Stock Annex: Herring (*Clupea harengus*) in subdivisions 25–29 and 32, excluding the Gulf of Riga (central Baltic Sea)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Herring
Working Group:	Baltic Fisheries Assessment Working Group (WGBFAS)
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A. General

A.1. Stock definition

The stock comprises mainly spring-spawning herring and a small autumn-spawning population. Spring-spawning occurs at the coast with a temporal gradient from south to north. After spawning, individuals migrate to the deep basins for feeding. In addition, migrations between subareas of the Baltic have been observed (Aro, 1989). Since 2005, the stock has been managed together in units SD 25–27, 28.2, 29 and 32 (EC and Russian quotas).

A.2. Fishery

Pelagic stocks in the Baltic Proper (Subdivisions 25–29, 32) are mainly taken in pelagic trawl fisheries, of which the majority take herring and sprat simultaneously. But coastal gillnetters and purse seine fisheries targeting herring for consumption also exists. The estimates of pelagic catch compositions are based on logbooks and landing declarations. Discarding at sea is not considered to be a problem for this stock. The major part of the catch is historically taken by Sweden, Poland and Finland. Landings of central Baltic herring caught in the Gulf of Riga are included in the assessment.

A.3. Ecosystem aspects

Drastic changes in the weight-at-age (WAA) of herring have been observed since the late 1980s (Parmanne *et al.*, 1994; Cardinale and Arrhenius, 2000). A decrease was observed in almost all age groups and in all open areas of the Central Baltic, with the exception of the most northerly (Cardinale and Arrhenius, 2000). The low WAA has had dramatic effects on the biomass and the catches of herring. Additionally, the poor condition of the fish (i.e. low fat content) has important implications on the marketing for human consumption (Raid and Lankov, 1995).

Three different hypotheses have been put forward to explain the decrease in WAA of Baltic herring, which include (i) a reduction in selective predation of cod on smaller herring (Sparholt and Jensen, 1992; Beyer and Lassen, 1994), (ii) an influx of slow-growing individuals from the northern areas, and (iii) a real decrease in growth rates due to changes in stock size and feeding environment.

The latter hypothesis has been also supported by Flinkman *et al*. (1998) showing changes in WAA in the Northern Baltic to be related to the mesozooplankton species composition. For the Central Baltic, Horbowy (1997) modelled growth of herring in relation to the biomass of *Mysis mixta*. Similarly Szypula *et al*. (1997) stressed the importance of the macrozooplankton fraction in the diet of planktivores. Other studies have shown the importance of the copepod *Pseudocalanus* sp. for nutrition of Baltic herring (Davidyuka, 1996, Möllmann *et al*., 2003). Low salinity conditions have negatively affected the stock development of this copepod (Möllmann *et al*., 2003), which is the most important food item for open-sea herring in spring. The increased competition with the sprat stock has been indicated as another crucial factor in the decrease of herring growth, operating via top-down regulation and density-dependent mechanisms (Cardinale and Arrhenius, 2000; Casini *et al*., 2006).

B. Data

B.1. Commercial catch

The sampling for age composition is considered adequate. Most countries provide age composition of their major landings (landed in their waters by quarter and Subdivision*)*. The landings for which age composition was missing represented about 15 % of the total landings in 2011. Denmark, Sweden and Poland use fisheries independent sampling to estimate the landing figures for herring and sprat from trawl fisheries. In this fishery the logbook data may not be sufficient and the sampling is used to increase accuracy in the input data.

B.2. Biological

Weight at age in the stock is assumed to be the same as weight at age in the catch. No survey information from the first quarter is available, which could be used as the mean weight in the stock.

Natural mortalities were derived by SMS -runs performed by WGSAM and are used both in the assessment and forecasts. The latest update covered the years 1974-2011 (WGSAM 2012). When new updates are not available, this series should be extrapolated using the average of the most recent 3 years as an estimate of M.

The proportion of natural mortality before spawning (Mprop) is set at 0.30 and the proportion of fishing mortality before spawning (Fprop) is set at 0.35. The proportions mature at age were 0 for age 1, 0.7 for age 2, 0.9 for age 3 and 1 for older.

B.3. Surveys

The revised stock abundance estimates from the Baltic International Acoustic October Survey (BIAS) were available for the years 1991–2011. The data were revised by WGBIFS experts (further details see Annex H4). The estimates for the years 1993, 1995 and 1997 were excluded due to an incomplete coverage of the standard survey area. There was less than 4% decrease in the recalculated BIAS tuning fleet index for Central Baltic herring in the SD 25–27, 28.2 and 29 due to the corrections made in the database. The BIAS tuning fleet index for Central Baltic herring recruitment in the SD 25–27, 28.2 and 29 has now been area corrected and a correction of the rectangle assignments was performed. Due to these changes, the herring recruitment indices increased quite substantially in some years (e.g. 1991 and 2002).

