Age determination of Baltic cod

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Introduction

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Growth is one of the most important factors in fisheries management. If the growth of the fish, G, is less than the natural mortality, M, the year class will loose weight without any fishing. As an example, if the natural mortality is 20%, the weight of the fish has to increase more than 20% if a catch reduction is to be recommended.
Growth is usually expressed as "weight at age" but no information on growth of Baltic cod is found in the ICES advice.
In the ICES advice from 2009 on the Cod in Subdivisions 25-32, 8.4.2, it says:

"Uncertainties in assessment are mainly due to problems with underreporting, discarding, and age-reading. **Large inconsistencies exist in age determinations for the Eastern Baltic cod stock owing to the lack of clear growth rings in the otoliths.** This results in poor quality catch-at-age and survey data, and a likely underestimation of fishing mortality. ICES attempted to resolve the inconsistencies in age reading for this stock, but no consensus on the interpretation of age readings was reached. An EU-funded study initiated in 2007 (project DECODE) will take a different approach to deliver validated aging data for the assessment."
"Problems with the catch and survey data and inconsistent age determinations make it difficult to precisely determine the strengths of the 2005 and 2006 year classes".

In other words, the growth of the Baltic cod is not known. Despite that, ICES calculates the short- medium- projections of the stock according to different management plans, which only relates to adjustment of the fishing pressure. This is an impossible task without knowing the growth rate. Also: The figure they use for the natural mortality rate, 18%, is plain guess work.

Age can also been determined from growth rings in scales. This is the most common method used for ageing salmon and trout and is can also be used to age haddock, cod, saithe and other gadoids.
I was interested to see if it was possible to use the method on Baltic cod, and got some samples from Poland.

Material, methods

Scales were collected from 15 Baltic cod, 42-77 cm long. Length and weight were recorded but no other data were collected, i.e. maturity, stomach content, parasites etc.
Scales were pressed into soft celluloid plate to obtain a mold of the scale surface. The molds were placed in a micro film reader for age reading. Length at age was back calculated by measuring the distance from the of the annuli from the centre of the scale, assuming a linear relationship between scale size and fish length.

Results, discussion

It was possible to read the age from the scales. Results of the age reading is shown in table 1 and back calculated lengths of individual fish are shown in fig. 1.
Mean back calculated lengths of the year classes is shown in table 2. A plot of the mean growth of 4,5 and 6 year old fish is shown in fig. 2.

Growth of cod is not linear, it seems that growth slows down after age of 3, and the asymptotic length of cod is around 50 cm, that is after the fish has reached the length of 50 cm, the growth becomes very slow. However if cod is on, or turns to, fish diet, the growth will become faster. No dietary information is available to me, neither information on size at maturity.

Age reading from scales is possible but more information is needed to verify (or reject) the age readings, such as length distribution of the first 3 year classes from a survey, length at maturity for males and females, liver index, food analysis etc.

Mesh sizes in fishing gear have been increased in recent years to increase selectivity that is let more small fish escape from he fishery and increase pressure, relatively of big fish. If the results from the age reading are near to be correct, this is wrong management policy that will lead to less catch and poor state of the stock in the long run. This will (as history shows) lead to further restrictions in the fishery.

In a lack of better methods there is ongoing program to read the age of the cod by weighing the otoliths. Establish a correlation factor between otholith weight and fish age. This is incredible, as if all fish grow at the same uniform linear rate. Growth of course differs from one site to another, year to year, it is related to feeding pattern, benthic, pelagic, cannibals, etc.etc.
There is no easy way around. Fish **have to be aged on an individual basis** to see growth patterns.

Nr	Date	Age	Length	Weight	Condition
1	10.2.2010	6	53	1200	0.81
2	10.2.2010	6	68	2920	0.93
3	10.2.2010	6	55	1252	0.75
4	10.2.2010	5	43	758	0.95
5	10.2.2010	5	57	1500	0.81
6	10.2.2010	5	44	706	0.83
7	10.2.2010	5	42	682	0.92
8	10.2.2010	5	51	962	0.73
9	10.2.2010	7	68	2500	0.80
10	10.2.2010	7	51	1158	0.87
11	10.2.2010	7	72	2666	0.71
12	10.2.2010	7	77	4259	0.93
13	10.2.2010	5	55	1220	0.73
14	10.2.2010	5	46	862	0.89
15	10.2.2010	4	47	860	0.83

