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Control of assessment for demersal fish stocks in ICES area: analysis for 36 stocks and investigation of some potential bias sources.

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Abstract

We analyzed here the reliability of assessments performed between 1997 and 2001 for 36 demersal stocks evaluated by ICES. Taking as a starting point the metrics of bias and variability defined by Jónsson and Hjörleifsson (2000), we highlighted stocks for which parameters of fishing mortality or spawning stock biomass were significantly over or underestimated. Then we explored the possible causes of these assessment biases by examining three hypotheses: i) assessments were biased when the exploitation rate or stock biomass was variable; ii) assessments were biased when parameters F or SSB presented a pronounced trend over the studied period; iii) the years of increasing trend of F or SSB (reciprocally decreasing) led to underestimate (reciprocally to overestimate) this mortality or this biomass. For a large majority of stocks we observed an underestimation of F and an overestimation of SSB. On average, diagnostics were therefore "excessively optimistic". A logical negative correlation between the two types of biases was found. Significant errors on F were observed for the third of the studied stocks and also the third of the stocks were found to show significant errors on SSB. Average biases indicated that assessment errors reached 50% over the 5-years period for the fifth of the studied stocks. Moreover, certain stocks presented extremely variable biases reflecting sometimes important but non-systematic biases in the assessment.

Keywords : Stock assessment quality, fishery management

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Introduction

Stock assessment is the basis for scientific advice used in fisheries management. The ICES working groups yearly gather to assess the different European stocks. This assessment consists in a complex process that requires a large amount of data. The quality of these assessments is questioned and in particular by fishermen. Despite their importance, a very few studies deal with their reliability and put forward the origin of the potential error sources.
This note comes under the Work Package "evaluation of performance of assessments" of the European Advisory System Evaluation project (EASE). We were interested in the diagnosis performed between 1997 and 2001 for 36 demersal stocks evaluated by the working groups of ICES. Several indicators were calculated that made it possible on the one hand, to analyze the reliability of assessments, and on the other hand allowed the exploration of various causes likely to explain the demonstrated biases.

Data and methods

Data sources

The data used came from the Quality Control Diagrams (QCD) provided by the various EASE partners. For both stocks of Megrim (divisions VIIIc and Ixa), 2002 was supplemented by ACFM data.

Stocks

QCD's were available for the 36 following stocks (Table 1).

Table 1: List of the stock considered in the present analysis and corresponding ICES subdivisions

Group 3	ICES subdivisions	Group 4	ICES subdivisions
NEA Cod	I; II	**Anglerfish (L. piscatorius)**	VII b-h, j, k ; VIII a, b, d
NS Cod	III a; IV a, b, c; VII d	**Anglerfish (L. budegassa)**	VII b-h, j, k ; VIII a, b, d
VIa Cod	VI a	**Celtic Cod**	VII e-h, j, k
Baltic Cod W	22, 23, 24	**Hake North**	III a; IV; VI; VII; VIII a, b
Baltic Cod E	25, 26, 27, 28, 29, 30, 31, 33	**Hake South**	VIII c; IX a
NEA Haddock	I; II	**Megrim North**	VII b-h, j, k; VIII, a, b, d
NS Haddock	III a; IV a, b, c	**Megrim South (L. boscii)**	VIII c; IX a
VIa Haddock	VI a	**Megrim South (L.whiffiagonis)**	VIII c; IX a
VI b Haddock	VI b	**VIIe Plaice**	VII e
Norway pout	III a; IV a, b, c	**Irish Plaice**	VII a
IIIa Plaice	III a	**Celtic Plaice**	VII f, g
NS Plaice	IV a, b, c	**Irish Sole**	VII a
VIId Plaice	VII d	**VIIe Sole**	VII e
NEA Saithe	I; II	**Biscay Sole**	VIII a, b
NS Saithe	IV a, b, c; III a; VI a, b	**Celtic Sole**	VII f, g
Sandeel	IV a, b, c		
IIIa Sole	III a		
NS Sole	IV a, b, c		
VIId Sole	VII d		
NS Whiting	IV a, b, c; VII d		
VIa Whiting	VI a		

Notations

F_i^j and SSB_i^j represent the fishing mortality and the spawning stock biomass of the year i estimated the year j respectively. Parameters were noted a_i^j in a generic way. Conventionally, parameters estimates from the 2002 assessments were used as a reference. They were regarded as true values and were compared with the same parameter estimates from the previous years.

Reliability of assessments

The reliability of assessments established for the year i during the year i+1 was analyzed by taking into account two parameters: the fishing mortality (F) and the spawning stock biomass (SSB). Two indicators called assessment ratios were estimated, according to the assumption that the 2002 estimates could be considered as true value:

$$\frac{F_i^{i+1}}{F_i^{2002}} \text{ and } \frac{SSB_i^{i+1}}{SSB_i^{2002}}$$

Ratios higher than 1 indicate an overestimation of the parameter, those less than 1 an underestimation.

