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Combined *Ex post* and *ex ante* evaluation of the long term management plan for sole and plaice in the North Sea, including responses to ICES review

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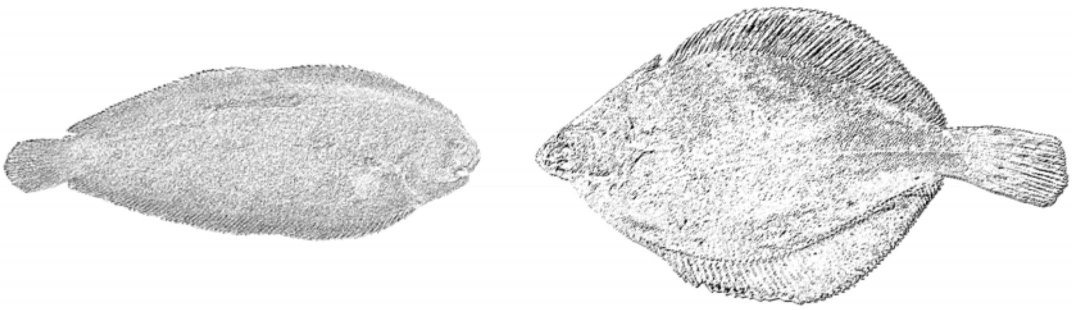

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Summary

This report describes the combined ex post and ex ante evaluation of the multiannual plan for sole and plaice in the North Sea as laid out in Council Regulation (EC) No 676/2007. It extends previous reports by IMARES (C114/09, C104/10). This plan has been in place since 2007. The plan aims to ensure, in its first stage, that stocks of plaice and sole in the North Sea are brought within safe biological limits, i.e. above Bpa and below Fpa. Following this, and after due consideration by the Council on the implementation methods for doing so, the plan will ensure that the stocks are exploited on the basis of maximum sustainable yield and under sustainable economic, environmental and social conditions. This report extends work previously carried out by Wageningen IMARES evaluating the multiannual plan for plaice and sole in the North Sea as described in Council Regulation EC 676/2007 (Machiels *et al*. 2008). That evaluation has been redesigned to take into account comments and criticisms highlighted by two ICES reviewers.

The ex ante evaluation of the plan includes an examination of its implementation, and the stock and fleet dynamics in relation to the measures and objectives of the plan. The stock dynamics were evaluated using two different stock assessment models: an XSA model and a statistical catch at age (SCA) model. Changes in fleet dynamics were evaluated in terms of overall fishing effort and number of vessels in the Dutch beam trawl and otter trawl fleets.

The regulations in the Council Regulation have been used as the basis for establishing TACs for North Sea plaice and sole for the last two years. However, the actual implementation of these regulations has required a degree of interpretation by those implementing them. The regulations by themselves lack transparency, without proper specification of how they are to be implemented (e.g. how F_{sq} is to be calculated) and how the achievement of objectives is to be assessed (neither in terms of the model used to specify this, nor in the level of uncertainty that is acceptable).

The multiannual plan, without further specifications than the regulations alone, can appear to lack direction. A simple 10% reduction from an unclearly defined F_{sq} does not necessarily steer the stock towards the objectives. This is especially true given retrospective problems in the North Sea plaice and sole stock assessment. A stepwise decrease in the ‘distance’ between current *F* and the target *F*, while potentially invoking the 15% TAC change more often, may be more successful in assuring progress towards the objectives and prevent issues such as the projected increase in sole *F* from 2008 to 2009.

The rationale for the target fishing mortality reference points in the long term management plan is not given in the Council Regulation. The objective *F* for the North Sea plaice stock is similar to, though slightly high than, the current proxy of F_{MSY} for this stock as used by ICES. In the case of North Sea sole, the management objective *F* lies within the broad range of potential proxies for F_{MSY} for the stock. North Sea plaice *F* is currently below the target *F* level while, a significant decrease in the *F* of North Sea sole is still required, especially considering that the current management *F* for the stock is likely to represent an increase in *F* from 2008 to 2009. In this context, the long term management plan will steer towards a further decrease in fishing effort by the main fleets targeting sole and plaice.

Under the multiannual plan, the North Sea plaice TAC has been increasing. This increasing trend is likely to persist as long as the stock continues to recover because fishing in the near future should fluctuate around what is considered to be the optimum *F* for long term sustainable yields. Discarding levels remain high, but currently they are near the lowest level of the past ten years and show a downward trend. North Sea sole TACs have stabilised to a degree under the multiannual plan in the most recent years, but these are likely to continue to fluctuate depending on the strength of incoming year classes.

The data available to analyse the stock dynamics under the multiannual plan allow the following conclusions to been drawn with respect to the chosen reference points and the safe biological limits of the stock:

- Spawning Stock Biomass (SSB) of both species have increased since the implementation of the plan. The XSA assessment for plaice (giving only point estimates), indicates that SSB has been larger than B_{pa} for two consecutive years. The SCA assessment (following Aarts and Poos 2009) indicates that plaice indeed has a larger than 95% probability of having reached a stage where the SSB is above B_{pa} for two consecutive years. For sole, the XSA stock assessment indicates that SSB has been above B_{pa} for two consecutive years. An alternative assessment including uncertainty estimates indicate that the probability of being above B_{pa} in not yet larger than 95%.
- The annual fishing mortality rates (*F*) of the two stocks have been declining in recent years. The North Sea plaice stock is now fished at a level below the management regulation target for this stock (<0.3 per year). The annual rate of *F* for the North Sea sole stock remains above the management regulation target for this stock (>0.2 per year).
- According to the latest assessment results, both stocks appear to be within the precautionary zone with regards to SSB and *F* in 2008.

Hence, despite a lack of clarity in the implementation of the management regulations, the multiannual plan, given the current perception of the stock, appears to be resulting in stock trajectories and fishing levels moving towards the desired objectives and is, therefore, in line with the principles of the precautionary approach.

In the first year of its implementation (2008), it appears that the effort regulations defined for the multiannual plan have been having the desired effect. Overall fishing effort has declined, along with a decrease in the size of the main fishing fleets utilising these resources. These reductions in effort seem to be compensating for issues relating to the practical application of management regulations on the setting of TACs.

In the ex-ante evaluation, three different approaches were used to test the effects of the management plan. The first was a yield curve analysis for the two stocks under different stock and recruit relationship assumptions to assess the equilibrium fishing mortality targets in the plan. The second approach is a projection of the two stocks under the rules of the plan, varying only future recruitment under different assumptions. Finally, the third approach is a full feedback MSE approach where in addition to the biology the fisheries system is also modelled. In order to show that the management plan is precautionary for the two species under consideration according to ICES, we use the Criteria agreed during WKOMSE to be applied in the evaluation of Harvest Control Rules/Management Plans in relation to precautionary reference points.

The results presented here suggest that the multiannual plan can be considered to be precautionary for both of the managed stocks according to the criteria described by WKOMSE for the evaluation of multiannual plans. The plan allows for increases in yield to 2015 and in the long term while reducing the current levels of F. There is a very high likelihood of stock growth in terms of SSB for both stocks. Both the simple stock projections and full feedback MSE analysis showed that F is likely to remain at low levels allowing for increases in stock biomass. Caution needs to be taken in the interpretation of the MSE, and stock projection results because future projections take the stock to outside the range of historic observations. But by examining the performance of the plan at the lower ends of the simulation ranges and considering 'worst case' recruitment scenarios the likely risk of a management failure can be considered to be adequately estimated.

The results presented show that the plan is very likely to be precautionary but it is more difficult to assess whether it achieves the goals of long term yields and sustained healthy populations. This is essentially a question over whether the F targets specified for the two stocks are reasonable and whether in practice they can be achieved simultaneously. The former relies of the definition of MSY for these two stocks and the corresponding stock sizes that can deliver these yields while the latter depends on how fisheries behaviour and gear selection changes into the future. Given the uncertainty associated in the estimation of Fmsy reference points and that expert opinion has been incorporated into the determination of target F points, the targets as they stand seem plausible. Regardless, it is clear that both stock growth and long term increases in current yield levels are likely should the multiannual plan be implemented.

1 Introduction

In 2007, the European Commission adopted Council Regulation (EC) No 676/2007, establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea (Appendix A). The objective of the plan is to ensure, in its first stage, that stocks of plaice and sole in the North Sea are brought within safe biological limits. This shall be attained by reducing the fishing mortality rate on plaice and sole by 10 % each year, with a maximum TAC variation of 15 % per year until safe biological limits are reached for both stocks. Following this, and after due consideration by the Council on the implementing methods for doing so, the plan will ensure in its second stage that the stocks are exploited on the basis of maximum sustainable yield and under sustainable economic, environmental and social conditions.

The adopted plan should be the main instrument for flatfish management in the North Sea, and should contribute to the recovery of other stocks such as cod. In drawing up the multiannual plan, the Council tries to take into account the fact that the high fishing mortality rate for plaice is to a great extent due to the large discards from beam-trawl sole fishing with 80mm nets in the southern North Sea. The control of the fishing mortality rates envisaged in the plan is to be achieved by establishing an appropriate method for the establishment of the level of total allowable catches (TACs) of the stocks concerned, and a system including limitations on permissible days at sea. Fishing effort on the stocks is restricted to levels at which the TACs and planned fishing mortality rates are unlikely to be exceeded, but are sufficient to catch the TAC allowed on the basis of the fishing mortality rates established in the plan.

Following the establishment of the plan, a simulation study was carried out by Machiels *et al.* (2008) to address an ICES request to test if the management plan could be considered precautionary. ICES subsequently requested a review of the Machiels *et al.* study to "ascertain that the evaluation of the (agreed) flatfish management plan has been carried out appropriately and whether the management plan is in accordance with the precautionary approach." A number of concerns were raised and suggestions for improving the simulation methodology and analysis were suggested. One of the main conclusions was that, based on the simulation study, the plan could not be considered precautionary because the simulated stock assessment estimates of annual fishing mortality rates (F) and Spawning Stock Biomass (SSB) do not show a high probability (>95%) of the plaice stock being within safe biological limits for two consecutive years before 2018. It was then decided that "*depending on the criterion for the precautionary approach that is adopted, this could be seen as non-precautionary*."

In order to ensure sufficient input to the proposed evaluation by the Commission, Wageningen IMARES evaluates the plan, in a study commissioned by the Dutch Ministry of LNV. The evaluation comprised of an *ex post* comparison of the historic performance against the objectives mentioned in the plan (Miller and Poos 2009), and an *ex ante* test of the plan in terms of its sustainability as defined by ICES. Those reports were reviewed by three independent reviewers, answering the question if the plan was in line with the precautionary approach. Here. The two reports are combined, and the comments of the reviewers is being dealt with.

2 Assignment

This report extends work previously carried out by Wageningen IMARES evaluating the multiannual plan for plaice and sole in the North Sea as described in Council

Regulation EC 676/2007. That evaluation has been redesigned to take into account comments and criticisms highlighted by five ICES reviewers of the previous reports and is also updated with the latest available data and assessment models of the stocks. The primary aim of this evaluation is to assess whether or not the management measures specified by the plan constitute a precautionary approach to the management of the two stocks. Further, it aims to evaluate the likelihood of the long term management of the stocks being in line with the principle of managing fisheries for maximum sustainable yield as agreed upon at the World Summit on Sustainable Development in Johannesburg (September 2002). This evaluation includes tests of the robustness of the plan to uncertainty by evaluating its implementation across a range of plausible scenarios of stock dynamics, starting conditions and fisheries dynamics.

