

## Introduction

Market sampling is the basis for producing estimates of catch numbers-at-age to feed into Working Group stock assessments. The SAMFISH project (EU Study Contract 99-009) considered a range of issues relating to documenting, assessing and improving the quality of market sampling for Western and Southern European Atlantic fisheries. Here we demonstrate an approach to assessing coverage and precision of the sampling for ICES Division VIIa cod. Then, through an extension of the bootstrap methodology, investigate the effect of ageing errors on estimates of catch numbers-at-age.

## Coverage

A straightforward summary of coverage is to compare the division of reported landings against number of fish measured and aged. Such reports can be produced automatically at a range of stratification levels by the International Sampling and Landings Database (ISLDB) developed within SAMFISH (see CM 2001/P:27). Figure 1 shows a coverage report at the national level for ICES Division VIIa cod, based on data from the reports of the Working Group on Assessment of Northern Shelf Demersal Stocks (ICES 2000).

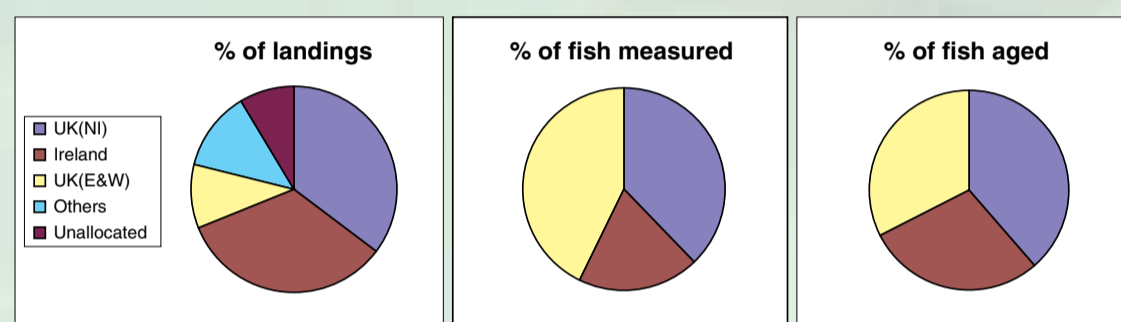


Figure 1: Average share of landings and sampling for ICES Division VIIa cod, 1994 - 1998

## We see:

- The main nations landing the stock are UK (Northern Ireland), UK (England & Wales) and Ireland.
- UK (England & Wales) took a relatively large share of length samples.
- Overall, the sampling coverage was reasonably distributed at the national level.



## Acknowledgements

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## References

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## Precision

Precision of the market sampling schemes was assessed by calculating coefficients of variation (CVs). Either analytical or bootstrap methods (or both) were used as appropriate to the data.

### Analytical estimates

Analytical estimates of CV for catch numbers-at-age are calculated with the method routinely used by UK(E&W) through the relationship:

$$\text{Variance catch numbers-at-age} = \text{Variance due to ageing} + \text{Variance due to length sampling}$$

The variance due to length sampling is based on variability between the sampling units and the variance due to age is based on the assumption of a binomial distribution for proportion at age in each length group. (See Flatman (1990) and Appendix 3 of the Report of Study Contract 94/013 for further details).

### Non-parametric bootstrap.

Figure 2 gives an overview of the bootstrap procedure. It was applied by tailoring SAS code developed for EMAS (CFP Study Contract 98/075), to the stock and raising procedures of UK (England & Wales), UK (Northern Ireland) and Ireland.

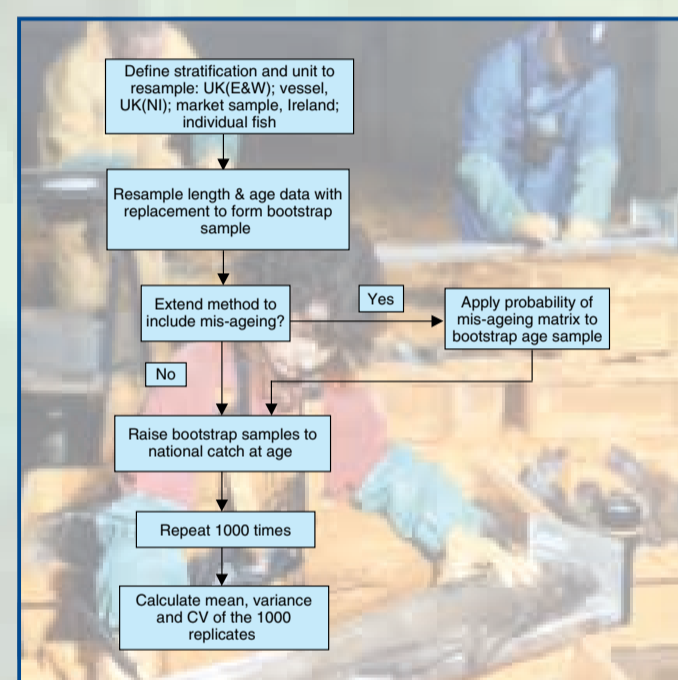


Figure 2: Overview of bootstrap procedure

## CV results

Figure 3 shows the national CV estimates. The points represent annual estimates from 1991-8, the lines represent the average across years. For UK (NI) the analytical approach was used, for Ireland and UK (E&W) the bootstrap. The plot for UK (E&W) also includes the average from the analytical approach for comparison.