For each ratio, two indicators were calculated on the five years period before 2002. Thus these indicators took into account assessments carried out from 1997 to 2001 (and therefore concerning the 1996-2000 estimations)[1]. These two indicators were similar to those defined by Jónsson and Hjörleifsson (2000):

Average bias: $$ab\left(\frac{a_i^{i+1}}{a_i^{2002}}\right)=\frac{1}{5}\sum_{1996}^{2000}\ln\left(\frac{a_i^{i+1}}{a_i^{2002}}\right)$$

Average standard deviation: $$asd\left(\frac{a_i^{i+1}}{a_i^{2002}}\right)=\sqrt{\frac{1}{5}\sum_{1996}^{2000}\left(\ln\left(\frac{a_i^{i+1}}{a_i^{2002}}\right)-ab\left(\frac{a_i^{i+1}}{a_i^{2002}}\right)\right)^2}$$

The first indicator measures the average bias in the parameter estimate a_i^{i+1}, the second its variability. Values of the ***ab*** indicator above 0 pointed out an overestimation of the parameter all over the period considered, those below 0 pointed out an underestimation. In order to identify the stocks whose parameters were significantly over or underestimated, a statistical test of comparison to the 0 value was carried out on the average bias ***ab*** for three risk levels: 1, 5 and 10 %.

Mean level and variability of parameters

In order to explore the hypothesis considering that assessments were biased due to the variability of the parameters studied, several statistics were calculated for the parameters estimates from the 2002 assessment : the mean, the standard deviation and the coefficient of variation. They allowed us to consider the mean value and the variability of these parameters over the period 1996-2001. We therefore analyzed the relationship between the average bias **ab** of a parameter and its coefficient of variation.

Interannual evolution of parameters

1. For 5 stocks and for fishing mortality, these calculations were performed over 3 or 4 years. Data were missing for one or two years over the selected period. Similarly, for 2 stocks and for the spawning stock biomass, these calculations were performed over 3 or 4 years. Data were missing for one or two years over the selected period.

In order to check whether assessments were biased when parameters F or SSB presented a pronounced trend over the 1996-2000 period, the evolutions of fishing mortality and spawning stock biomass were analyzed. The evolution of these parameters between year i and year i-1 was assessed by examining the two following indices called evolution ratios:

$$\frac{F_i^{2002}}{F_{i-1}^{2002}} \text{ and } \frac{SSB_i^{2002}}{SSB_{i-1}^{2002}}$$

Ratios higher than 1 pointed out that the parameter increased between year i-1 and year i. Those less than 1 showed that it decreased. As for the assessment ratios, we calculated both **ae** and **sde** indicators for these new ones :

Average evolution: $$ae\left(\frac{a_i^{2002}}{a_{i-1}^{2002}}\right)=\frac{1}{5}\sum_{1996}^{2000}\ln\left(\frac{a_i^{2002}}{a_{i-1}^{2002}}\right)$$

Standard deviation of evolution: $$sde\left(\frac{a_i^{2002}}{a_{i-1}^{2002}}\right)=\sqrt{\frac{1}{n-1}\sum_{1996}^{2000}\left(\ln\left(\frac{a_i^{2002}}{a_{i-1}^{2002}}\right)-ab\left(\frac{a_i^{2002}}{a_{i-1}^{2002}}\right)\right)^2}$$

A value below 0 for **ae** pointed out that on average the parameter decreased over the last five years, those above 0 that it increased. In order to identify stocks which presented a significant decreasing or increasing trend in the parameters values, a statistical test of comparison of the average evolution **ae** to 0 was carried out for three risk levels, 1, 5 and 10%.

Relation between estimation and evolution of parameters

In order to examine the hypothesis that years of increasing fishing mortality or increasing spawning stock biomass (reciprocally decreasing) lead to underestimate (to overestimate reciprocally) these parameters, we tried to sought for a negative correlation between the assessment ratios and the evolution ratios.

We therefore calculated the slope of the regression line between the assessment ratio $\frac{a_i^{i+1}}{a_i^{2002}}$ and the evolution ratio $\frac{a_i^{2002}}{a_{i-1}^{2002}}$, and the coefficient of determination R^2. This last one is equal to the square of the linear correlation coefficient of Pearson between the variables $\frac{a_i^{2002}}{a_{i-1}^{2002}}$ and $\frac{a_i^{i+1}}{a_i^{2002}}$.

Calculations were made on the total number of yearly available data, which ranged between 3 and 14 according to stocks. To identify the stocks for which there were correlations between the assessment ratio and the evolution ratio, a statistical test of significance of the Pearson coefficient for several risks (1, 5 and 10%) was carried out, we checked whether the Pearson coefficient was significantly below 0.

Results

Reliability of assessments

For the fishing mortality, **ab** ranged from -0.61 to 0.44 according to stocks, which reflected sometimes important average errors reaching for example, -54% for the Southern Hake stock and 56% for the North East Artic Saithe stock. The mean of this indicator was -0.13 on the 1997-2001 period. On average, the fishing mortality was underestimated for the studied stocks.
For the spawning stock biomass, **ab** was also considerable for some stocks. It ranged from -0.36 to 0.42 according to stocks. Errors spread out from –70% for the Southern Hake stock to 52% for the North East Arctic Saithe stock. The value of 0.09, estimated as a mean for all stocks, showed that the spawning stock biomass was on average overestimated on the 1997-2001 period. For a large majority of stocks (72%), we observed an underestimation of fishing mortality and an overestimation of the spawning stock biomass (Fig. 1). On average, diagnostics were therefore "excessively optimistic". Logically, we noticed a negative correlation between the two types of bias. The more F was overestimated, the more SSB was underestimated and reciprocally. Figure 1 shows that average bias could be important. Only 6 stocks were inside the 10% circle of the target (average bias less than 10% for F and SSB), 11 were between 10 and 15%, 12 between 25 and 50%. For 7 stocks, the average bias was above 50%.

