depth of more than 70 m. These cods are concentrated in the depth of the thermocline and below the thermocline. The CPUE-values of the spring survey in the Bornholm Sea in 1998 showed comparable distribution patter for the cod of the different length intervals.

The observations regarding the relationship between the CPUE-values and the temperature can be summarized in a model as described in Figure 13. Cods with a total length of less than about 40 cm are concentrated in areas above and close to the thermocline. The highest concentrations of the cods with a total length of more than about 60 cm can be observed in areas below the thermocline.

The distribution patterns of the CPUE-values for the length range from 10 to 69 cm support the model of Figure 13. Table 9 summarizes the number of observations (N), the mean CPUE-values (E) and its standard deviations (S) for 10 m depth layers. The estimates for 1996, 1998 and 1999 are combined in one table. The highest mean CPUE-values can be observed in the area with a water depth between 50 m and 80 m.

Higher densities of cod were observed in water depth between 30 m and 40 m only in 1996. However, this high mean density was determined by a single station southern of Bornholm.

The distribution in the depth range varied from year to year influenced by the depth of the thermocline and the different densities of the length intervals.
Using the standard deviations and the area the depth layers the optimal distributions of the stations planed were estimated and were presented in Table 10. The table summarizes for the depth layers the area of the strata in nm^2, as well as the standard deviation of the CPUE-values and the portions of the optimal number of stations in percentage, n*(h). As a basis the CPUE-values of the length range from 10 cm to 69 cm were used. Additionally the means of the optimal number of stations for depth layers, E(n*(h)) are given.
The distributions of the stations for the different depth layers show that about 60% of the planed stations should be carried out in the depth range between 50 m and 80 m every year, The proportions change from year to year depending on the depth of the thermocline and the strength of the cods in the different length ranges. In the surface layer with could water the numbers of station proposed were smaller. In the area with a water depth of more than 80 m only about 10% of the planed stations should be carried out since in this area the largest cods are concentrated which occurred in the last years with low densities only. The distribution of cod can also be influenced by hydrogen sulphide as observed by the Institute of Baltic Research in Warnemunde in spring 1996.
Since the depth of the thermocline varied from year to year an alternative proposal for the stratification of the Bornholm Sea is presented in Table 11 .This stratification uses only three depth strata, the could surface layer until 50 m, the depth layer between 50 m and 80 m which includes the thermocline and the area with more than 80 m. The differences between the estimates of S_a and S_m are relative small. This result suggests that this stratification is an suitable proposal for a long-term survey design. However, the differences show furthermore that a adaptive survey design which bases on the actual hydrographical situation produces the estimates with the highest accuracy in the Bornholm Sea in spring.

International spring surveys in the ICES Subdivisions 25, 26 and 28

For these analyses the CPUE-values, catch per hour, of the surveys from Denmark, Latvia, Poland, Russia and Sweden were combined. The values of the different countries were corrected with the fishing power of the research vessels estimated by Sparholt & Tomkiewicz (1988). These values used are presented in Table 3.
Table 12 to 14 summarize the distribution parameters mean (E) and standard deviation (S) for ICES subdivisions and years. For each year both parameters are presented for depth layers. Additionally the number of stations (N) is shown. The parameters are presented for the length range from 10 cm to 69 cm.
The investigations of the Institute of Baltic Research in Warnemunde show that the vertical temperature structure was comparable in Subdivision 26 and 28 in spring. The surface layer with a temperature of less than 4°C were observed until a depth between 60 m and 70 m. The temperature of 4°C was situated between 75 m and 85 m. In this depth range the temperature increased until more than about 5°C. After this change a relative constant vertical structure of the temperature follows. In this deep water the temperature varied between 5°C and about 7°C from year to year depending on previous influxes. Hydroxide sulphide was observed in the Bornholm Sea in 1996 and in the Gotland below 100 m in February 1999. In contrast to this oxygen were observed until 250 m in spring 1995.
These results suggest in combination with the observations of the German surveys in the Bornholm Sea that the distribution patterns of cod in Subdivision 25, 26 and 28 are influenced by the hydrographical conditions significantly. The vertical temperature structures suggest in combination with the observed relationship between the temperature and the density

distribution of the different length ranges of cod furthermore, that the highest concentrations of cod can be expected in the depth range between about 50 and 90 m.
The use of the CPUE-values of the different national surveys can be leading to results their interpretation is complicated. Besides the different catchability of the different vessel-gear combinations the national surveys were partly carried out with large differences in area and time. An example should illustrate the situation. In 1996 the surveys were carried out in the Bornholm Sea by Poland and Sweden. Together 58 stations were realized in the different depth layers. The Polish survey covered in the southern part of the Bornholm Sea between 18 January and 23 January. The Swedish survey was carried out in the more northern part of the same area between 29 February and 11 March. Both, the areas and the periods of the surveys were different.
Since the changes of the hydrographical conditions can be fast influenced by different factors the combination of both data sets can produce estimates where the interpretation is difficult, too, if the CPUE-values were corrected by the estimates of the fishing power.

ICES Sub-division 25

Table 12 presents the distribution patterns of the CPUE-values for 10 m depth layers. Additional multiple variable analyses showed that in all years relative stable relationships existed between the CPUE-values of the different 10 cm length intervals. Significant positive relationships were found between the CPUE-values of the 10 cm length intervals between 30 cm and 69 cm. In some years significant positive correlations were also found between the length intervals of 10 cm and 20 cm. However, it must be pointed out that these results were strongly influenced by single stations with extreme high values.
The distribution of the CPUE-values of the 10 cm length intervals in relation to the depth showed comparable patterns as it was observed from the German data in SD 25.
The highest densities of the smaller cods were found in areas with water depth between 40 m and 60 m. The result showed that the smallest cod preferred the cold water above the thermocline. Larger cods were caught with higher densities between 50 m and 80 m. High CPUE-values were also found in the area with a water depth of more than 80 m. These different structures support the results of the German surveys in the same area.
Table 13 presents the area of the 10 m depth layers, the standard deviations of the CPUE-values and the estimated optimal distribution of the stations, n*(h), for the different years. Additionally the standard deviations of the stratified assessment are given. S_a presents the standard deviation if the optimal distribution of the station was used. S_m shows the standard deviation if the mean optimal distribution of the station was the basis. The estimates of n*(h) varied considerably for the different years. The largest changes from year to year were observed in the area with a water depth between 40 m and 49 m. These changes are the reason for the differences between the estimates of S_a and S_m.
Table 14 and 15 summarize the same estimates for the stratification scheme as used for the German data, too. Only three strata were used. Larger differences can be observed in the distribution pattern of the optimal station, n*(h). This large variability of the CPUE-values was not observed for the German data in the same area.
Since the estimates of Table 14 and 15 are influenced by the different vessels, gears and survey periods and since the results were comparable inn 1997 and 1998 it is proposed that the results of Table 11 should be the basis for the first international co-ordinated survey. However, an adaptive design should be used for producing the highest accuracy of the stock indices in the following years.

