ICES Workshop on Limit and Target Reference Points (WKREF)
Gdynia, Poland, 29 January – 2 February 2007

Report by Ad Corten (observer for Pelagic RAC)

1. Terms of reference for the meeting

a) review and update the biological basis of limit reference points for fish stocks in the ICES area, taking into account the possible effects of species interactions and regime shifts. As a minimum the limit reference points for North Sea herring, Norwegian spring spawning herring, North Sea cod, Baltic cod and Kattegat sole stocks;

b) review the scientific and management literature on the implementation of maximum sustainable yield reference points in line with the Johannesburg agreement 2002;

c) comment on potential target references points for fish stocks in the ICES area as suggested by SGMAS, taking into account the possible effects of species interactions and regime shifts and the framework on the evaluation of management strategies.

2. Background

ICES management advice is based on "reference points" for stock size and fishing mortality. These reference points may be divided into two categories: target reference points that should be aimed for (such as MSY) and limit reference points that should be avoided.

Two well-know limit reference points are the minimum stock size Blim and the precautionary stock size Bpa. The minimum stock size Blim is a value that should be avoided at all cost. In order to do so, a precautionary stock size Bpa is defined somewhere above Blim. When the stock declines to Bpa, management action has to be taken to assure that the stock does not further decline to Blim.

Values of Blim and Bpa are set by ICES for each fish stock. The choice of these reference points is to some extent arbitrary. Annex 1 explains this problem, and for a proper understanding of this report, it may be advisable to read this annex first. In some cases, the value of Blim already contains a precautionary element. Adding an extra safety margin (Bpa) to this may lead to an over-cautious approach that creates unnecessary fluctuations in TACs.

Because the choice of reference points is arbitrary, the discussion on the definition of these points revives at regular interval in ICES. The first time when ICES has set a lower limit for a fish stock was in 1977 (a Blim of 800,000 tons for North Sea herring). Since then there have been numerous ICES meetings in which this subject has been discussed. The discussion takes place both within the fish working groups (such as the Herring Working Group) and in working groups on methodology (such as the present one).

Once a certain reference point has been chosen and has been used for a number of years, there is a reluctance to change it. ICES normally argues that an existing reference point can only be changed on the basis of scientific information that shows a new reference point to be better than the old one. However, since every method to determine reference points involves a subjective element, it is hard to show that from a scientific point of view a new reference

point is better than the old one. There is a tendency therefore, to continue the debate endlessly, and to pass the problem from one working group to another.

On the positive side, it should be mentioned that some reference points have been used successfully in fisheries management. The success in rebuilding the North Sea herring stock may be attributed partly to the use of the Blim value of 800,000 tons and the target fishing mortality of 0.25. Managers and industry need certain "road signs" in formulating management strategies, and this is what reference points are meant to be.

3. General comments on the handling of the subject by the meeting

The terms of reference for the meeting covered a broad range of subjects and fish stocks. Although the meeting was attended by a large number (21) of participants, time and manpower was not sufficient to deal with all subjects in great detail.

About half the participants were from the Baltic area, and consequently most time was devoted to a discussion of the main species in this area (cod and sole). The other half of the participants were experts on general assessment methodology. No specialists on pelagic species attended the meeting (except for the observer from the Pelagic RAC). This restricted the opportunities of the group to do an in-depth analysis for these species.

The main work of the group consisted of re-analyzing existing data series. There was a large variety of models that could be applied, and the data sets could also be changed in a number of ways (adding new years or splitting the series). Methods tested by the group included the "segmented regression" (see Annex 1), and a new "probabilistic approach" proposed by John Simmonds. The end conclusion was that the results of both methods were sensitive to the addition of new data points, and/or depended on subjective choices of parameters.

This outcome was not surprising considering the nature of the stock/recruitment relationship. The mathematical models try to find a sharp breaking point on a line that most likely is a smooth curve. If a sharp breaking point does not exist in reality, the models trying to define it, will always come up with inconclusive results.

In the end, the meeting did not come up with concrete proposals to change existing reference points for any of the stocks concerned

4. Role of observers from RACs and industry

Because the study of reference points has now become a matter of higher mathematics, it is difficult for newcomers to take actively part in the scientific part of this work. However, the presence of observers from the industry is useful because they constitute a kind of interface between the theoretical world of science and the practical world of fisheries management.