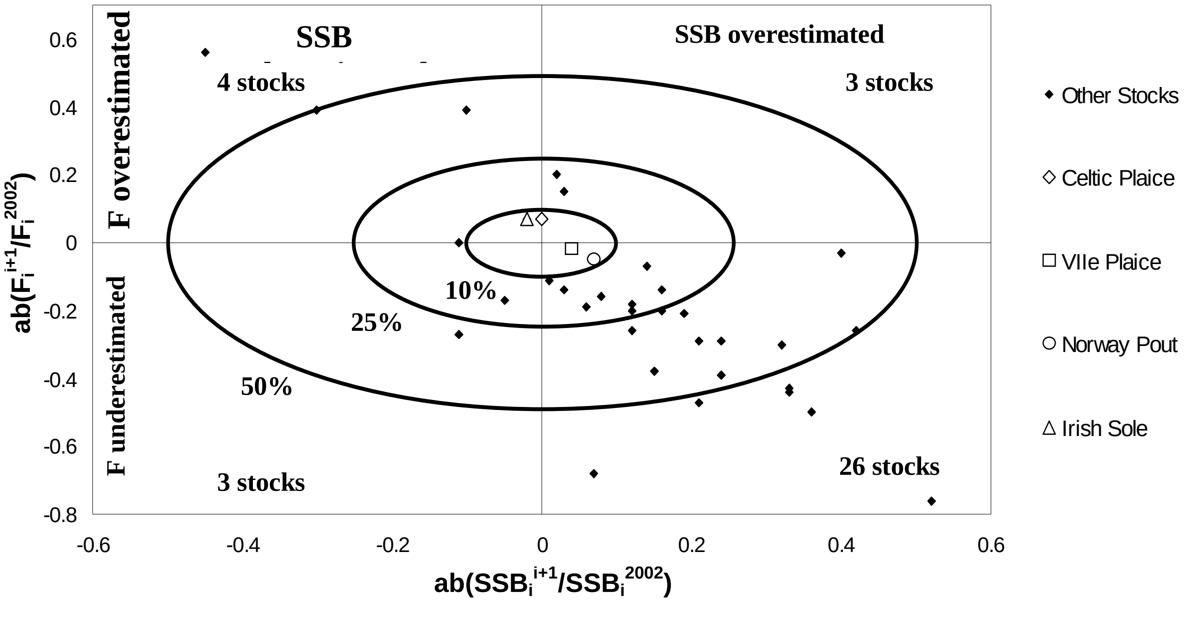

Fig. 1. Estimate of the average biases over the period 1997-2001, for F and SSB parameters of 36 demersal stocks.

For 12 stocks, i.e. 33% of the studied stocks, the fishing mortality was badly estimated over the period 1997-2001 (Fig. 2.), **ab** was significantly different from 0 with 95% of significance. For 11 stocks, the fishing mortality was underestimated.
Moreover, extremely variable biases were observed for some stocks (high **asd**) reflecting sometimes important but non-systematic biases in assessments. It was the case for the stocks of VIb Haddock, Megrim South, IIIa Sole and IIIa Plaice. For 12 stocks, i.e. 33% of stocks, the spawning biomass was badly estimated over the 1997-2001 period, **ab** was different from 0 with 95% of significance (Fig. 3.). For 10 stocks, the spawning stock biomass was overestimated and for the 2 others it was underestimated.

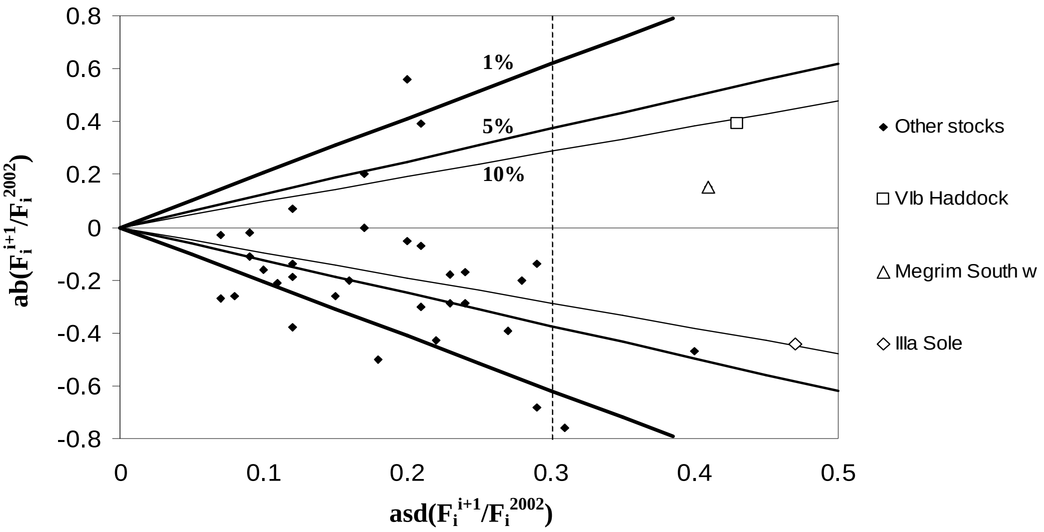

Fig. 2. Average biases over the period 1997-2001 for F according to its variability. The straight lines represent $y = t_{\alpha/2} * x / \sqrt{5}$ and $y = - t_{\alpha/2} * x / \sqrt{5}$ for α = 1, 5 or 10%. Very variable bias on the right of the dotted line.

