

Appendix 11– Stock Annex

Quality Handbook

ANNEX: Baltic Sprat SD 22-32

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Baltic Sprat in Subdivisions 22-32

Working Group: Baltic Fisheries Assessment Working Group

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A. General

A.1. Stock definition

Sprat is distributed mainly in the open sea areas of the whole Baltic Sea. However high concentrations of YOY specimens appears in coastal areas (especially in mixed fresh water from rivers and sea waters), primarily in autumn and in 1st quarter of the year. Above mentioned areas are preferred in the some season also by juvenile herring. During the year mixed sprat and herring shoals occur very often in both open sea and coastal areas.

Based on the ICES WGs and ACFM advice's sprat in the Baltic Sea was assessed from last 15 years as a single unit within the ICES Subdivisions 22–32. In the 1980s and on the beginning of 1990s some attempts to distinguish different Baltic sprat stocks/populations were conducted, but significant evidence about sprat stock heterogeneity was not published.

A.2. Fishery

The main part of the sprat catches is taken by pelagic single and pair trawling (using a mesh size of 16mm in the codend). In addition there are demersal trawling activities for Baltic sprat in some parts of the Baltic. The sprat fishery is carried out in the whole year around. However the main fishing season in most countries is in the first half of the year, but in the northern part of the Baltic ice covering is limiting factor for all fishing operations.

In a part of countries Baltic sprat is fished by two type of fleets - small cutters (17-24 m length) with engine power up to 300 h.p., and by medium size cutters (25-27 m length) with engine power up 570 h.p. In some countries third type of vessels is engaged in sprat fishery, i.e. large vessels – over 40 m length with engine power of 1050 h.p. The last type of fleet, having the trawls with high vertical opening and operate in the areas deeper than 50 m and according to national regulation (e.g. in Russia) they obliged to use the sorting machines, that can separate herring from sprat. This fleet, targeting sprat for the human consumption, during 1st and 2nd quarters. During summer this fleet targets sprat for the animal food and by-catches of small herring is increased.

Up to now in most countries annual sprat quota was not fully utilized, and in opposite low herring quota was fully utilized. This fact with increasing sprat TAC and decreasing herring TAC created a strong incentive to misreport herring as sprat.

A.3. Ecosystem aspects

Stock trends in Baltic sprat have been driven since the 1990s mainly by released predation by cod and high (although varying) recruitment success (Köster et al. 2003). The latter may be related to the unusual high state of the North Atlantic Oscillation (NAO), resulting in unusual high temperature conditions. Variations in temperature may be large enough to affect sprat biology (Kalejs and Ojaveer, 1989). Sprat in the Baltic Sea are located near the northern limit of the species' geographic distribution (Muus and Nielsen, 1999), which ranges from the Black Sea to southern-central Norway. Low temperatures can therefore be expected to be detrimental for production and survival in the Baltic Sea. Laboratory experiments have shown that cold water prevents hatching of sprat eggs from the North and Baltic Seas (Thompson *et al.*, 1981; Nissling, 2004). Field studies show that the temperatures which suppress sprat egg development in the laboratory also occur in the Baltic Sea at times, places and depths where sprat eggs occur

(MacKenzie and Köster, 2004). Comparison of interannual variability in sea temperatures at main sprat spawning time (May) with sprat recruitment shows a statistically significant positive relationship (MacKenzie and Köster 2004). The same temperatures that affect sprat recruitment are themselves influenced by winter severity indices, including ice coverage in the Baltic Sea and a winter index (January-February) of the North Atlantic Oscillation (MacKenzie and Köster 2004).

Another mechanism how the increase in temperature may have affected sprat recruitment is the change in the food environment. Sprat larvae have a strong preference for the copepod *Acartia* spp. (Voss et al. 2003), which has been drastically increased since the 1990s in parallel to the increase in temperature (Möllmann et al. 2000). This may have lead to in general higher larval survival.

Beside an increase in temperature, the unusual climate situation during the 1990s have been resulted in a change in the circulation pattern and thus in the drift pattern of sprat larvae (Hinrichsen et al. 2003). Recent investigation using 3d-hydrodynamic modelling have shown that retention vs. dispersion in the Baltic deep basins have a strong influence on recruitment success of sprat (Baumann et al. 2004).

