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Report of the Study Group on Baltic Fish and Fisheries Issues in the BSRP (SGBFFI)

20–23 February 2006

Vilnius, Lithuania

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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The hydrocoustic survey database on herring growth is completed with inclusion of Russian data. This database comprises all herring individual data from 1986 to 2003 sampled in ICES SD 25–29. The successive step will be to recalculate the growth and condition indices, as weight at age and weight at length, after the inclusion of the Russian data and to test of the effect of both biotic and abiotic variables on growth of herring for the different areas of the Baltic Sea. For this purposes, estimate of abundance from MSVPA could be used as an index of density dependence while time series of zooplankton data available from different sources might constitute an index of food abundance in the sea. Also, abiotic factors as temperature and salinity should be included into the analysis. Finally, a modified von Bertalanffy growth curve or a power curve (Miller *et al.*, 1999) where weight at age is dependent to both biotic and abitioic factors could be suitable candidate for including growth in stock short term forecast

SGBFFI recommends that herring and sprat data-bases are annually updated and that in the future they are mastered by Study Group on Multispecies Assessment in the Baltic.

Population structure of flounder

Flounder is distributed in all parts of the Baltic Sea except in the Bothnian Bay (SD31), the eastern part of the Gulf of Finland and the deepest areas of the Gotland Deep. It is considered that there are several local flounder stocks. These assumptions are mainly based on tagging experiments. However the total number of flounder stocks can differ by different literature sources. Presently existing tagging information suggests that there are 9 or 15 potential stocks of flounder in the Baltic Sea.

A recent genetic study tries to identify flounder stocks in the Baltic Sea (Florin *et al*., 2005). The study concludes that flounder in the NE Baltic Sea is genetically different from that in the SE Baltic Sea and Kattegat, Skagerrak and the North Sea. It is suggested that ICES Subdivisions are in this regard unsuitable management units. However as the genetic analyses are not yet performed for all subareas of the Baltic Sea, establishment of stock units is premature at this stage.

So far, the only internationally coordinated assessment of flounder is carried out for SD 24–25 during Baltic Fisheries assessment working group. The AlantNIRO, Russia in SD26 also performs assessment that is based on the age-structured model. Therefore SGBFFI summarizes the available information of flounder stock assessment for SD 24–25 and 28. Additionally, several SURBA runs (SURBA 2005) were performed to investigate the flounder stock development trend consistency in SD 24–25 and in SD 28 based on the Latvian BITS survey data in the first quarter. It was concluded that separation of flounder stocks for assessment and management units is possible only after 1) results of the genetic analysis is available and 2) regional behaviour information data compilations is completed (e.g. migration, stock trends, spawning behaviour, recruitment, etc). Although it was demonstrated that different stock development trends in different SD exist, establishment of the assessment units of flounder should directly be linked to management measures in different areas. It is recommended to have a flounder stock units establishment workshop after the flounder genetic studies is completed.

Overview on environmental factors influencing recruitment success of Baltic fishes

The following major topics were covered when addressing the environmental factors that affect recruitment success of the **Baltic herring**: stock-recruitment relationship, egg mortality on spawning grounds, larval and fry mortality, differences in recruitment factors of open sea and gulf herring populations. While studying the effects of temperature and NAO on the Baltic fish (cod, herring and sprat) recruitment success, a new approach was used where the effect of SSB on recruitment was disentangled in case it was found to be significant. About 44% of the stocks show a SSB effect. However, for those stocks no relationship was found between SST and recruitment anomalies. For the remaining stocks, an effect of SST on recruitment was found for 33% of stocks analysed. Interestingly, those stocks were represented by gulf stocks of herring (Gulf of Riga herring and SD 30 herring) and Baltic sprat while for stocks of herring in open waters no effect of SST was found.

In the Baltic there are several populations of **flounder** with different egg characteristics. In the basins up to Gotland that so-called "deep-flounder" produce eggs with low specific gravity which are found buoyant in the water. On the shallow banks and in the coastal areas of the Baltic Sea, with salinities of only 5–7 psu, the flounder, called also "bank-flounder" produce smaller and heavier eggs that develop at the bottom. The two most important factors which influence flounder recruitment are salinity and oxygen content in the spawning place. Salinity determines buoyancy of eggs. Oxygen content determines distribution of spawning flounder and lowest bound of survival of eggs.

The slope of the size spectra of coastal fish communities

Two examples on the analyses that estimate slopes of the ln(abundance) versus ln(body length) of coastal fish communities are presented. The time trends of the calculated slopes were related to fishing effort and eutrophication indices. In the first example (west-Estonian Archipelago Sea), the results show a negative trend over the studied period of 1993–2005. This decrease corresponds to a large increase of fishing effort in the early 1990s. Although the effort decreased in the late 1990s, the effect of the earlier intense fishing was continued during the next years by tremendous changes in the fish community. It is suggested that results should be used to indicate long-term trends rather than for detail descriptions of annual variations. Another example (SW Bothnian Sea) demonstrates an opposite trend in the abundance-body length relation during 1983–2002. Results show a decreasing slope of the abundance-size relation, which indicates that mean size in the fish community had increased. The slopes were significantly related to the increased abundance of larger fish species but not to smaller fish species. Thus, it is suggested here that the slope analyses appears to be a useful tool to compare the long term overall trends between different areas or regions.

After consulting with the ICES WGRED 2006 draft report on the Baltic Sea overview, several further suggestions were made for improvement of the text. It was noted that as the Baltic Sea consists of a set of several sub-systems, the sub-basins approach should be applied for the ecosystem biotic components described in the overview. Substantially more information should be inserted from other areas than the open Baltic that is rather well-covered in the existing text. Further suggestions included both expansion of some existing sections (like 'Contaminants' and 'Broad scale climate and oceanographic features and drivers', 'The major effects of fishing on the ecosystem' and 'By-catch of fish') and insertion of the new ones (like 'Eutrophication' and 'Cormorants' under respective paragraphs). Responsible scientists by all proposed amendments were suggested.

During the SGBFFI meeting the conclusions of Sprat Age Reading Workshop that took place in Charlottenlund, Denmark from 24 to 27 January 2006 and workshop on recent biological changes of herring in the Bothnian Sea that took place in November 2005 at Öregrund were presented and discussed.

The following recommendations for future activities were made:

1) Special ad-hoc workshop for analysis of herring and sprat growth in **June 2006** is needed. The workshop will be held at LATFRA and coordinated by Michele Casini. Also, it should be preceded by compilations of all necessary databases.

2) Workshop on Recruitment Processes of Baltic Sea herring stocks [Co-Chaired by M. Cardinale, Sweden and C. Möllmann, Denmark) to be held in early March 2007 for investigation the relationships between herring recruitment and climate-related ecosystem changes, e.g. changes in zooplankton abundance and composition and evaluating the feasibility of including environmental variables into stock-recruitment relationships.

3) To abandon the SGBFFI as a separate group and merge it with SGMAB by maintaining the specialist's network and still being able to address all relevant ToR's of the previous two SG's.

4) It is necessary to coordinate all ongoing activities for developing of fish and fisheries related indicators in the Baltic Sea. It was suggested that the Institute of Coastal Research, Öregrund, Sweden, should take the leading role for Baltic coastal fish and fisheries community and species indicators

5) It was emphasised to continue flounder genetics analysis and to organise a flounder stock assessment unit workshop after the genetic analyses data are available.

1 Introduction

1.1 Participation

Massimiliano Cardinale	Sweden
Michele Casini	Sweden
Redik Eschbaum	Estonia
Valeri Feldman	Russia
Włodzimierz Grygiel	Poland
Georgs Kornilovs	Latvia
Linas Lozys	Lithuania
Atis Minde	Latvia
Johan Modin	Sweden
Christian Möllmann	Denmark
Henn Ojaveer (Co-Chair)	Estonia
Wojciech Pelczarski	Poland
Valdas Piscikas	Lithuania
Maris Plikshs (Co-Chair)	Latvia
Tiit Raid	Estonia
Rimantas Repecka	Lithuania
Svajunas Stankus	Lithuania
Didzis Ustups	Latvia
Dace Zilniece	Latvia
Tomas Zolubas	Lithuania

The full list of participant are presented in Annex 1

1.2 Terms of Reference

2005/2/BCC03 The **Study Group on Baltic Fish and Fisheries Issues in the BSRP** [SGBFFI] (Co-Chairs: Maris Plikshs, Latvia and Henn Ojaveer, Estonia) will meet in Vilnius, Lithuania, from 20–23 February 2006 to:

a) finalize the databases on herring and sprat growth data and environmental variables;

b) finalize meta-analyses of growth changes of Baltic herring and sprat, and conduct growth modelling for stock development forecasts;

c) review knowledge on population structure of flounder stocks in the Baltic and propose possible stock assessment units;

d) determine environmental factors including open sea – coastal interactions and their influence on fish recruitment, especially for herring and flounder;

e) apply the coastal fish database for calculation of the slope of the size spectra for some selected coastal commercial fish species and try to relate these changes to fishing effort-related indices;

f) update the Baltic sea overview taking into account open sea and coastal interactions;

g) take into account the recommendations of the Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (WKIAB).

SGBFFI will report by 31 March 2006 for the attention of the Baltic Committee.

1.3 Activities and achievements of the BSRP Fish and Fisheries Coordination centre

The Baltic Sea Regional Project (BSRP) has facilitated substantial development of joint research activities in the field of fish and fisheries in the Baltic Sea. Until very recently, international cooperation in this field has been mainly focused on internationally managed four major species (cod, herring, sprat and salmon) while the rest of the fish community component has received substantially less attention. The respective activities were coordinated by the Fish and Fisheries coordination centre and carried out by the following lead laboratories: 1) ICES surveys, 2) coastal activities, 3) fish age and stomach analyses and 4) Salmon river restoration. Most important activities can be outlined as follows:

1) Addressing various methodological issues for coastal fish monitoring and data analysis with the ultimate aim of better characterization of the structure and dynamics of the Baltic fish communities, especially in coastal areas;
2) Improvement of open sea monitoring e.g. hydroacoustic and trawl surveys in methodological aspects and with equipment;
3) Inclusion of fish community aspects to Baltic fish and fisheries studies at the international level;
4) Update and purchase of new equipment that will facilitate further move towards ecosystem surveys and data analysis, and more close collaboration with other relevant ICES Study Groups/Working Groups;
5) Participation at ICES SG/WG and HELCOM meetings ensuring better representation of the Baltic Sea expertise;
6) Facilitate establishment and development of historical databases for fish stock assessment purposes;
7) Further development of existing approaches to incorporating environmental influences on key life history stages in models for stock projections

The following achievements can be highlighted:

1) Establishing and maintaining the network of fish experts with active participation in joint activities;
2) Involvement in preparation of comprehensive coastal fish thematic assessment report (issued by HELCOM in 2006) and coastal fish meta-database;
3) Organization of a set of fish ageing workshops for inter-calibration purposes for several species (herring, sprat, flounder and perch) with concrete proposed follow-up activities;
4) Organization of a set of workshops on data upload, release and management in internationally coordinated databases used for fish stock assessment e.g. Baltic Trawl Survey (DATRAS) and Commercial Fishery Sampling (FishFrame);
5) Development of databases and methodology for growth modelling used in short term projections of pelagic fish species in the Baltic;
6) Organization of historical otolith weight data compilation for development of new methodology of age group partitioning of Baltic cod;
7) Organization of update of cod feeding database for the multispecies assessment models;
8) Developments a plan for improvement of area coverage in hydro-acoustic surveys in the Baltic. Organization of the workshop on Acoustic survey data preparation applying Sonar Data Echoview software.

2 Growth changes of Baltic herring and sprat

2.1 Status of herring and sprat database

The herring database for the analysis of herring growth changes was established in 2005 that consisted of national data from hydro-acoustic surveys. Estonia and Finland submitted herring data from commercial fishery since they don’t have hydro-acoustic surveys. The description of this data-base could be found in SGBFFI Report of 2005 (ICES, 2005a). Since then the data-base has been supplemented by Russian herring data from hydro-acoustic survey. The first analyses of herring growth changes are presented in SGBFFI Report of 2005 (ICES, 2005a) and in Report of Study Group on Multispecies Assessment in the Baltic (ICES, 2005b).