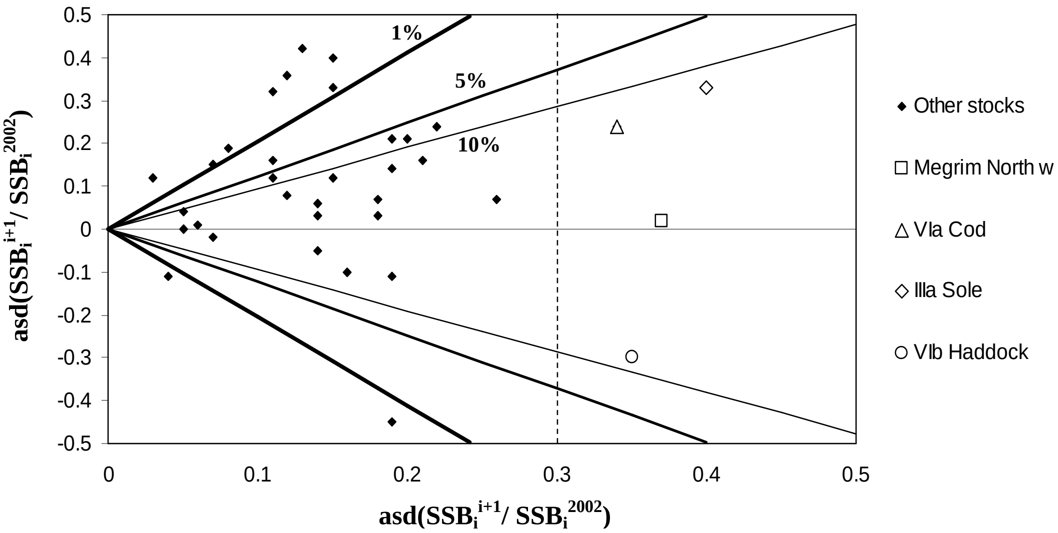

Fig. 3. Average biases over the period 1997-2001 for SSB according to its variability. The straight lines represent $y = t_{\alpha/2} * x / \sqrt{5}$ and $y = - t_{\alpha/2} * x / \sqrt{5}$ for α = 1, 5 or 10%. Very variable bias on the right of the dotted line.

Table 2: Classification of the 36 stocks according to their average bias on F and SSB and their variability. The 7 stocks underlined, had an average bias above 50%.

	Significant average bias on SSB	**Average bias on SSB non significant and very variable**	**Average bias on SSB non significant and not very variable**
Significant average bias on F	NS Cod Baltic Cod E NEA Haddock NS Haddock VIa Haddock Hake South Irish Plaice NEA Saithe NS Sole VIIe Sole 10		Anglerfish North b VIId Sole **2**
Average bias on F non significant and very variable		VIb Haddock IIIa Sole 2	Megrim South w IIIa Plaice **2**
Average bias on F non significant and not very variable	NEA Cod, VIa Whiting 2	VIa Cod Megrim North w 2	Celtic Cod Baltic Cod W Hake North Megrim South b NS Plaice Norway Pout VIId Plaice VIIe Plaice Celtic Plaice NS Saithe Sandeel Irish Sole Biscay Sole Celtic Sole NS Whiting Anglerfish North p **16**

As for fishing mortality, certain stocks presented extremely variable biases (high **asd**) reflecting sometimes important but non-systematic biases in assessments. It was the case for the stocks of VIb Haddock, Megrim North w, IIIa Sole and VIa Cod.
The results showed that stocks can be classified according to the degree of error on F and on SSB (Table 2). We could thus identify 14 stocks, for which at least one of the two parameters presented an average bias significantly different from 0. For 10 of these stocks, the two parameters considered were regularly badly estimated. For 6 stocks, biases were not significantly different from 0, but the very high standard error indicated sometimes large and not systematic errors in assessments. Finally, only 16 stocks presented non-significant biases and low standard errors.

Relation between reliability of estimates and variability of parameters

Among the 12 stocks whose average bias was different from 0 with 95% of significance, 6 were found not to have a very variable fishing mortality with a CV below 15% (Fig. 4 and Table 4).
For 24 stocks the indicators calculated on F did not reveal biases, **ab** was not significantly different from 0.7. These stocks showed a low variability in F, with a CV under 15%.

Logically, in case of high variability in F, CV above 20%, no systematic error on the F estimates was found excepted for the Irish Plaice stock. On the other hand the high **asd** indicates that in some years, important errors can be done.
When fishing mortality was relatively stable (CV below 15%), the proportion of stocks for which F was significantly biased, 6 stocks out of 13 (i.e. 54%), did not seem different from what was generally observed for all stocks.