3 Materials and Methods

3.1 The management regulation

We follow the description of the long term management plan in Council Regulation EC676/2007 by Machiels *et al*. (2008):

<u>Objectives</u>

On 11 June 2007 the Council of the European Union adopted a management agreement for fisheries exploiting stocks of plaice and sole in the North Sea. The multiannual agreement should be deemed to be a recovery phase during its first stage and a management plan during its second stage, within the meaning of art 5 and 6 of the Council Framework Regulation adopted under the reform of the Common Fisheries Policy (Council Regulation (EC) No 2371/2002).

In its first stage the objective of the plan is to ensure that stocks of plaice and sole in the North Sea are brought within safe biological limits, and in a second stage and after due consideration by the Council on the implementing methods for doing so that those stocks, are exploited on the basis of maximum sustainable yield and under sustainable economic, environmental and social conditions.

The operational objectives of the first stage of the agreement are to bring the two stocks to within safe biological limits. For plaice, these safe biological limits are a fishing mortality below 0.6 and an estimated spawning biomass exceeding 230 000 ton. For sole the safe biological limits are a fishing mortality below 0.4 and 35 000 ton. TACs applied will corresponds with fishing mortality that will be reduced by 10% year-on-year until the target levels have been reached, while annual variations in TACs will be kept within 15%. According to article 5 of the Regulation the Council will amend the agreed plan when the stocks of plaice and sole have been found to have returned to within safe biological limits for two years in succession. The council shall decide on the basis of a review proposal from the European Commission that will permit the exploitation of the stocks at a fishing mortality rate compatible with maximum sustainable yield. The proposal for review shall be accompanied by a full impact assessment that takes into account the opinion of the North Sea Regional Advisory Council.

Advice on long-term management from ICES indicates that at low target fishing mortalities (considerably lower than the present levels), low risk to reproduction and high long-term yields are achieved simultaneously. The general pattern is that there is no conflict between the two objectives. A low fishing mortality will lead simultaneously to high yield and a low risk to reproduction (lower than the 5-10% risk which has generally been considered acceptable by managers).

Measures

The legal management measures agreed on by the Council of the European Union are given in Chapter II of the Regulation (total allowable catches). Chapter I deals with subject-matter and objective (Article 1-4).

Article 6

Setting of total allowable catches (TACs)

1. Each year, the Council shall decide, by qualified majority on the basis of a proposal from the Commission, on the TACs for the following year for the plaice and sole stocks in The North Sea in accordance with Articles 7 and 8 of this Regulation.

Article 7

Procedure for setting the TAC for plaice

1. The Council shall adopt the TAC for plaice at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:
    a. that TAC whose application will result in a 10% reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year.
    b. that TAC whose application will result in the level of fishing mortality rate of 0.3 on ages 2 to 6 in its year of application.
2. Where application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15%, the Council shall adopt a TAC which is 15% greater than the TAC of that year.
3. Where application of paragraph 1 would result in a TAC which is more than 15% less than the TAC of the preceding year, the Council shall adopt a TAC which is 15% less than the TAC of that year.

Article 8

Procedure for setting the TAC for sole

1. The Council shall adopt a TAC for sole at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:
    a. that TAC whose application will result in the level of fishing mortality rate of 0.2 on ages 2 to 6 in its year of application;
    b. that TAC whose application will result in a 10% reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year.
2. Where the application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15%, the Council shall adopt a TAC which is 15% greater than the TAC of that year.
3. Where the application of paragraph 1 would result in a TAC which is more than 15% less than the TAC of the preceding year, the Council shall adopt a TAC which is 15% less than the TAC of that year.

Article 9

Fishing effort limitation

1. The TACs referred to in Chapter II shall be complemented by a system of fishing effort limitation established in Community legislation.
2. Each year, the Council shall decide by a qualified majority, on the basis of a proposal from the Commission, on an adjustment to the maximum level of fishing effort available for fleets where either or both plaice and sole comprise an important part of the landings or where substantial discards are made and subject to the system of fishing effort limitation referred to in paragraph 1.
3. The Commission will request from STECF a forecast of the maximum level of fishing effort necessary to take catches of plaice and sole equal to the European Community's share of the TACs established according to Article 6. This request will be formulated taking account of other relevant Community legislation governing the conditions under which quotas may be fished.
4. The annual adjustment of the maximum level of fishing effort referred to in paragraph 2 shall be made with regard to the opinion of STECF provided according to paragraph 3.
5. The Commission shall each year request the STECF to report on the annual level of fishing effort deployed by vessels catching plaice and sole, and to report on the types of fishing gear used in such fisheries.
6. Notwithstanding paragraph 4, fishing effort shall not increase above the level allocated in 2006.
7. Member States whose quotas are less than 5% of the European Community's share of the TACs of both plaice and sole shall be exempted from the effort management regime.
8. A Member State concerned by the provisions of paragraph 7 and engaging in any quota exchange of sole or plaice on the basis of Article 20(5) of Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy that would result in the sum of the quota allocated to that Member State and the quantity of sole or plaice transferred being in excess of 5% of the European Community's share of the TAC shall be subject to the effort management regime.
9. The fishing effort deployed by vessels in which plaice or sole are an important part of the catch and which fly the flag of a Member State concerned by the provisions of paragraph 7 shall not increase above the level authorised in 2006.

3.2 Background information on reference points

The fishing mortality target reference point for North Sea sole mentioned in Council Regulation (EC) No 676/2007, originates from “a committee of experts examining multi-annual management plans”. This committee indicates that “the highest yield of sole can be taken at a fishing mortality rate of 0.2 on ages two to six years”. Although it is not explicitly stated which committee report is referred to in this case, it is very likely to be the report of the Report of the ICES ad hoc Group on Long Term Advice (AGLTA) in 2005 (ICES 2005). Likewise, the fishing mortality reference point for plaice is based on an advice from the Scientific, Technical and Economic Committee for Fisheries (STECF) that the fishing mortality rate necessary to produce the highest yield from the stock of plaice in the North Sea in the long term is 0.3.

The target F values can be compared to long term maximum sustainable yield proxies given by ICES. For North Sea plaice, ICES considers F_{max} a candidate for the reference point consistent with taking high long-term yields. Currently, F_{max} is estimated to be 0.17 (ICES 2009). This value is thus lower than the target in the management plan. For sole, for which F_{max} is poorly defined, candidates for reference points consistent with high long-term yields (and a low risk of depleting the productive potential of the stock) are in the range of $F_{0.1}$–F_{pa}. With $F_{0.1}$ being estimated at 0.11 per year, and F_{pa} being estimated at 0.4, a proxy for the high long term yield is thus found in between this range of 0.11-0.4.

It should be noted that the use of single species estimation of biological reference points, such as the ones used in the management plan and the proxies for long term maximum yields, is currently under much study. For several North Sea roundfish species, ecosystem model results suggest that it is not possible to simultaneously achieve yields corresponding to MSYs predicted from single-species assessments (Mackinson *et al*. 2009). However, for North Sea plaice and sole, no ecosystem model is currently available to test such hypotheses, mainly due to insufficient diet data needed to parameterize predator prey relations in the sole and plaice food webs. However, the extent to which this applies to the the co-management of these two North Sea flatfish species is unclear. There is no strong predator-prey relationship between these to species and common resource limitation, at least In the short term, seems unlikely with both stocks still below the stock biomass level required to produce maximum sustainable yield. The distributions of the two stocks do not overlap completely, with more adult plaice found further north and sole found predominantly further south in the coastal regions. Discard mortality in plaice does not appear to be related to the fishing mortality exerted on sole (results not shown here), so mixed fishery issues should not prevent the simultaneous achievement of both MSY objectives.

This ill-defined connectivity between the F levels of these two stocks makes it difficult to define an 'optimal' ratio of plaice F_{MSY} to sole F_{MSY}. The proportionality between the fishing mortality targets for North Sea plaice and sole, expressed as F_{plaice}/F_{sole}, is 1.5, although in the long term values would be expected to fluctuate around this. Historically, the proportionality between the two F values (Figure 3.1) has generally been lower than this (1.18 on average). However, there have been periods where it was at 1.5 or above. Given the current estimated fishing mortality rates of the two stocks of 0.75 it is likely that the fishing patterns of the fleets will have to change if the factor of 1.5 is to be achieved. In recent years the ratio of plaice to sole landings catchability (q, calculated as landings F divided by the fleet effort corrected for the selectivity of the fleet) has decreased from 0.60 in 2004 to 0.49 in 2006 and further to 0.37 in 2008, the last year of effort data available for this analysis. This reflects the focusing of fishing effort in the southern North Sea, nearer to the landings ports, in the face of high fuel costs over this period. Reconciling the target F s in the long term will require a reversal in the current trend of catchabilities. In other words, catchability of the plaice stock will need to increase in relation to that of the sole stock, and this is most likely to be achieved with a northward shift in the centre of gravity of the effort by the fleets fishing these two stocks. It is expected that if plaice TACs continue to increase at a greater rate than those for sole this is likely to occur. However, it may be that target ranges of F for each species, rather than point values, are necessary to allow simultaneous achievement of objectives for both stocks.

An overview of the different F and SSB reference points important for management of the two stocks is given in Table 3.1

Table 3.1. F and SSB reference points important for management of the two stocks

	F_{target}	F_{pa}	F_{lim}	B_{pa}	B_{lim}
Sole	0.2	0.40	NA	35 000 t	25 000 t
Plaice	0.3	0.60	0.74	230 000 t	160 000 t

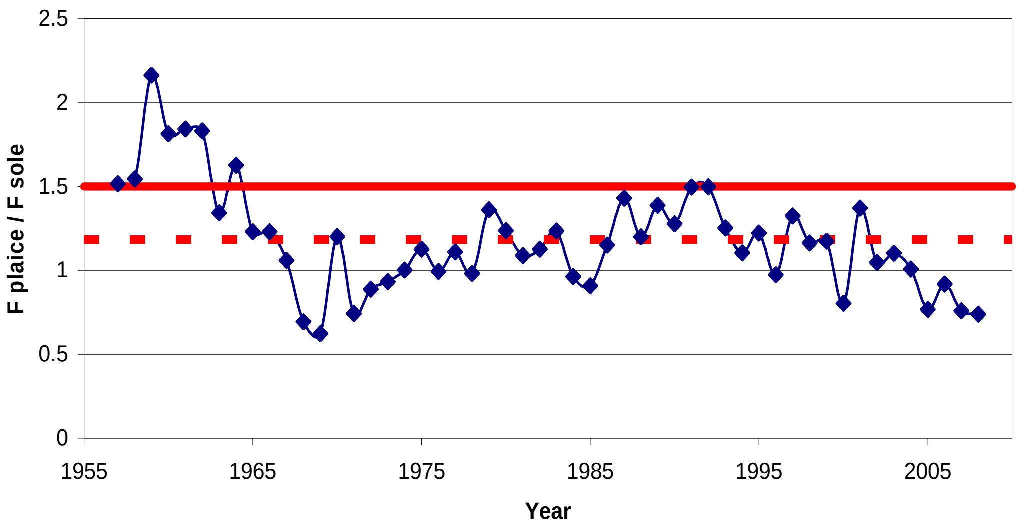


Figure 3.1. Time series of proportionality of sole and plaice fishing mortality, expressed as F_{plaice}/F_{sole}. The solid horizontal red line indicates the same proportionality in the target *F* values in the multi-annual plan (1.50), and the dashed horizontal red line indicates the mean value over the whole period (1.18).