ICES Sub-division 26 and 28

Table 16 and 17 present the distribution parameter of the CPUE-values of Subdivision 26 and 28 for different years. The tables demonstrate that the distribution patterns of the stations were different during the surveys. Therefore, the use of these data for a survey design is difficult. The results of both subdivisions suggest that the generalized structure of the cod distribution was comparable with the results of Subdivision 25.
The largest densities were observed in the depth layers between 60 m and about 100 m. In some years larger concentrations were also found in water depth between 40 m and 49 m (Subdivision 26). The structure of the CPUE-values corresponds with the hydrographical situation in these subdivisions.
From these results it can be concluded that the model of Figure 13 can also be used for these areas. Furthermore, these results support the use of four depth layers with less than 50 m, between 50 m and 80 m, between 80 m and 120 m and more than 120 m. Since the data do not present the total depth range it is difficult to propose an optimal distribution of the stations planned. However, the results of the last years suggest that about 15% of the stations planed should be realized in the area with a water depth of less than 50 m. In the following layer about 65% of the stations planed should be carried out. In area with a water depth between 80 m and 120 m again 15% and in the deeper water about 5% of the stations planed should be carried out. The analyses also support the use of an adaptive model for the later surveys.

German autumn surveys in the Arkona Sea

Only few hydrographical stations were carried out during the German autumn trawl surveys in November. However, these few data and the reports of the Institute of Baltic Research in Warnemunde suggest that the influence of the temperature and the salinity regarding the distribution pattern of cod is low. Therefore, only the distribution patterns of the CPUE-values are presented in Table 18 for depth layers and years. The length range of cod is separated into the intervals from 10 cm to 19 cm and from 20 cm to 69 cm. This separation was carried out since the length range from 10 to 19 cm presents a large part of the age group 0 of the western Baltic cod stock. These individuals were spawned in Kiel Bay, in Mecklenburg Bay or in the Arkona Sea in spring.
The estimates of Table 18 show that the portion of the smallest cod of the total stock varied from year to year. The largest concentrations of the age group 0 were observed in the area with a depth between 30 m and 39 m. In shallower, as well as, in deeper water the densities were lower. The distribution of larger cod was more homogeneous
Using the total length range the optimal distributions of the station planed were estimated as given in Table 19. The estimated n*(h) of the different years varied considerably, influenced by the variability of the smallest cods.
Since the variability of the optimal stations is relative low in the area with a depth of less than 30 m the use of only two strata as proposed in Table 11 seems to be useful.

Discussion

The different national demersal trawl surveys have a long tradition. The results are the basis of different stock assessment methods. Pennington & Strømme (1998) pointed out that the results of trawl surveys are conservative estimates which are appropriate for the principle of the precautionary approach. They proposed the use of methods of time series analysis for improving the quality of the estimates of the trawl surveys. The length distributions of the German trawl surveys in the Baltic Sea were used for producing quantitative estimates of the exchange processes between both cod stocks in the Baltic Sea (Oeberst 1999).
The data of the German trawl surveys were analysed with statistical methods to optimize the survey design (Schulz & Vaske 1988). Since the stock structures changed in the previous years dramatically (ICES 1999c) it seems to be necessary to evaluate the current survey design. Furthermore, an international co-ordinated demersal trawl survey is in preparation which covers the whole Baltic in the spring and in November (ICES 2000). The different national surveys were carried out in different areas and different periods. The results are combined using estimates of the fishing power as correction factors. These corrected CPU&values were used for developing a survey design for all ICES subdivisions which should be covered normally.
The goal of the planed international surveys is the estimation of stock indices for both cod stocks and for flatfishes. Since the importance of the cod stocks is higher and the distributions pattern are different only the CPUE-values of the cod were used for optimizing the survey design.
The analyses were concentrated upon the spring surveys because the most national surveys were carried out in the first quarter, yet. The German CPUE-values in combination with the hydrographical parameters temperature and salinity showed that the distribution patterns of the cods are significantly influenced by the thermocline. From the observations the model if Figure R1 1 were derived which describes that the highest concentrations of smaller cod can be observed above the thermocline. In contrast to this the highest CPUE-values of larger cod were found within and below the thermocline. The analyses showed that the two factors

- the vertical temperature structure and
- the strength of the smaller cods

influence the distribution pattern of the CPUE-values significantly.
The structure of the CPUE-values in combination with the hydrographical conditions supports the use of stratification of the ICES subdivisions by depth layers. Both factors together produce a high variability of the optimal distribution of the stations planed if 10 m or 20 m depth layers are used. The high dynamic and the high variability of the hydrographical conditions especially make it difficult for developing an optimal survey design,
Two ways seems to be possible to solve this problem. The first way is the reduction of the number of strata. In this case the total area is separated in the parts

- the area with water depth above the thermocline (could water),
- the area with water depth where the thermocline can be observed with high probability and
- the area with water depth where relative homogeneous warm water occurs.