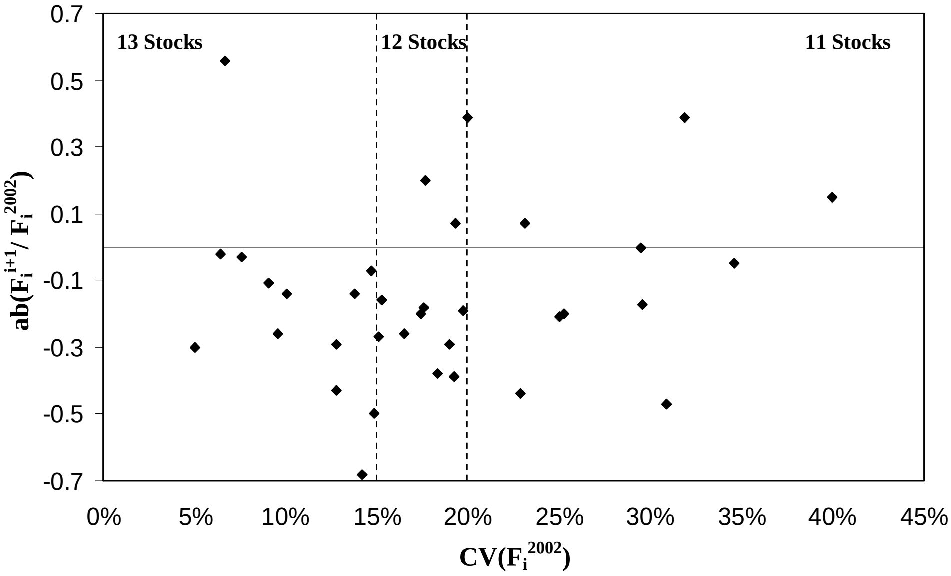

Fig. 4. Distribution of average biases on F according to its variability for the 36 stocks

Table 3: Classification of stocks according to the average bias on F and its variability

	Significant average bias on F		Average bias on F non significant and very variable		Average bias on F non significant and not very variable	
CV > 20 %	Irish Plaice	**1**	VIb Haddock Megrim South w IIIa Plaice IIIa Sole	**4**	Megrim South b Norway Pout VIId Plaice NS Saithe Sandeel Irish Sole	**6**
15 < CV < 20 %	NEA Haddock NS Haddock Hake South VIId Sole VIIe Sole	**5**			Anglerfish North p Megrim North w Celtic Plaice NS Plaice Biscay Sole Celtic Sole NS Whiting	**7**
CV< 15 %	Anglerfish North b NS Cod Baltic Cod E VIa Haddock NEA Saithe NS Sole	**6**			VIa Cod NEA Cod Baltic Cod W Celtic Cod Hake North VIIe Plaice VIa Whiting	**7**

For the SSB, 24 stocks presented an **ab** not different from 0 with 95% of confidence. For half of them, the variability of the SSB was high, with a CV above 15%. On the contrary, for the 12 stocks whose average bias was significant, the two thirds were those whose variation on SSB was high, with a CV above 15% (Fig. 5 and Table 5).

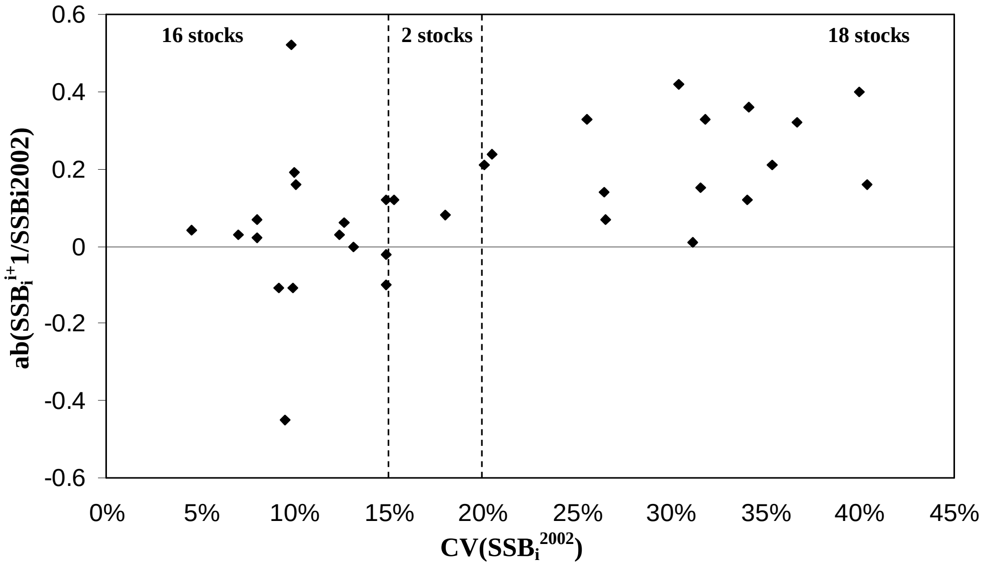

Fig. 5. Distribution of the average biases on SSB according to its variability for 36 stocks.

Table 4: Classification of stocks according to their bias on SSB and its variability.