3.3 Evaluation of the progress of the management plan to date

The management plan was evaluated, describing the implementation of the management plan, and the stock and fleet dynamics in relation to the measures and objectives of the plan.

The stock dynamics were evaluated using two different stock assessment models: an XSA model and a statistical catch at age (SCA) model. The XSA models are currently used by ICES to assess the two stocks. Details of model configurations can be found in ICES (2009). These XSA models were also used as the basis of the previous *ex ante* management plan evaluation (Machiels *et al*. 2008). The new statistical catch at age (SCA) model (Appendix B) was originally derived for North Sea plaice by Aarts and Poos (2009) with an alternative treatment of discard estimations. This model was adapted for North Sea sole by removing the discard estimation component.

Changes in fleet dynamics were evaluated in terms of overall fishing effort and number of vessels in the Dutch beam trawl and otter trawl fleets.

3.4 Evaluation of the effects of the management plan to date

Three different approaches were used to test the effects of the management plan. The first approach is the simplest, where we do yield curve analyses for the two stocks under different stock and recruit relationship assumptions. Such analysis gives the equilibrium results of the fishing mortality targets in the plan. The second approach is a simple projection of the two stocks under the rules of the plan, taking into account only recruitment variability and different assumptions of future mean recruitment. Finally, the third approach is a full feedback MSE approach , including the different uncertainties in the assessment and recruitment. In addition to the biology, the fisheries system is modelled with simple fleet dynamic rules for three different fleets targeting the two species.

All analyses were carried out using the FLR package (Kell *et al*. 2007), a collection of data types and methods written in the R language (R Development Core Team 2008) as part of the EU EFIMAS-COMMIT-FISBOAT project cluster. All code, data and additional sources for checking, validating and evaluation are freely available upon request.

3.4.1 Precautionary criteria

In order to show that the management plan is precautionary for the two species under consideration according to ICES, we use the Criteria agreed during WKOMSE to be applied in the evaluation of Harvest Control Rules/Management Plans in relation to precautionary reference points (Table 3.2). Results were examined to 2015 and beyond and the risk will be evaluated over the ten year period 2011-2020.

Table 3.2. Precautionary criteria agreed during WKOMSE for evaluating multiannual plans (ICES 2009a)

Element	Criterion	Notes
Time frame	2015: The performance of the HCR (MP) will be evaluated using as time horizon the year 2015 (in agreement with the Johannesburg Declaration)	The simulations will use as starting year the population parameter estimates from the most recent assessment (e.g. from WG or benchmark).
Biological Reference Points	Limit reference points: Evaluate the HCR (MP) based on Blim and Flim	If new limit reference points have been accepted (ACOM) these should be used in the evaluation; In the absence of defined limit reference points such as Blim, use proxies (e.g. xlim derived from %SPR, or 0.5Bmsy, or 20%Bo, ….)
Risk	5%: The HCR (MP) is considered to be precautionary if the probability of SSB<Blim (or x<xlim) is less than 5%	Criteria for management plan of stocks within safe biological limits to be precautionary: no more than 5% of 10 year simulation runs having one or more years outside of safe biological limits. Criteria for recovery plan qualifying as precautionary: at least 95% of simulation runs recovering by 2015 (the year WSSD committed for rebuilding fish stocks). The 5% will be used unless managers specify another percentage.

3.4.2 F_{MSY} criteria

The MSY objective is explicit in both the Johannesburg Declaration and in the second stage of the EU management plan. As noted in Section 3.2, the target F_{MSY} values for the two stocks are still a matter of debate. As a result definitive targets to be reached, both in terms of exploitation rate and long term maximum sustainable yield, are lacking. However, the *F* targets set in this plan were chosen according to analyses that at the time suggested these values corresponded to likely F_{MSY} values. The likelihood of achieving the target *F*s by 2015 could be used as a measure of success with regards to MSY objectives. However, given that *F* would naturally fluctuate around these target levels it is better to examine qualitatively if the median value achieves this target before 2015.

3.5 Individual weights

The different ex-ante analyses (Yield curve analyses, stock projections, and the full MSE require the weights of individuals of the two stocks. These weights are estimated from the stock weights-at-age available from the ICES WGNSSK 2010 report. Future weights-at-age are assumed either the average weight-at-age of the last five years, or a random draw from the weight-at-age of the last five years.

3.6 Yield curve analyses

Yield curve analysis based on age structured stock assessment data is a common technique for estimation of the effect of fishing mortality targets. It assumes that the population goes to an equilibrium situation for any chosen F value, with a spawning stock biomass estimate in the equilibrium and a corresponding yield. Here we consider the yield to be the landings. Yield curve analysis for age structured assessment data basically uses two different sources of information: the yield per recruit curve (depending on growth, selectivity and natural mortality), and the stock and recruit curve.

All yield curve analyses were done using FLBRP package 1.0.0, in R version 2.10.1. The analysis of the yield per recruit reference points used selectivity, natural mortality and weight data taken to be the average of the observations and assumptions of the period between 2004 and 2008. This recent period was chosen as a representation of the current state of the stock and the fishery with respect to general life-history characteristics and fishing patterns. The results obtained here have also been presented in the ICES WKFRAME 2010 group (ICES 2010a).

3.7 Stock projections

The second approach is a simple projection of the two stocks under the rules of the plan, taking into account only variability of future recruitment under different assumptions of future mean recruitment. We show SSB, R, F, and landings, setting the F values according to the rules of the plan. This is done in a forward projection from the ICES WGNSSK 2010 assessment (ICES 2010b).

The forward projection uses a random resampling schedule from historic observed recruitments in the period 1957-2006 . In total, 500 iterations are done in the resampling schedule. The median of the resampled recruitments is within the range of the recruitment in the last 5 to 10 years (Figures 4.2.2a and 4.2.4a). In the forward projection, the standard short term forecast assumptions for these stocks have been made (ICES 2010b), and discards were taken into account. The stock was projected forward for 12 years. All computations were done using the FLSTF 1.99-1 package in R 2.8.1. From the iterations the quantiles are used to derive 95% confidence limits.

3.8 Full management strategy evaluation

3.8.1 Model formulation

The evaluation of the multiannual plan is carried out using a numerical simulation model for the interplay between the biological dynamics of the stocks and the dynamics of the fleet. 'Real' populations and 'real' fleets are simulated from the best information available using simple population and fleet dynamics principles. In the model, the future management of the stocks strictly follows the rules in multiannual management plan, based on observations of the 'real' populations and fleets. The observation uncertainty is modelled by assuming random noise for the landings, discards and surveys, based on historical estimates of uncertainty. Several scenarios are tested as a sensitivity analysis of the implementation uncertainty. Each scenario was simulated 100 times out to 2021 (i.e. fishing mortality estimates out to 2020). FLCore version 3.0 was used in R version 2.8.1.

Biological operating model

The biological operating model consists of age structured population models of the 'real' plaice and sole stocks in the North Sea. The models are conditioned to reflect our current understanding of the states and dynamics of the two stocks. The results presented here are based on two WGNSSK 2009 assessments: the XSA model (Darby and Flatman 1994) and SCA model (Aarts and Poos 2009) for sole and plaice stocks in the North Sea, utilising data up to and including 2008 values.

The simulation was initiated in 2003. The stock numbers at age in the initial year were taken from the assessment results (ICES WGNSSK, 2009b). Landings, discards and survivors of the two stocks were calculated for the years up to 2009 given the model estimated (natural & fishing) mortality rates for the period 2003 to 2009. Recruits up to 2009 were also taken from the assessments results. This was done to assess the impact of future catchability assumptions (results not shown here). Catchability, relating F to effort, varies from year to year, but an average value is used in the future projections. By running the simulation from 2003 to 2009 using alternatively the observed values and the mean value, the impact on stock status can be examined. This was found to be minimal, making the use of the mean catchability value acceptable. From 2010 onwards fishing mortality is determined by the multiannual plan and the simulation continues with recruits estimated from the stock-recruitment relationship, given the stock sizes, with random noise added that corresponds to the observed residual variation over the last 25 years.

The historic numbers at age (starting point) and the future stock-recruit relationship are considered to be the primary sources of biological error in the evaluation. There is no variation in future weights at age (mean of the last five years), maturity ogives (knife edge values as used in the assessments of the stocks) or natural mortality (a value of 0.1 for all ages and years for both stocks).

Stock-recruitment functions

The spawning stock biomass (SBB), the biomass of the sexually mature part of the population, determines the number of recruits of the next year. Stock recruit relationships were examined over the period 1985-2009, the historic period with SSB and recruitment estimates available for both the XSA and SCA models (the SCA model estimates values over a shorter time period due to its reliance on survey indices). Given that neither of the stocks show any clear stock recruit relationship, geometric mean recruitment with error based on that observed in the historic period is used as the 'base case' scenario. The reviewers of the previous evaluation raised doubts over the suitability of the stock recruit relationships considered. So to bound the geometric mean scenario with higher and lower recruitment potential scenarios two alternative functions were considered: Beverton and Holt fits and a 'minimum recruitment' scenario. For the sole stock the Beverton and Holt fit is very flat, hence the behaviour is very similar to the geometric mean function. The minimum recruitment scenario sets recruitment for all future years to the lowest observed recruitment over the historic period. The probability of this happening, given the statistical distribution of historic recruitment is extremely low.

Starting points

The considered scenarios in the previous *ex ante* evaluation of the multiannual plan put a high degree of confidence in the most recent assessment and failed to consider the possibility of either a healthier or more threatened stock. None of the evaluation scenarios considered accounted for the magnitude of the observed retrospective pattern in plaice. Accounting for the uncertainty about the current stock states this *ex ante* evaluation considers alternative initial stock status scenarios. The SCA model (Aarts and Poos 2009) provides uncertainty estimates of the current stock status and this is incorporated in the alternative scenarios. Incorporating the uncertainty in the current stock status within the process error considered for the stochastic simulations will translate into a lower degree of certainty when evaluating likely success of the management regulations.

We use four distinct starting conditions (Table 3.3) rather than incorporating uncertainty in starting point into all simulations. The first set of starting values are the results of the XSA assessment done by ICES WGNSSK in 2009. The second set of starting values are pessimistic, alternative and optimistic views of the current situation from the SCA assessment. Namely, the set of starting values associated with the lower 5%, the 50% and the 95% SSB 2008 estimate, respectively. It should be noted that the XSA estimate of SSB in 2008 lies well within the range of SCA estimates for the plaice stock, in the case of the sole stock the XSA estimate is towards the lower bounds of the SCA distribution, similar to the 5^{th} percentile. Hence the alternative scenarios are more optimistic in the case of the sole stock. Unique starting points were chosen rather than using the full range of SCA values (i.e. one scenario with 100 different starting points corresponding to the SCA estimates). Starting with diffuse starting points limits the confidence in you upper and lower bounds of projections by placing higher importance on a few of the runs at the lower and upper limits. By running 100 runs from the 95^{th} percentile and 5^{th} percentile, the estimates of the likely upper and lower bounds in future projections are improved by incorporating fully the likely future variation from these initial points.