The optimal distribution of the station planed are given for the different strata in the several tables. Using this stratification the mean optimal distribution of the last years is comparable with the actual optimal distribution of the different years. A further consistency of this alternative stratification is the increase of the variance of the estimated indices.
In contrast to Schulz & Vaske (1988) the logarithmic transformation of the CPUE-values was not used. McConnaughey & Conquest (1993) compared the use of different estimators of the mean, They suggest according to Koch & Link (1970) that the arithmetic mean can be used if the coefficient of variation is less than 120. The analyses of the CPUE-values showed that in

most cases the CV-values were smaller than 120. Additionally, the results of the Taylor method (196 1) did not propose a logarithmic transformation of the CPUE-values.
Analyses showed furthermore, that the hypothesis can not reject that the CPUE-values are normal distributed if data were analyses with were caught on station with almost the same temperature. Since, however, the vertical temperature structure varies within the area of the ICES subdivisions and in contrast to this the CPUE-values were analysed for depth levels it can be that the distribution of the CPUE-values suggests a logarithmic normal distribution. The analyses showed furthermore the significant influence of the depth of the thermocline for the distribution patterns of the CPU&values and for the distribution of the station planed if 10 m or 20 m depth layers are used for the stratification. The alternative stratification schemes reduce this variability of the distribution of the station planed. Therefore, these schemes seem to be the best approach during the first surveys. The results also suggest that it is necessary to sample the hydrographical parameters temperature, salinity and oxygen after each haul close to the tow. Furthermore, yearly analyses of the data are necessary for assessing the influence of the hydrographical situation with higher accuracy.
A more effective survey design can be developed using the actual hydrographical situation and preliminary information regarding the strength of the recruitment for the adaptation of a more general design.
Since this method needs a lot of organization and a fast analyses of the current status of the situation this method seems to be not suitable during the first phase of the establishing the international co-ordinated trawl survey in the Baltic Sea

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Tables

Table Proposed number of stations in the different ICES Sub-divisions

SD	Number of squares	Number of hauls
21	6.5	26
22	5.5	22
23	1.5	6
24	7.5	30
25	14.0	56
26	11.5	46
27	5.5	22
28	9	36
total	61	244

Table 2: Number of stations for ICES subdivisions and by countries for the 1 .quarter and for the 4. quarter

		1. Quarter (March)						4. Quarter					
SD	Year	Denmark	Germany	Latvia	Poland	Russia	Sweden	Denmark	Germany	Latvia	Poland	Russia	Sweden
24	1995	14	31				10		31				
	1996	8	31				9		31				
	1997	8	31				8		31				
	1998	7	31				8		31				
	1999		31						31				
25	1995	34				15	21						10
	1996	25	32			14	25						10
	1997	28				30	21						2
	1998	33	32			32	22						9
	1999		32										
26	1995	15		2	32	44	3						3
	1996	16		8	57	57	4						4
	1997	9			39	46	4			10			
	1998	19			37	50	4						
	1999												
28	1995	5		31			13						8
	1996	6		21			12						3
	1997	5					12			10			3
	1998	5					11						11
	1999												

Table 3: Estimated fishing power by country based on survey data 1982 – 1998 including data from sub-divisions 25, 26 and 28

	AtlantNiro 1997-1998	Denmark	Former GDR	Germany	Latvia include Russia – up to 1996	Poland	Sweden GOV trawl	Sweden Foto
Fishing power	0.885	0.537	0.826	0.554	0.419	0.323	0.948	

Table 4: Estimates of the Taylor's b-value for the surveys in the Arkona Sea

Length range	Month	b-value
10 – 30 cm	November	1.4
	February	1.6
30 – 60 cm	November	1.6
	February	1.8

Table 5: Regression model and parameters for the non-linear regression between the CPUE-values and the temperature as well as the salinity for the February surveys in 1996 and 1999.

Year	model	Independent variable	Intercept	Slope	Number	Correlation coefficient
1996	Square-root-y	temperature	7.14	4.85	25	0.83
1999	Square-root-y	temperature	-3.16	4.52	31	0.72

Table 6.1: Parameters of the CPUE distributions number of stations (N), mean (E) and standard deviation (S) for 10cm length intervals and depth layers in the Arkona Sea February 1996

		L10		L20		L30		L40		L50		L60		L20-60		L10-60	
Depth	N	E	S	E	S	E	S	E	S	E	S	E	S	E	S	E	S
< 30	11	1.2	2.1	0.45	0.9	9.9	11.3	22.4	42.1	6.9	8.5	0.9	1.3	40.5	58.7	41.7	58.8
30 - 40	4	4.8	2.4	3.5	3.8	77.5	72.9	59.3	32.3	12.3	9.3	2.3	1.9	155	104	160	106
40 - 60	16	4.1	4.5	69.6	80.7	221	143	65.1	48.5	10.2	7.4	1.9	2.2	367	239	372	239
0 - 60	31													224	234	227	235

'able 6.2: Parameters of the CPUE distributions number of stations (N), mean (E) and standard deviation (S) for 10 cm length intervals and depth layers in the Arkona Sea February 1997

		L10		L20		L30		L40		L50		L60		L20-60		L10-60	
Depth	N	E	S	E	S	E	S	E	S	E	S	E	S	E	S	E	S
< 30	11	3.0	5.3	1.3	2.6	0.4	0.7	2.4	3.3	3.2	3.5	0.3	0.7	7.5	10.3	10.5	15.5
30 - 40	4	341	449	82.5	94.7	4.5	3.4	9.3	6.1	3.2	2.1	1.0	0.8	101	106	441	543
40 - 60	16	145	134	71.0	71.0	11.0	9.2	24.0	20.8	4.8	4.0	0.8	1.1	111	98.2	256	227
0 - 60	31													73	91.8	193	279

Table 6.3: Parameters of the CPUE distributions number of stations (N), mean (E) and standard deviation (S) for 10cm length intervals and depth layers in the Arkona Sea February 1998

		L10		L20		L30		L40		L50		L60		L20-60		L10-60	
Depth	N	E	S	E	S	E	S	E	S	E	S	E	S	E	S	E	S
< 30	11	10	12	3.7	5.6	6.7	13.6	4.3	6.1	0.4	0.5	0.2	0.4	15.3	21.7	25.3	33.0
30 - 40	4	339	247	224	149	54.0	42.7	13.7	7.2	0.7	0.6	0	0	298	182	681	424
40 - 60	16	222	327	187	225	74.7	56.8	14.4	8.8	1.2	1.1	0.2	0.4	228	224	500	536
0 - 60	31													189	212	354	497