	Significant average bias on SSB		Non significant bias on SSB but very variable		Non significant bias on SSB and not very variable	
CV > 20 %	NEA Cod NS Cod Baltic Cod E NEA Haddock NS Haddock VIa Haddock NS Sole VIa Whiting	**8**	VIa Cod VIb Haddock IIIa Sole	**3**	Anglerfish North p Baltic Cod W Celtic Cod Norway Pout IIIa Plaice NS Plaice Sandeel	**7**
15 < CV < 20 %					Biscay Sole Celtic Sole	**2**
CV< 15 %	Hake South Irish Plaice NEA Saithe VIIe Sole	**4**	Megrim North w	**1**	Anglerfish North b Hake North Megrim South w Megrim South b VIId Plaice VIIe Plaice Celtic Plaice NS Saithe VIId Sole Irish Sole NS Whiting	**11**

For the spawning stock biomass, results did not present any systematic relation between the reliability of the SSB estimation and its variability. Errors were not found to be significant for half of the stocks with a high variation in SSB (CV above 20%).
As previously, the stocks that presented diagnostics variable in quality (high **asd**) were those with a variable level of SSB. The results concerning the SSB, differed from those related to F on two points:

- systematic biases, **ab** significantly different from 0, that corresponded to SSB overestimations were frequently observed for variable stocks.
- in contrast, when the SSB was more stable, CV below 15%, SSB estimates seemed to be generally reliable (11 stocks out of 16, i.e. 69%).

Reliability of assessments and trend-setting evolution of the parameters

Regarding to the evolution ratios, the mean of the **ae** indicator for F was 0.01, which means that for the studied stocks F was on average stable. On the other hand the SSB was decreasing for the studied stocks, this indicator was on average -0.06.
For 19 stocks, i.e. 52% of the studied stocks, the fishing mortality was underestimated in case of increasing trends (Fig. 6). For 23 stocks, i.e. 64% of the studied stocks, the spawning stock biomass was overestimated in case of decreasing trends (Fig. 7).
For half of the stocks (52%), we observed an increase in F and a reduction in SSB (Fig. 8). We noticed a negative correlation between the two types of evolution. The more F increased, the more SSB decreased (and reciprocally).

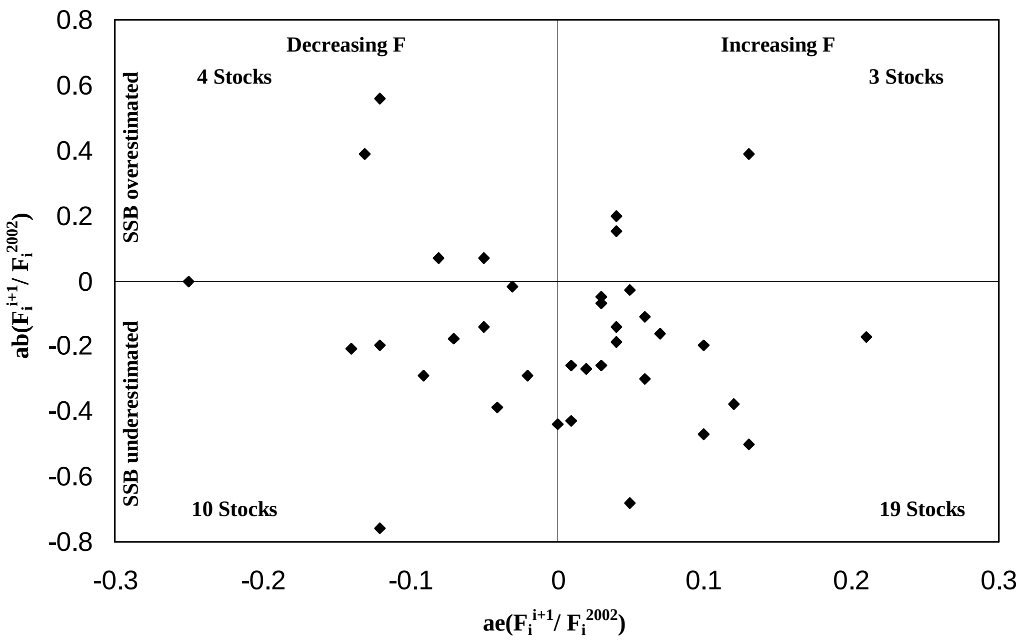

Fig. 6. Average biases on mortality F according to its evolution over the period 1996-2000

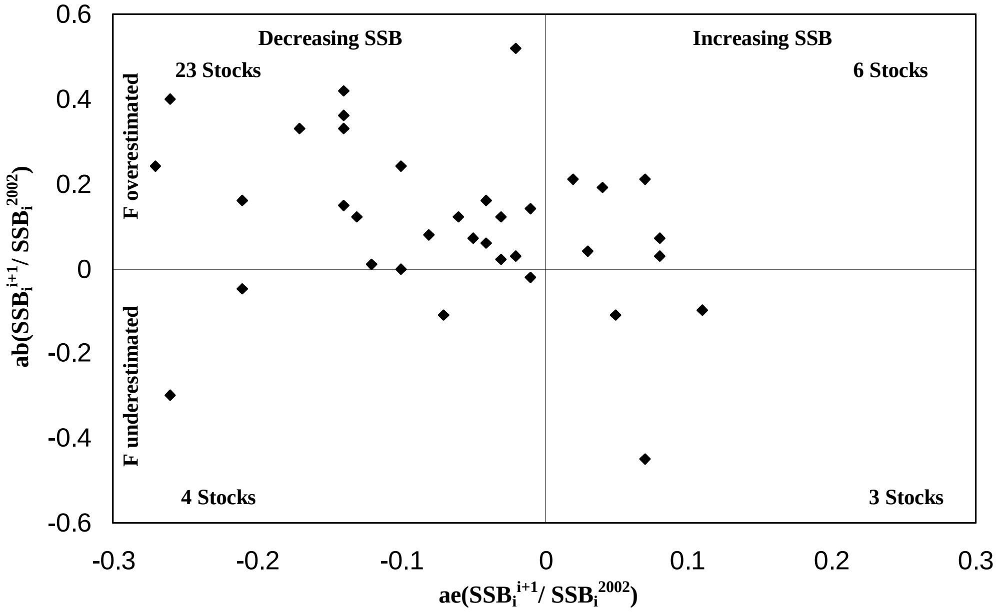

Fig. 7. Average biases on spawning biomass SSB according to its evolution over the period 1996-2000