Beside recruitment a further important ecosystem-related aspect of sprat in the Baltic is the decrease in growth during the 1990s (Grygiel and Wyszynski 2003, Götze and Gröhsler 2004). This is related to the decrease in abundance of the copepod *Pseudocalanus* sp., one of the most important food item of sprat during spawning in spring (Szypuła et al. 1997, Möllmann et al. submitted), and the strong intraspecific competition due to the large stock during the 1990s.

B. Data

B.1. Commercial catch

In 1997 sprat catches were at a record high of 529,400 t for the whole Baltic, and have since decreased to 308,260 t in 2003. In 2003 sprat catches decreased about of 34-81 thousand tonnes in comparison with the recent three years. They were 10% less than in 2002 and 42% less than the record high level in 1997.

Sprat catches are utilized for industrial purposes and human consumption. In most of the countries discards of sprat are not supposed to exist because small and lower quality fish can be used for production of fish meal and feeding in animal farms. In fishery directed for human consumption, however, young fish are discarded with higher rates in the years with strong year classes recruiting to the fishery. The amount of this discard is unknown.

The species composition of the mixed catches is defined from logbooks and, partly, by observers on board of larger commercial vessels in compliance with the special agreement between institute and vessel owners. In some countries e.g. in Denmark and Sweden, data about catch composition and other biological data are delivered by fishery inspection in harbors and by managers of fish stock exchange.

B.2. Biological

Weight at age in the stock is assumed to be the same as weight at age in the catch.

The natural mortality coefficient used for assessment varied between years and ages (0.250-1.187). For forecast values (0.276-0.407) from year 2003 were taken.

Both proportion of natural mortality (M_{prop}) and proportion of fishing mortality (F_{prop}) before spawning are set to 0.4.

In the years 1974-2003 knife-edge maturity at age 3 was used for this stock. At the assessment in 2002 a new maturity ogive was introduced for the whole time series. This ogive is based on the distribution of age at first spawning estimated for the last 20 years.

B.3. Surveys

The data on clupeids stock size in the Baltic Sea, estimated by hydroacoustic methods, are submitted to the WGBFAS from 1983 till recent years. Mentioned data are collected in autumn (October) each year and elaborated by most of the countries around the Baltic. In the assessment procedure two options of data are applied:

- one is the Russian-Latvian data for recruitment estimates,

- second is the international and the Russian-Latvian data for tuning fleets for XSA input data.

The results from the individual vessels are placed in the database BADI. For each ICES rectangle the following data was compared between vessels - the covered area of the rectangle and the number of hauls in the rectangles.

The differences between herring and sprat and length composition were being supposed as stochastic variations. If the whole rectangle was investigated by both vessels and the number of hauls was more than one the arithmetic mean of both data sets were used. If the coverage of the rectangles were quite different or the number of hauls were zero for one vessel the handling of the data were discussed.

During the last meeting (April 2004) WGBIFS recommends that the data from 2003 can be used in the assessment process of the Baltic herring and sprat stocks.

B.4. Commercial CPUE

Preliminary and very limited in time and areas, new submitted to WGBFAS meeting 2004 data on fishing effort and CPUE in sprat fishery not allowed on analyses of the effect of changes in mentioned parameters on sprat stock assessment.

B.5. Other relevant data

New data about recruitment, estimated from statistical relationship between sprat recruitment and NAO, were applied for short-term forecast for 2005.

C. Historical Stock Development

Model used: XSA

Software used: IFAP / Lowestoft VPA suite

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability dependent of stock size for ages 1 - 3

Catchability independent of age for ages ≥ 4

Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.75

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1974 – last data year		Yes
Canum	Catch at age in numbers	1974 – last data year	1 – 8+	Yes
Weca	Weight at age in the commercial catch	1974 – last data year	1 – 8+	Yes
West	Weight at age of the spawning stock at spawning time.	1974 – last data year	1 – 8+	Yes - assumed to be the same as weight at age in the catch
Mprop	Proportion of natural mortality before spawning	1974 – last data year	1 – 8+	No – set to 0.4 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1974 – last data year	1 – 8+	No – set to 0.4 for all ages in all years
Matprop	Proportion mature at age	1974 – last data year	1 – 8+	No – the same ogive for all years, averaged over noisy long time series (1981-2002)
Natmor	Natural mortality	1974 – last data year	1 – 8+	Yes – estimated from most recent MSVPA

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Latvian/Russian acoustic in Sub-div. 26 + 28	1983 – last data year	1 - 7
Tuning fleet 2	International acoustic	1983 – last data year	1 - 7

Alternative procedures were analysed in previous WG reports, the recent one is presented in the 2003 WG report.