Table.1 Age determination of 15 cod from the Baltic

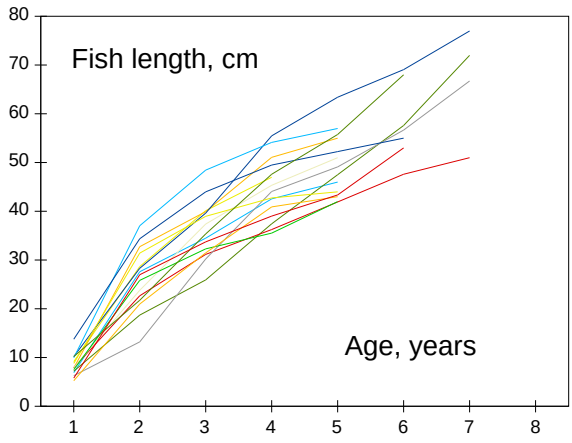


Fig 1. Plot of back calculated growth of individual fish

Age	Mean weight	Year class	No.	Mean length	l_1	l_2	l_3	l_4	l_5	l_6	l_7
Years	kg			cm	cm	cm	cm	cm	cm	cm	cm
4	0.86	2006	1	47	9	29	40	47			
5	0.96	2005	7	48	8	28	38	45	48		
6	1.80	2004	3	59	10	28	38	45	50	59	
7	2.65	2003	4	67	8	21	32	43	50	58	67
Avg					9	26	37	45	50	58	67

Table 2. Age determination of Baltic cod. Length was back calculated from scales, l 1, l 2, ..l 7, show the calculated growth of the year classes. Mean lengths at age of 4-6 year old cod is plotted in figure 2.

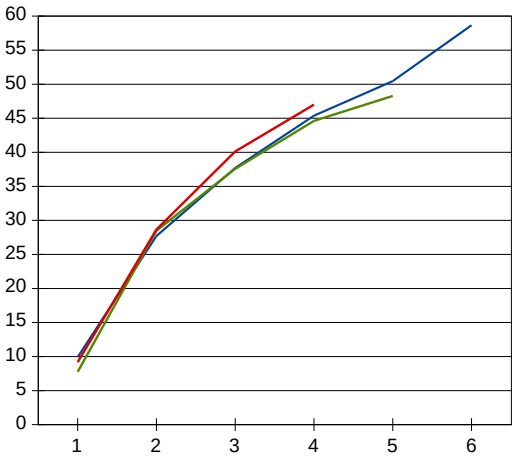


Fig. 2. Plot of the mean growth of 4, 5 and 6 years old cod, back calculated from scales. Data are from table2.

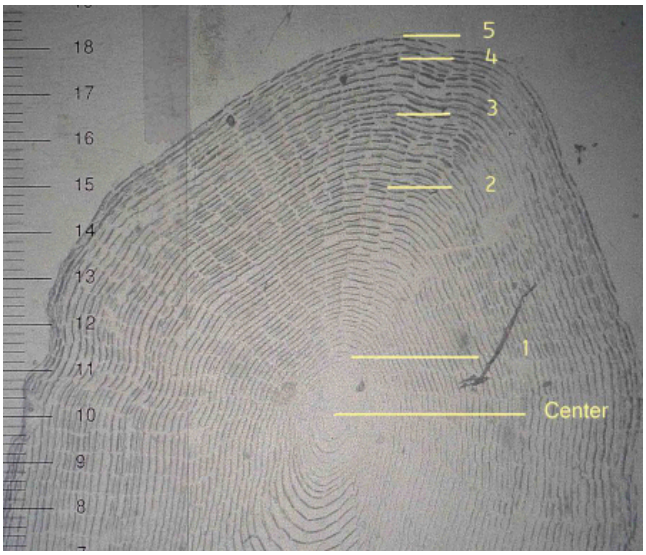


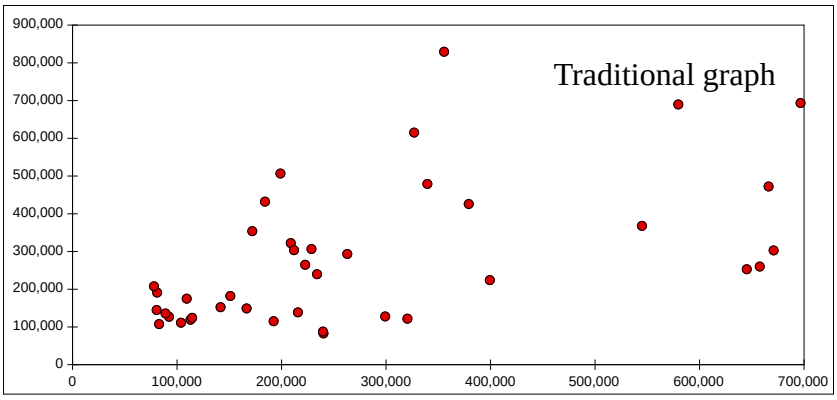
Fig. 3. A scale from a 5 year old cod. Growth in the two first years is fast, then is slows down and the growth in the fifth year is very slow.