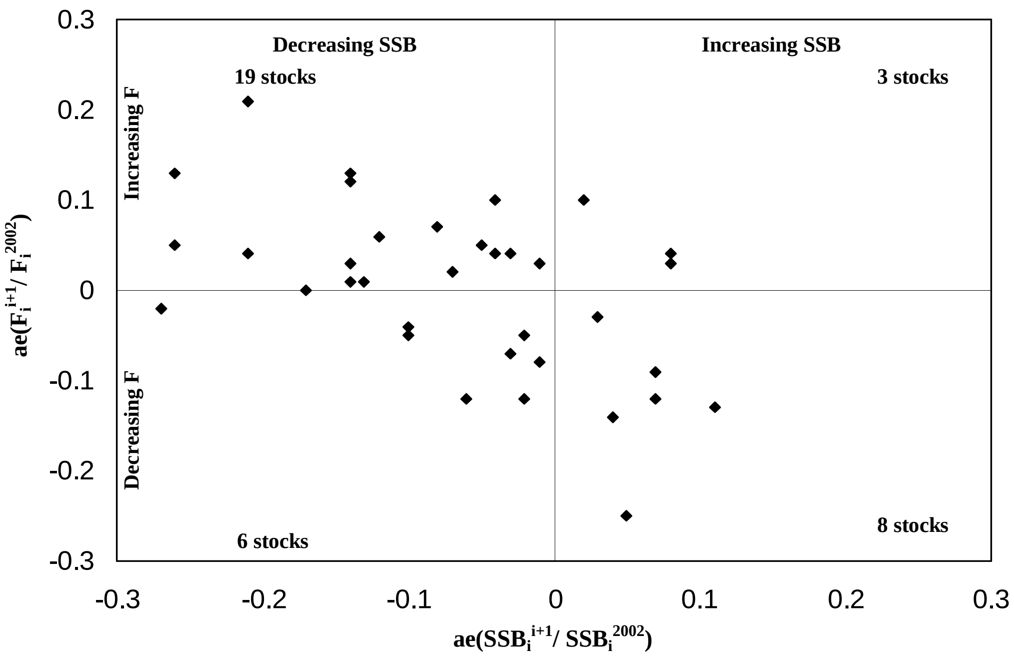

Fig. 8. Evolution over the period 1996-2000 of the parameters F and SSB for 36 demersal stocks

Table 5: Classification of stocks according to their average bias on SSB and its evolution

	Significant average bias on SSB		**Average bias on SSB non significant and very variable**		**Average bias on SSB non significant and not very variable**	
Significant decrease in SSB	Baltic Cod E VIIe Sole	**2**	VIa Cod VIb Haddock	**2**	Celtic Plaice Biscay Sole	**2**
No significant trend in SSB	NEA Cod NS Cod NEA Haddock NS Haddock VIa Haddock Hake South Irish Plaice NEA Saithe NS Sole VIa Whiting	**10**	IIIa Sole Megrim North w	**2**	Anglerfish North b Hake North Megrim South w Megrim South b VIId Plaice VIIe Plaice NS Saithe VIId Sole Irish Sole NS Whiting Celtic Sole Anglerfish North p Baltic Cod W Celtic Cod Norway Pout IIIa Plaice NS Plaice Sandeel	**18**

However the logarithmic mean **ae** was not significantly different from 0 for a majority of stocks, F and SSB did not have a significant increasing or decreasing trend. For each stock, the **ae** indicator pointed out a significant evolution in F over the period 1996-2000. Trends were more pronounced for SSB. 6 stocks were identified for which SSB significantly decreased over the 1996-2000 period (Table 5). Although a relation seemed to appear clearly on the figures (Fig. 6 and 7), the statistical tests did not allow us to establish any significant relation between the trend-setting evolution of the F and SSB parameters and the assessment errors for these parameters. Processes have probably to be regarded here as preliminaries and will have to be taken again thereafter.

Relation between reliability of assessments and inter annual evolutions of the parameters

For 12 stocks, i.e. 33% of stocks (table 6),we demonstrated a negative correlation between the assessment ratios and the evolution ratios concerning the fishing mortality. For these stocks, the more the F increased, the more underestimated. This relation appeared particularly clear for the stocks of Celtic Cod, VIb Haddock, North Sea Cod and VIId Sole. For these lattes, the years of increase in F or in SSB (reciprocally decrease) resulted in underestimating (reciprocally in overestimating) F or R respectively. The diagnosis was always late on the real evolution. For each stock, the correlation existed for both parameters at the same time.

