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Harvest Control Rules and Changing Productivity: the working example of North Sea Herring.

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Abstract

North Sea herring is managed by the EU and Norway through a harvest control rule where the target fishing mortalities are changed if the estimated SSB falls below a trigger biomass level (1.3 million tonnes). This management agreement was adopted in December 1997, and last amended in November 2004. The management agreement includes target fishing mortalities for both adult and juvenile fish. Initial studies to test the robustness of the rule assumed a stable state of productivity, with stochastic variability in recruitment.

Recruitment in North Sea herring has been relatively poor for the last 4 year classes (2002, 2003, 2004 and 2005). This sustained sequence of reduced recruitment has not been observed before at current levels of stock biomass. According to a recent ICES study group (SGRECVAP) this serial poor recruitment has been caused by an increase in the mortality of the larvae over the first winter, and was not due to overexploitation of the stock. Thus, at least in the short term, the productivity of North Sea herring has changed, whilst the management agreement currently has not. As the agreement is primarily based on target fishing mortalities, changes in productivity should not undermine the management agreements ability to protect the stock, because the trigger points are based on biomass, nevertheless the agreement may no longer be optimum for sustainable exploitation.

In 2006, the ICES advice changed to account for the changes in the productivity of North Sea herring. Projected catches and SSBs were estimated assuming a shift in recruitment from the average of the last 25 years (since the stock recovered from collapse) to the average of the last four years to reflect the more recent low levels. The management agreement is ambiguous during the recovery the SSB was taken as the assessment year, currently ICES advice is based on the TAC year. In addition to the less than optimal biomass trigger points the agreement (amended in 2004) also now includes a maximum change in TAC rule, with a limit of 15% change per year, which if implemented at all levels of biomass would conflict with the need to respond swiftly to changes in productivity of the stock in the presence of sustained decline.

Keywords: Herring, changing productivity, North Sea harvest control rule, advice

Background

There is a long documented history of the exploitation of North Sea herring (Figure 1) and the associated collapses and recoveries of the stock (Cushing & Bridger, 1966; Burd, 1985; Nichols, 2001; Simmonds, 2005). The productivity of North Sea herring changes over annual and decadal scales (Figure 2). The changes in productivity are caused by both anthropogenic (fisheries) and non-anthropogenic effects and the interaction of the two. Whilst the management has centred on an acknowledgment that the fisheries impact on the productivity of the herring stock, management to date has assumed that the rate of production of herring is stochastic due to unspecified ecosystem effects, but that the mean is not influenced by the ecosystem. The current biomass-based harvest control rule that is used to manage North Sea herring, was tested prior to implementation under this assumption of a stable mean productivity.

Every habitat or ecosystem has a carrying capacity which impacts on the productivity of fish stocks (Greenstreet et al., 1997; Jennings et al., 2002). These carrying capacities may and do vary with time. The impact of changing carrying capacity on fish stock productivity is primarily through influencing growth rates and the stock to recruit relationship (Kell et al., 2005). In recent years, evidence from varying production of North Sea herring, does suggest that the carrying capacity of the North Sea has changed. The growth and maturity of the large 2000 year class was reduced once the fish were older than 2 winter rings, this was interpreted by the ICES herring assessment working group as a density effect. Similar sized year classes in the past did not show this reduction in growth, suggesting a change in carrying capacity of the North Sea. Also recently, the recruitment for the year classes 2002 to 2005 was well below average, despite the spawning stock being above levels thought to impede recruitment (Figure 3). This suggests that the production of recruits per spawner has also changed. Kell et al. (2005) emphasise that in testing management measures, the mechanism behind these changes must be known and incorporated into simulations, this was not done for North Sea herring. The recent serial poor recruitment has the potential to cause problems and has given us the current challenges for the management of North Sea herring.