Baltic Sea, 25-32

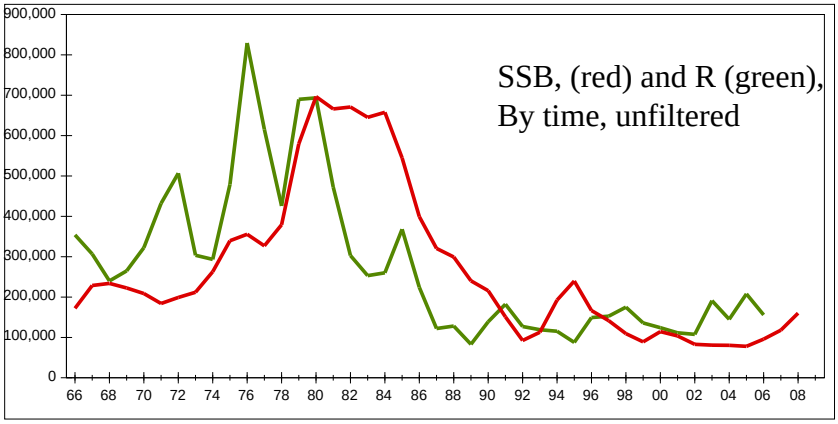
J.Kr. 2009

Some thoughts on Stock Recruitment relationship

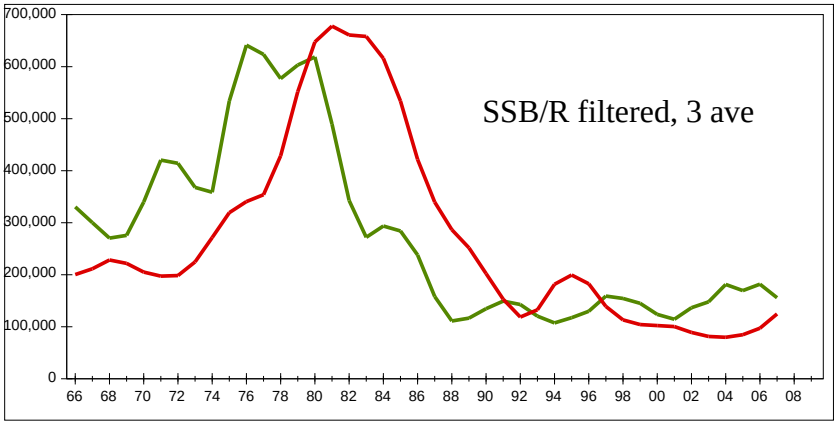
One of ICES's important issues is the size of the spawning stock. The believe that it has to be over a certain size to "secure" good recruitment. However, this has not been proven, but is one of the things that "must be" true.



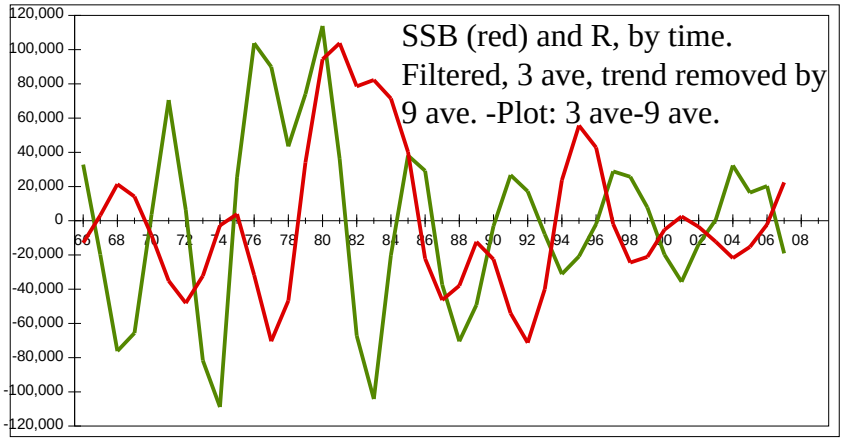
This is the traditional graph. But as food and environmental parameters are constantly changing, a size of a fish stock is not an absolute figure. The term "big" or "small" must be relative.