Table 6: Classification of stocks according to the average bias on F and the existence of a correlation between assessment ratios and evolution ratios for the fishing mortality

	Significant average bias on F		**Average bias on F non significant and very variable**		**Average bias on F non significant and not very variable**	
Negative correlation with at least 95% of significance	NS Cod Baltic Cod E VIId Sole	**3**	VIb Haddock IIIa Sole	**2**	NEA Cod Baltic Cod W Celtic Cod VIId Plaice Sandeel Celtic Sole VIa Whiting	**7**
Negative correlation between 90 and 95% of significance	NS Haddock VIa Haddock NEA Saithe NS Sole	**4**	IIIa Plaice	**1**	Megrim South b	**1**
Non significant negative correlation	Anglerfish North b NEA Haddock Hake South Irish Plaice VIIe Sole	**5**	Megrim South w	**1**	Anglerfish North p VIa Cod Hake North Megrim North w Norway Pout VIIe Plaice Celtic Plaice NS Plaice NS Saithe Irish Sole Biscay Sole NS Whiting	**12**

Table 7: Classification of stocks according to the average bias on SSB and the existence of a correlation between assessment and evolution of SSB

	Significant average bias on SSB		Average bias on SBB non significant and very variable		Average bias on SSB non significant and not very variable	
Negative correlation with at least 95% of significance			VIb Haddock	**1**	Biscay Sole NS Plaice	**2**
Negative correlation between 90 and 95% of significance	NS Sole	**1**	IIIa Sole	**1**	VIId Sole	**1**
Non significant negative correlation	Baltic Cod E NEA Cod NS Cod NEA Haddock NS Haddock VIa Haddock Hake South Irish Plaice NEA Saithe VIIe Sole VIa Whiting	**11**	VIa Cod Megrim North w	**2**	Anglerfish North b Hake North Megrim South w Megrim South b VIId Plaice VIIe Plaice Celtic Plaice NS Saithe Irish Sole NS Whiting Celtic Sole Anglerfish North p Baltic Cod W Celtic Cod Norway Pout IIIa Plaice Sandeel	**17**

Discussion

The fishing mortality estimate in stock assessment is produced by Virtual Population Analysis (VPA). The spawning stock biomass is also a result produced by the VPA as it is derived from the numbers at age matrix. Thus all the data used by this process include a potential source of error. The data for this part of the stock assessment are various: catch at age matrix, weight at age matrix, total landings, tuning fleet matrices, maturity matrix and natural mortality matrix… These data used by the working groups for stock assessment are incremented each year with the new year information, and reviews are done when new consistent information is accepted. When this occurs, the changes occasioned (mainly in the number of age groups and in tuning fleets) could be as well cause of errors in the parameters estimates. The results presented here are a synthetic overview that gather a large array of potential errors. It surely mixed different error sources but gives a clear sight of the assessment reliability for stocks. The method used here emphasizes stocks whose parameters F and SSB are generally speaking misestimated. More particularly, this study underlines the underestimation of the fishing mortality for a large part of the stocks, leading to an optimistic point of view that could have great impact on management options.

The reference parameters used were taken on the assumption that the assessment quality improves each year. This is linked to the convergence property of the VPA (Jones 1961) and to the fact that the data become more accurate with the increase of stock knowledge. Thus the last assessment done could be considered as more reliable than the previous ones. The parameters estimated from this last assessment are the best and they can be taken as the "truth". Despite these considerations, data improvement is not systematic each year and particularly considering the discards. Great changes can occur in only five years regarding the biological perception of a stock, and the reviews made could heavily affect the assessment results. A lack of discard data could lead to underestimate the recruitment of the current assessment and to overestimate the fishing mortality first ages of the next ones. Discard data remain an important issue on stock assessment that could be influenced by stock management options as well as economy. For example if fish under commercial size are banned from landings, discard data become inaccessible and this will produce an overestimate of the fishing mortality in the next assessments.

A high variability in bias estimates could be related to the variability in recruitment estimate, that is known to be a highly variable parameter, and thus the type of errors observed could be tied to the stock particularities. The recruitment estimate has an effect on the fishing mortality and particularly on the spawning stock biomass, this could create an amplification of the misestimate if it exists an inconsistency with the young ages number estimate. For example if a high recruiting estimate is not noticed because of a lack of discard data, this can produce an important false increase in the fishing mortality the next years, not reflected by the F indicator. We thus obtain a stable F indicator with an overestimate of F at young ages and a very low SSB due to the increase in F. In this case the assessment would have led to a pessimistic point of view corrected the following years.

The VPA the most used by ICES working groups is tuned. It requires Catch Per Unit Effort data from scientific and professional fleets (tuning fleets). This mainly allows to improve the last year fishing mortality estimate. This last year estimate is the most unreliable one as no convergence occurred, but it is often the most used of the series and in terms of comparison it will lead to greater misestimate than previous ones.
We here used a F that was a mean of the fishing mortality vector calculated over the ages the more exploited. This had the advantage not to take into account too much variability in F that might be caused by cohort effects. However this could induce some inconsistency with the

spawning stock biomass. For example changes in the young age catches could have no impact on the SSB as these ages are not mature, but this could affect the fishing mortality. The software used to compute the VPA has a lot of different options that might affect the results and cause errors. Here we worked on stock assessment models parameters. But they are not the only ones, the fishing mortality and the spawning stock biomass are not two independent variables and an increase in F should produce a decrease in SSB in a short while. An underestimation in F obviously leads to an overestimation of the SSB if all parameters of the assessment models are not changed. The fact that this relation was not systematically found could be the occurrence of transition states, where a fishing mortality underestimation did not impact yet heavily the population age structure. An other argument could be the evolution of the other parameters as recruitment that could efficiently increase the SSB.

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