During SGBFFI meeting in Riga in June 2005 it was proposed to create a similar database also for sprat and to perform analysis of sprat growth changes on the basis of it. At present the sprat data from commercial fishery has been submitted by Estonia and Finland and sprat data from hydro-acoustic surveys has been submitted by Poland and Latvia. It is planned to prepare the sprat data-base in the necessary format for the analysis in spring 2006.

SGBFFI recommends that herring and sprat databases are annually updated and that in future they are mastered by Study Group on Multispecies Assessment in the Baltic.

2.2 Preliminary results of effects of biotic and abiotic variables on growth of herring and sprat

An analysis of herring and sprat condition in the Subdivision 28 using data time series from 1986 to 2004 was performed by using step-wise regression and General Linear Model (GLM) (Casini *et al.*, 2006). Biological data (individual fish length and weight) were collected onboard the Swedish RV "Argos" in September-October during hydroacoustic surveys. Abiotic variables (temperature and salinity) were provided by the Swedish Meteorological and Hydrological Institute (SMHI) for the Gotland Basin. According to the results of Casini *et al.* (2006), the main predictor of herring and sprat condition in autumn (i.e., at end of the main feeding period) was the total abundance of clupeids (Subdivisions 22–32 for sprat and 25–29+32, Gulf of Riga excluded, for herring) (ICES, 2005c). The summer (August) dataset explained a higher deviance than the spring (May) dataset, indicating that clupeid condition in autumn is mostly determined during the summer period. Total abundance of clupeids explained more than 90% of model deviance of herring and sprat condition. On the other hand, salinity averaged over the 0–50 m depth layer explained around 4% of deviance for sprat, whereas single prey (copepods) biomass in summer accounted for a minor percentage of the model deviance for herring. A decrease of total zooplankton biomass with increasing clupeid abundance and a co-variation between stomach content (weight of zooplankton in stomachs) in summer and clupeid condition in autumn were also observed. These results point to that clupeid condition in the Subdivision 28 is mainly influenced by density-dependent factors mediated by intra- and inter-specific feeding competition (Casini *et al.*, 2006). The density-dependent growth of herring and sprat in autumn was also found in the other Subdivisions of the Baltic proper using simple linear regressions (Cardinale and Arrhenius, 2000; Cardinale *et al.*, 2002), even thought in these two last papers the mechanisms involved were not identified. Other studies indicated, conversely, that the growth of herring in the Baltic Sea is climate-mediated (Möllmann *et al.*, 2003; Rönkkönen *et al.*, 2004). This incongruence could be explained by the fact that either abundance was not considered as a factor influencing growth or that the single species abundance was used instead of the total abundance of clupeids in the sea. Moreover, feeding competition could be supposed to be triggered only above a certain threshold of clupeid abundance, this making the density-dependent mechanisms evident only in certain circumstances. The positive relation between salinity and sprat condition can be a result of salinity-mediated changes in zooplankton dynamic (for example in *Pseudocalanus elongatus*, e.g. Möllmann *et al.*, 2003) or of lower energy expenditure for osmo-regulation in situations of higher salinity (Cardinale *et al.*, 2002). Nevertheless, salinity seems to be a limiting factor for sprat condition only in the northern Subdivisions of the Baltic proper, where salinity is lower than in southern areas (Cardinale *et al.*, 2002; Casini *et al.*, 2006).

2.3 Growth modelling of herring for stock development forecasts

The hydroacoustic survey database on herring growth has been now completed with the inclusion of the Russian data. This database comprises all herring individual data from 1986 to 2003 sampled in SD 25–29.

The successive step will be to recalculate the growth and condition indices, as weight at age and weight at length, after the inclusion of the Russian data and to test of the effect of both biotic and abiotic variables on growth of herring for the different areas of the Baltic. There is no data from SD 32 (Gulf of Finland) and growth from this area could be estimated using commercial data collected in the same period as for the hydroacoustic surveys. This task will be specifically addressed by Dr. Michele Casini that will be hosted by the LATFRI as guest researcher from April to July to:

1) re-calculate growth rates of herring after inclusion of Russian data,
2) compile and finalize the survey database on sprat from the Baltic proper,
3) Model the effect of several variables on the growth of both herring and sprat,
4) Conduct a growth modelling for the stock short term forecast

For this purposes, estimate of abundance from MSVPA could be used as an index of density dependence (Casini *et al*., 2006) while zooplankton data time series available from different sources might constitute an index of food abundance in the sea. Also, abiotic factors as temperature and salinity should be included in the analysis. The results of task 3 is planned to generate a manuscript together with SGBFFI members that are willing to contribute. The possible title of the manuscript could be: *"Effects of biotic and abiotic factors on growth of herring and sprat in different areas of the Baltic sea."*

Finally, a modified von Bertalanffy growth curve or a power curve (Miller *et al*., 1999) for weight at age from both hydroacoustic and commercial catch could be candidates for growth modelling for stock short term forecast.

3 Population structure of flounder in the Baltic

3.1 Separation of flounder populations based on tagging experiments

Flounder is distributed in all parts of the Baltic Sea except in the Bothnian Bay (SD31), the eastern part of the Gulf of Finland and the deepest areas of the Gotland Deep (Anon., 1978, Bagge, 1989). It can be concluded that there are several local flounder stocks in the Baltic Sea. These assumptions are mainly based on tagging experiments. However the total number of stocks varies by different sources (Tab. 3.1.1).

Table 3.1.1: The number of stocks of flounder in the Baltic Sea.

<table>
<tr><th>SD
No of stoks</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>28</th><th>29</th><th>30</th><th>32</th><th>Total</th></tr>
<tr><td>Bagge, 1981; Bagge and Steffensen 1989</td><td>3</td><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td><td>2</td><td colspan="2">1</td><td>2</td><td>15</td></tr>
<tr><td>Aro, 1989</td><td colspan="5">3</td><td>1</td><td>2</td><td colspan="2">1</td><td>2</td><td>9</td></tr>
</table>

Tagging experiments in the Baltic Sea took place during 1960–1970. Tagging in the SD 22 and SD 23 (Bagge, 1966; Bagge and Steffensen 1989) identified three local stocks in SD 22 and one in SD 23. In the southwestern Baltic, the flounder stocks are characterized by great locality. The feeding migrations in spring in the Western Baltic occur along the coasts mainly in westerly and northerly directions, but in late autumn and early winter the spawning migration starts to the deeper areas (Bagge, 1966).

Tagging studies in SD 24 and SD 25 indicate that each SD supports a distinct stock (Otterlind, 1967). Other opinion is that in the southwestern and southeastern Baltic SD 22 – SD 26 there are three stocks (Aro, 1989). The migrations of the adult flounder stock are also fairly limited in the southwestern and central Southern Baltic (Otterlind, 1967). Spawning takes place in the Arkona Deep, the Splupsk Furrow and the Borholm Deep (Bagge, 1981). The feeding migrations from the Bornholm Basin are directed to the Polish and Germany coast and occur along the coast to the west up to the areas of Rugen Island and to the east up to the areas of Rozewie. The migrations to the south coast of Sweden results in the west, east and northward migrations along the Hano Bay coast (Otterlind, 1967).

Tagging experiments in Subdivisions 26 and 28 (Cieglewics 1961; 1963; Otterlind 1967; Vitinsh 1972; Bagge and Steffensen, 1989) reveals that there are two stocks in each subdivision. The Gotland basin, with low oxygen content, seems to prevent flounder from mixing of east and west stocks and acts as boundary (Aro 1989; Bagge and Steffensen, 1989). The spawning migrations of flounder in the SD 26 during winter are directed to the Bornholm Basin, the Gdansk Deep and the southern Gotland Deep (Cieglewicz, 1963). After spawning there are feeding migrations to the coastal feeding grounds in the Gdansk Bay, along the Pomeranian coast westwards and to the feeding grounds south of Bornholm.

Stock in the SD 28, including the Gulf of Riga, is greatly confined to the coastal areas and have limited connections with the stocks in Subdivisions 26 and 32 (Vitinsh, 1972; 1976).

It is unclear if the SD 27 supports one (Aro 1989) or two (Bagge and Steffensen, 1989) stocks of flounder. Tagging experiments in Subdivisions 29, 30 and 32 (Aro, 1989) suggest that there is one stock of flounder in Subdivisions 29 and 30 and a separate stock in the SD 32. Ojaveer *et al.* (1985) further speculates that flounders in the SD 32 are divided into two stocks – one along the Finnish coast and one along the coast of Estonia, which is connected with the stock along the coast in the SD 28 (Vitinsh, 1972).

The spawning, contrary to southern stocks, occurs in the littoral and coastal zones (Sandman, 1906; Suuronen, 1979). The feeding migration takes place to deeper areas and during the feeding period there is a diurnal migration patterns between the deeper and shallower areas (Suuronen, 1979).

In the Archipelago Sea, the Aland Sea and the southern Bothnian Sea the feeding migrations are quite local and a vast majority of the specimens stay inside these areas (Aro and Sjoblom, 1982; 1983). Some exchange between the stocks in the Aland Islands and the Stockholm archipelago occurs, however, but the more intensive migration westwards is blocked by the 250 m deep on the west side of the Aland Islands (Aro and Sjoblom, 1983).

According to information this gives 9 or 15 potential stocks of flounder in the Baltic Sea (Table 3.1.1).

3.2 Population structure of flounder based on microsatellite/genetic analyses

A recent genetic study indicates stock separation of flounder in the Baltic Sea (Florin *et al.*, 2005). During spring and summer 2003, around 50 genetic samples from each site were collected from 15 coastal and open sea areas in the Baltic Sea, Kattegat, Skagerrak and the NW North Sea (Figure 3.2.1). DNA was extracted and amplified by standard methods and exposed to analysis on seven microsatellite loci. Preliminary results based on 12 sampling areas suggest a significant genetic difference between flounder in the northern and eastern Baltic Sea compared to that in the western areas (Figure 3.2.2). There was also an indication of genetic differentiation between flounder in the SW Baltic Sea compared to flounder in Kattegat, Skagerrak and North Sea. An analysis of genetic versus geographical distance show that the main difference occurs between Subdivisions 26 and 25. This difference might be related to different reproductive strategies, i.e., laying of pelagic eggs in south and demersal eggs in the less saline northern Baltic Sea.

The study concludes that:

- Flounder in the NE Baltic Sea is genetically different from flounder in the SE Baltic Sea and Kattegat, Skagerrak and the North Sea.
- The fixed ICES Subdivisions cannot be considered as suitable management units for flounder.
- The analysis should be completed and final conclusions should be drawn after inclusion of analysis of samples from the eastern Baltic Sea (Latvia and Poland).

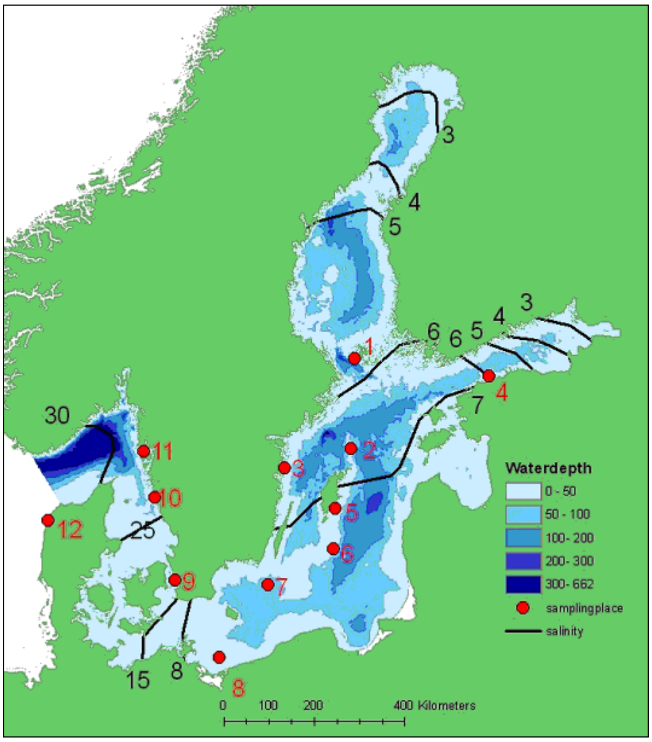

Figure 3.2.1: Sampling sites of flounder for microsatellite/genetic analyses.