Table 3.3. Starting point values for the given scenarios

Starting Point	F 2008	SSB 2009*	Rec 2007	Rec 2008
Plaice				
XSA	0.25	384 782	1 031 601	890 569
SCA 5th	0.25	314 401	799 859	561 132
SCA 50th	0.20	433 036	1 084 344	966 862
SCA 95th	0.20	426 264	1 064 058	1 034 173
Sole				
XSA	0.39	35 111	59 766	93 793
SCA 5th	0.31	37 436	48 716	53 129
SCA 50th	0.26	46 318	58 656	78 031
SCA 95th	0.30	51 471	70 404	107 138

*** Note: percentiles of the SCA were chosen based on SSB in 2008. Projecting one year further amde 95th%ile is worse than the median %ile in the case of plaice (which has narrow confidence bands on SSB)**

Starting points need to be based on the data available for the stock. Potential starting points are limited by the range of possibilities that we can produce from models that have been fit to the data available. It is not possible to know how certain the XSA values are, and hence a range of SCA values was used. It is felt that this range is adequate for exploring the effects of management in the short term.

Fleet dynamics and the fishery

The effects of the fishery on the two stocks is modeled as the combined effect of three different fishing fleets: a Dutch beam trawl fleet (80mm mesh, targeting plaice and sole), a BT1 fleet for the other countries (100mm mesh, targeting plaice only), and a BT2 fleet (80mm mesh, targeting plaice and sole) for the other countries. This allows for a distinction between OTB (fishing almost exclusively plaice) and TBB (fishing both species) gears. The Dutch fleet is modeled separate from the other two fleets because it has a very high proportion of the North Sea sole and plaice landings (WGNSSK 2009), as well as being a data-rich component of the fishery. Further division of the fleet was not possible due to data availability that would limit the parameterising of the sub-fleets.

The fleet operating model affects the number at age in the two fish stocks via the fishing mortality rate (F) per year. Conversion from numbers to weights is done using the individual weights at age. These weights are different for the individuals in the population, and between landings and discards, because of differences in the size selectivity of the gear and the discarding process. Fishing mortality rate for each age group is calculated as the product of fishing effort (f), catchability (q) and selectivity. This simplistically implies a linear relationship between F and fleet effort for each species. The historic selectivity-at-age (Figure 3.2) and catchability were estimated from the Fishbase dataset that holds all landings at age for the different international fleets, the international discards data, and the demersal assessment working group stock assessment results. The latter include estimates of fishing mortality by year and age. The total fishing mortalities can be used to create partial fishing mortalities by age and year for the different fleet segments using the discards-at-age and landings-at-age data.

In plaice, a substantial proportion of the catches are discarded, especially for the younger ages that are caught but fall below the minimum landing size. This was dealt with in the simulations by calculating separate discards and landings selectivities and catchabilities for each fleet targeting plaice. This resulted in a simulated dataset with 'real' landings values for the two species and discard values for the plaice stock used in fitting the assessment model (XSA) during each year of the simulations.

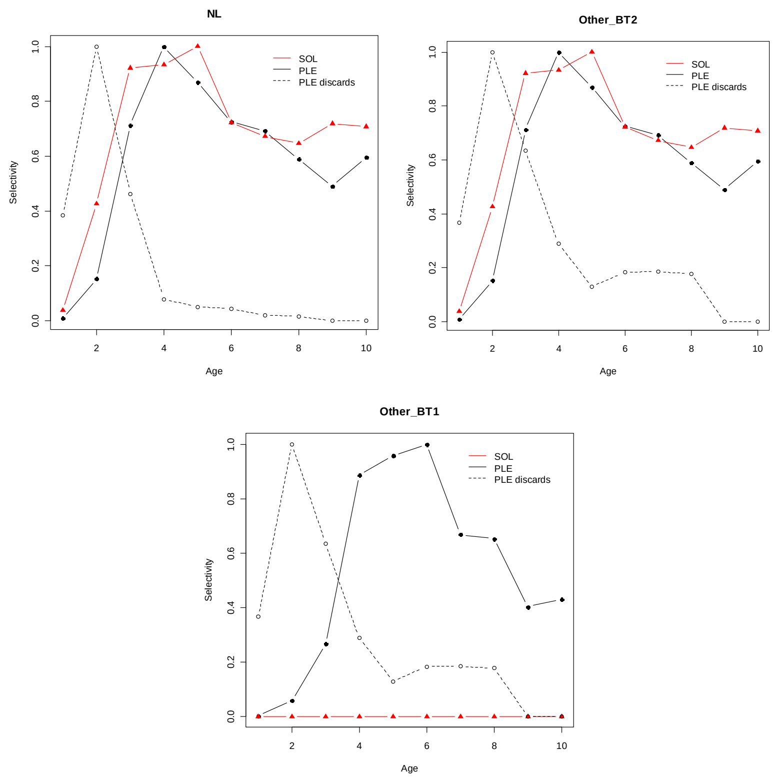


Figure 3.2. The selectivities by age (relative to the maximally selected age) of each species by the three fleets used in the MSE simulations.

Possible increase of efficiency of the fleets over time has been taken into account in the current model in the form of technological creep percentages (Rijnsdorp *et al.*, 2006). Estimates of partial fishing mortality rate for sole and plaice were found to increase annually by 2.8% (sole) and 1.6% (plaice) in the recent period. The positive trend was considered to be due to an increase in skipper skills and investment in auxiliary equipment, the replacement of old vessels by new ones and, to a lesser extent, to upgrade engines. These values were used to incrementally increase the catchability of sole and plaice over the simulated period. There are no trend changes in selectivity through time, future selectivity is based on the mean recent historic values (5 years).

Most of the scenarios assume that the fleets will fish up both TACs while avoiding catching overquota fish. In other words, no implementation error is assumed in this scenario. This form of evaluation tests the multiannual plan as if it will be implemented as specified. Given that this is an evaluation of the plan and that none of the articles contained within the plan include any strange or novel concepts that would require special enforcement measures, it seems reasonable to consider any deviations from the application of the plan in reality cannot be considered to be a result of the plan itself. However, it is worth considering the likely impacts of mixed fishery dynamics on the success of the multi-annual plan.

In order to examine the possible effect of the mixed fishery, three scenarios of fishing effort were examined in a further analysis. These scenarios cover a range of potential reactions to the TAC of one of the stocks being caught before the TAC for the other has been caught. In this case the fishery will either stop (*Least_Eff*: i.e. the mixed fishery is limited by the least effort required), continue while avoiding catching the other by some technical or spatial changes in fleet behaviour (*Both_Eff*: i.e. catches of stocks considered independent, both TACs caught) or continue to fish until the TAC of both stocks is caught, discarding the over quota catch caught for the other stock (*MostSOL_Eff*: i.e. effort only limited by the most demanding TAC). Because sole is the main (most profitable) contribution to the landings, it is more likely that if sole is limiting (i.e. low TAC that can be caught with less effort) fishing for plaice only does not occur, simply because this would not be profitable. In the unlikely situation that there is a big discrepancy between the TACs, and plaice fishing would still be profitable, then plaice can be caught cleanly by spatial changes or technical restrictions. There are areas where plaice is present but not sole (e.g. further north in the North Sea). Also, changing gear used can prevent large overquota of sole while still landing plaice (e.g. shift from 80mm to 100mm mesh size). Considering these mitigating factors, the final scenario considers that fishing will continue until all sole is caught, but extra effort to catch plaice beyond this will not impact on the sole stock.

3.8.2 Assessment and forecast

In order to set a management measure for year *y*, assessment data will be available up to year *y*-2 and the assessment itself is carried out in year *y*-1. The stock assessment process results in fishing mortalities estimates until year *y*-2 and survivor estimates and SSB estimates (at the first of January) until year *y*-1. A deterministic short-term forecast procedure then calculates the TAC for year *y*, based on assumptions about F and recruitment in the year *y*-1 and *y*. The assessment output and short-term forecast data might deviate from the real population characteristics as modeled in the biological operating model part because of the introduction of process error, model error, estimation error and observation errors.

The information or perception on the stocks status is generated through the explicit inclusion of a stock assessment in the simulation. Catches, discards and landings of the fleets are "recorded" in the model. Mimicking the assessment procedures, three surveys sample the plaice stock, and two surveys sample the sole stock by fishing with a constant and low fishing effort. Catches per unit of effort are assumed to be linearly related to stock abundance, thus result in two survey indices on the state of the stocks. The implementation of the XSA stock assessment in simulations for use in the multiannual plan HCR means that the MSE explicitly takes into account the impact of error generated by the stock assessment process.

To simulate observation error, the assessment input data were generated from the "real" population with error coefficients. Variance estimates for observations by age (Table 3.4) were used to generate log-normal error. The error coefficients for the simulated survey catches are generated from the catchability residuals at age for each survey as estimated by the WGNSSK stock assessment. The error coefficients on the landings and discards are generated from the standard errors estimated by the SCA assessments for sole and plaice. Biological parameters of the stocks in the assessment process are assumed to be equal to the biological parameters set in the operating model.

Table 3.4. Variances associated with the generation of observation errors for the catch (landings and discards) and survey indices for use in the annual assessments of the two stocks in the simulation model (observation error component of the simulation).

	Plaice					Sole				
	Catch		Surveys			Catch		Surveys		
Age	Lan	Dis	BTS-Isis	BTS-Tridens	SNS	Lan	Dis	BTS-ISIS	SNS	NL Beam Trawl
1	1.31	0.2	0.22	1.33	0.23	2.13	-	0.06	0.07	-
2	0.25	0.1	0.18	0.38	0.55	0.12	-	0.22	0.29	0.09
3	0.03	0.18	0.2	0.08	0.92	0.02	-	0.31	0.2	0.03
4	0.01	0.24	0.11	0.08	-	0.02	-	0.17	0.43	0.04
5	0.01	0.68	0.28	0.1	-	0.02	-	0.49	-	0.05
6	0.01	0.9	0.32	0.08	-	0.01	-	0.48	-	0.06
7	0.01	1.9	0.39	0.1	-	0.04	-	0.39	-	0.06
8	0.02	8.69	0.75	0.13	-	0.06	-	0.49	-	0.16
9	0.08	-	-	0.1	-	0.2	-	0.39	-	0.05
10	0.08	-	-	-	-	0.2	-	-	-	-
Min	0.01	0.1	0.11	0.08	0.23	0.01	-	0.06	0.07	0.03
Max	1.31	8.69	0.75	1.33	0.92	2.13	-	0.49	0.43	0.16
Mean	0.18	1.61	0.31	0.26	0.57	0.28	-	0.33	0.25	0.07

3.8.3 Simulation of the multiannual plan management measures

Both output and input management measures are included within the plan. The output measures, described in Chapter II (Articles 6-8), consist of setting TACs for each stock based on fishing mortality objectives (annual reductions in F and target Fs for each stock). The input measures, described in Chapter III (Article 9), are implemented as effort reductions in which the change in effort (days at sea) is proportional to the fishing effort required to land the TACs. In addition to these specified management measures there is also a Special Circumstances clause (Chapter V, Article 18) that allows for a greater reduction in TAC/effort should the SSB of either stock be found to be suffering from reduced reproductive capacity.