Also new BIAS tuning fleet indices for testing with two new Central Baltic herring assessment units were evaluated and provided for benchmark assessment. These new data-series include the BIAS tuning fleet index (numbers in millions) for Central Baltic herring in the ICES Sub-divisions 25–27, BIAS tuning fleet index (numbers in millions) for Central Baltic herring in the ICES Subdivisions 28.2 and 29, and corresponding recruitment tuning fleets for both of these areas. The internal consistency of these new tuning fleets is worse compared to the BIAS tuning fleet index for Central Baltic herring as one assessment unit.

An alternative data-series for Central Baltic herring was presented with the exclusion of the data from the inconsistently covered area of ICES Sub-division 29N. That new tuning fleet had somewhat better internal consistency compared to the ones that include SD29N herring data.

Additionally, the inclusion of the herring acoustic data from SD 32 to the tuning data-series was tested. The internal consistency of these tuning fleets was very poor and the inclusion of the SD 32 data would lead to an opposite trend of Central Baltic herring abundance. On this basis, it was decided to postpone the testing of these new tuning fleets, including the acoustic data from SD 32, until the next benchmark assessment of the Central Baltic herring.

Two acoustic time-series were selected for the final assessment of Central Baltic herring: BIAS tuning fleet index for Central Baltic herring in the SDs 25–27, 28.2 and 29 for the years 1991-2011, and BIAS tuning fleet index for Central Baltic herring recruitment (age 0) in the SD 25–27, 28.2 and 29 for the years 1991-2011. For the calculation of these data-series all the data from the ICES Sub-division 29 were included. Index values for the years 1993, 1995 and 1997 were excluded from both time series.

B.4. Commercial CPUE

B.5. Other relevant data

C. Historical Stock Development

Model used: XSA

Software used: Lowestoft VPA suite

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability dependent on stock size for ages < 2

Catchability independent of age for ages >= 6

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 = 1.500

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

Prior weighting not applied

Model Options chosen:

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	1-8+	No
Canum	Catch at age in numbers	1974-last data year	1-8+	No
Weca	Weight at age in the commercial catch	1974-last data year	1-8+	No
West	Weight at age of the spawning stock at spawning time = WECA.	1974-last data year	1-8+	No
Mprop	Proportion of natural mortality before spawning	1974-last data year	1-8+	No
Fprop	Proportion of fishing mortality before spawning	1974-last data year	1-8+	No
Matprop	Proportion mature at age	1974-last data year	1-8+	No
Natmor	Natural mortality	1974-last data year	1-8+	Yes

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Acoustics	1991-last data year	1-8+

D. Short-Term Projection

Model used: Age structured

Software used*:* MDFP vers. 1a

Initial stock size: in the 2010 assessment from the XSA for age 2–8+. The recruitment at age 1 from RCT3. The long-term geometric mean recruitment for a period of unchanged pattern in recruitment is used for age 1 in all projection years (1988-last data year -1).

Natural mortality:

M: Average of the three last years, optionally the last year only when a clear and consistent trend in M occurs.

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

F and M before spawning: Set respectively to 0.3 and 0.35 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: Average weight of the three last years

Exploitation pattern: Average of the three last years, optional rescaling of Fbar (3-6) to the level of the last year, depending on existing or non-existing time trend in F(3-6) in recent years; Intermediate year assumptions: TAC constraint or status quo F or both

Stock recruitment model: None, the long term geometric mean recruitment at age 1 is used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

G. Biological Reference Points

Blim was set at Bloss=430 000 t and Bpa was set at 600 000 t (WKBALT 2013). MSY Btrigger was set at Bpa=600 0000 t. The values of Flim and Fpa were estimated at 0.52 and 0.41, respectively.

In 2015 ICES (ICES 2015) provided new precautionary FMSY ranges [Flower, Fupper] that are derived to deliver no more than a 5% reduction in long-term yield compared with MSY. In order to be consistent with the ICES precautionary approach Fupper is capped, so that the probability of SSB< Blim is no more than 5%. Two approaches have been used to derive the values of the cap on Fupper. One conforms to the ICES MSY advice rule (AR), and requires reducing F linearly towards zero when SSB is below MSY Btrigger. The second uses a constant F without an advice rule. Although the first often provides a wider FMSY range, it requires the ICES MSY advice rule to be used. The new estimate of F_{MSY} is 0.22. The resulting ranges are shown in the text table below.

MSY Flower	FMSY	MSY Fupper with AR	MSY Btrigger (1000 t)	MSY Fupper with no AR
0.16	0.22	0.28	600	0.22

H. Other Issues

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