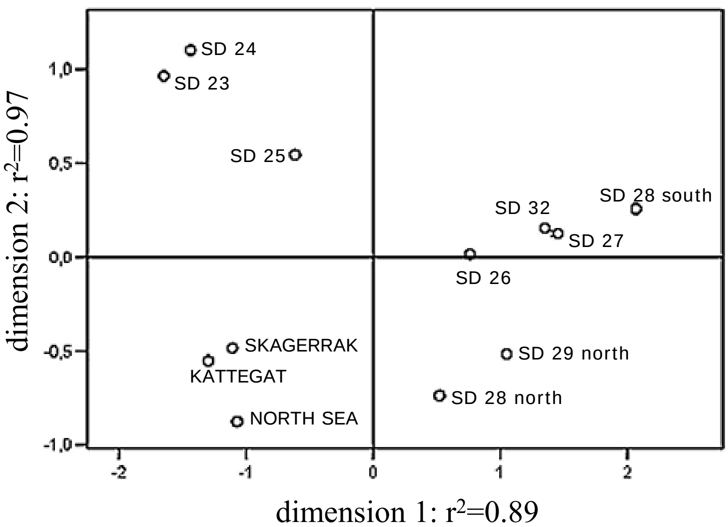

Figure 3.2.2: Multidimensional scaling plot of Nei genetic distance between flounder samples. Samples closer together are more genetically alike. Note that dimension 1 explains most of the variation (r2=0.89) compared to dimension 2 (r2=0.08).

3.3 Comparison of flounder stock development trends in selected areas

So far, the only internationally coordinated assessment of flounder is carried out in Subdivisions 24–25 during the Baltic Fisheries assessment working group (ICES, 2005c). AtlantNIRO, Russia also performs flounder assessment, based on the age-structured model, in the SD 26. Therefore, the SGBFFI summary contains the available information on flounder stock assessment for Subdivisions 24–25 and 28. Additionally, several SURBA runs (SURBA 2005) were performed to investigate the flounder stock development trend consistency in Subdivisions 24–25 and 28 based on Latvian BITS survey in the first quarter.

Data from BITS, POLBTS and DEUBTS surveys were used in a SURBA run for the estimation of founder stock size (SSB), recruitment (R) and fishing mortality (F) in Subdivisions 24–25 and Latvian BITS survey – in SD 28 (Eastern part). Those tuning fleets together with time series of weight at age, maturity at age and natural mortality from age 2 to age 8+ were the same as those used in the XSA based exploratory assessment of stock in SD 24–25 during WGBFAS (ICES, 2005c). Catchability was assumed to be 0.1 and 0.5 for age classes 2 and 3, 1 for all others age classes except for age class 8+ that was fixed at 0.5. Similar settings were assumed for flounder in SD 28. Obviously, this is an ad hoc assumption and other fixed or model estimated catchabilities could have been used instead.

The comparison of founder stock size (SSB), recruitment (R) and fishing mortality (F) are presented in Figures 3.3.1– 3.3.3.

For SD 24–25 compared to XSA assessment, SSB shows a declining trend from 1990 to 1996 and then stabilize thereafter. In the XSA assessment, no clear trend was detected (ICES, 2005). F was estimated to be around 0.9 and without clear pattern in the time series considered. This should be compared with an F around 0.5–0.6 as estimated from XSA. Considering R, XSA estimated relatively large year classes during the late 1990´s and 2000´s while SURBA indicated two large year classes in 1998 and 2002. Therefore, from this first preliminary SURBA assessment run of flounder stock in SD 24–25, the stock seems to be more exploited as compared with results from traditional XSA from WGBFAS, with a SSB declining trend associated to a relatively high fishing mortality in the last 15 years.

For SD 26 comparing with SD 24–25 recruitment show increasing that is more pronounced in SD 24–25. Contrary the trends in SSB are different e.g. decrease in SD 26 and increase in SD 24–25**. In SD 28** recently recruitment and SSB has strong increase in last 20 years. This is obviously related, first stock recovery after overfishing in the mid of 1980s and, secondly, due to decrease of flounder fishing, especially in the Gotland basin.

Anyhow, above conducted stock parameter estimations with SURBA was meant only to be a preliminary analysis of surveys information based assessment for some flounder stock in the Baltic. Also the traditional XSA assessment of flounder in SD 24–25 indicative only for stock trends and exact size of flounder stocks is unknown. The main problem with assessment obviously is clear stock unit separations and poor quality of data.

SGBFFI has concluded that separation of flounder stocks in assessment unites is possible only after the genetic result and regional behaviour information data compilations (e.g. migration, stock trends, spawning behaviour, recruitment etc). Although it was demonstrated different stock development trends in the different SD, the assessment unites of flounder if such are requested to establish should be linked to management measures in different areas. Therefore the establishment of a workshop on specific flounder stock unit separation it is recommended after completing the genetic investigations.

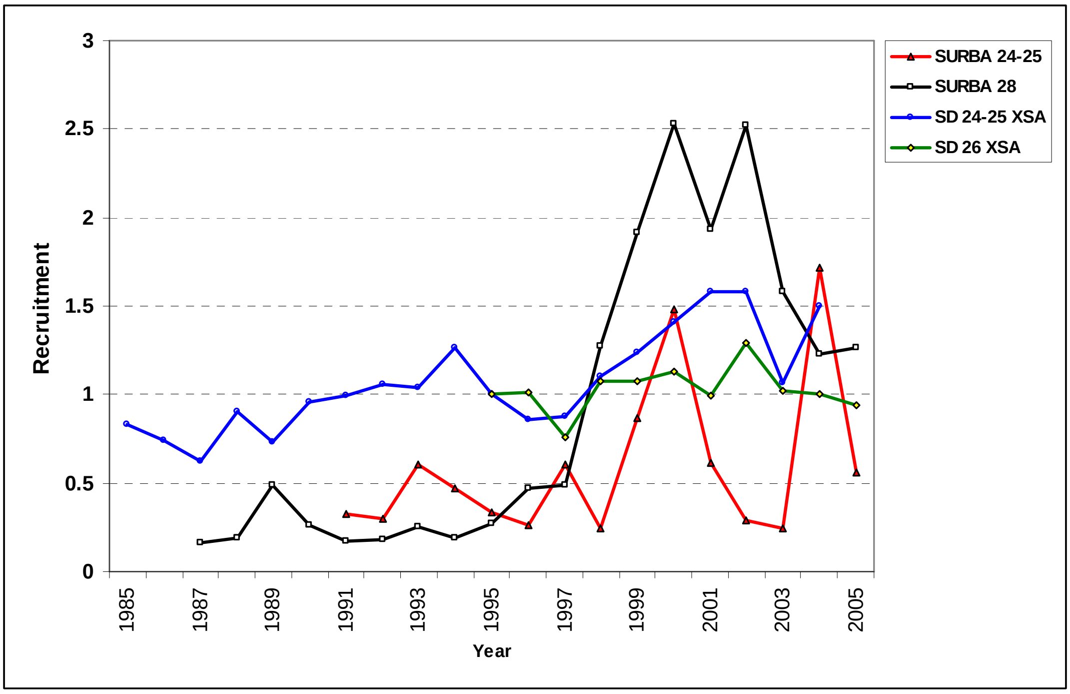

Figure 3.3.1: Comparison of trends of SSB (in relative scale), of flounder stock by Subdivisions as estimated by SURBA and VPA.

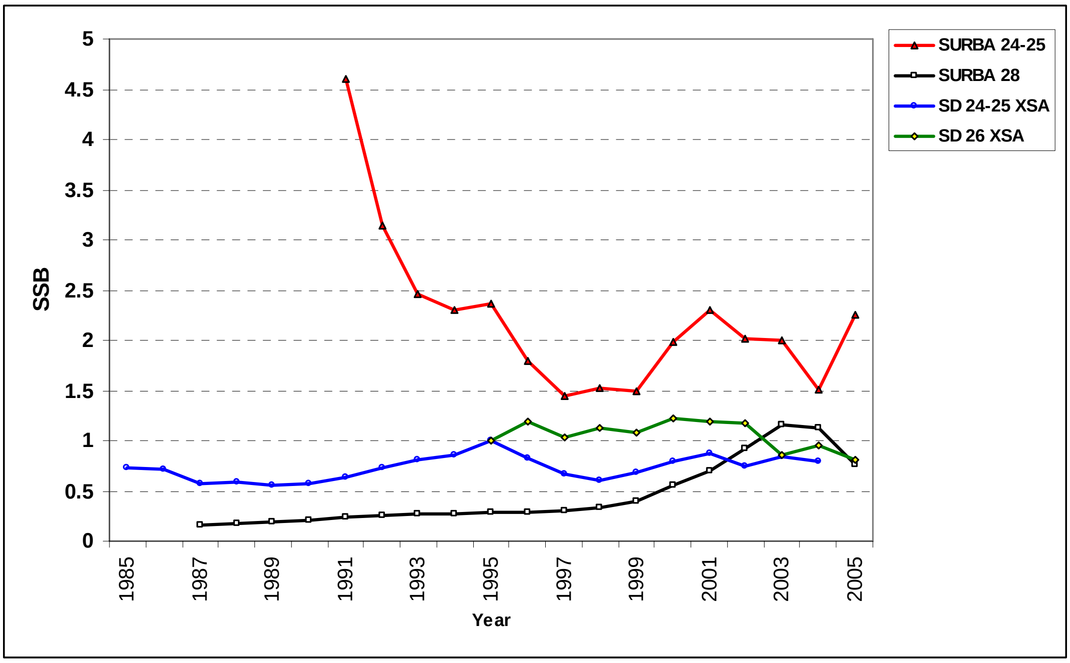

Figure 3.3.2: Comparison of trends of recruitment at age 2 (in relative scale) of flounder stock by Subdivisions as estimated by SURBA and VPA.

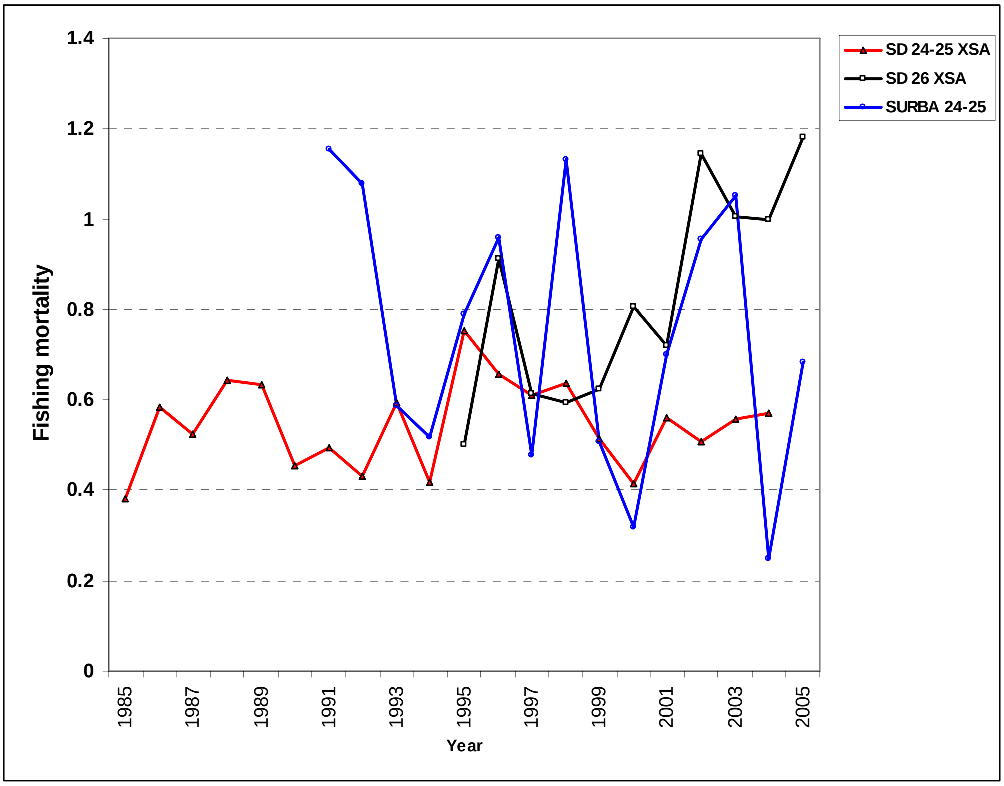

Figure 3.3.3: Comparison of trends of SSB F of flounder stock by Subdivisions as estimated by SURBA and VPA.