In the management part of the model, the perceived fishing mortality (F) from the XSA assessments and the target reference points specified in the multiannual plan are used as inputs to the harvest control rule (HCR). F_{sq} in year y has been calculated as the mean F of the previous three years (y-3 *to* y-1) rescaled to the selection pattern of the most recent year. This corresponds to the way that it has been calculated in practice in recent years. The HCR formulates the advice for setting the TACs according to the intended fishing mortality. The HCR also defines the allowable fishing effort for the fleets based on the F required to land the TAC or effort restrictions that need to be applied when the target F value as not yet been achieved.

Each year the total effort to be applied by the 'real' fishery is calculated as the *maximum* of the amounts needed to land the full TAC of each species (based on the 'real' population and the relationship between F and effort). The overquota landings of the species that required less effort to take the total catch are ignored i.e. landings beyond the TAC are not removed from the population. Total effort may be reduced if the HCR sets an upper limit on the total allowable effort (e.g. if F remains above F_{tar}, reduce allowable effort by 10%, or the percentage required to get F down to the target value, whichever is lowest), which would obviously reduce overquota and may lead to the TACs not been fully caught. The total effort is converted to *F* for each species.

For article 18 in the plan, the limit reference points were used to determine whether the stocks suffer from 'reduced reproductive capacity'. A 25% TAC reduction would result if they were.

3.8.4 Simulation scenarios

Seven simulation scenarios were run for the evaluation (Table 3.5). The simulations are run with 100 stochastic realizations, where the two sources of noise are: (1) process error in the biology part, via random noise around the stock-recruitment relationship and (2) observation error in the management part, by including a random sampling error around the observed fleet and survey catches. In reality there are probably more sources of random noise, like for instance mortality rates. In the simulation model a number of simplifications and assumptions were made (e.g. constant natural mortality).

Table 3.5 The ten scenarios run for the evaluation of the multiannual plan.

Number	Description	Starting point	Stock recruit relationship	Mixed fishery
1	BaseCase	XSA	Geometric mean	No
2	SCA	SCA	Geometric mean	No
3	SCA_5	SCA 5 percentile	Geometric mean	No
4	SCA_95	SCA 95 percentile	Geometric mean	No
5	BevHolt	XSA	Beverton and Holt	No
6	minRec	XSA	Minimum recruitment	No
7	worstCase	SCA 5 percentile	Minimum recruitment	No
8	Both_Eff	XSA	Geometric mean	No
9	Least_Eff	XSA	Geometric mean	Yes, no over quota catch
10	Most_Eff	XSA	Geometric mean	Yes, over quota catch

Scenarios 1 and 7 (base case and worst case scenarios) are used to assess whether or not the plan can be considered as precautionary. The base case scenario is according to WKOMSE specifications ("*The simulations will use as starting year the population parameter estimates from the most recent assessment*") and strictly speaking the multiannual plan only needs to satisfy criteria under this scenario. However, if the plan is found to be precautionary under the worst case scenario, this will allow greater confidence in the results. The remaining scenarios are presented as checks or sensitivity analyses of the multiannual plan to different starting points (scenarios 2-4), stock recruit relationships (scenarios 5 and 6) and mixed fishery issues (scenarios 8-10).

4 Results

4.1 Management plan implementation

The management plan was published on the 11th of June 2007, coming into action on the 1st of July 2007. However, the advice of the ICES Advisory Committee on Fishery Management on the sole and plaice stock in the North Sea did not take the management plan into account when setting the TAC for 2008, because the plan was not evaluated by ICES. TACs were thus advised on the basis of bringing the stocks back to within biologically safe limits within one year. However, the actual TACs for North Sea sole and plaice set by the European Commission were based on the plan. The actual calculations for the TACs were done by STECF. As a result of this, the TAC for 2008 was the first outcome of the implementation of the management plan.

In addition to the TACs for sole and plaice in 2008 being an outcome of the rules in the management plan, the sea days were also restricted following Council Regulation (EC) No 40/2008. For beam trawlers with mesh sizes ≥ 80 mm and < 90 mm, the maximum days a vessel was allowed to be present in area IV was reduced from 132 days in 2007 to 119 days in 2008. For beam trawlers with mesh sizes ≥ 100 mm and < 120 mm, the maximum days a vessel was allowed to be present in area IV was reduced from 143 days in 2007 to 129 days in 2008.

In 2008, the management plan was evaluated by ICES, and found that for plaice, it could not yet conclusively be regarded as consistent with the precautionary approach. ICES concluded, however, that for sole the management plan could provisionally be accepted as precautionary. Subsequent TAC advice for 2009 and 2010 on the two flatfish species in the North Sea was then based on the management plan.

One of the implementation details that was not described in Council Regulation (EC 676/2007) was the exact specification of the calculation of the fishing mortality rate estimated for the year preceding the implementation of the TACs in article 7 and article 8. This lack of specification is problematic because the fishing mortality rate *F* in that year (the current year) cannot be known in the assessment year. Assumptions on the derivation of this *F* then of course strongly affect the level of TAC and the rate at which the *F* declines, especially in the case when the stock assessment shows a recurring estimation bias.

4.2 Trends in spawning biomass and fishing mortality

The objective of the plan is to ensure, in the first stage, that stocks of plaice and sole in the North Sea are brought within safe biological limits. Here we compare the historic trends of SSB and *F* to these initial management objectives.

Plaice is deemed to be within safe biological limits in those years in which (a) the spawning biomass SSB of the stock exceeds 230 000 tonnes, and (b) the average fishing mortality rate *F* on ages two to six years experienced by the stock is less than 0.6 per year. Sole is deemed to be within safe biological limits in those years in which (a) the spawning biomass of the stock exceeds 35 000 tonnes, and (b) the average fishing mortality rate on ages two to six years experienced by the stock is less than 0.4 per year. Once both stocks are considered to be within these safe biological limits for two successive years, the first stage of the multiannual plan is considered completed.

The SSB estimates for North Sea plaice from the two stock assessment models, the ICES XSA model and the Aarts and Poos (2009) SCA, are presented in Figure 4.1. There are some differences between the estimates from these two models; the SCA estimating slightly lower absolute levels of abundance. However, the general agreement between these models is good, particularly in the trends that they indicate. The spawning biomass of North Sea plaice has fluctuated within the range of the precautionary biomass limits over the recent period. It should be noted that there has been some retrospective pattern in the plaice SSB, that has been revised upwards for a number of years since 2004 (Figure 4.1c). Also since 2004, an increase has been observed, gradual at first but more marked in the last two years. Both stock assessments indicate that this increase has left the stock above B_{PA} for two years (2008 and 2009) as required by the management regulation.

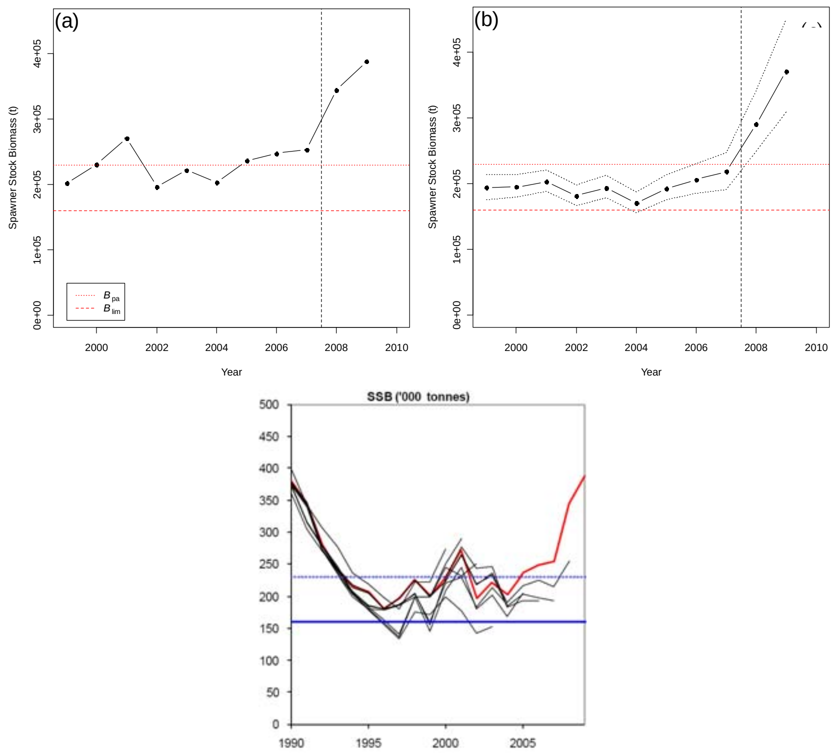


Figure 4.1. Recent North Sea plaice SSB estimates derived from (a) an XSA stock assessment with identical settings to the most recent ICES advice, (b) a statistical catch at age stock assessment following Aarts and Poos (2009), with 95% confidence intervals (dotted lines), and (c) the comparison of the 2009 assessment and previous assessments (source ICES 2009 advice sheet for plaice in the North Sea). In panels (a) and (b): B_{pa} (230 000 t; dotted red line) and B_{lim} (160 000 t; dashed red line) reference points are indicated.

The SSB estimates for North Sea sole from the two stock assessment models are presented in Figure 4.2. The two models give almost identical results, both in trends and absolute estimates of abundance. The spawning biomass of North Sea sole has fluctuated considerably during the last ten years, in one case with observations being lower than B_{lim} in one year, and higher than B_{pa} in the next. In 2008, the SSB increased above B_{pa}, and remained there in 2009. However, the statistical catch at age model indicates that it is less than 95% certain that SSB has been above B_{pa} for these two consecutive years (2008 and 2009). The retrospective pattern in the assessment means that the SSB has been revised downwards for a number of years (Figure 4.2c).