It is more interesting to look at how recruitment and spawning stock change with time. To the left are the raw data.



To see trends, it is better to filter the data. here by three year running average. The big top in the spawning stock from 1980, is a result of a good recruitment few years earlier, when the spawning stock was moderate. But the big spawning stock did not produce good recruitment later.



By removing the long time trend we can use nine year running average. If now the short term (3 year running) average is placed upon the long term average (9 year average), it shows how spawning stock and recruitment are related by time:
They are in anti phase, which means that small spawning stock gives good recruitment and vice versa.

Something to think about?

Appendix 1

Excerpts from ICES report - and the report on "Otolith Weight in Age determination of Baltic Cod".

ICES advice: Cod in subdivisions 25-32
http://www.ices.dk/committe/acom/comwork/report/2009/2009/cod-2532.pdf

Selectivity
All of these measures to reduce effort have led to an apparent decrease in the fishing mortality for this stock. (Cod-2532 2009) A Bacoma codend with a 120-mm mesh was introduced by IBSFC in 2001 in parallel to an increase in diamond mesh size to 130 mm in traditional codends. The expected effect of introducing the Bacoma 120-mm exit window was nullified by compensatory measures in the industry. This was to some extent explained by the mismatch between the selectivity of the 120-mm Bacoma trawl and the minimum landing size. In October 2003, the regulation was changed to a 110-mm Bacoma window. This was expected to enhance the compliance and to be in better accordance with the minimum landing size, which was changed to 38 cm in the same year.

The Baltic cod stock is at present harvested outside safe biological limits. In a situation with a low cod stock, very narrow and young age distribution as well as a decreasing quality of the catch data, it is of crucial im-portance to use the best available methods to improve the precision of the stock assessment. Age estimation is a focal point in assessment where improvement is possible.

The initiative of investigating the possibilities of revising the age in-terpretation of the Baltic cod came about as a result of discussions during the ICES study group meeting in Riga May 2004 (SGABC). The agreed collaboration among Baltic Fisheries institutes on the age-revision pro-vided a unique opportunity to solve a long time recognised problem. The present project was initiated to make progress in coordinating activities within the large network of ageing expertise from institutes around the Baltic Sea where all countries were involved in different constellations of responsibilities and means of funding. The present Nordic initiative pro-vided the infrastructure and the organizational abilities in connection with scientific expertise to co-ordinate collection and analysing biometric data from cod otoliths.

Otolith Weight in Age determination of Baltic Cod

http://www.norden.org/is/utgafa/utgefid-efni/2008-575/at_download/publicationfile

The proposal included a co-operation between Denmark, Finland and Sweden to investigate the potential of otolith biometrics (mainly otolith weight) coupled with length frequency distributions to improve age de-termination of Baltic cod. The Institutes have been represented by Dr Henrik Mosegaard (Danish Institute of Fisheries Research), Dr Eero Aro (Finnish institute of Game and Fisheries) and Ms Yvonne Walther (Insti-tute of Marine Research, Sweden). Other experts from the three institutes have been involved in different tasks e.g. data base management, analysis of otolith biometry and statistical analysis of age structure. The project was carried out in collaboration with the other national fisheries institutes around the Baltic Sea. The project directly addressed the following topics in the NAF work programme:

The present ageing method of Baltic cod is based on reader interpretation of annual rings in the otoliths of the fish. This method is subjective and without any proper validation. The problem in age reading of cod has been recognised since the beginning of the 1970ies. The first exchange program of Baltic cod otoliths was organised in 1980. The differences between age-readings have continuously been observed during the 1990ies and a succession of meetings and exchange programs with the countries around the Baltic Sea have tried to reach consensus between age-readers.

Since the use of otolith biometrics, particularly otolith weight has proven successful in other stocks with age-reading problems, preliminary investigations were carried out indicating that using otolith weight could be a potential method for facilitating improvement in assigning age classes to Baltic cod. The project was planned to aim at investigating and facilitating a series of steps towards a revision of the Baltic cod stock assessment by:
Introduction of routine collection of the necessary otolith data
Co-ordination of a database holding this information
Reviewing the state of art in using otolith weight in combination with available analytical methods
Investigation of the requirements for development and implementation of statistical methods specific for the Eastern Baltic Cod case. As a basis for the project was the commitment by the fisheries laboratories around the Baltic to supply otolith weight data for the period 2001 2003. During the project period part of the activities would then further involve a continued updating of the time series of weighed otoliths and corresponding survey and fisheries data.
The project was granted by NAF in 2005.