4 Recruitment of Baltic fishes

4.1 Overview of environmental factors influence on recruitment success of herring

The Study Group of Herring Assessment Units in the Baltic Sea has distinguished 11 local open-sea and gulf herring stocks in the Baltic Sea (ICES, 2001). These local stocks differ from each other to a smaller or larger extent in morphology, behaviour as well as in dynamics in performance of stock parameters.

The gulf herring spend all year in the large gulfs, while the open sea stocks perform annual migrations to and from the spawning grounds located along the open-sea coasts of the Baltic Proper and also in the large gulfs.

The gulf and open-sea stocks show different, and often opposite recruitment pattern over the most recent time period, probably indicating at different responses by the open sea and gulf herring on recruitment formation conditions (Figure 4.1.1). The recruitment dynamics of gulf populations has been showing similar pattern both in most recent period, but also in the past. (Figures 4.1.2 and 4.1.3).

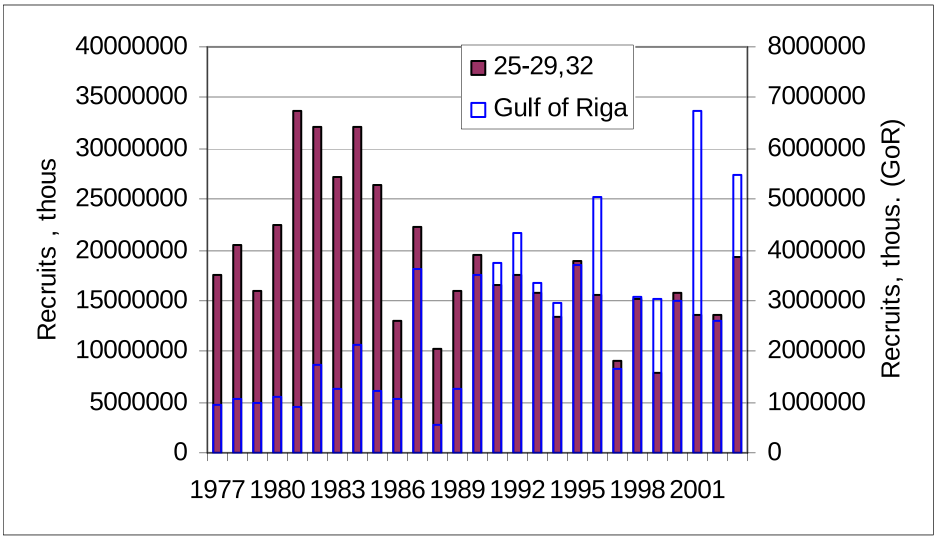

Figure 4.1.1: Herring in Subdivisions 25–29 and 32 and in the Gulf of Riga. Opposite trends in recruitment abundance (ICES, 2005).

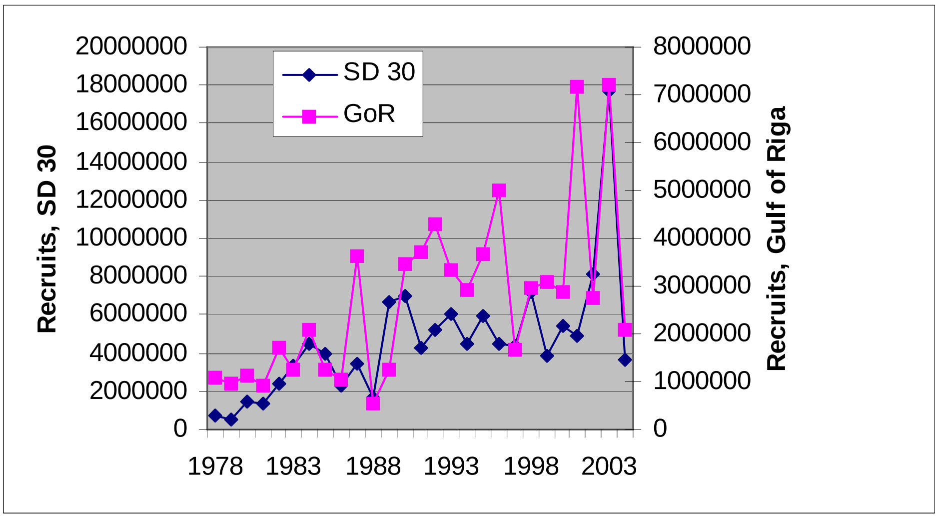

Figure 4.1.2: Herring in Subdivision 30 and in the Gulf of Riga. Recruitment trends in 1978–2004 (ICES, 2005).

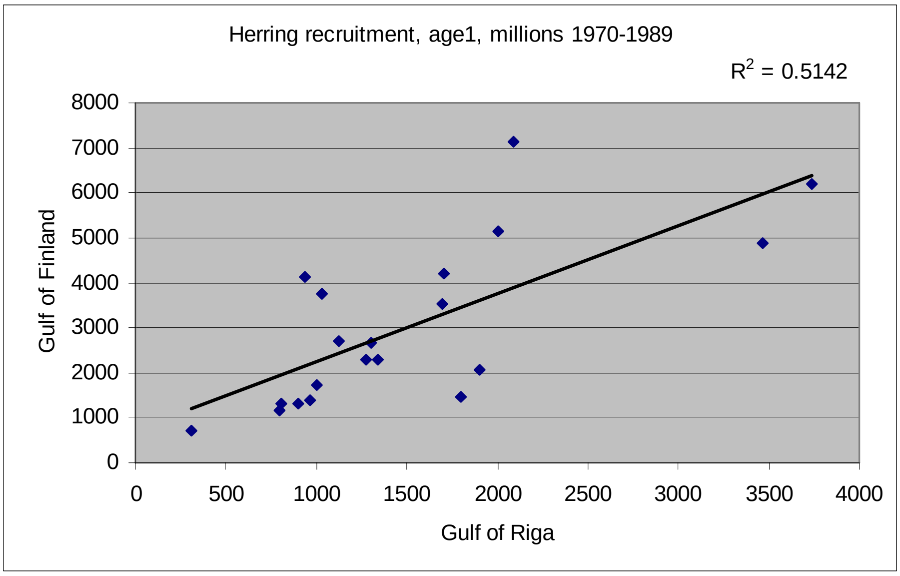

Figure 4.1.3: Herring in the Gulf of Finland and in the Gulf of Riga. Recruitment estimates in 1970–1989 (ICES, 1990).

The age group 1 is considered as recruitment for the Baltic Sea herring. Therefore the recruitment formation processes during the 1 life-year should be taken into account.

4.1.1 Stock-recruitment relationship

The investigations of possible connection between parent stock and recruitment have given mixed and rather variable results. So, L. Rannak (1974) has demonstrated different character of S/R relationship for different populations:

- Gulf of Riga and Gulf of Finland, Vistula Bay herring- "certain relation exists"- less spawners – less recruitment; there is a optimum size of spawning stock, producing the highest recruitment ;
- Saaremaa-Irbe Strait stock (Subdivisions 28–29 (open sea))- positive correlation between stock and recruitment abundance;
- NE Baltic stocks (Saaremaa-Irbe Strait stock, Gulf of Riga and Gulf of Finland – S/R shows high year-to year variation.

4.1.2 Egg mortality on spawning grounds

The success of embryonic development of herring depends both on parent stock as well as on environmental conditions on spawning grounds. Laine and Rajasilta (1999) have demonstrated that the good condition females produce eggs with higher survival rate. There are a number of studies showing that the success of herring embryonic development essentially depends on conditions of spawning grounds (e.g. on composition and coverage of algal spawning substrates, temperature regime). In this respect, the availability of some red and brown algae like *Furcellaria*, *Ceramium*, *Polysiphonia* is crucial (e.g. Aneer et *al*., 1982; Oulasvirta, 1987; Raid, 1985; Rajasilta *et al*., 1989;1993; and others).

Eutrophication of coastal waters, resulting in degradation of algal communities has caused disappearance of functioning of the spawning beds and changes in location of spawning areas in Archipelago Sea, thus emphasizing the importance of algal spawning substrates as a factor affecting the hatching success, (Oulasvirta, 1987; Oulasvirta and Lehonen, 1988; Rajasilta *et al*., 1989).

However, the general knowledge on present status of the herring spawning grounds in the Baltic Sea should be considered as relatively poor.

The temperature conditions effect directly on embryonic development. The experimental studies have shown that hatching success depends on temperature dynamics: high temperatures during the incubation period cause increase of lethal developmental abnormalities. Also, perhaps there seems to be the population – specific optimum temperature/salinity ranges, supporting the successful embryonic development and hatch (Ojaveer, 1981, 1981a). However, egg mortality has not, n general, been regarded as a factor of crucially affecting the size of the recruitment.

4.1.3 Larval and fry mortality

Larval mortality has been pointed out as one of the most crucial factors affecting the resulting recruitment abundance. The mortality largely depends on feeding possibilities (abundance of copepod *nauplii*) during the onset of active feeding (e.g. Rannak, 1971, Arrhenius and Hansson, 1993). The feeding conditions can be affected by temperature but also by general state of the coastal zone, where larval development occurs. So, for instance, the eutrophication level can substantially effect (via zooplankton abundance and composition on abundance of recruitment (Urho *et al*., 2003). Also, there has been a general knowledge that later spawning might have negative effect on year-class abundance, because of sorter growth period prior to first winter. The prolonged spawning season (due to the temperature pattern), could favour the recruitment by increasing probability, that at least part of the offspring might develop under favourable feeding conditions (Rannak, 1971).

However, the direct effects of storms and winter temperatures on larval/fry survival have been poorly investigated.

4.1.4 Differences in recruitment factors of the open sea and gulf herring populations

It has been stated that in the open sea populations, abundant generations appear in the periods of higher salinity and intense water exchange between the Baltic and the North Sea favouring vertical mixing of water layers and up-mixing of nutrients to support high biological production and abundant stock of copepod *nauplii* in herring spawning and larval retention areas in the period of transfer of herring larvae to exogenous feeding. In open-sea stocks the effect of spawning stock on recruitment formation also seems to be more evident (e.g. Rannak, 1974).

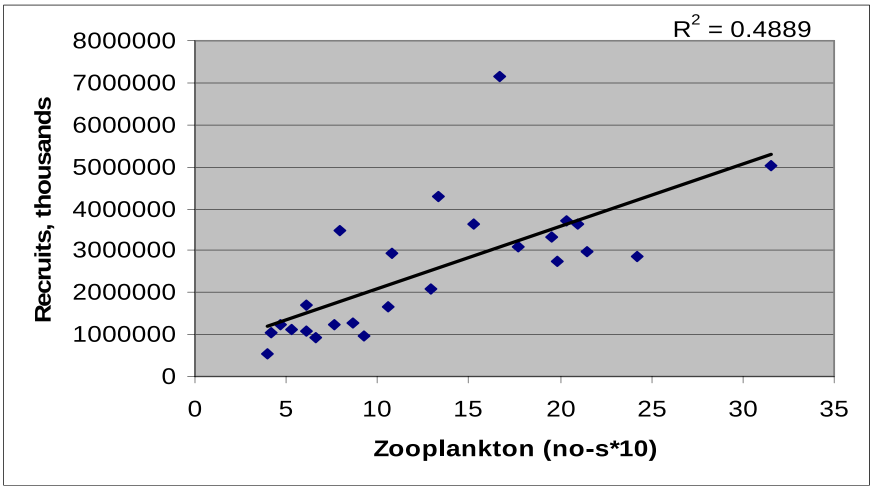

Figure 4.1.4: Recruitment estimates of the Gulf of Riga herring plotted against of mean zooplankton abundance in May (ICES, 2005).