One element that came out clearly, was the different interpretation of the concept Blim by scientists and industry. The industry thinks that Blim represents a threshold value below which the stock is likely to collapse. ICES on the other hand defines Blim as the value of stock size below which average recruitment starts to decline. In case of a domed-shape relationship, the decline of average recruitment already starts at stock sizes just below the

long-term mean. It is clear that in this case there is no imminent danger of stock collapse when the stock size declines below Blim.

Participating in ICES meetings gives representatives of the industry a chance to look into the ICES kitchen. This increases the understanding of the way in which ICES is constructing its advice. Such an understanding is important for the dialogue between ICES and industry on issues of fisheries management.

One cannot expect that the presence of industry observers in ICES working groups will greatly affect the choices made by these groups. As mentioned above, the observers do not have the same level of technical expertise as the ICES experts. Moreover, there will always be a slight suspicion among ICES experts that the observers from industry are trying to lower the stock reference points in order to alleviate current problems of the industry. The presence of industry observers may even have the opposite effect that ICES experts take on a defensive stand against proposals for changing reference points.

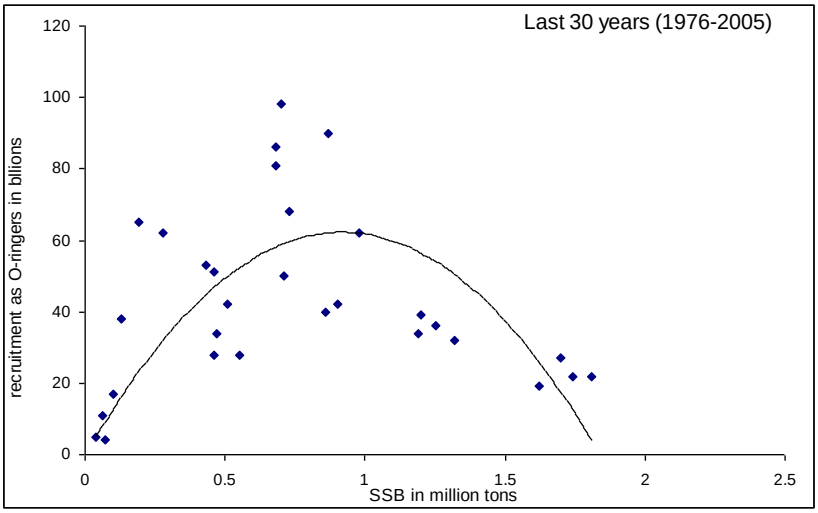
Because the choice of reference points is very much a matter of evaluating risks for the industry, the discussion on this subject should be transferred to the RACs. Here the industry (and other stakeholders) are well represented, and they can balance the risk of the stock dropping below a certain threshold against the need for stability in the catches. This discussion, however, will only be fruitful if both sides understand each other's language and ideas. It is precisely this requirement that can be fulfilled by a regular attendance of industry observers to ICES working groups.

5. Results of the meeting

Only the results for pelagic species are presented in this brief report. For demersal species, the reader is referred to the final report of the working group

5.1. North Sea herring

I presented a working document showing the dome-shaped form of the stock/recruitment relationship. This dome-shaped relationship (applied to data for the most recent 30 years) has a maximum at 0.8 - 1.0 million tons. At stock sizes above this level, recruitment starts to decline. I also presented data that suggested that the declining recruitment at high stock sizes may be due to cannibalism.



The meeting took note of these findings, but did not use them to change the existing limit reference points. These are:

Blim = 800,000 tons
Bpa = 1.3 million tons

The value for Blim has been in use for the last 30 years. It was first established during the period of herring closure as the condition for reopening the directed herring fishery in the North Sea. The choice of 800,000 tons was based on data for the period 1947 - 1975. In later years, ICES has used this figure as the MBAL (Minimum Biological Acceptable Level) for North Sea herring, and still later as the Blim.

In recent years, there has been a feeling among ICES scientists that the value of Blim should be revised on the basis of more recent data and new methods. An ICES working group in 2003 applied segmented regression analysis to data for the period 1960 - 1999. They found a breaking point at 560,000 tons. The present working group repeated this calculation, extending the data series until 2005. The result of this calculation gave a breaking point of 500,000 tons.