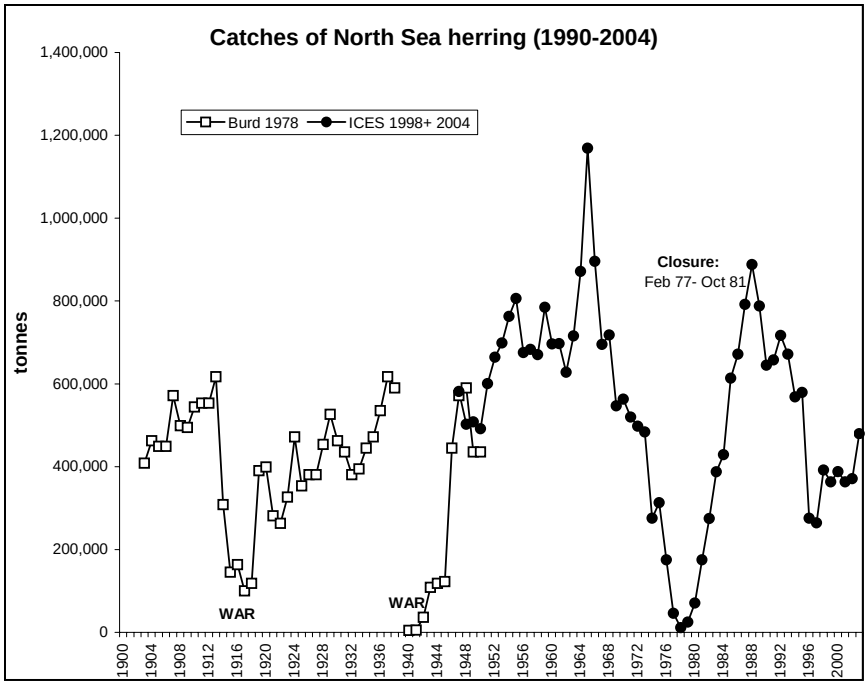

Figure 1. Time series of herring landings from the North Sea. Note Burd data adjusted from tons to tonnes.

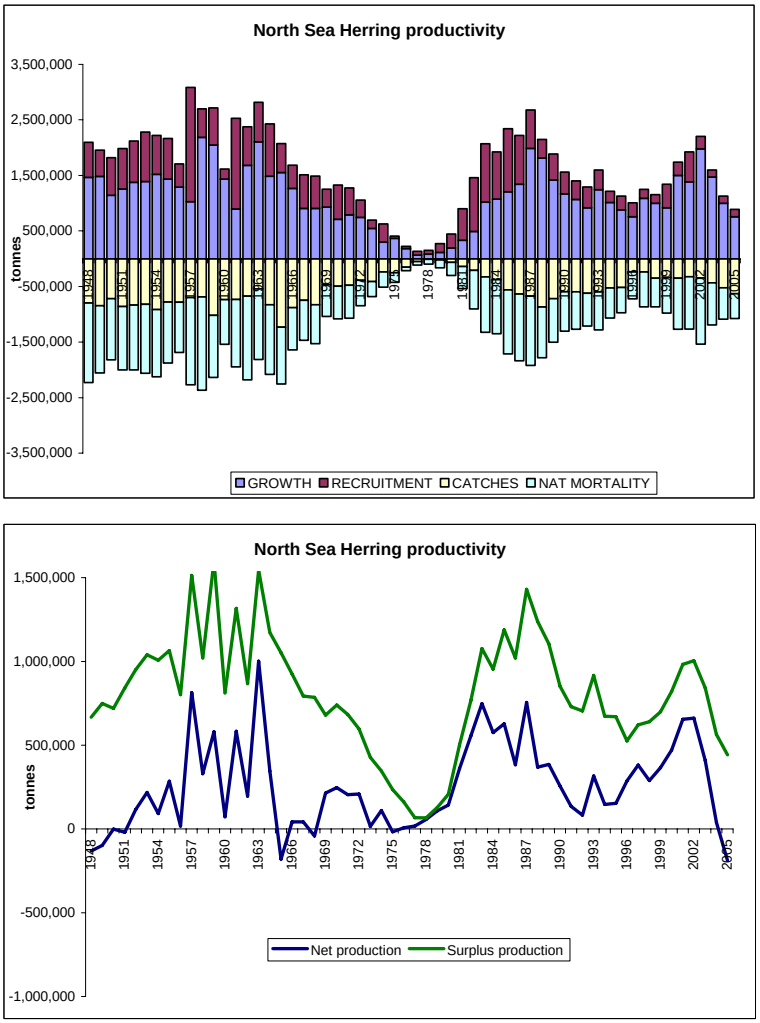

Figure 2. Estimates of production in North Sea herring from 1948 to 2005; based on the methods of Dutil & Brander (2003) and described in Dickey-Collas & Nash (2005). The difference between increase biomass (growth and recruitment) and decrease biomass (catches and natural mortality) form the surplus production per year, net production is when fisheries catches are not accounted for.