Table 6.4: Parameters of the CPUE distributions number of stations (N), mean (E) and standard deviation (S) for 10cm length intervals and depth layers in the Arkona Sea February 1999

		L10		L20		L30		L40		L50		L60		L20-60		L10-60	
Depth	N	E	S	E	S	E	S	E	S	E	S	E	S	E	S	E	S
< 30	11	1.4	1.2	1.9	3.2	15.4	19.9	9.8	13.6	1.3	1.5	0.1	0.3	28.5	30.8	29.8	31.1
30 - 40	4	17	15	25.8	21.9	59.3	38.1	4.8	2.8	1.3	1.3	0.5	0.6	91.5	50.8	108	40.1
40 - 60	16	24	26	56.8	39.7	67	56.4	13.8	12.1	2.3	1.7	0.4	0.5	140	103	164	121
0 - 60	31													94.3	92.7	109	108

Table R7: Estimated optimum number of stations (n(h)* in percent) for February survey in the Arkona Sea

		1996		1997		1998		1999		Mean
depth layer	area in nm²	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
20 - 29	1091.3	58.8	13	15.5	2	33.0	3	31.1	14	8
30 - 39	621.4	105.9	13	543.1	48	424.0	23	40.1	10	24
40 -	1549.1	239.1	74	227.1	50	535.8	74	120.5	76	68
S_a		235		469		1166		57		
S_m		254		626		1204		54		

Table R8: Estimated optimum number of stations (n(h)* in percentage) for February survey in the Arkona Sea – alternative design

		1996		1997		1998		1999		Mean
depth layer	area in nm²	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
< 30	1091,	58,8	11	15,5	2	33,0	3	31,1	12	7
> 30	2170,	233,4	89	305,0	98	510,5	97	110,7	88	93
S_a		306		433		1230		71		
S_m		313		448		1262		73		

Table 9: Parameters of the CPUE distributions number of observations (N), mean (E) and standard deviation (S) for the length interval from 10 cm to 69 cm and for depth layers during the Bornholm Sea February in 1996, 1998 and 1999

		1996		1998		1999	
Depth (d)	N	E	S	E	S	E	S
d < 30	7	39.3	24.6	46.4	75.9	2.4	5.2
30≤d<40	2	134.0	175.4	0.0	0.0	1.5	0.7
40≤d<50	2	79.0	104.7	29.0	8.5	75.0	75.0
50≤d<60	5	374.4	456.3	137.6	178.0	252.2	149.1
60≤d<70	5	255.4	241.9	196.4	138.5	104.2	97.9
70≤d<80	6	149.3	125.7	89.0	127.0	76.2	106.9
80≤d	5	71.6	98.2	9.6	20.9	82.0	91.7
d<100	32	161.0	232.0	82.4	121.3	90.9	118.3

Table 10: Estimated optimum number of stations (n(h)* in percent) for February survey in the Bornholm Sea

		1996		1998		1999		Mean
depth layer	area in nm²	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
20 - 29	1324.6	24.6	2	75.9	12	5.2	1	5
30 - 39	2096.5	175.4	19	0	0	0.7	0	6
40 - 49	1749.4	104.7	9	8.5	2	75	16	9
50 - 59	1504.4	456.3	35	178	33	149.1	28	32
60 - 69	1531.6	241.9	19	138.5	26	97.9	19	21
70 - 79	1505.4	125.7	10	127	23	106.9	20	18
80 -	1460.8	98.2	7	20.9	4	91.7	17	9
S_a			312		54		52	
S_m			409		69		64	

Table 11: Estimated optimum number of stations (n(h)* in percentage) for February survey in the Bornholm Sea – alternative design

		1996		1998		1999		Mean
depth layer	area in nm²	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
< 50	5170.5	104.7	52	61.7	32	38.0	21	35
50 – 79	4531.4	77.4	34	145.0	65	136.2	65	55
> 80	1461.8	98.2	14	20.9	3	91.7	14	10
S_a			86		81		72	
S_m			100		87		79	

Table 12: Distribution parameters number of observation (n), mean (E) and standard deviation (S) of the CPUE-values, catch per hour, for depth layers in Sub-division 25 - cod

Year	1994			1995			1996			1997			1998		
Depth	N	E	S	N	E	S	N	E	S	N	E	S	N	E	S
20 - 39	0			4	241.0	455.4	2	352.0	497.8	8	4.8	6.0	8	140.6	272.3
40 - 49	6	358.5	704.3	5	1431.8	2954.3	6	932.8	1240.0	9	134.7	214.3	12	503.4	1604.4
50 - 59	4	485.0	437.4	5	422.0	308.3	11	247.1	281.8	14	309.1	439.4	13	334.9	426.6
60 - 69	5	436.0	489.8	6	619.5	295.7	12	1008.7	662.2	20	219.0	248.2	23	243.3	342.5
70 - 79	5	465.4	677.7	10	343.2	498.4	14	305.9	360.1	15	197.8	271.6	20	195.6	280.0
80 -	5	883.8	843.1	6	193.0	283.6	14	130.1	196.1	11	41.0	81.0	9	257.8	422.5

Table 13: Estimated optimum number of stations (n(h)* in percent) for February survey in the Bornholm Sea using international data

		1994		1995		1996		1997		1998		Mean
depth layer	area in nm²	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
20 - 39	3421.1	0	0	455.4	18	497.8	28	6.0	1	272.0	16	13
40 - 49	1749.4	704.3	25	2954.3	59	1240	36	214.3	19	1604	47	37
50 - 59	1504.4	437.4	13	308.3	5	218.8	5	439.4	34	427.0	11	14
60 - 69	1531.6	489.8	15	295.7	5	622.2	17	248.2	19	343.0	9	13
70 - 79	1505.4	677.7	21	498.4	9	360.1	9	271.6	21	280.0	7	13
80 -	1460.8	843.1	25	283.6	5	196.1	5	81.0	6	423.0	10	10
S_a			1921		6220		2925		309		2831	
S			2750		8037		3803		486		3068	