In the gulf populations, strong year classes are formed mainly in warm springs with dominating westerly winds promoting rich biological production in the period of larval development and favouring their high survival (Rannak, 1971; Ojaveer, 1988; Raid, 1997; Grygiel, 1999). The positive correlation between zooplankton abundance and herring recruitment abundance has been revealed in several cases. Gulf of Riga herring (ICES, 2005, Figure 4.1.4), herring in Gdansk (Grygiel, 1999; Parmanne and Sjöblom, 1982)

The recent period of low salinity and mild winters seem to be favourable for the gulf stocks

Stronger short-term environmental effects (e.g. lower water temperature in winter, pollution, eutrophication), and also lack of geographical buffer for spawning distribution (possibility to spawn somewhere else except the local gulf) make the recruitment formation of gulf stocks more environment-depending. The population structure or at least stock type should be taken into account while considering recruitment mechanisms.

The existing knowledge on recruitment formation mechanisms indicates that environmental factors have key role in recruitment formation, at least in gulf herring stocks. However, the environmental interactions are incorporated into assessment processes only in a few cases (e.g. the Gulf of Riga herring) so far. In order to explore the possible relationships between herring recruitment including climate- related ecosystem changes, e.g. changes in zooplankton abundance and composition, the SG is proposing a special workshop allowing the respective experts to focus on recruitment issues of the Baltic herring stocks.

4.2 Effects of temperature on the Baltic fish recruitment success

As suggested by Cardinale and Hjelm (2006), climate–recruitment studies should use a more formalised approach when testing the effect of abiotic variables on recruitment strength. The first step of this approach is to disentangle the SSB effect. Beverton (2002), in one of his last lectures at Woods Hole suggested an approach for exploring this relationship. Because of the biological mechanisms behind the classical SSB–R relationships, recruitment success (R_s) should improve as SSB decreases (Figure 4.2.1). However, if recruitment is mediated by physical environmental events, this negative relationship may not be as obvious. For example, when the stock is declining, a negative effect of the climate on R will result in a decrease in R_s; this is reversed in the case of a positive effect of climate on R (Figure 4.2.1). Therefore, the variability in the relationship between R_s and SSB can be considered as a proxy for recruitment anomalies (R_a) and it is assumed to be partially determined by the stochasticity in the physical environment (Beverton 2002). Nevertheless, this approach is only valid when a significant effect of SSB on R_s can be demonstrated. Only in such cases can R_s – and therefore R_a – be used in climate–recruitment analysis. On the other hand, and as a second step, when SSB has no significant effect on R_s, climate variables can be directly correlated to recruitment itself. Importantly, if SSB has no effect on R, using R_s instead of R can actually mask any recruitment–climate relationship.

This approach has been used here to investigate the effect of temperature and NAO on the recruitment of Baltic stocks of cod, herring and sprat. The results are shown in Table 4.2.1. It is evident that about 44% of the stocks show a SSB effect. This again hints to the fact that climate-recruitment studies should always disentangle the SSB effect prior to the climate effect analysis to avoid masking existing relationship between recruitment and climate or even finding spurious between recruitment and climate. For those stocks where a SSB effect was evident, no relationship was found between SST and recruitment anomalies. For the remaining stocks, an effect of SST on recruitment was found for 33% of stocks analysed. Interestingly, those stocks were represented by gulf stocks of herring (Gulf of Riga herring and SD 30 herring) and Baltic sprat while for stocks of herring in open waters no effect of SST was found.

The results of this analysis, including the approach described here, could be used as a starting point to investigate into details the effect of climate and other variables on the recruitment of cod, herring and sprat in different areas of the Baltic Sea.

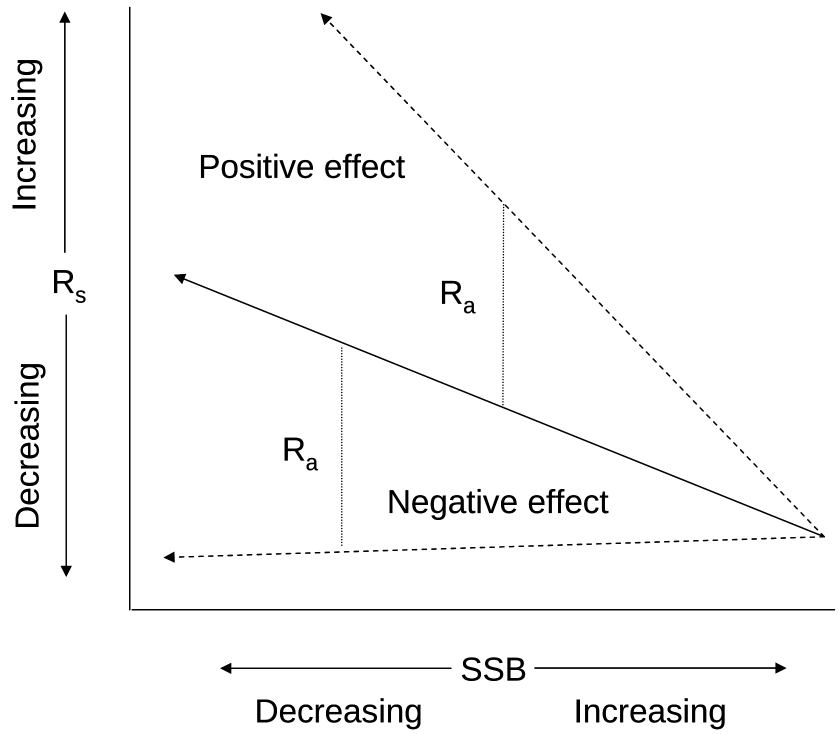

Figure 4.2.1: Relationship between spawning stock biomass (SSB) and recruitment success (R_s) (R/SSB, where R is number of recruits) when the physical environment has positive or negative effects (dashed lines) on R_s . R_a : recruitment anomaly.

Table 4.2.1: Results of the analysis of the effect of temperature on recruitment of Baltic fish stocks.

	R_s ~ SSB		R_a ~ Temp		R ~ Temp	
Stock	r^2	p	r^2	p	r^2	p
Central Baltic herring	-0.31	0.001	0.03	ns		
Gulf of Riga herring	-0.01	ns			0.47	< 0.001
Northern Bothnian herring (SD 31)	-0.33	0.003	0.01	ns		
Southern Bothnian herring (SD 30)	-0.01	ns			0.51	0.002
Western Baltic spring spawners herring	-0.62	0.001	0.08	ns		
Baltic Sea sprat	-0.10	ns			0.28	0.003
Eastern Baltic cod	-0.18	<0.01	-0.02	0.38	-	-
Kattegat cod	-0.09	ns	-	-	0.01	0.71
Western Baltic cod	-0.06	ns	-	-	-0.03	0.34

4.3 Overview of environmental factors influence on recruitment success of flounder

In the Baltic Sea, flounder spawns between April and June. Spawning time is delayed eastwards and northwards.

In the Baltic, there are several populations of flounders with different egg characteristics. In the basins up to the Gotland the so-called “deep-flounder” produce eggs with low specific gravity which are found buoyant in the water. On the shallow banks and in the coastal areas of the Baltic Sea, with salinities of only 5–7 psu, the flounder, called “bank-flounder” produce smaller, heavier eggs which develop at the bottom (Table 4.3.1.).

Deep-flounder spawn on the depth from 70 – 130 m; minimal hydrological requirements are salinity – 12 psu, oxygen concentration – two ml/l (Nissling *et al*., 2002). Other literature source show, that minimal oxygen concentration is only 1 ml/l (ACFM, 1978; Anon., 1988). There are differences between spawning depths in the Baltic Sea. In Southern part (Bornholm, Gdansk and south part of Gotland Depths) spawns take place in the depths between 60 to 120 meters. The egg and larvae development take place in more inconstant hydrological conditions because stagnation process development in deep basins due to irregular water inflow from the North Sea. In the deeper parts of Baltic Sea distribution of flounder eggs is limited due to oxygen deficit. Nevertheless flounders eggs are distributed in the deeper part of Baltic Sea, 30–60 m above bottom. Thereby in oxygen deficit situation, flounder could spawn in pelagic part of water column (Grauman, 1980).

Bank-flounder spawns in shallow banks of central and north part of Baltic Sea. Eggs from these areas are smaller and heavier and they develop at the bottom of the sea. Minimal required salinity is much lower, only 6–7 psu.

Therefore two most important factors which influence flounder recruitment are salinity and oxygen content in the spawning place. Salinity determines buoyancy of eggs. Oxygen content determines distribution of spawning flounder and lowest bound of survival of eggs.

Table 4.3.1: Spawning characteristics of Deep- and Bank-flounders.

	DEEP-FLOUNDER	BANK-FLOUNDER
Subdivision	22, 23, 24, 25, 26, 27, 28, 29, 30, 32	27, 28, 29, 30, 32
Depth, m	40–120	10–30
Salinity, psu	12	6–7
Oxygen, ml/l	1 (or 2)	?
Eggs size, mm	1.25 mm	0.8–1.2 mm
Egg type	Pelagic	Demersal
Larvae type	Pelagic	Pelagic

5 The slope of the size spectra of coastal fish communities

5.1 The slope of the size spectra for some selected coastal commercial fish species and its relation to fishing effort-related indices and environmental changes

Marine ecosystems are size structured with larger predators eating smaller prey (Sheldon *et al.*, 1972). This is reflected within fish species where life cycle size often spans up to five orders of magnitude (Cushing, 1975). Metabolic theory and empirical results also suggest that fish abundance scales with body size (Jennings and Mackinson, 2003). Therefore size-based indicators of the fish community have been developed as a tool to support ecosystem management in a similar way that species based indicators (e.g. SSB and fishing mortality) are used for single species management. Gislason (1994) used time series of size spectra study the effects of fishing and Blanchard *et al.* (2005) extended a similar trend analysis to disentangle the effects of climatic factors and fishing.

Here we present some exploratory examples to reveal the effect of fishing and eutrophication in the Baltic Sea by size-based indicators. No size-structured data were available from the open sea and the examples are therefore confined to standard net surveys in coastal areas of the northern Baltic Sea. The analyses estimate slopes of the ln(abundance) versus ln(body length) and relates time trends of the calculated slopes to fishing effort or eutrohication indices. Jennings and Mackinson (2003) showed that in a non-affected environment abundance scales with body weight with a factor of –1.2 (i.e., $N \sim W^{-1.2}$). Using the cube of the length as a proxy for weight suggests that abundance should scale with body length with a factor of –3.8 (i.e., $N \sim L^{-1.2*3}$) in an un-fished and non-disturbed environment. However since the data only included larger fish with a larger length-weight exponent the slope estimates were expected to be steeper in non-affected areas.

In the first example we used data from the annual coastal fish monitoring in the west-Estonian Archipelago Sea (Väinameri). During the investigation period (1993–2005), fishing was performed annually in August at 2–5 m water depths using gill net sets (Thoresson, 1993). The gill nets were set between 14:00 and 16:00 and lifted the next day between 07:00 and 10:00. Each gillnet set consists of six separate nets with mesh sizes of 17, 21.5, 25, 30 33, 38 mm, respectively. Two methods were used to calculate the slope of the size spectrum of coastal fish community. In the first exercise we used all length groups of all fish species that were caught. However, the smallest length group (<15 cm TL) is not fully selected. Therefore this size groups were excluded from further analysis in order to avoid problems caused by selectivity patterns. Results show a negative trend over the studied period (Figures 5.1.1 and 5.1.2), where slope values decrease from around −3.4 to −6.9. The decrease corresponds to a large increase of fishing effort in the early 1990s after the independence of Estonia (Vetemaa *et al.*, 2005). Although the effort decreased in the late 1990s, the intense earlier fishing has caused continuation of tremendous changes in the fish community in the following years. The calculated slopes thus confirm other observations on less-abundant large species and changes in the biodiversity. The results should be used to indicate the long-term trends rather than describe annual variations since the annual perturbations in environmental or anthropogenic factors might confound the analysis. The important consideration is not the slope or intercept of a spectrum for a particular year, but how the spectrum changes over a longer period (Rice and Gislason, 1996).