However, the present working group decided not to use these findings for changing the current Blim value. The argument was that given the dome-shaped patterns of the S/R relationship, the use of segmented regression to establish a limit reference point was not appropriate. When adding data points at the right hand side of the curve (low recruitments at high stock sizes) the horizontal leg of the segmented relation will shift downwards, thereby forcing the point of intercept to the left (Blim gets smaller).

This conclusion was in line with that of the ICES Herring Assessment Working Group (HAWG) in 2006. Referring back to the results of a segmented regression analysis by the Study Group on Precautionary Reference Points For Advice on Fishery Management (SGPRP) in 2003, the HAWG in 2006 concluded that:

> "*In 2003, SGPRP (ICES 2003a) suggested to reduce Blim from the current 800 000 tonnes to about 560 000 tonnes, based on the results of the segmented regression analysis of the stock and recruitment data. (…) Although it is apparent that the recruitment historically has been at about the same level when the SSB was somewhat below 800 000 tonnes as above, HAWG decided not to propose any revision of the Blim reference points at present for the following reasons:*
>
> - *There is some doubt as to the validity of the calculation procedure used by the SGPRP*
> - *Currently there is concern that the stock dynamics are changing*
> - *HAWG would prefer to consider all reference points together, rather than revising just Blim.*
>
> *Most importantly, a downward revision of reference points now would not be helpful in precautionary management of the stock. While the harvest control rule in place for this stock has worked well in the recent past, and apart from Blim, the current reference points are derived from this HCR. The target F in the HCR was adopted by ACFM as Fpa, while the trigger point at which F* (sic!) *should be reduced below the target is adopted as Bpa.*"

The present working group did not change this conclusion of the ICES HAWG in 2006. They

concluded that there was no basis for changing Blim based on current analysis. They decided to refer the subject to the SGRECVAP (Study Group on recruitment variability in North Sea planktivorous fish) that will meet again in 2007. The question where Bpa should be placed in relation to Blim concerns the question of how much risk the industry is willing to take. Therefore, the group decided that this subject should be discussed with stakeholders and managers in the context of harvest control rules.

Personal comments

It is not surprising that the present working group did not want to change the advice of the Herring Working Group in 2006, and refrained from adapting the current Blim for herring. ICES is a bureaucratic organization in which individual scientists or even working groups are reluctant to take the responsibility for changing existing procedures, even when these are based on tradition rather than on science.

However, there is a growing awareness among ICES scientists that the existing Blim for North Sea herring, in combination with the Bpa, represents a too conservative approach. It is only a matter of time for ICES to accept this new reality.

The present working group decided to pass the problem on to the SGRECVAP because this group has to consider the causes of poor recruitment in herring (including cannibalism). However, it is doubtful whether this group in 2007 will come to a conclusion concerning the cause of the recruitment problem. Most likely, they will conclude that the matter requires a lot more study.

There is no reason, however, for ICES to wait for the final results of this working group. Whether the low recruitment at high stock sizes is caused by cannibalism or by another cause is irrelevant. The fact is that current data clearly show a dome-shaped stock recruitment relationship. The present WG used this fact even as an argument for rejecting the results of the segmented regression. It is now time for ICES to draw the consequences of this conclusion, and define an new Blim (and Bpa) on the basis of the dome-shaped curve. These new values for Blim and Bpa will most likely be considerably lower than the current ones.

Until the moment ICES has finally made these adjustments, management advice of ICES based on the old values for Blim and Bpa should not be taken too literally.

5.2. Blue whiting

In the recruitment time series 2 periods can be distinguished. The period 1981-1994 with relative low recruitment and a period 1995-2005 with recruitment about twice as high. The present limit reference points for blue whiting are:

Blim = 1.50 million tons

Bpa = 2.25 million tons

These limit points were set in 1998 before the change in the productivity of the stock was observed. The causes for the change in productivity are unknown.

The blue whiting is an example of a species in which a "regime shift" has occurred. The working group therefore tried to split the data into one series for the low production regime, and one series for the high production regimes. Stock/recruitment relationships were calculated for each period separately.

The calculations by the group resulted in a Blim of 1.5 million tons for periods of low productivity, and Blim = 2.0 for periods of high productivity. The group realized, however, that it will be impossible to decide at what moment the regime shifts from one phase to another. Applying different limit points for different regimes may therefore be unpractical. Therefore, the group decided that there was no basis to change the existing reference points for Blue whiting.