Table 14: Distribution parameters number of observation (n), mean (E) and standard deviation (S) of the CPUE-values, catch per hour, for depth layers in Sub-division 25 - cod

Year	1994			1995			1996			1997			1998		
Depth	N	E	S	N	E	S	N	E	S	N	E	S	N	E	S
< 50	9	433.0	671.6	9	951.0	2319	8	795.1	1102	17	74.6	166.1	20	375.8	1309
50 – 79	15	618.0	755.2	21	463.9	429.5	37	532.8	581.3	49	246.4	326.7	57	353.3	807.0
> 80	5	883.8	843.1	6	193.0	283.6	14	130.1	196.1	11	41.0	81.0	9	257.8	422.5

Table 15: Estimated optimum number of stations (n(h)* in percentage) for February survey in the Bornholm Sea – alternative design

		1994		1995		1996		1997		1998		Mean
depth layer	area in nm^2	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
< 50	5170.5	671.6	43	2319	84	1102	66	166.1	35	1309	14	48
50 – 79	4531.4	755.2	42	429.5	14	581.3	31	326.7	60	807.0	74	44
> 80	1461.8	843.1	15	283.6	3	196.1	3	81.0	5	422.5	12	8
S_a			5300		16522		5957		489		1967	
S_m			5716		24796		6749		536		2907	

Table 16: Distribution parameters number of observation (n), mean (E) and standard deviation (S) of the CPUE-values, catch per hour, for depth layers in Sub-division 26 - cod

Year	1994			1995			1996			1997			1998		
Depth	N	E	S	N	E	S	N	E	S	N	E	S	N	E	S
20 - 39	16	188.3	518.2	7	108.5	151.8	12	3.0	4.8	9	6.0	7.9	9	18.4	47.0
40 - 49										6	56.8	90.8	6	93.8	182.8
50 - 59															
60 - 69							9	960.0	1174.2	8	285.9	317.6	7	451.4	437.2
70 - 79	7	286.6	159.3	7	1325.4	1897.9	12	3851.5	11548	8	316.5	377.3	12	144.3	123.3
80 - 99	13	131.0	169.7	8	149.0	264.4	24	1120.8	1408.9	15	405.8	507.3	18	248.6	328.6
100 -	5	211.2	244.8	4	25.0	22.0	10	195.8	197.4	5	242.4	226.4	5	34.2	31.4

Table 17: Distribution parameters number of observation (n), mean (E) and standard deviation (S) of the CPUE-values, catch per hour, for depth layers in Sub-division 28 - cod

Year	1994			1995			1996			1997			1998		
Depth	N	E	S	N	E	S	N	E	S	N	E	S	N	E	S
20 - 39															
40 - 49	4	11.0		5	61.8	87.7				4	415.5	820.3	3	357.3	332.6
50 - 59													2	56.5	71.4
60 - 69				2	354.0	497.8	3	41.0	51.2	6	169.8	334.3	10	146.2	273.6
70 - 79	3	30.7	4405	5	20.8	21.8	3	65.3	99.4	3	186.7	272.0	2	638.0	896.0
80 - 99	7	116.6	159.3	6	401.0	674.3	8	656.6	1189.8	10	119.4	137.3	8	5.9	8.0
100 -	4	3.0	4.8	4	10.0	8.2	4	35.4	43.1	6	5.0	8.9			

Table 18: Parameters of the CPUE distributions number of observations (N), mean (E) and standard deviation (S) for the length interval from 10 cm to 19 cm and from 20 cm to 69 cm for depth layers during the November Survey in the Arkona Sea in 1996, 1997 and 1998

Year		1996				1997				1998			
		10 cm – 19 cm		20 cm – 69 cm		10 cm – 19 cm		20 cm – 69 cm		10 cm – 19 cm		20 cm – 69 cm	
Depth	N	E	S	E	S	E	S	E	S	E	S	E	S
< 30	11	49.4	123.4	42.9	40.9	14.4	30.1	96.2	101.7	2.8	4.7	142.4	114.8
30 – 39	4	789.8	243.7	61.0	33.3	607.3	570.7	392.5	98.7	431.5	738.7	563.0	405.5
> 40	16	137.9	190.0	78.1	31.7	98.2	124.2	235.4	249.1	37.6	28.9	256.3	86.8

Table 19: Estimated optimum number of stations (n(h)* in percent) for November survey in the Arkona Sea

		1996		1997		1998		Mean
depth layer	area in nm²	stand. dev.	n*(h)	stand. dev.	n*(h)	stand. dev.	n*(h)	E(n*(h))
20 - 29	1091.3	142,5	25	120,1	12	116,2	13	17
30 - 39	621.4	237,5	24	631,9	37	1139,4	71	44
40 -	1549.1	200,5	52	349,8	51	103,5	16	39
S			354		1067		931	
S_m			413		1130		1222	

Figures

Figure 1: Southern part of the Baltic Sea an overview of the trawl stations in the   quarter 1997