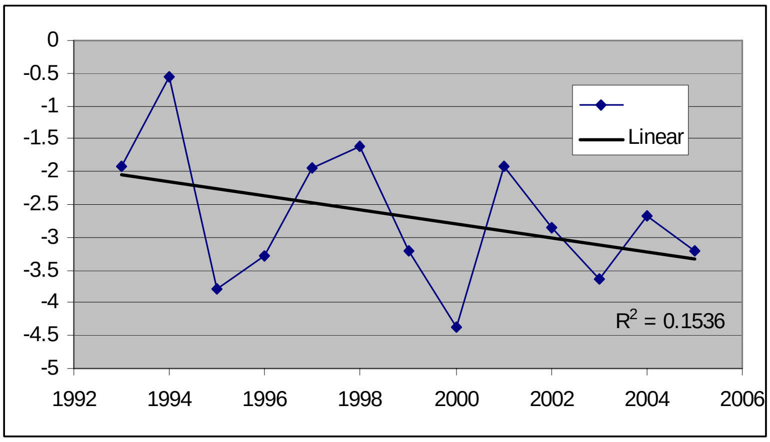

Figure 5.1.1: Regression of slopes of annual community size spectrum from the west-Estonian Archipelago Sea in 1993–2005 (all length groups included).

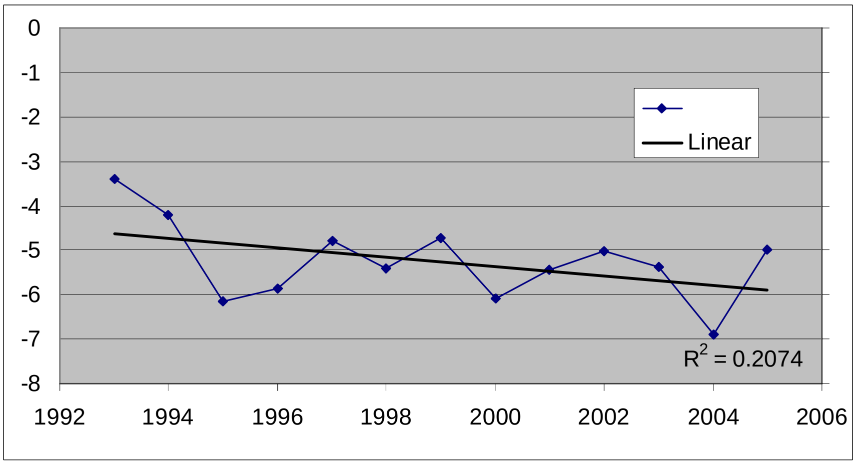

Figure 5.1.2: Regression of slopes of annual community size spectrum from the west-Estonian Archipelago Sea in 1993–2005 (length <15 cm excluded).

Another example demonstrates an opposite trend in the abundance-body length relationship. The data originate from research surveys in August 1983 to 2002 with the Nordic nets in the Forsmark archipelago of the SW Bothnian Sea. Length frequencies of all the fish caught larger than 17 cm were included in the analysis. Results show decreasing slopes from –5.4 to – 4.1 of the abundance-size relation (Figure 5.1.3), which indicates that mean size in the fish community had increased. The slopes were significantly related to the increased abundance of larger fish species such as bream *Abramis brama* and zander *Sander lucioperca* but not to smaller fish species, such as roach *Rutilus rutilus* and herring *Clupea harengus membras* (Table 5.1.1). Bream and zander are known to be favoured by muddy water and may therefore be used as an index of eutrophication. The hypothesis is further supported by a significant regression of Secci-disc depth against abundance-size slopes (Table5.1.1). Temperature may be a confounding factor but the relevant data were not available and temperature effects could not be tested.

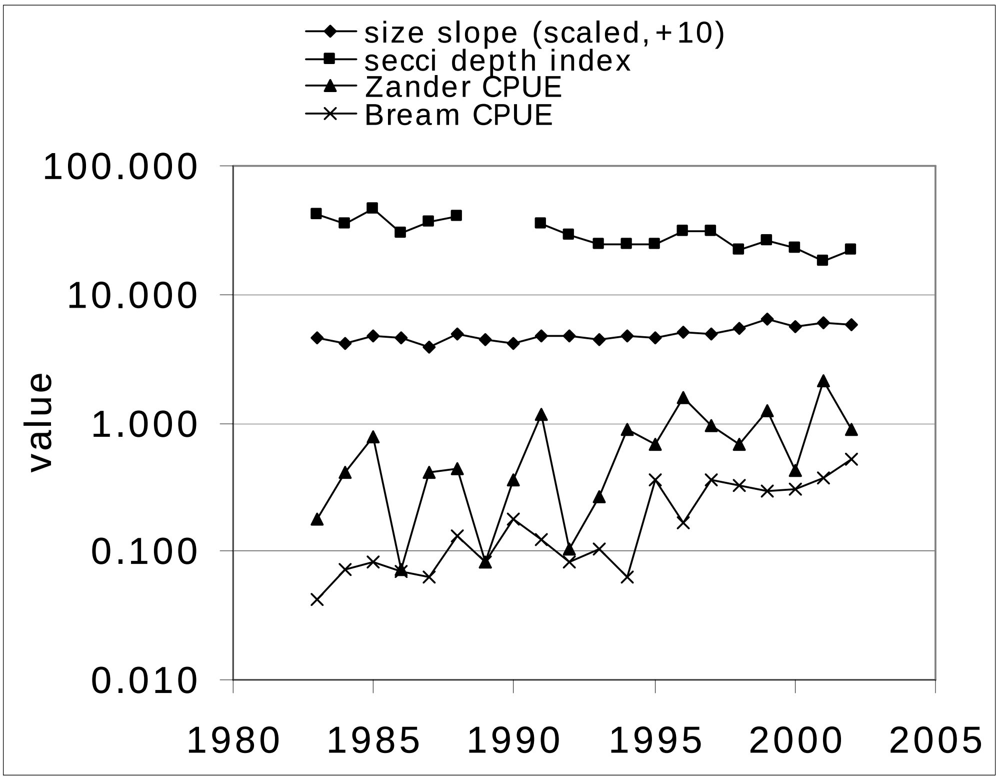

Figure 5.1.3: Dynamics of the Secci disk depth, CPUE (numbers per net night) of zander *Sander lucioperca* and bream *Abramis brama* and size slope in the Forsmark Archipelago of the SW Bothnian Sea during 1983–2002.

Table 5.1.1: Linear regression of eutrophication indices on size abundance slopes in the SW Bothnian Sea 1983–2002.

FACTOR	N	R^2	P
Bream, numbers / net and night	20	0.47	0.001
Zander numbers / net and night	20	0.35	0.006
Secci depth, m	18	0.33	0.013

The slope analyses appear to be a useful tool to compare the long term overall trends between different areas or regions. The evaluation of other ecosystem indicators of coastal fish species and communities is one of the main tasks of the BSRP/HELCOM MONAS Coastal Fish Monitoring Workgroup. The following indicators were chosen and will be calculated and evaluated by participating countries.

Community level

- Total number of species and number of species by categories (marine and freshwater origin)
- Total biomass
- Species diversity based biomass (Shannon and Weaver index)
- Slope of size spectrum
- Average trophic level of catch based on biomass
- Number of alien species

Species level

- Species abundance

- Species biomass
- Mortality
- Size and age structure of population (median size and age ± 90 percentiles)
- Growth rate

Size based indicators holds promise as a tool for long-term surveillance and monitoring. However in order to use them for ecosystem management reference points need to be developed. Reference values can then be used to suggest management actions. Reference values can be derived from theoretical considerations (e.g. Jennings and Duvly, 2005). Studies indicate that such values can be used for the support of ecosystem management, but the power of the present surveys to detect trends is poor. Therefore, specific targeted research is required to support monitoring and determine management options. A pragmatic approach to derive reference values is suggested based on long-time series. Similar approaches have already been in use to formulate biological advice in single-species management.

5.2 Comparison of the performance of the slope of the size spectra to other coastal fish indicators

The west-Estonian Archipelago Sea was selected for the fish community slope of the size spectra analysis because there has been tremendous change in the fish community during the study period, presumably mostly due to fishing activities. It was expected that these changes should be easily observable also on the slope analyses results. The general trend in the annual slope values was negative (Figure 5.1.1), which reflects most probably the increased fishing effort in the given area. Although the slope analyses reflect the overall changes in the fish community, the magnitude of the changes is more understandable when compared to some other indicators, which are presented by the figures below. Due to over-fishing during the early 1990s, the population abundance of perch *Perca fluviatilis*, the dominant and commercially most important coastal fish species in this region, has almost collapsed (Figures 5.2.1. and 5.2.2) and has not recovered until now. Although some indicators, as the catch-per-unit-effort (CPUE, Figure 5.2.1) and the trophic level (Figure 5.2.3), demonstrate the recovery of perch and the local fish assemblage, respectively, the abundance of older and bigger fish is still poor as evident from the official catch statistics (Figure 5.2.2) and CPUE of older year classes (Figure 5.2.1). Abundance of the predatory fish species has slightly recovered (Figure 5.2.4) by causing visible changes in the trophic level of the fish community (Figure 5.2.3). However, the difference in magnitude between the last two indicators could be explained by the fact that perch, which is the most abundant predator in these areas, was considered predatory when it exceeded the length of 20 cm but when calculating the trophic level of the community, species-specific values for trophic levels were used according to Fishbase (2004) and the size of the particular fish were not taken into account. It is important to note that gear, which is being used in the coastal fish monitoring, does not sample representatively smaller fish. Therefore, there is a basis to assume that substantial changes have also taken place at the level of small-sized fish in the fish community. Apparently the slope of the size spectra could indicate the change in community more clearly if the smaller fish species and size classes are included.

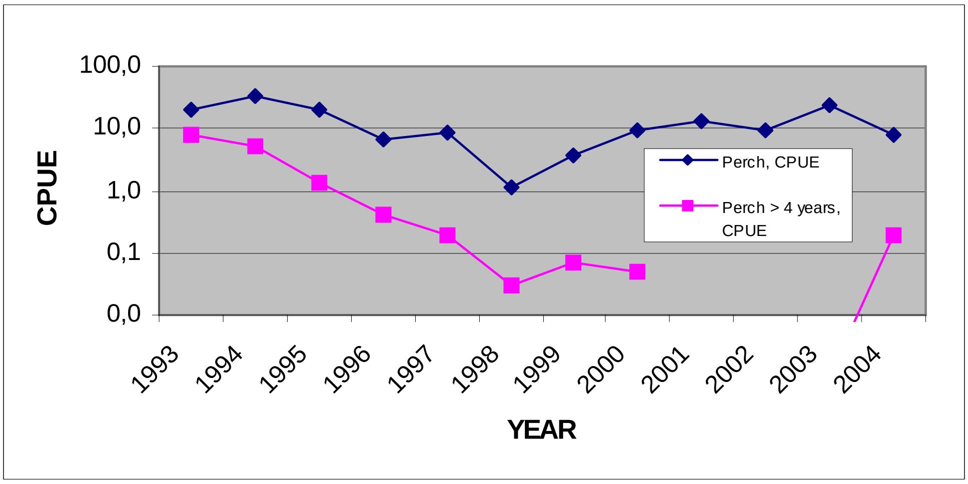

Figure 5.2.1: Catch per unit effort of perch *Perca fluviatilis* from experimental net surveys in Matsalu Bay (the west-Estonian Archipelago Sea) 1993–2004 (Vetemaa *et al.*, 2005).