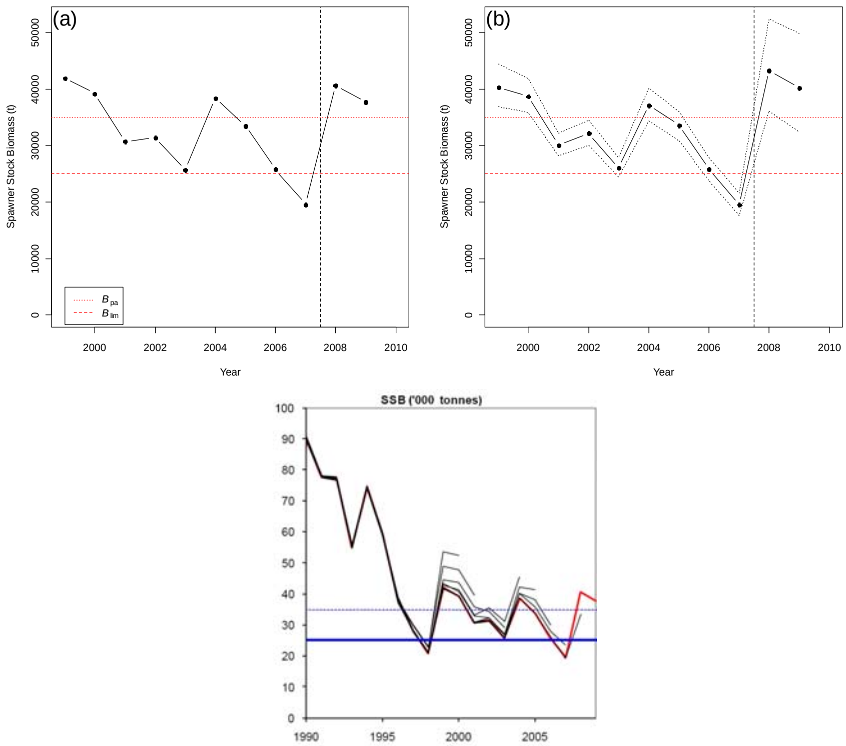


Figure 4.2. Recent North Sea sole SSB estimates derived from (a) an XSA stock assessment with identical settings to the most recent ICES advice, (b) a statistical catch at age stock assessment following Aarts and Poos (2009), with 95% confidence intervals (dotted lines), and (c) the comparison of the 2009 assessment and previous assessments (source ICES 2009 advice sheet for sole in the North Sea). B_{pa} (35 000 t; dotted red line) and B_{lim} (25 000 t; dashed red line) reference points are indicated.

The most recent assessments are only able to estimate *F* values up to 2008. The fishing mortality rate for North Sea plaice (Figure 4.3) has decreased considerably over the last 6 years. This decline thus started *before* the implementation of the management plan. The two different stock assessments disagree on the absolute levels of *F* in the most recent period, but do agree on the downward trend. The perceived decrease has been even more marked, due to a substantial retrospective bias in the XSA assessment, which has downgraded the estimates of *F* for each of the last three assessments. As a result, the realized *F* in 2008 is lower than the F_{mgt} used to derive the TAC following the management regulations (Figure 4.3, red points). However, according to the latest XSA assessment, the *F* value in 2008 is estimated to be approximately 19% lower than the *F* value in 2007, exceeding the management regulation requirement of a 10% decrease.

Importantly, both stock assessments indicate that the *F* estimate in 2008 is below the target level, F_{tar}, of 0.3 per year. This means that, given a proper implementation of the long term management plan, the *F* values should fluctuate around this level for the next couple of years.

The fishing mortality rate for North Sea sole has shown a downward trend in recent years, although this trend is not as strong as that of plaice. Again, this decline started before the implementation of the management plan. The two different stock assessments conform closely on the absolute levels of *F* in the most recent period, with the XSA estimated levels of *F* falling within the confidence levels of the SCA estimates. Unlike the plaice assessment there has been no substantial retrospective bias in estimation of *F* in the last three years for North Sea sole. As a result, the realized *F* in 2008 is as was recommended by the management plan. However, according to the XSA assessment, the *F* value in 2008 is estimated to be approximately 17 % lower than the *F* value in 2007.

The *F* values used to derive the TACs in 2008-2010 do not show a clear downward trend (Figure 4.4, red points). There are two reasons for this lack of trend. The increase from 2008 to 2009 is the result of the retrospective increase in the *F* estimates. The decrease from 2009 to 2010 is mainly a consequence of the method used to calculate F_{sq} to give the TAC advice. F_{sq} is calculated as the mean *F* of the previous three years and hence the high *F* value in 2005 was included in the calculation of F_{sq} for 2007 and 2008, but was not included in the calculation of F_{sq} in 2009. It should be noted that the actual trend in *F* in these years cannot yet be estimated.

Even though the *F* value for North Sea sole is estimated to be below F_{pa}, it remains well above the *F* target of 0.2 per year. Further reductions in fishing mortality are thus required to fulfil the objectives of the management plan.

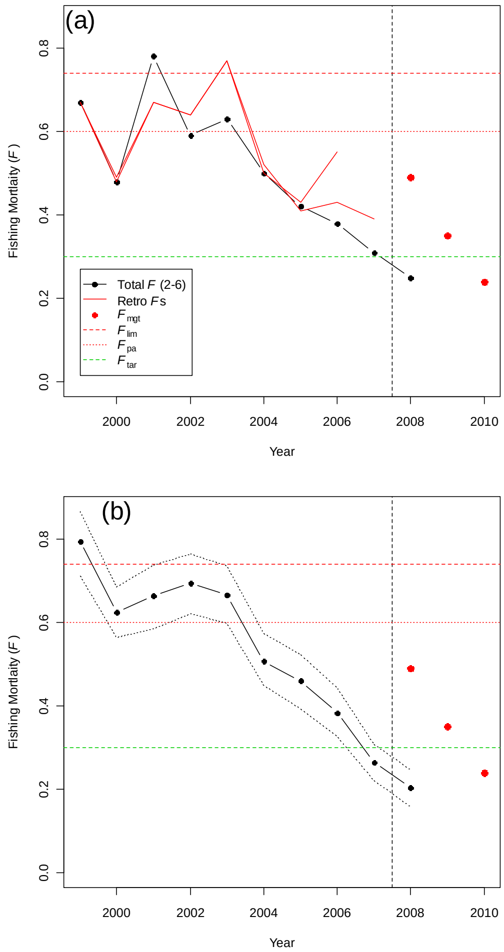


Figure 4.3. Recent North Sea plaice *F* estimates derived from (a) an XSA stock assessment, with identical settings to the most recent ICES advice, and (b) a statistical catch at age stock assessment following Aarts and Poos (2009), with 95% confidence intervals (dotted lines). The XSA retrospective error in the *F* estimate is indicated by red lines in panel (a). The F_{mgt} values on which the TAC advice was based are plotted in red (note: the value for 2010 is from the ICES advice and is at present a provisional value). F_{pa} (0.6; dotted red line), F_{lim} (0.74; dashed red line) reference points and the management regulation target F_{tar} (0.3; dashed green line) are indicated.

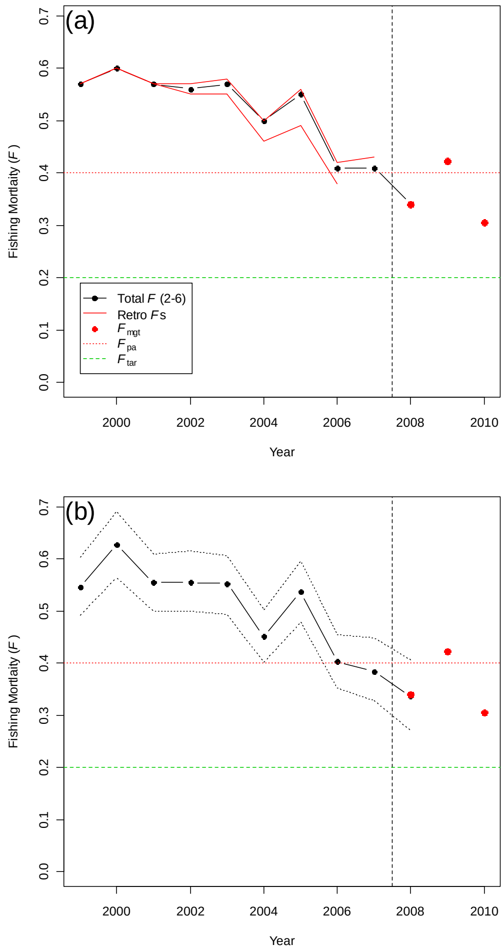


Figure 4.4. Recent North Sea sole *F* estimates derived from (a) an XSA stock assessment, with identical settings to the most recent ICES advice, and (b) a statistical catch at age stock assessment following Aarts and Poos (2009), with 95% confidence intervals (dotted lines). The XSA retrospective error in the *F* estimate is indicated by red lines in panel (a). The F_{mgt} values on which the TAC advice was based are drawn in red(note: the value for 2010 is from the ICES advice and is at present a provisional value). The F_{pa} (0.4; dotted red line) reference point and the management regulation target F_{tar} (0.3; dashed green line) are indicated. Note; F_{lim} Is not defined for the stock.

4.3 Trends in TACs, landings and discards

Prior to the implementation of the management plan, TACs for North Sea plaice had decreased for 8 consecutive years (Figure 4.5). The first management plan TAC also represented a small (< 5%) decrease but subsequently for 2009 and 2010 TACs have represented large increases from the previous year. In 2010 the TAC recommendation based on the *F* value alone would have meant a greater than 15% increase in TAC, contravening article 7, item 2 of the management regulation. Therefore the TAC was increased by the maximum allowed increase of 15%, corresponding to an *F* lower than 0.3 per year. The actual landings correspond closely to the TACs for North Sea plaice, and have decreased over the last 8 years. Likewise, the discards have decreased, but there is no trend in the proportionality of discards over landings. As the fishing mortality is expected to stay at the current levels, which are lower than those observed earlier, this discard proportionality is expected to decrease if the selectivity pattern of the fishery stays constant.

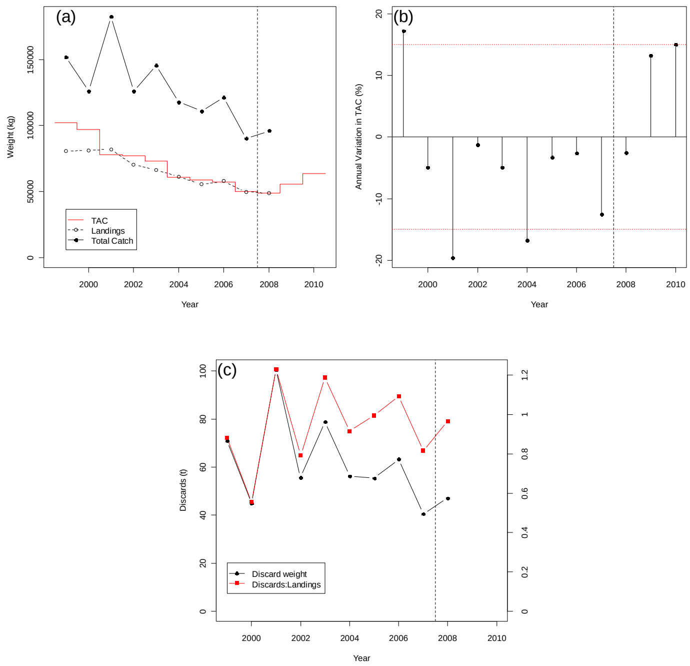


Figure 4.5. Recent trends in the fishery of North Sea plaice: (a) TACs and ICES estimates of landings (dashed lines), catch (solid lines); (b) annual percentage changes in TAC; and (c) ICES estimates of discards and the discard to landings ratio (red line).

The TACs for North Sea sole have fluctuated more over the recent period than those of North Sea plaice. The first management plan TAC represented a large decrease, just short of the 15% limit, but the TACs have increased thereafter for 2009 and 2010. The 15% TAC change regulation has not yet needed to be enforced for the North Sea sole. The actual landings do not correspond as closely to the TACs as is the case for North Sea plaice. The TAC was exceed from 1999 to 2004, but following this sections of the TAC remained uncaught for three years. In the first year of the management plan the TAC was exceeded by approximately 10%.