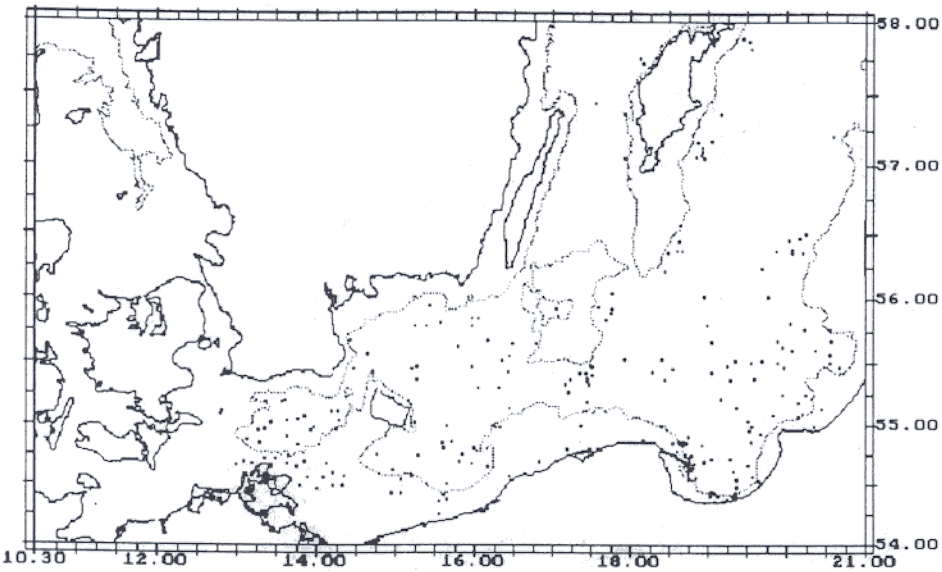

Figure 2: Overview of the trawl stations in the 4. quarter 1997

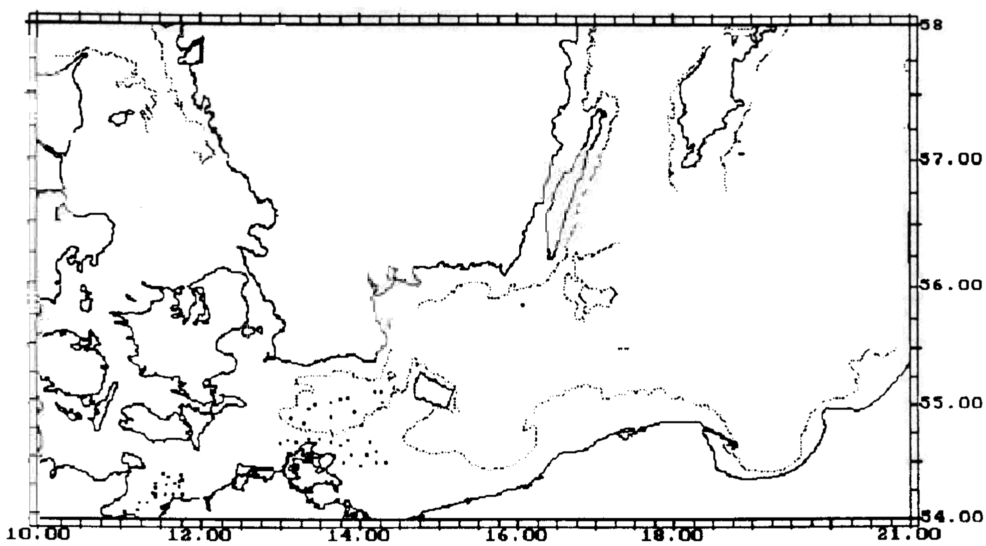

Figure 3: Relation between the CPUE-value in number and the temperature in °C close to the bottom during the German trawl survey in the Arkona Sea in 1996 (*) and in 1999 (□)

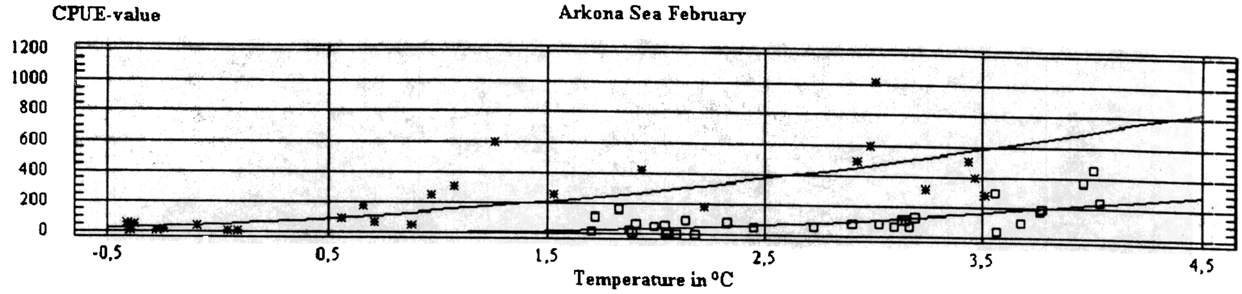

Figure 4: Relation between depth and temperature close to the bottom during the German trawl survey in the Arkona Sea 1996

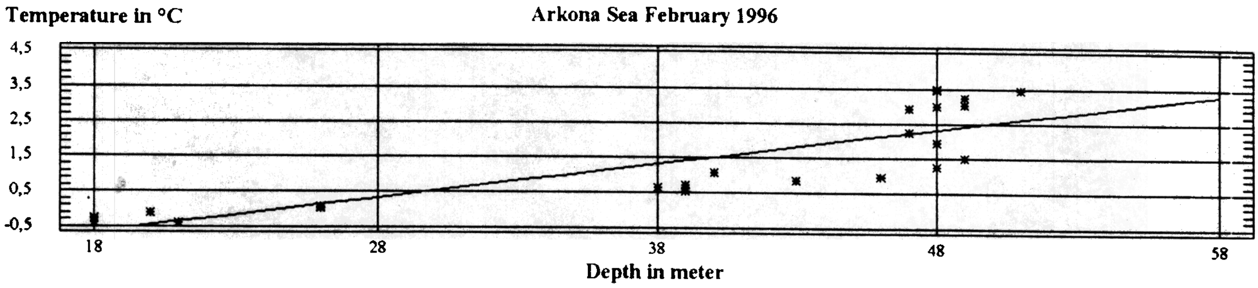

Figure 5: Relation between depth and temperature close to the bottom during the German trawl survey in the Arkona Sea 1999