D. Short-Term Projection

Model used: Age structured

Software used: MFDP ver 1.a

Initial stock size: Taken from the XSA – survivors for assessment year at age 2 and older. The recruitment at age 1 for year in which assessment is conducted is estimated using RCT3. The recruitment in next 2 years is taken as the long-term geometric mean since 1989.

Natural mortality: Set to average of the 3 last years in assessment.

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: The same values as in assessment

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: Set to average weight of the 3 last years in assessment

Exploitation pattern: Average of the 3 last years in assessment. Un-scaled if no clear trend in F_{bar} (3-5) is observed, otherwise scaled to F_{bar} level of the last assessment year.

Intermediate year assumptions: Usually both F_{sq} and TAC constraint options are presented and the option preferred WG is indicated.

Stock recruitment model used: None.

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

Model used: Age structured

Software used: Excel spreadsheet

Initial stock size: The same as in the short-term predictions.

Natural mortality: The same as in the short-term predictions (the 3 years average of recent MSVPA estimates)

Maturity: The same as in the short-term predictions

F and M before spawning: The same as in the short-term predictions i.e. set to 0.4 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: Assumed as average of the data from 1997 onwards (period of data fluctuation without trend)

Exploitation pattern: The same as in the short-term predictions, i.e. average of the last three years, scaled or unscaled to the F_{bar} (3-6), depending on existence of a trend in F_{bar}

Intermediate year assumptions: The same as in the short-term predictions

Stock recruitment model used: Beverton and Holt model

Uncertainty models used:

- Initial stock size: for age 2 and older the lognormal distribution with mean as in the short-term predictions and standard deviation assumed to be the larger value of the internal or external standard error estimated for the survivors in XSA; for recruiting age (age 1) the lognormal distribution with mean and standard deviation estimated by RCT3
- Natural mortality: no uncertainty is assumed
- Maturity: no uncertainty is assumed
- F and M before spawning: no uncertainty is assumed
- Weight at age in the stock: Assumed to be the same as weight at age in the catch.
- Weight at age in the catch: normal error distribution with the 1997-present average and standard deviation estimated from the same series
- Exploitation pattern: no uncertainty is assumed
- Intermediate year assumptions: no uncertainty is assumed
- Stock recruitment model used: Beverton and Holt model with lognormal errors, the model is fitted to whole time series of data, i.e. 1974 onwards.

F. Long-Term Projections

The PA software (CEFAS, Lowestoft) has been used.

The F_{max} is not reliably estimated.

The $F_{0.1}$ is estimated as 0.56

G. Biological Reference Points

In 1996 the WG estimated MBAL at 200,000 t, based on the Mayer *et al* (1994) approach. The approach assumes the MBAL as biomass which produce half of maximal recruitment on fitted stock-recruitment curve. Next, this MBAL was treated as the estimate of B_{lim} as only few points left to the MBAL were observed in stock-recruitment plot. The B_{pa} was consequently estimated at about 275,000 tons, multiplying of B_{lim} by $\exp(1.65*SE)$, where SE was assumed 0.2 (approximately SE of XSA estimates of survivors). However, re-estimation of B_{lim} in 2003 using Mayer *et al* (1994) method produces the B_{lim} of 510,000 tons. This change from the 1996 estimate is the effect of new maturity ogives as well as new observations on stock-recruitment graph.

The segmented regression analysis conducted recently by ICES Secretariat produces estimate of B_{lim} as 200,000 tons.

The F_{pa} was adopted as F_{med} by ACFM in 1998. This value is not stable and varies from year to year assessment within 0.3 – 0.45. Presently F_{pa} of 0.4 is assumed.

H. Other Issues

None.

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