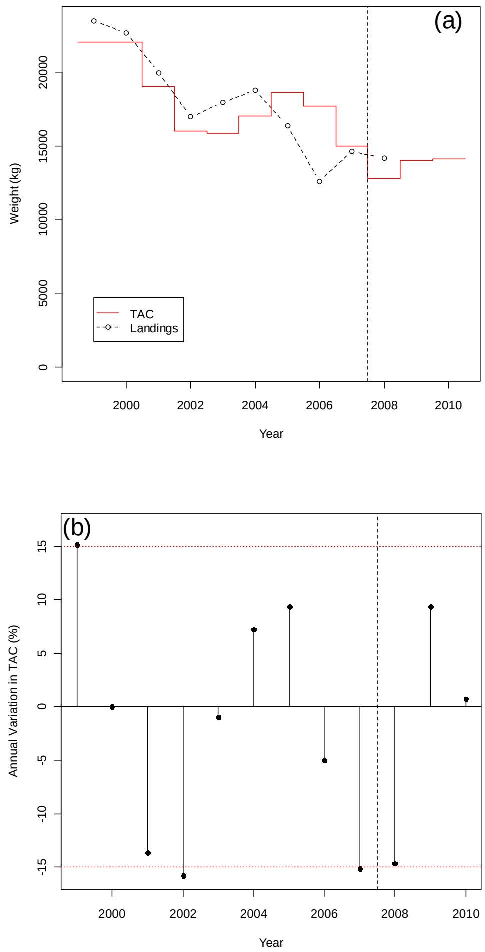


Figure 4.6. Recent trends in the fishery of North Sea sole: (a) TACs and ICES estimates of landings (dashed lines); and (b) annual percentage changes in TAC.

4.4 Trends in the fishing effort of the Dutch trawl fleet

The Dutch trawl fleets fishing in the North Sea have consistently been responsible for more than a third of the plaice landings and the majority of the sole landings from this area (ICES 2009). The Dutch fleet fishing for plaice and sole in the North Sea comprises two gear types: the main being the beam trawl (TBB) and the other being the Otter bottom trawl (OTB). The OTB fleet catches plaice, but at much lower catch rates than the TBB fleet. This lower catch rate, in combination with the much smaller OTB fleet size, makes the beam trawl fleet the main flatfish fishery in the Netherlands.

Both fleets can be divided into two main size classes based on the engine power (HP) of the vessels: ≤300HP (HP class 1) and >300HP (HP class 2). While the management regulation has no constraint controlling the number of vessels in the fleet, entry of new vessels into the fishery is controlled. Over the last six years the number of TBB vessels in the Dutch fleet has steadily decreased, mainly due to a reduction of HP class 2 vessels (Figure 4.7). There has also been a reduction in OTB vessels over this period, although for the last two years the number of these vessels has increased slightly. The number of HP class 1 OTB vessels has decreased notably and is remaining just short of 30 vessels, but the number of HP class 2 OTB vessels fluctuates more over the years and it is these vessels that are accounting for the overall increase over the last two years. Overall, the number of vessels in the Dutch fleet has decreased from approximately 290 in the years up to 2003, to just short of 190 in 2008, mainly due to the decrease in TBB vessels. This decrease in fleet size combined with the management regulations regarding days at sea per vessel has resulted in a decrease in the number of days at sea and number of horsepower days at sea. This decrease is sharpest in 2008 when a further 23 Dutch trawl vessels were decommissioned (ICES 2008).

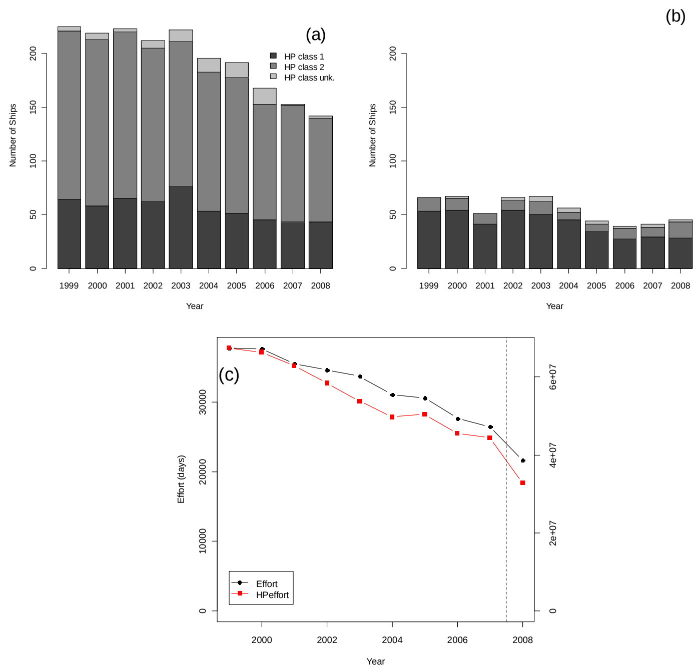


Figure 4.7. The number of vessels, with an effort of at least 10 sea days per year, in the Dutch fleets fishing for sole and plaice in the North Sea by HP class (HP class 1: ≤300HP, HP class 2: >300HP) for (a) the beam trawl (TBB) and (b) the Otter bottom trawl (OTB) gear type; and (c) total effort (black line, left axis) and HPeffort (red line, right axis) of the Dutch fleet (TBB and OTB combined).

The LPUE time series for plaice indicates that while the fishing effort went down, the LPUE went up during the last three years. This is in direct relation to the increase in plaice SSB. In 2008, the increase was especially large for the OTB gear type. The LPUE time series for sole indicates an increase in LPUE over the last 2 years, related to the strong recruiting 2005 year class, that increased the SSB in 2008. It should be noted that the demersal otter trawl gear has much lower LPUEs that the beam trawl gear, especially for sole.

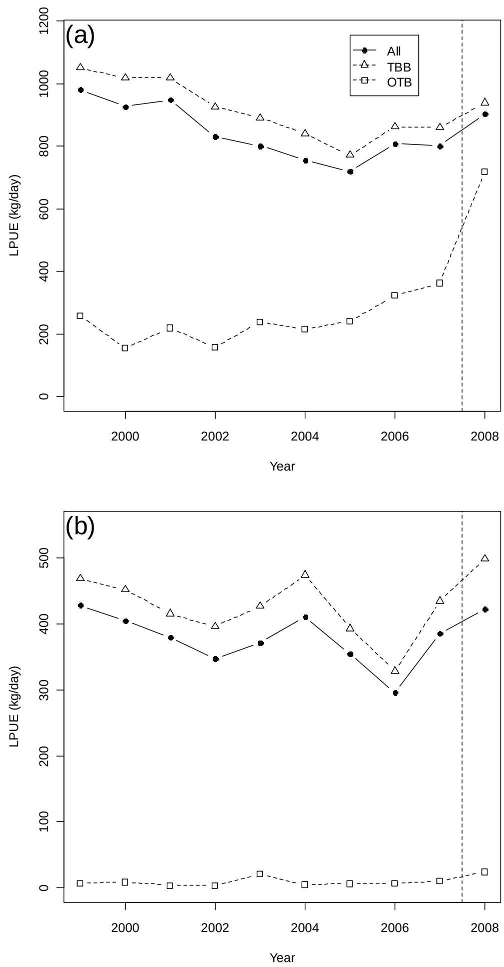


Figure 4.8. Landings per unit effort (LPUE) of the Dutch fleet fishing in the North Sea for (a) plaice and (b) sole, by gear and overall.

4.5 Comparison with previous evaluation scenarios

The previous *ex ante* evaluation of the multiannual plan (Machiels *et al*. 2008) was based on the 2007 ICES XSA assessment utilizing stock abundance estimates up to 2007 and fishery data up to 2006. Seven scenarios were modeled incorporating alternative fleet behaviours, interpretations of the application of the regulations and stock recruit models (see Machiels *et al*. 2008 for full details). However, none of these scenarios consider the possibility of a significant estimation error as to the current status of the stock. As a result, the projected scenarios of the North Sea plaice stock (Figure 4.x) all fail to match what is currently considered to be the current status and recent history of the stock. The retrospective decrease in *F* and increase in SSB has placed the stock out of the range of any of the projected scenarios. The projections of the North Sea sole stock (Figure 4.x) bear a closer resemblance to the current perception of stock status, indicating similar trends in *F* and SSB, due to the tighter retrospective pattern of this stock.

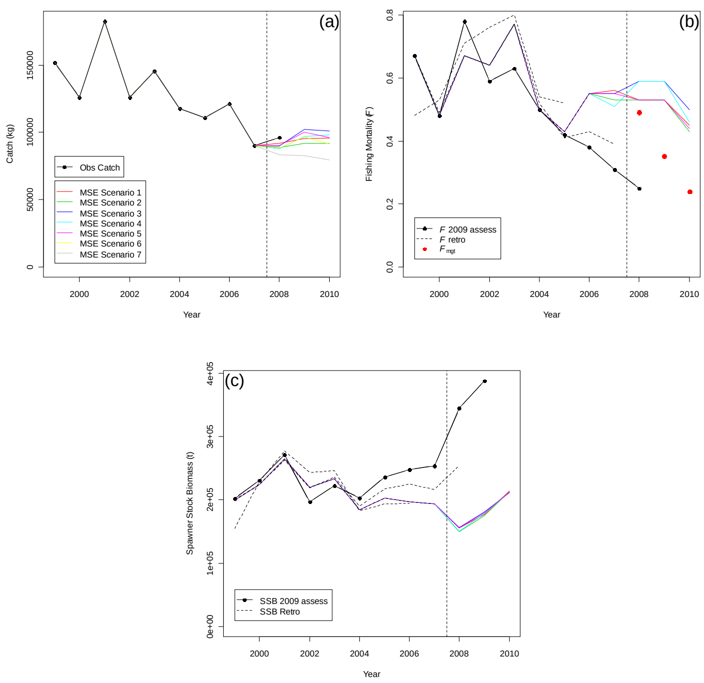


Figure 4.9. A comparison of the most recent ICES assessment for North Sea plaice and the seven evaluation scenarios (mean values) considered for this stock in the previous *ex ante* evaluation of the multiannual plan (Machiels *et al*. 2008) in terms of (a) catch, (b) fishing mortality and (c) spawner stock biomass.