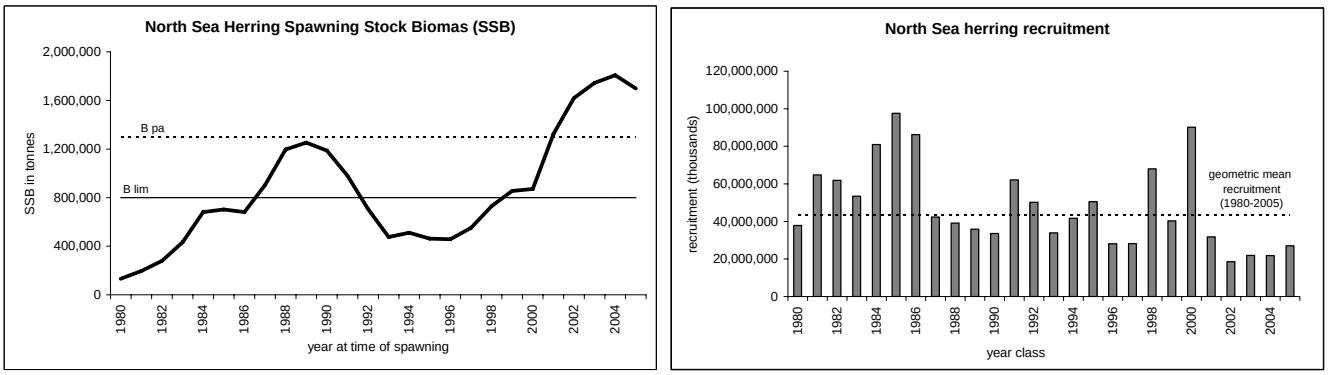

Figure 3. Time series of SSB and recruitment for North Sea herring (taken from ICES 2006a), showing biomass trigger points and mean recruitment since the recovery of the stock.

The Current Management Agreement for North Sea herring.

North Sea herring is managed by the EU and Norway through a harvest control rule where the target fishing mortalities are changed if the estimated SSB falls below a trigger biomass levels (1.3 million tonnes and 0.8 million tonnes, Figure 4). This management agreement was first adopted in December 1997, and last amended in November 2004 (Appendix 1). The management agreement includes target fishing mortalities for both adult and juvenile fish. Initial studies to test the robustness of the rule assumed a stable state of productivity, dependent only on the size of the spawning stock with added stochastic variability in recruitment. These studies suggested that the management agree was robust and conformed to the precautionary approach. It is important to note that the trigger biomass of 0.8 million tonnes was the MBAL (minimum biological acceptable level), which then became B_{lim} under the precautionary approach, and 1.3 million tonnes is the currently agreed B_{pa}. Though the use of the 1.3 million tonnes trigger point in the agreement is one of convenience rather than that a explicit requirement to use B_{pa} for this value.

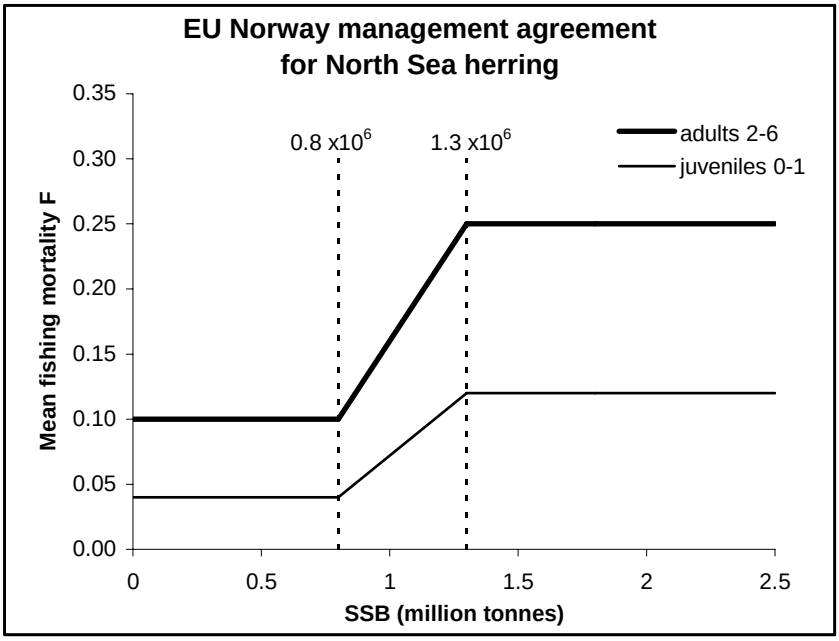

Figure 4. Conceptual illustration of the decision rules for the EU Norway North Sea herring management agreement. Trigger points are biomass (SSB) based at 1.3 million tonnes and 0.8 million tonnes and passing these points triggers changes to the target fishing mortalities for both adults and juveniles.