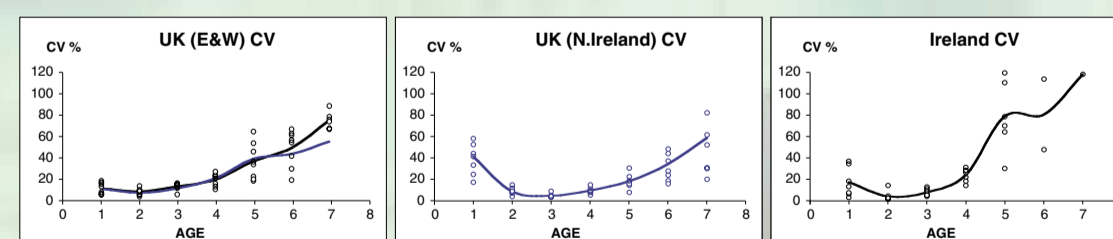


Figure 3: CV of annual estimates of catch numbers-at-age. Points show estimates by year, lines show average across years. Black represents bootstrap approach used, blue represents analytical approach used

## We see:

- The analytical and bootstrap approaches give consistent results.
- Overall the results from the three countries show a similar trend. The differences between countries are comparable to the annual differences for a country.
- CVs for ages 2 & 3 are around 10% with poorer precision for the older ages due to the scarcity of older cod. Results from EMAS (ICES 2001) indicate that this level of uncertainty will not make market sampling a major source of uncertainty in the assessment results.
- The same pattern in CVs has been observed for other stocks, for example cod, plaice and herring in the North Sea. The results here support the finding from EMAS of a power relationship between variance (catch numbers-at-age) and mean (catch numbers-at-age).

## Effects of mis-ageing on estimates of catch numbers-at-age and CVs.

The standard approach to estimating CVs assumes that there is no uncertainty in the age of each fish in the age-length key (ALK). However, even experts may disagree in the age determination of some otoliths. Therefore, an extra step was included in the bootstrap method (Figure 2) to assess the effect of mis-ageing on CVs. For simplicity we assume the age data were initially correct. Within each iteration, after selecting the age samples, a table of probabilities (Table 1) was used to randomly assign a new age to each fish based on the length and age of the fish.

Table 1: Table of probabilities used to assign ages

True age	0	1	2	3	4	5	6	7	8	9
10-14	0.992	0.048								
15-19										
20-24										
25-29	1.000	0.000	1.000	1.000	0.000	1.000	0.000	0.000	1.000	0.000
30-34										
35-39										
40-44										
45-49										
50-54										
55-59			0.958	0.042						
60-64										
65-69				0.040	0.929	0.032				
70-74										
75-79										
80-84										
85-89										
90-94					0.042	0.778	0.167	0.014		
95-99										
100-104										
105-109										

An otolith exchange scheme for ICES Division VIIa cod is in progress within SAMFISH. Table 1 was derived from a provisional analysis of the exchange. Accuracy in age determination for VIIa cod should be comparable to that from VIIa cod.

For each otolith in the exchange, the modal age was calculated using the age comparison workbook by Eltink (2000). Then, for readers who had completed the exchange, the proportions of read age were calculated by modal age and length group. The table was simplified by combining length groups with similar values and recalculating the proportions.

## Results

Table 2: UK (E&W) 1998 Annual Estimates. Difference between results with and without ageing errors

Age	Mean Catch at age			CV % Catch at age		
	Without	With	% change	Without	With	% change
1	58668	58668	0	16.8	16.8	0
2	326006	313398	-4	3.8	4.0	+6
3	20479	32601	+59	13.3	16.0	+20
4	2814	2882	+2	22.4	29.8	+33
5	983	1128	+15	33.6	41.2	+23
6	105	327	+211	61.1	64.1	+5
7	77	121	+57	88.5	87.2	-1

Table 2 shows the effect of including mis-ageing for the E&W 1998 data. For these data the probabilities of mis-ageing used give an expected average of 95% of otoliths aged correctly. This is in line with agreement percentages from quality assurance within CEFAS; VIIa cod are considered a relatively easy stock to age.

- Mis-ageing a relatively small proportion of 2 year-olds leads to a large % increase in the estimated numbers of 3 year-olds.
- Uncertainty due to mis-ageing increases the CVs but is a smaller component than the variation between samples.

## Discussion

We think that the XSA assessment results will not be strongly influenced by the observed pattern of changes in catch-at-age. Fishing mortality is estimated along cohorts and not all ages are affected. Therefore the ratio between ages will go up in some cases and down in others. Ratios that are more variable are down-weighted in the estimation process. Running assessments on bootstrapped data with ageing errors would confirm or disprove this.

## Conclusions

For ICES Division VIIa cod, 1991-8 :

- The share of sampling by nation relative to landings was appropriate.
- Variability in the market sampling data was unlikely to have been a major component in the variability of assessment results.
- If uncertainty in age-reading was taken into account CV estimates could increase by up to a third.