5.3. Norwegian spring spawning herring

Current limit reference points for Norwegian Spring Spanwing Herring are:

Blim = 2.5 million tons
Bpa = 5.0 million tons

The working group recalculated Blim, using more recent data on recruitment, and also new results from VPA (used to estimate historical stock sizes). The application of segmented regression now resulted in an estimate for Blim of 4.0 million tons. The cause of this large change in the estimate for Blim was a change in stock estimates for the years 1969-1972 when the stock was very small. Apparently, the method of segmented regression is very sensitive for changes in stock estimates close to the origin.

The WKREF could not explain this sensitivity of the model, and decided to refer this matter to the ICES Methods Working Group. Given this problem, the use of segmented regression technique to establish a limit biomass reference point for Norwegian spring spawning herring was not considered appropriate until the methodological issues have been resolved. Therefore, the existing limit reference points were unchanged for the time being.

Annex 1

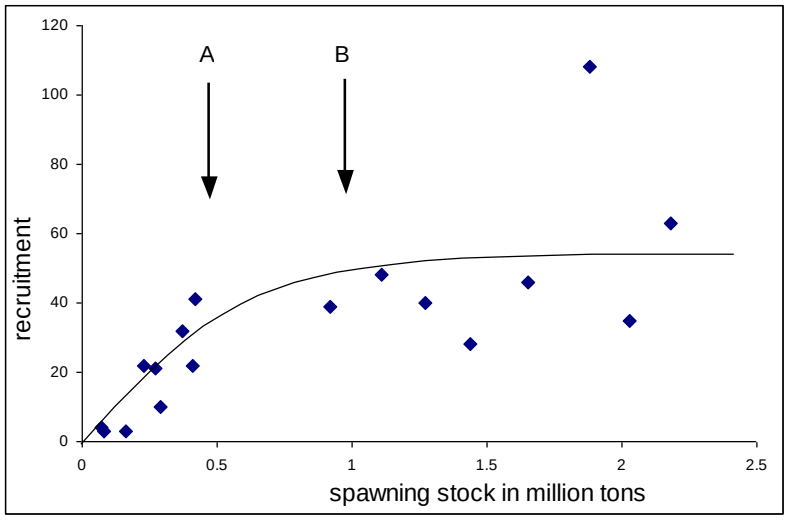
Definition of limit reference points

Limit reference points are values of stock size and fishing mortality beyond which the stock gets into danger. The best known limit reference point is the minimum level of spawning stock size Blim. This value has originally been defined as the minimum spawning stock that is required for the production of average recruitment. Other definitions have been used also, such as the stock level "below which recruitment is impaired". The idea of Blim is to define a critical level below which the stock will get in danger.

If Blim was the only reference point used, managers might have a tendency to maintain stocks just above Blim. However, because stock assessments contain a certain margin of error, the stock might drop below Blim even when the assessments suggests that it is still above this level. In order to minimise this risk, a second reference point has been introduced which is called the precautionary biomass (Bpa). This reference point compensates for possible errors in the assessment. If managers keep the stock above Bpa, the risk of the stock actually dropping below Blim, due to assessment errors, is small.

Two problems exist in defining these limit reference points: (1) how do we define Blim, and (2) how cautious should we be in avoiding the stock to drop below this level.

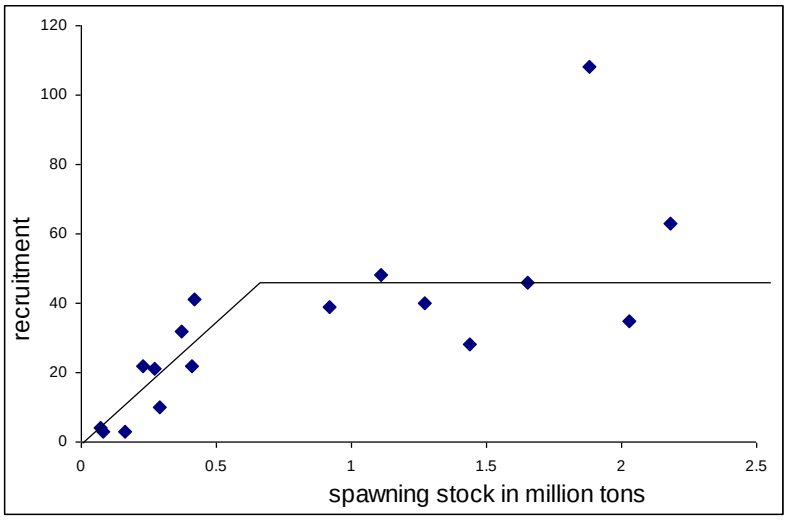
The first problem (defining the precise value of B_{lim}) may be illustrated by the following example.