Reduced recruitment and its impact on the development of the stock

The sustained sequence of reduced recruitment has not been observed since 1947 at current levels of stock biomass. According to a recent ICES study group (SGRECVAP- ICES 2006b) this serial poor recruitment has been caused by an increase in the mortality of the larvae over the first winter, and was not due to overexploitation of the stock. This conclusion was reached from the evidence that the spawning stock biomass has been above 0.8 million tonnes for the last 5 years (Figure 3) and these SSBs produced high numbers of young 10 mm larvae which were detected in the International herring larval survey (ICES 2006a). These high larval abundances did not result in high abundances of older larvae as observed 2 to 5 months later in a Methot Isaacs Kidd net (MIK) survey, or subsequent larger year classes in the catch (see Nash & Dickey-Collas 2005 for further explanation of the detecting the recruitment dynamics

of North Sea herring). Both the ICES herring assessment working group and SGRECVAP concluded that at least in the short term, the productivity of North Sea herring has changed.

During its development, the management agreement however, was not tested with this pattern of four years of poor recruitment. The assessment working (WG) in 2006, suggested that until evidence to the contrary was detected from empirical data, it should be assumed that the reduced recruitment will continue. The WG projected catches and SSBs were estimated assuming a shift in recruitment from the average of the last 25 years (since the stock recovered from collapse) to the average of the last four years to reflect the recent serial reduced recruitment (ie reflecting a change carrying capacity of the stock to recruit relationship). Projections with either levels of recruitment suggested that the stock would decline to below the trigger biomass of 1.3 million tonnes by 2007. However, the assumption of a lower recruitment lead to a more sustained decline and a higher risk of the stock falling below B_{lim} in subsequent years. ACFM accepted that it was appropriate to assume the lower level of recruitment and thus changed the basis for the advice to account for the changes in the productivity of North Sea herring.

The Management agreement and changes in productivity

The management agreement however, does not necessarily respond immediately to this advice about lower productivity, as the agreement decisions are ambiguous and may be triggered by the current state of the stock, not necessarily the projected state. This process is precautionary in the case of recovery, the regime under which the rule was developed, but would have the opposite effect if implemented in the situation of the current sustained projected decline.

Kell et al. (2005) suggest that in a changing environment, the targets for management should be based on fishing mortality, and not on biomass. In North Sea herring, the management targets are specific fishing mortalities, but these targets are changed on the basis of trigger points that are biomass based. Specifically with a stock to recruit relationship, a lower carrying capacity does not necessarily mean that the limit reference points should be the same. A different state of productivity may have a lower carrying capacity, but the point at which recruitment is effected by the amount of spawner biomass may also change (Figure 5), particularly if depensation does or does not occur.

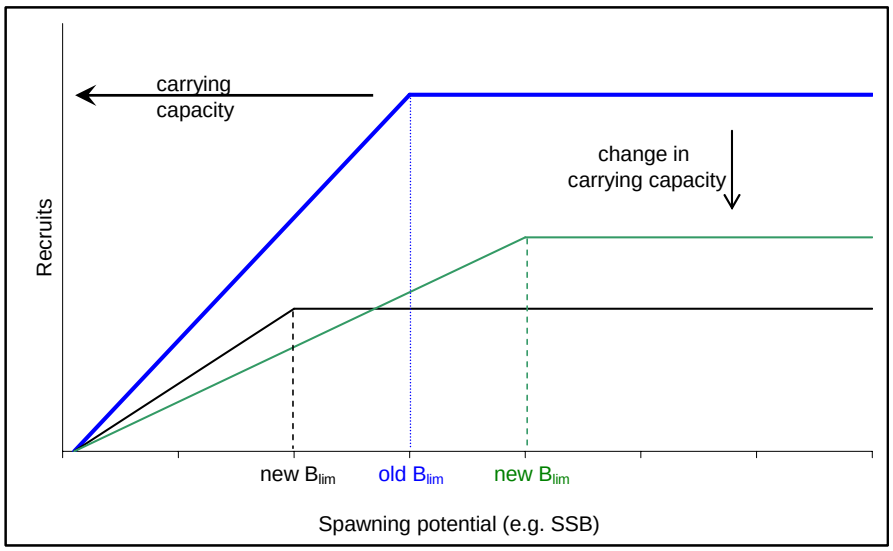

Figure 5. Illustration of two potential scenarios of reductions in mean recruitment and their impact on the limit reference point.