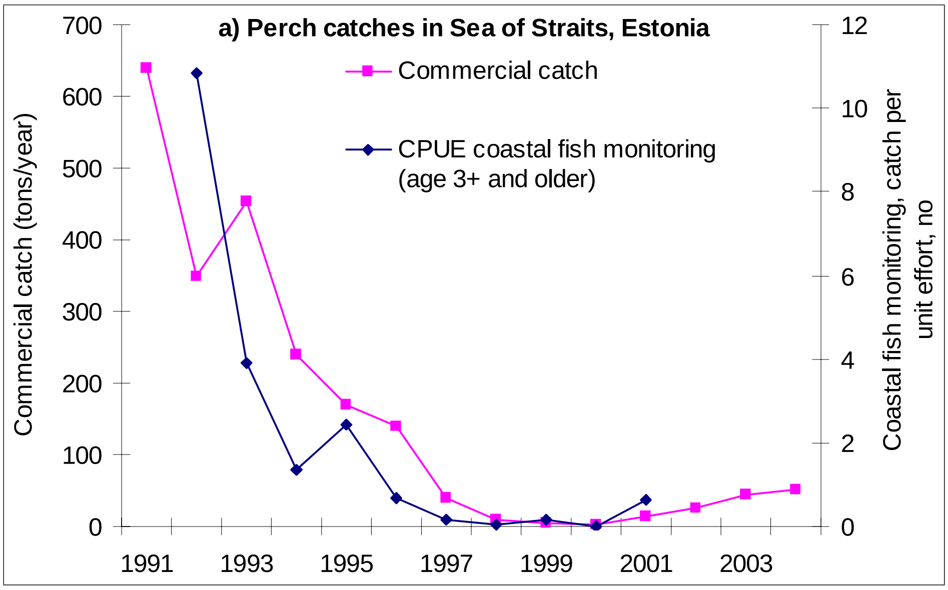

Figure 5.2.2: Commercial perch catch and catch per unit effort of older perch in the west-Estonian Archipelago Sea (1991–2004) (HELCOM 2006).

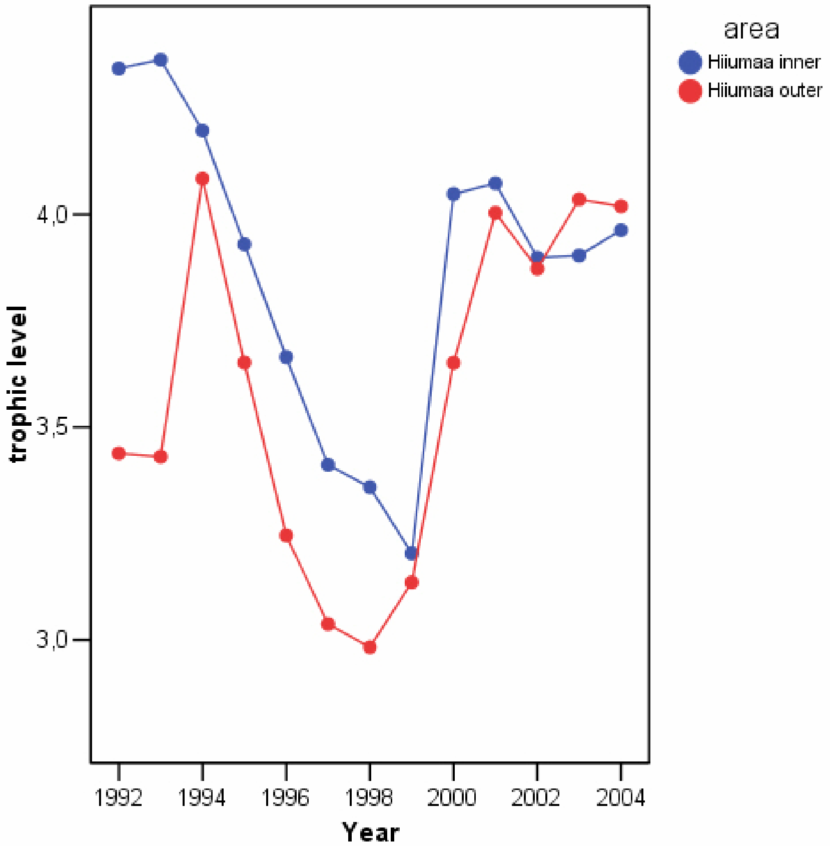

Figure 5.2.3: Trophic level of fish community in the west-Estonian Archipelago Sea 1993–2004 (HELCOM 2006).

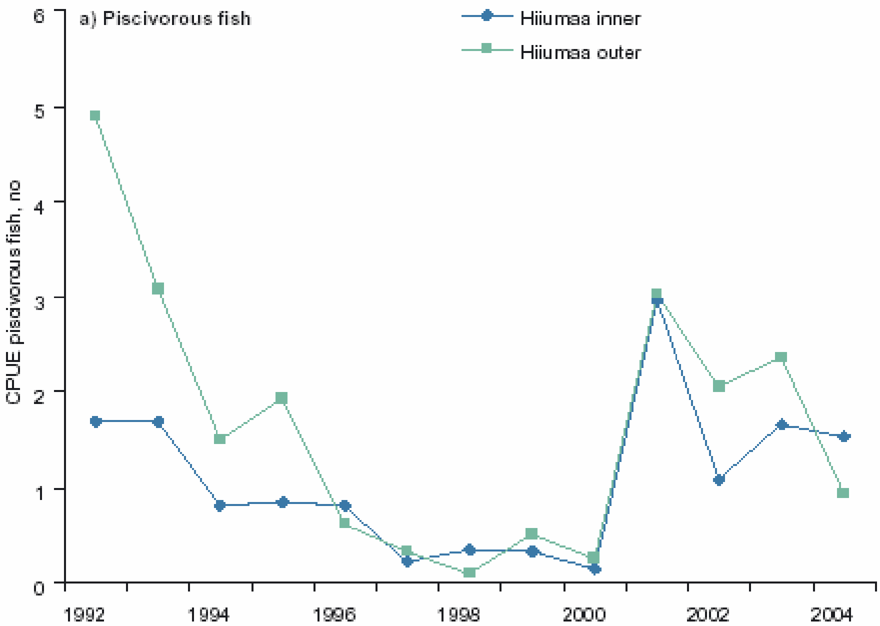

Figure 5.2.4: Catch per unit efforts (based on abundance) of piscivorous fish at Hiiumaa (the west-Estonian Archipelago Sea) during 1993–2004 (HELCOM 2006).

6 Update the Baltic Sea overview taking into account open sea and coastal interactions

After consulting with the ICES WGRED 2006 draft report on the Baltic Sea overview, the following suggestions were made for improvement of the text:

'Contaminants' and 'Broad scale climate and oceanographic features and drivers' sections under the 1.1.1.2. Physical and Chemical Oceanography should be expanded. The suggested responsible persons to ask for advice will be Rolf Schneider for Contaminants and Christian Möllmann for Climate. In addition, Bärbel Müller-Karulis should be invited to write the additional sub-item on 'Eutrophication' under Section 1.1.1.2 of the Baltic Sea description of the existing WGRED report.

As the Baltic Sea consists of a set of several sub-systems, the sub-basins approach should be applied for the ecosystem biotic components described in the overview.

Description of the ecosystem biotic components would strongly benefit from having some additional aspects to be included. Specifically, biodiversity issues with regard of the origin of the species according to categories, e.g. marine species, freshwater organisms, glacial relicts and alien species should have special attention. Especially, substantially more information should be inserted from other areas than the open Baltic that is rather well-covered in the existing text. Under the zooplankton section, predation effects of pelagic fish were suggested to be added. In the fish section, the following issues should be added: salmon; sprat and herring recruitment; impact by seabirds and mammals. In addition, the part dealing with 'non-ICES' fish should be revised. Short paragraph on cormorants should be added under the Birds and Mammals section. Advice for doing this was suggested to ask from:

1) Zooplankton: Ilppo Vuorinen
2) Benthos: Jonne Kotta and Erik Bonsdorff
3) Fish:
h) Salmon – ICES WGBAST
i) Sprat and herring recruitment – Rudi Voss and Tiit Raid
j) 'Non-ICES fish' and fish communities– Henn Ojaveer
k) Impact by seabirds (incl. cormorants) and mammals – Redik Eschbaum and Johan Modin (to contact Lunneryd)
4) Birds and mammals: Johan Modin (to contact Osterblum and Lunneryd)

Bycatch of fish should be revised and updated. The suggested contact: Maris Plikshs.

Ecosystem effects of the bottom trawling in southern Baltic should be added under 1.1.2, The major effects of fishing on the ecosystem. The suggested contact: Piotr Margonski

As it is impossible to do the suggested work during the SGBFFI 2006 meeting it was proposed that all the recommendations above should be completed by the WGRED 2007 meeting in order to be included in the report. Communication with the individuals indicated above and the WGRED Chairperson is the duty of the SGBFFI Co-Chairs: Maris Plikshs and Henn Ojaveer.

7 Framework for Integrated Assessment for the Baltic Sea and the future role of SGBFFI

During SGBFFI meeting in 2005 discussions on future role of the study group, the coordination with other study groups (especially those related to the BSRP and Baltic Committee) reveal the need to re-organise the Baltic Sea research within ICES. During joint SGBFFI and SGMAB session a new structure of ICES Baltic Committee was proposed. The main arguments for re-organising the WG/SG-structure were the need for advancing towards an Integrated Assessment (IA) of the Baltic Sea ecosystem, significant workload of scientists attending meetings and certain overlap of tasks in different study groups. Hence, the group once again supported the proposed general structural reorganization of the Baltic Committee work.

In general, it was agreed to abandon the SGBFFI as a separate group but stress the need to keep the network especially for the coastal fish specialists. Coastal fish research and monitoring aspects should be preferably shifted from the SGBFFI to the respective HELCOM groups in order not to double the work. Concerning the SG tasks related to open see investigations on the main commercial species and internationally assessed fish stock needs it was recommended to merge SGBFFI with Study group of Multispecies Assessment in the Baltic (SGMAB). This requires reorganization of the 'new' SGBMAB work structure: in one year, MSVPA of Central Baltic should be performed, in the next year, ecological and biological aspects of the Baltic Sea fishes in relation to improvement of assessments of the open-sea and coastal fishes should be dealt with. Additionally an important issue is establishment a "short living" workshops to deal with problematic issue for example recruitment, ageing or establishment of the stock units of certain species etc. The tasks for workshops should be quite narrow and it could be the forum for specialists of a given subject.

This proposal should be discussed during the next Baltic Committee and SGMAB meetings.

8 Age reading inconsistencies for the Baltic sprat

In 2004 the Lead Laboratory (LL) on Age Determination and Fish Stomach Analysis Baltic Sea Regional Project (BSRP) initiated exchange of sprat otolith samples between sprat age determination experts of all national fisheries institutes of the Baltic Sea. As a result 8 sprat otolith samples were prepared by spring 2004 and started their circle around the Baltic Sea. Ten age readers from nine countries participated in age determination of these sprat otolith samples. The age determination results were sent to LL where they were analysed and when the sample was treated by all the experts the final results of the analysis were distributed between national institutes. The exchange was finished by autumn 2005.

In general the age determination results showed the existence of significant differences in age determination between the readers. Thus according to Wilcoxon signed rank test the disagreement between all individual readings of the readers was stated from 28.9% in the Danish sample till 88.9% in the Estonian sample (on average for all the samples in 65.2% of the cases). The percentage of identically determined age was on average from 36.2% in the Estonian sample till 72.3% in the first part of the Polish sample (on average 58.3% for all the samples). The agreement between readers decreased with the age of the sprat in the samples. Thus in samples with lower average age the disagreement in Wilcoxon test was lower and the percentage of identically determined age was higher. Comparing the individual age determinations with the modal age the highest agreement was stated in the younger age groups and the agreement decreased with the age of sprat. For age group 1 the agreement was always above 80% – on average 91.7%, while for age group 5 it was on average only 55.5.%. As a result the average determined age of readers differed significantly, and in Estonian sample the difference of extreme values was 2.25 (4.41–5.66).

The above mentioned problems in age determination of sprat indicated the necessity for a meeting of sprat age readers. It was decided to hold a Sprat Age Reading Workshop in Danish Institute for Fisheries Research, Charlottenlund, Denmark from 24 to 27 January 2006. The Workshop was attended by 13 age determination experts from 9 countries, During the Workshop the participants summarized the results of sprat otolith sample exchange, indicated the possible reasons for differences in age determination of sprat, elaborated the criteria for age determination of sprat in the Baltic Sea, and produced recommendations for future cooperation between national institutes. The most important recommendations are the following:

1) to use microscopes with magnification of at least 100x for the age determination of sprat;
2) to prepare new sprat otolith samples for a new exchange and to start it by May 2006;
3) to hold the next Sprat Age Reading Workshop in three years time.

The Report of Sprat Age Reading Workshop will be available on BSRP website in March 2006.