The figure shows a very common pattern of recruitment and spawning stock size. At low stock sizes (in this case below 0.5 million tons), recruitment is obviously dependent upon spawning stock size. This is an area to be avoided. It is quite difficult, however, to define precisely the point at which recruitment starts to decline with decreasing stock size. There are various ways of fitting a curve through the data points, each of which has a different point of inflection. In the above example, we might estimate that the first decline of recruitment already starts at stock sizes below 1 million tons. In defining Blim, therefore, we have many choices. Some people may argue that Blim should be set at 0.5 million tons because this is

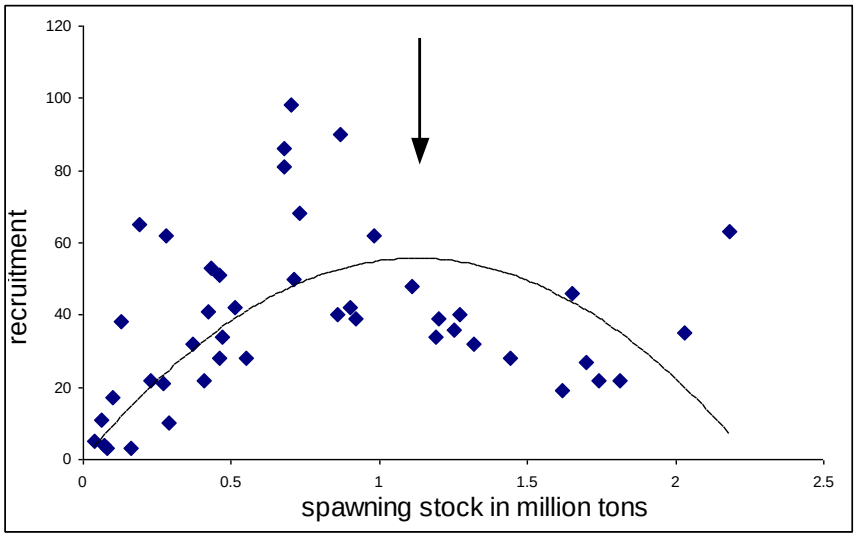
the region where the problems clearly start. Other, more cautious scientists will set Blim at 1.0 million tons because here we expect the first (small) effects of declining stock sizes on recruitment.

Because scientists feel uneasy with arbitrary ways of setting a limit for spawning stock size, they have come up with "objective" ways of determining the point of inflexion. One of these is the "segmented regression", in which the cloud of data points is divided in two parts: a left-hand cloud and a right hand-cloud. For the left-hand cloud, the regression between stock size and recruitment is expected to be a line going through the origin, and for the right hand cloud it is assumed that the regression is a horizontal line. The intercept of the two lines is defined as Blim:



The advantage of this method is that we now have a sharp breaking point, giving an unique value for Blim. The separation of the data points into two groups is done using a computer programme, so it appears that now we have an objective way of defining Blim. However, each time we add a new data point to the graph, the position of one of the lines will change, and thereby the position of the breaking point. Therefore, method is less reliable than it appears at first sight. Also, the underlying biological assumption of a sharp breaking point is likely to be false.

When we add more data points to the graph, we may get a pattern as in the figure below:



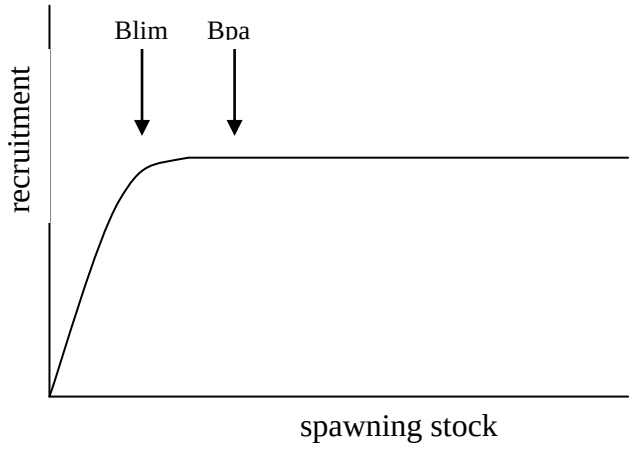
Now the relationship between spawning stock and recruitment seems to be dome-shaped. Recruitment is low not only at low stock sizes but also at high stock sizes. This is the relationship that seems most plausible from a biological point of view. Somewhere at high stock sizes, one would expect that recruitment will decline, due to competition for food with the older fish or to predation by older fish on juveniles (cannibalism).