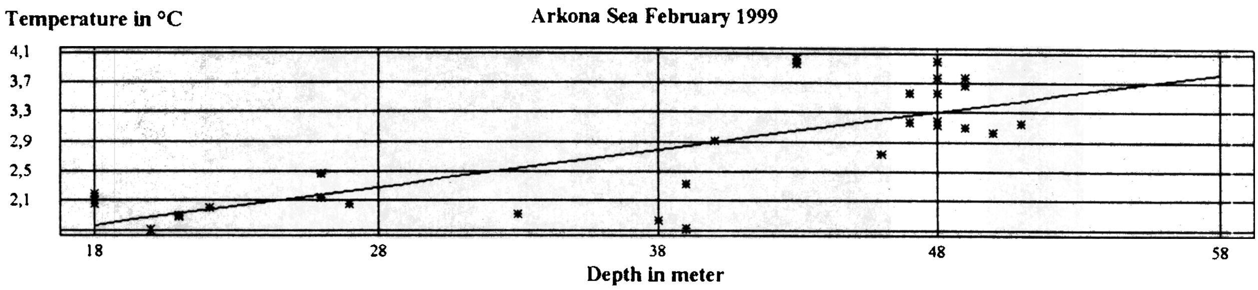

Figure 6: Relation between depth and CPUE-values during the German trawl survey in the Arkona Sea in 1996

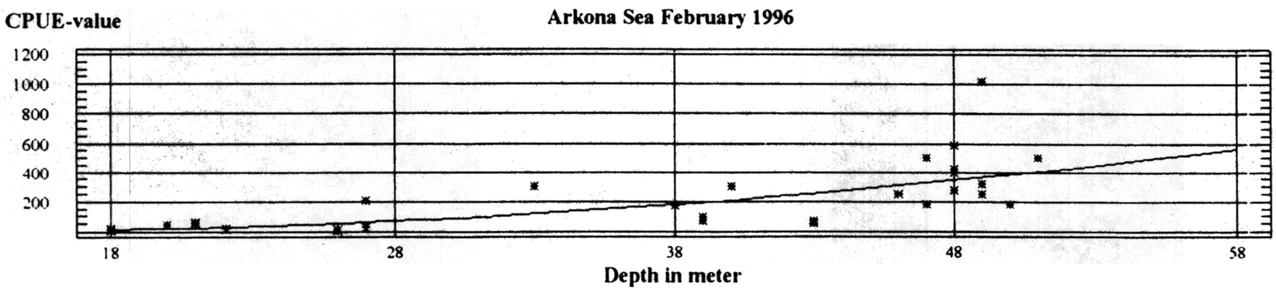

Figure 7: Relation between depth and CPUE-values during the German trawl survey in the Arkona Sea in 1999

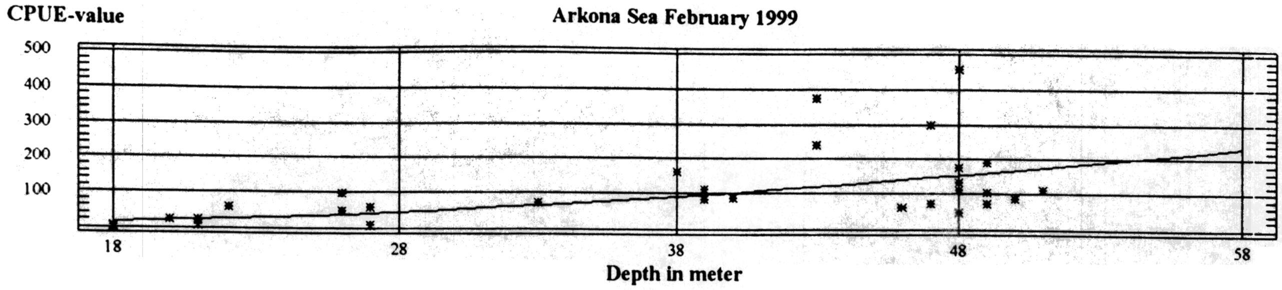

Figure 8: Relation between depth and CPUE-values during the German trawl survey in the Arkona Sea in 1997

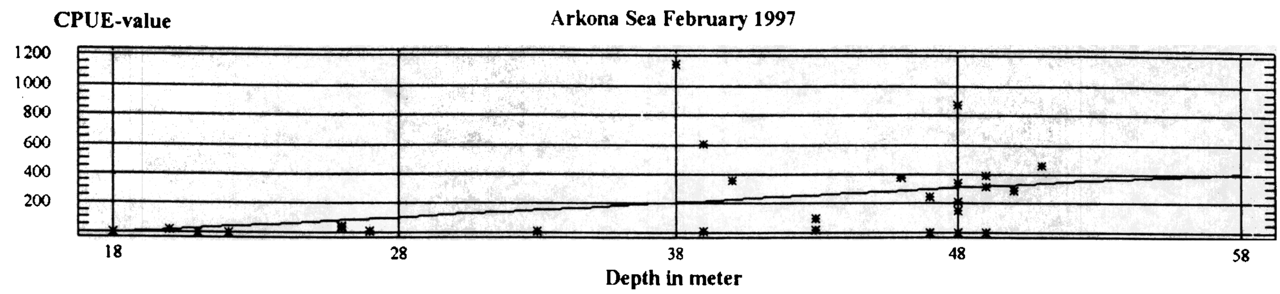

Figure 9: Relation between depth and CPUE-values during the German trawl survey in the Arkona Sea in 1998

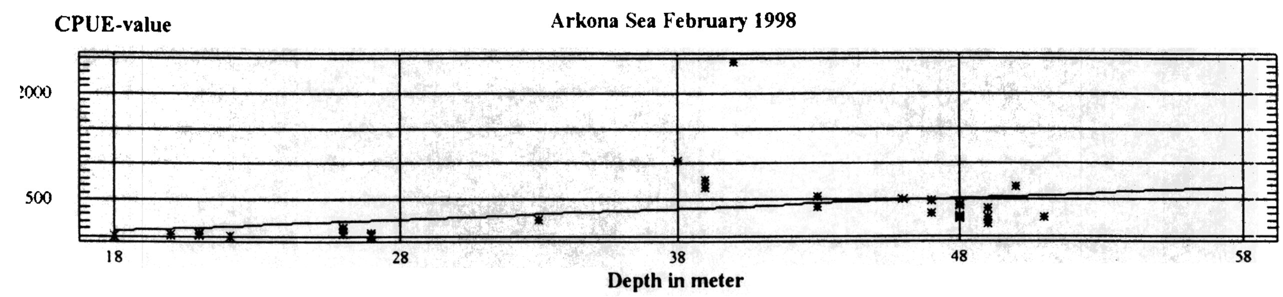

Figure 10: Relation between salinity and temperature during the German trawl survey in the Bornholm Sea in 1996 (*) and in 1999 (□)