In addition, there are other parts of the management agreement which also impact on whether the agreement is precautionary or not in the context of a change in productivity. The main issue being the maximium 15% change on annual TAC variation. ACFM advice on the management agreement from spring 2006 was as follows:

> *"ICES has examined the performance of this revised harvest control rule. ICES considers that the strict application of the TAC change limit of 15% (rule number 5) is not consistent with the Precautionary Approach in a situation like the present when four consecutive weak year-classes are recruiting to the population. The harvest control rule is in accordance with the precautionary approach if paragraph 6 is invoked sufficiently early to ensure that there is less than 5% chance of SSB falling below Blim in 10 years even in the case of several consecutive weak year-classes. Assuming that paragraph 6 would be invoked when TAC constraints would lead to SSB falling below Bpa, it is considered that the revised HCR is in accordance with the Precautionary Approach."*

Relatively rapid changes from a high productive to low productive states cannot be accounted for in the advice if the limit on TAC change is too small and if the limit on change continues to be implemented once the biomass falls below B_{pa}. In other words, management measures will not reflect the dynamics of the system unless the 15% rule is revoked once the stock is projected to fall below Bpa in the TAC year, and thus delivering the needed response swiftly to changes in productivity of the stock in the presence of sustained decline.

Issues arising from this example

1. Do biomass trigger points operate well in a scenario of switching between productive states? This depends on how the recruit to spawning biomass relationship changes close to the origin of the relationship. Although the interaction of biomass trigger points and target fishing mortalities needs to be tested within a range of simulations, we have no evidence to consider the current B_{lim} anything other than robust from a precautionary standpoint to recent productivity changes, but it may be suboptimal.
2. If biomass trigger points are close to or above equilibrium biomass for a particular state, then it is possible that some other management rule with a lower or higher biomass trigger and with the potential for more severe management changes may be more optimal. This is linked to issue 1 above. This issue leads to the question should rules be re-evaluated once shifts in productivity are detected?
3. Are restrictions to changes in TAC precautionary when productivity changes? We consider that it is important to ensure that such restrictions on the rate of decline are checked for robustness to shifts in productivity and that management agreements contain clauses to suspend these restrictions in the event of changes in productivity. It should be noted that it is generally more difficult to measure a rate. The 15% rule is designed to provide increased stability in catch. Sustaining a fishery in the short term when recruitment declines in a sustained manner may result in worse socio-economic outcomes to due to stock collapse than would have been the case if timely action had been taken (see Simmonds 2005).
3. Do we need both precautionary reference points and HCR trigger points? Is it not better to developed harvest rules that are intrinsically precautionary, rather than have biomass reference points that are both trigger and management targets? We consider this to be the case, these concepts are dealt with more fully in ICES Study Group on Management Strategies (ICES 2006c).

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Appendix 1

The EU Norway Management Agreement for North Sea herring (November 2004).

1. *Every effort shall be made to maintain a level of Spawning Stock Biomass (SSB) greater than the 800,000 tonnes (Blim).*
2. *Where the SSB is estimated to be above 1.3 million tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries , reflecting a fishing mortality rate of no more than 0.25 for 2 ringers and older and no more than 0.12 for 0-1 ringers.*
3. *Where the SSB is estimated to be below 1.3 million tonnes but above 800,000 tonnes, the Parties agree to set quotas for the direct fishery and for by-catches in other fisheries, reflecting a fishing mortality rate equal to:*

   0.25 – (0.15(1,300,000-SSB)/500,000) for 2 ringers and older, and*

   0.12 – (0.08(1,300,000-SSB)/500,000) for 0-1 ringers.*
4. *Where the SSB is estimated to be below 800,000 tonnes the Parties agree to set quotas for the directed fishery and for by-catches in other fisheries, reflecting a fishing mortality rate of less than 0.1 for 2 ringers and older and less than 0.04 for 0-1 ringers.*
5. *Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 15% from the TAC of the preceding year the Parties shall fix a TAC that is no more than 15% greater or 15% less than the TAC of the preceding year.*
6. *Not withstanding paragraph 5 the Parties may, where considered appropriate, reduce the TAC by more than 15% compared to the TAC of the preceding year.*
7. *By-catches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted.*
8. *The allocation of TAC for the directed fishery for herring shall be 29% to Norway and 71% to the Community. The by-catch quota for herring shall be allocated to the Community.*
9. *A review of this arrangement shall take place no later than 31 December 2007 .*