9 Status and dynamics of the gulf herring populations in the Baltic Sea

The SGBFFI participants were informed on an international workshop on herring that took place in November 2005 at Öregrund. The purpose was to discuss recent biological changes of herring in the Bothnian Sea and compare these changes with the situation in the other Baltic sub-basins. The meeting was attended by Estonian, Finnish and Swedish scientist. Below is a short resume of items that was discussed during the meeting.

Exploitation

Herring in the Bothnian Sea is caught by Swedish and Finnish fishermen. The offshore trawl fishery dominates while the coastal net fishery is of minor economic importance. Total landings were below 30 000 tons 1973–1989, increased to around 65 000 tons in 1997 and decreased to around 55 000 tons in 2004. ICES have classified herring in Subdivision 30 as having full reproductive capacity and as harvested sustainably. ICES concluded that catch quota could increase to more than 90000 tons in 2004 without jeopardizing the status of the stock. However, the ICES assessment is based on samplings from the fisheries and does not include fishery-independent data. The biological assessment indicates a dramatic shift in maturity towards young herring since the late 1990s. Growth appears to be density-dependent since mean weight per age is inversely related to herring abundance.

Migration patterns

Reviews from tagging experiments have indicated that herring in the Bothnian Sea belongs to local stocks and seldom migrates outside the Gulf of Bothnia. Experiments in 1963–1991 partly confirm this pattern. Recaptures from these experiments of mature herring show that herring migrate to feeding and over wintering areas in autumn-winter and return to the spawning grounds during spring. Main spawning occurs in April-June but spawning generally continues all through August.

Research and monitoring

Standard net surveys indicate that the abundance of herring along the Swedish coast has decreased since the 1980s. Larger herring (>15 cm TL) has decreased relatively more than smaller herring. Inquiries made to coastal fishermen suggest that the spawning behaviour of herring has changed in the recent 4–6 years. Less large spawners arrive in spring to the traditional spawning areas in shallow waters and spawning has shifted to deeper waters. However, larvae surveys in 2005 do not indicate any change in larval abundance compared to the 1984–1991.

Consumption by seals

The grey seal (*Halichoerus grypus)* population has increased in the Gulf of Bothnia. Preliminary studies suggest that consumption of fish by the grey seal is significant. Total consumption of herring in the Bothnian Sea only was estimated to 6600 tons per year, which corresponds to more than 10% of the total herring landings. Grey seals prefer larger herring and their effect on herring populations may confound estimates of the impact of size selective fishing.

Conclusions

Several similar trends in the performance of herring at individual and population level have been observed in several areas in the Baltic Sea. These include, amongst others, decreased individual growth rate, less large herring in a population, earlier maturation and reduced spawning at traditional spawning grounds. Local studies have shown changes in embryonic development, decreased larval abundance and increased seal predation. However, these changes have not been studied all over the Baltic Sea as yet in details and therefore, cannot be conclusively judged in terms of the change rates or the potential uniformity of the processes responsible for the observed changes in various sub-basins. However, it was suggested that local effects might be related to the large-scale changes in the sea.

The participants of the meeting agreed on a plan for further scientific cooperation. A next meeting was scheduled for spring 2006??? (perhaps 2007).

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Annex 2: Agenda

Monday 20 February (13.00–18.00)

13.00 – 14.00 Opening and welcome

Practical arrangements of the meeting (**Rimas Repecka**)

Adoption of agenda and timetable

Introduction of ToR's and responsibilities (**Maris Plikshs and Henn Ojaveer**)

Organization of sub-groups and distribution of tasks

14.30 – 15.00 Presentation and discussions

Didzis Ustup/Dace Zilnieces – Present knowledge of population structure of flounder stocks

Discussion on ToR c) – population structure of flounder stocks in the Baltic and possible stock assessment units

Discussion on ToR e) – slope of size spectra for selected coastal fish species

15.30 – 16.00 Coffee break

16.00 – 18.00 Presentations and discussions

Henn Ojaveer – Baltic Sea overview and possible updates of overview by information on open sea and coastal interactions in the Baltic

Discussion on ToR f) – WGRED 2005 the Baltic overview

Christian Möllmann – ICES/BSRP/HELCOM Workshop on Developing a Framework for an Integrated Assessment of the Baltic Sea

Discussions on possible role of SGBFFI in the context of integrated assessment in the Baltic – ToR g)

Tuesday 21 February (09.00–18.00)

09.00 – 10.30 Presentations and discussions

Johan Modin – Growth changes of herring in the Northern Baltic – short resume of herring specialist meeting in Öregrund, Sweden (autumn 2005)

Michele Casini – Herring and sprat growth modelling

Discussions on ToR a) and b) – herring and sprat growth changes, possible ways of modelling

ToR d) Establishment and allocation of tasks for growth modelling subgroup

10.30 – 11.00 Coffee break

11.00 – 13.00 Presentations and discussions

Tiit Raid – Herring recruitment in the Baltic: present knowledge

Max Cardinale – Effects of temperature on the Baltic fish recruitment success

Didzis Ustups – Factors influencing flounder recruitment in the Eastern Baltic

Discussions on ToR d) – environmental factor influence recruitment of herring and flounder.

13.00 – 14.30 Lunch

14.00 – 15.30 Work in Sub-groups

15.30 – 16.00 Coffee break

16.00 – 18.00 Work in Sub-groups

19.30 Dinner

Wednesday 22 February (09.00–18.00)

09.00 – 10.30 Work in subgroups

10.30 – 11.00 Coffee break

11.00 – 13.00 Work in subgroups

13.00 – 14.30 Lunch

14.00 – 15.30 Plenum: discussion of subgroup conclusions

15.30 – 16.00 Coffee break

16.00 – 18.00 Work in sub-groups and preparation of Sub-group texts

Thursday 23 February (09.00–14.00)

09.00 – 10.30 Work in subgroups

10.30 – 11.00 Café break

11.00 – 14.00 Plenary and closing

Finalization of the meeting report

Plenum: Summary and conclusions of the study group, final remarks

Closing of the meeting

Annex 3: Recommendations

1. Herring and sprat growth

- SGBFFI recommends to establish the special ad-hoc workshop in June 2006 Riga. The dates of workshop will be set intersessionally during May 2006;
- Deadline for national sprat data from hydro-acoustic survey 1993–2005 submission for their compilation for growth analyses was set to 1 April 2006;
- SGBFFI recommends that herring and sprat databases are annually updated and that in future they are mastered by Study Group on Multispecies Assessment in the Baltic. National laboratories are asked to supply herring data from 2004 and 2005 until 1 April 2006;
- SG reiterates the last year's recommendation that environmental data (e.g. hydrography and zooplankton) should be sent to LATFRA. Additionally existing international databases should be explored e.g. HELCOM.

2. Herring recruitment

The existing knowledge on recruitment formation mechanisms indicates that environmental factors have key role in recruitment formation, at least in gulf herring stocks. However, the environmental interactions are incorporated into assessment processes only in a few cases (e.g. the Gulf of Riga herring) so far. In order to explore the possible relationships between herring recruitment including climate- related ecosystem changes, e.g. changes in zooplankton abundance and composition, the SG is proposing a special workshop allowing the respective experts to focus on recruitment issues of the Baltic herring stocks.

An **ICES/BSRP Workshop on Recruitment Processes of Baltic Sea herring stocks** [WKHRPB] (M. Cardinale, Sweden and C. Möllmann*, Denmark will meet from 1–4 March 2007 to (*possibly one week later or beginning of February*) [venue to be decided]. The full draft resolution is included in Annex 4.

3. Future of SGBFFI

a) Generally, the SG agreed to abandon the SGBFFI as a separate group but stresses the need to keep the network, especially for the coastal fish;

b) It was recommended to merge SGBFFI with the Study Group on Multispecies Assessment in the Baltic (SGMAB). This requires reorganization of the 'new' SGBMAB work structure in this case – one year to perform MSVPA for the Central Baltic Sea, and the next year to fulfil tasks on biological and ecological aspects of the Baltic Sea fishes in relation to improvement of assessments of the open sea and coastal fishes. This proposal should be discussed during next SGMAB meeting.

4. Baltic fish indicators

a) SGBFFI recognizes the necessity for improvement of coordinated activities for developing the fish and fisheries related indicators in the Baltic Sea (e.g. SGEH, HELCOM MONAS, INCOFISH, INDECO, ICES SGBFFI);

b) It is suggested that the Institute of coastal research, Öregrund, Sweden is taking the leading role for the Baltic coastal fish and fisheries community and species indicators;

c) Analysis of ecosystem state by size based indicators (e.g. mean size or size spectrum analysis) can be used for surveillance and monitoring. However, in order to use them for ecosystem management reference points need to be developed.

5. Population structure of flounder:

a) SGBFFI recommends continuation of the flounder microsatellite/genetics investigations in order to establish possible stock units;

b) Separation of flounder stocks into the assessment units is possible only after results of the genetic studies and regional behaviour information data compilations is becoming available (e.g. migration, stock trends, spawning behaviour, recruitment etc);

c) The assessment units of flounder should be linked to management measures in different areas;

d) The establishment of a specific flounder stock unit separation workshop is recommended after completing the genetic investigations.

Annex 4: Draft resolution for ICES/BSRP Workshop

An **ICES/BSRP Workshop on Recruitment Processes of Baltic Sea herring stocks** [WKHRPB] (C. Möllmann*, Germany, and M. Cardinale*, Sweden) will meet in Hamburg, Germany, from 1–4 March 2007 to:

a) review existing knowledge on recruitment processes of the different Baltic Sea stocks;

b) review existing and compile new time-series on recruitment as well as biotic and hydroclimatic variables;

c) investigate direct and indirect effects of climate (e.g. changes in salinity/temperature, zooplankton abundance and composition, competition) on recruitment;

d) evaluate the feasibility of including environmental variables into stock-recruitment relationships;

e) suggest scientific studies to investigate the processes behind climate-related trends in recruitment.

WKHRPB will report by 4 April 2007 for the attention of the Baltic Committee.

Supporting Information

PRIORITY:	This Workshop aims at investigating and modelling the effect of direct and indirect effects of climate on the different Baltic Sea herring stocks. It further will review existing knowledge on recruitment process and develop proposals for future scietific studies.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	The Workshop contributes to Actions 1.2, 1.3, 1.6, 1.7, 1.12, 3.2, 3.5, 3.15, 4.11, 4.15, 5.3, 5.6., of the ICES Action Plan. Herring is an essential component of the Baltic ecosystem, being a food item for cod and exerting predation pressure on zooplankton populations. The different populations are of considerable commercial value for the countries bordering the Baltic. While growth of herring has been intensively studied, studies on recruitment processes of Baltic fish stocks have in recent decades been exclusively directed to cod and sprat. However, recruitment trends drive a large proportion of the dynamics of the different stocks, which are partly of opposite direction. Indications exist that these trends in recruitment are due to direct (temperature, salinity) and indirect effects (food availability, competition with sprat stocks) of climate. The Baltic, as many other ecosystems, underwent shifts between different regimes affecting most likely also the herring stocks. Reliable predicting recruitment is essential for proper stock management and environmentally-sensitive stock recruitment relationships are essentail for implementing precautionary and ecosystem approaches. The workshop will thus use the extensive amount of biotic and abiotic time-series as well as expertise to i) statistically investigate recruitment – environment relationships, ii) model environmentally sensitive stock-recruitment relationships, and iii) suggest future scientific studies to investigate the processes behind the relationships.

RESOURCE REQUIREMENTS:	Assistance of the secretariat in maintaining and exchanging information and data to potential participants.
PARTICIPANTS:	This Workshop is expected to attract 10-15 participants working on Baltic herring stocks, contributing data and expertise. Further, experts from other areas such as the North Sea should be encouraged to participate.
SECRETARIAT FACILITIES:	None.
FINANCIAL:	None.
LINKAGES TO ADVISORY COMMITTEES:	ACFM
LINKAGES TO OTHER COMMITTEES OR GROUPS:	BCC, LRC, SG/WG related to Baltic Sea issues, HAWG
LINKAGES TO OTHER ORGANIZATIONS:	Baltic Sea Regional Project (BSRP), HELCOM
SECRETARIAT MARGINAL COST SHARE:	ICES 100%.