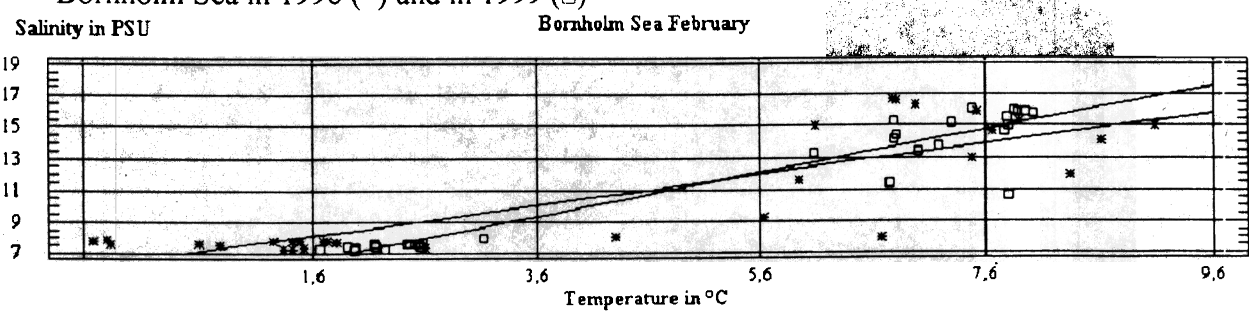

Figure 11: Relationships between temperature and depth during the German trawl survey in the Bornholm Sea in 1996 (*) and in 1999 (□)

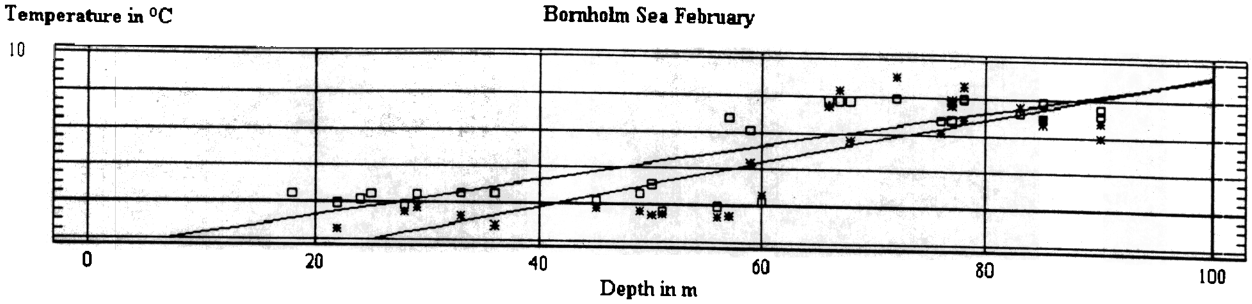

Figure 13: Model of the influence of the depth / termocline / halocline on the density distribution of the different length groups of cod in the Central Baltic

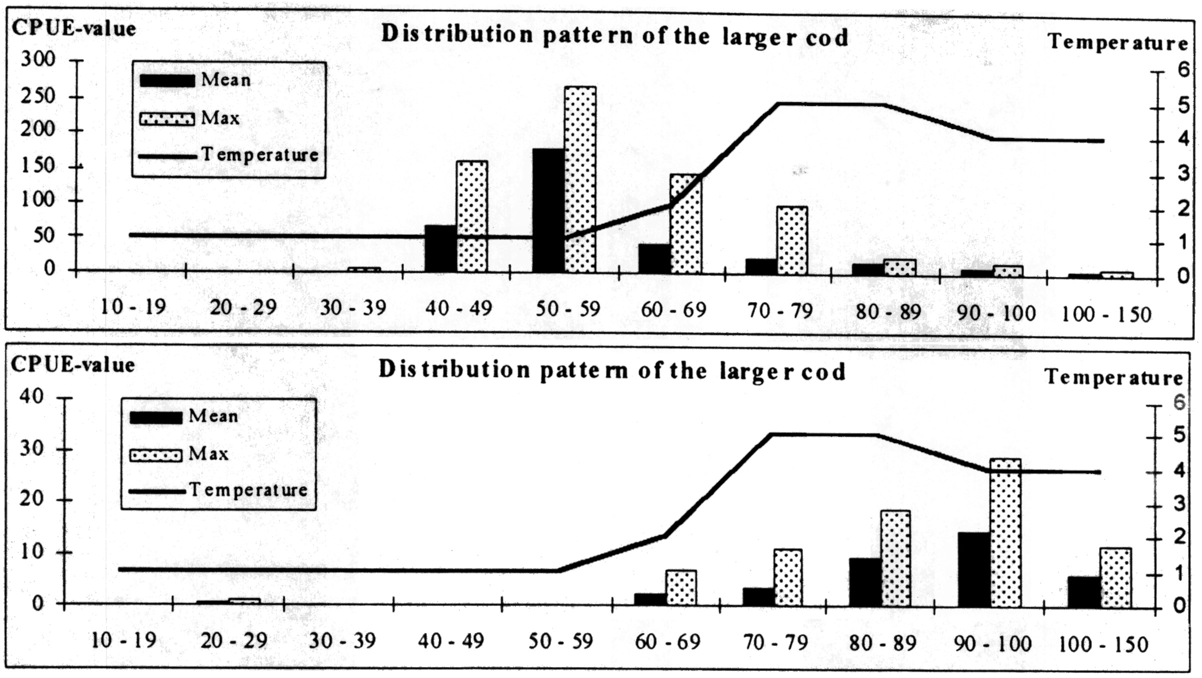

Figure12: Relation between depth and CPUE-values during the German trawl survey in the Bornholm Sea in 1996 (*) and in 1999 (□) for 10 cm length intervals in 1998