Defining Blim becomes even more difficult in this situation. If we define Blim as the stock level below which recruitment starts to decline, we have to chose the top of the curve (indicated by the arrow).

How cautious should we be in setting Bpa

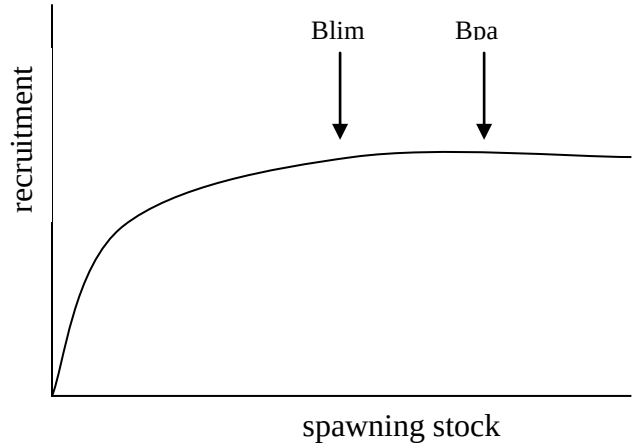
The purpose of having a precautionary stock size (Bpa) is to reduce the risk that the stock will accidentally drop below Blim, due to errors in the assessment.

Defining Bpa involves even more subjective choices than defining Blim. The choice of Bpa depends on the question how dangerous it is to reduce the stock below Blim, and how large a risk we are prepared to take that this happens. If going below Blim is very dangerous, we want to have a small risk of this happening. Conversely, if Blim itself already contains some margin of safety, it may be unnecessary to add another large safety margin. This is illustrated in the three examples below.



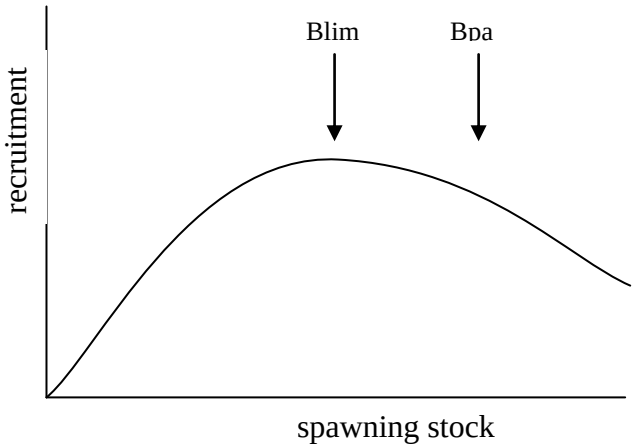
Example 1

The danger of going below Blim is very high. Consequently, it is wise to set a precautionary Bpa at a sufficiently large distance from Blim. This will minimise the risk of stock collapse.



Example 2

Although recruitment starts declining below Blim, the initial decline is not very steep. The effect on recruitment of reducing the stock a little bit below Blim is small. Consequently, setting an extra safety margin (Bpa) above Blim seems to be unnecessary.



Example 3

Here we have a dome-shaped relation. According to the ICES definition, Blim is defined as the top of the curve. If we add a safety margin and put Bpa at some distance to the right side of Blim, we find that recruitment will be reduced in the range of stock size that we consider acceptable (to the right-hand side of Bpa.

The conclusion is that the necessary safety margin (Bpa) depends to a large extent on (1) the actual shape of the stock/recruitment relationship, and (2) the point of the S/R relationship that we define as Blim. If scientists are already prudent in choosing the point of Blim, and then add an extra safety margin to make sure that the point of Blim will not be approached, they add precaution to precaution.

It is generally assumed that there is no harm in being overcautious. The reasoning is that if a large stock size doesn't have positive effects, it won't have negative effects either. This assumption, however, is not always true. Forcing the industry to respect a relative high Bpa may results in extra fluctuations in TAC. In the case of a dome-shaped S/R relationship, an over-cautious approach may even reduce recruitment and thereby reduce the yield of the fishery.