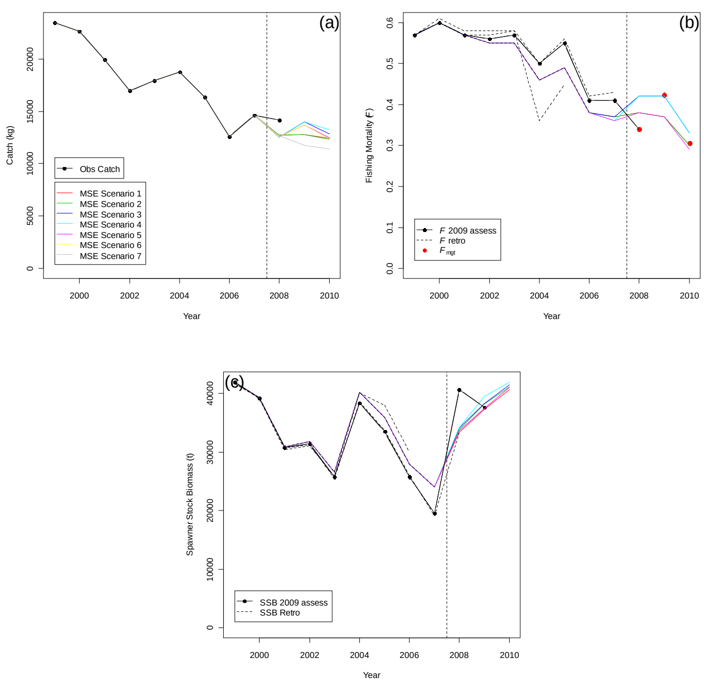
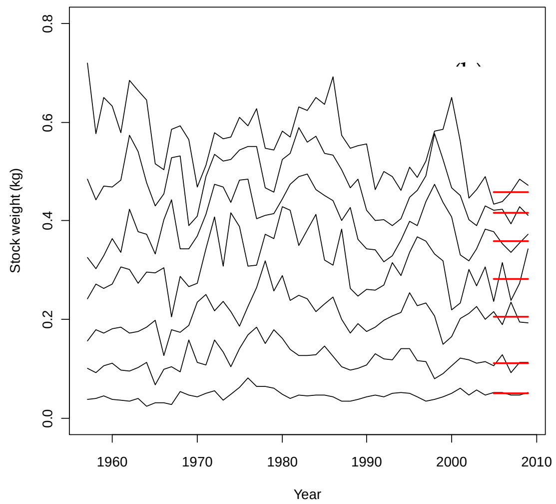


Figure 4.10. A comparison of the most recent ICES assessment for North Sea sole and the seven evaluation scenarios (mean values) considered for this stock in the previous *ex ante* evaluation of the multiannual plan (Machiels *et al*. 2008) in terms of (a) catch, (b) fishing mortality and (c) spawner stock biomass.

4.6 Weights-at-age

The weights-at-age for the two stocks have fluctuated over the years (Figure 4.11). For both stocks, growth has decreased since the 90s. For both species, the average weights in the last five years (used for the analyses in the subsequent sections) are in the lower tail of the statistical distribution of the weights in the entire time-series.



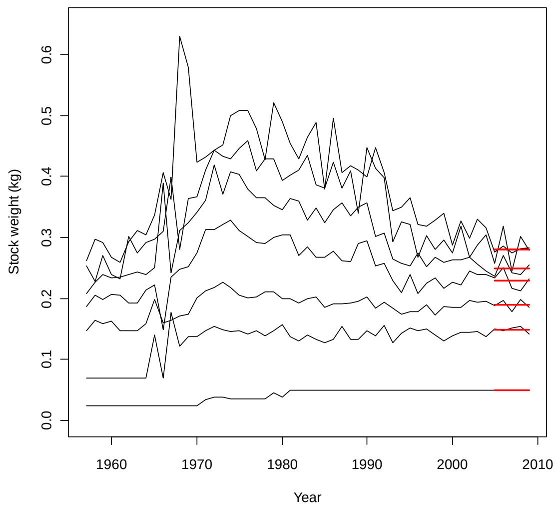


Figure 4.11. Stock Weights-at-age for plaice (a) and sole (b). Each line represents the weights for a given age over time. The lowest lines indicate age 1, while the highest line indicates age 7. The red horizontal lines indicate the 5-year average (over 2004-2009) used in the yield curves and forward projections.

4.7 Yield curve analyses

4.7.1 Plaice

The yield curve analysis for plaice was done for two different stock recruitment relationships: the segmented regression curve, and the Ricker curve. The results critically depend on the assumption that is made with respect to the functional form of these stock recruitment curves.

The historic recruitment series does not indicate a very strong effect of spawning stock biomass on recruitment in the observed ranges. When estimating a segmented regression S/R relation using FLCore 3.0, no breakpoint is found within the observed biomass range (Figure 4.12). As a result the

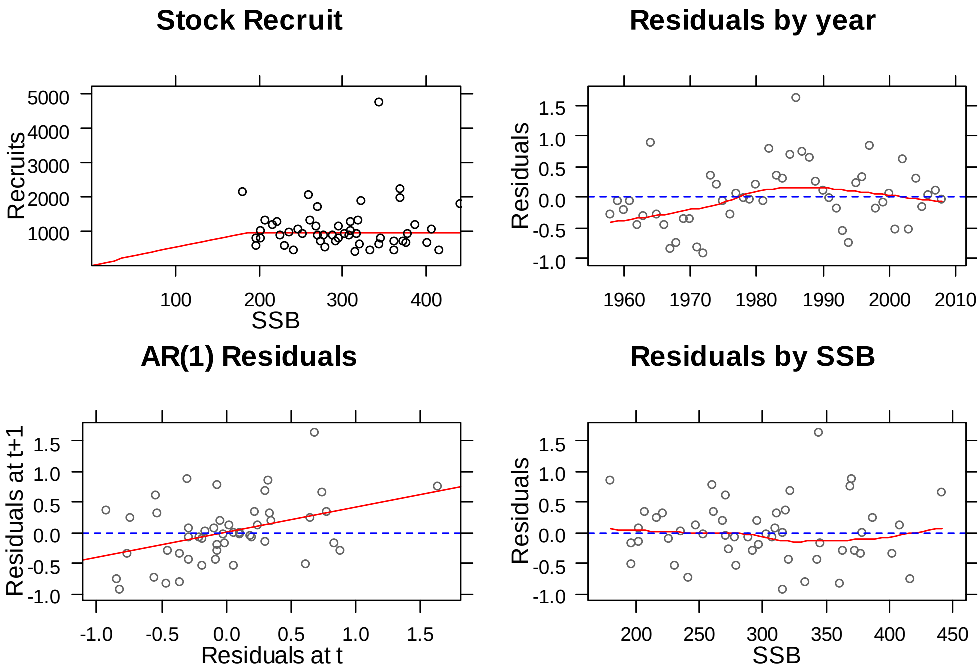


Figure 4.12. S/R analysis using a segmented regression model for plaice in area IV. Note that SSB is in 10^3 tons, and recruits are in 10^6.

breakpoint is put at the lowest SSB estimate in the time series. A Ricker S/R model shows a dome shape with a very flat top, the maximum being within the range of SSB estimates (Figure 4.13). A Beverton and Holt curve that was fitted to the data showed an extremely steep origin, and a flat curve at the asymptote through all observations. However there appears to be no information in the data from the assessment hat provides information on the actual slope in the origin. One feature that all fits share is that there are positive residuals in the 1980s. This indicates that there was strong recruitment in those years that is not explained by the stock-recruitment relationship.

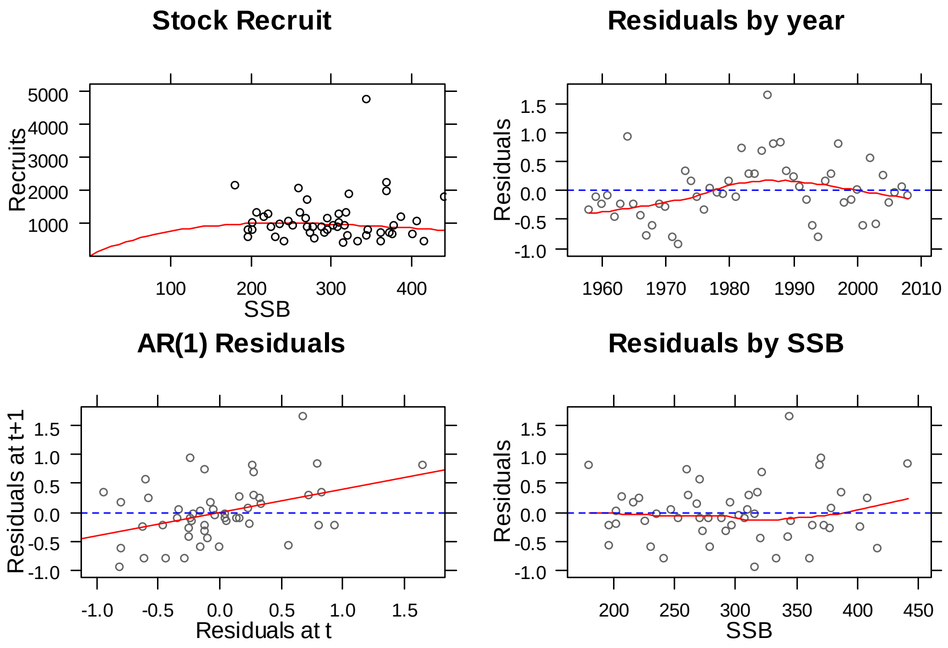


Figure 4.13 S/R analysis using a Ricker regression model for plaice in area IV. Note that SSB is in 10^3 tons, and recruits are in 10^6.

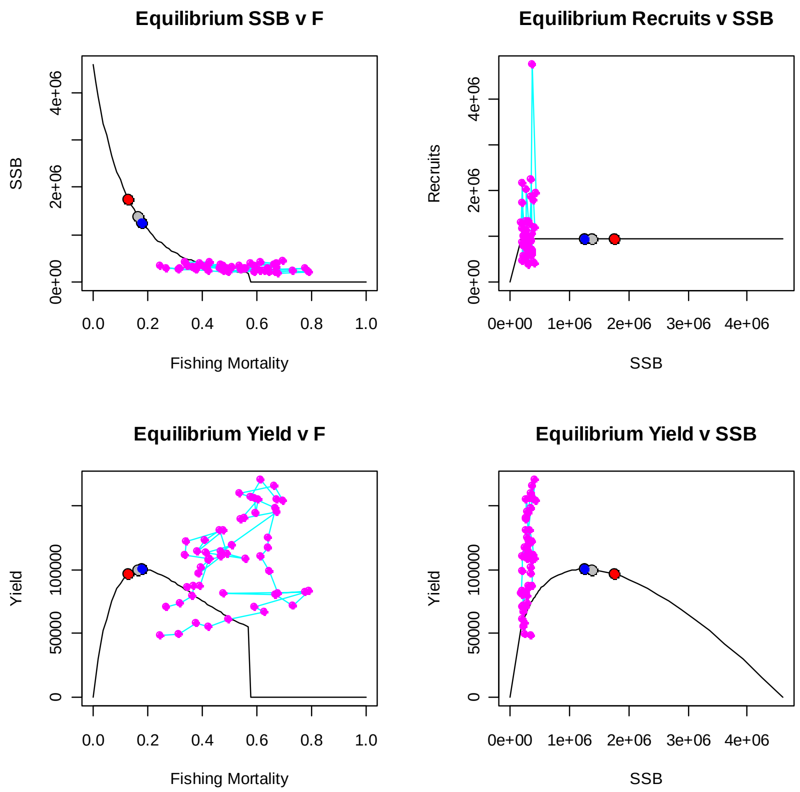


Figure 4.14. Results from equilibrium yield curve analysis for plaice in area IV, based on a segmented regression S/R curve. Blue dot indicates F_{msy}, grey dot indicates spr30, and red dot indicates $F_{0.1}$. Purple dots indicate the historic observations and estimates.

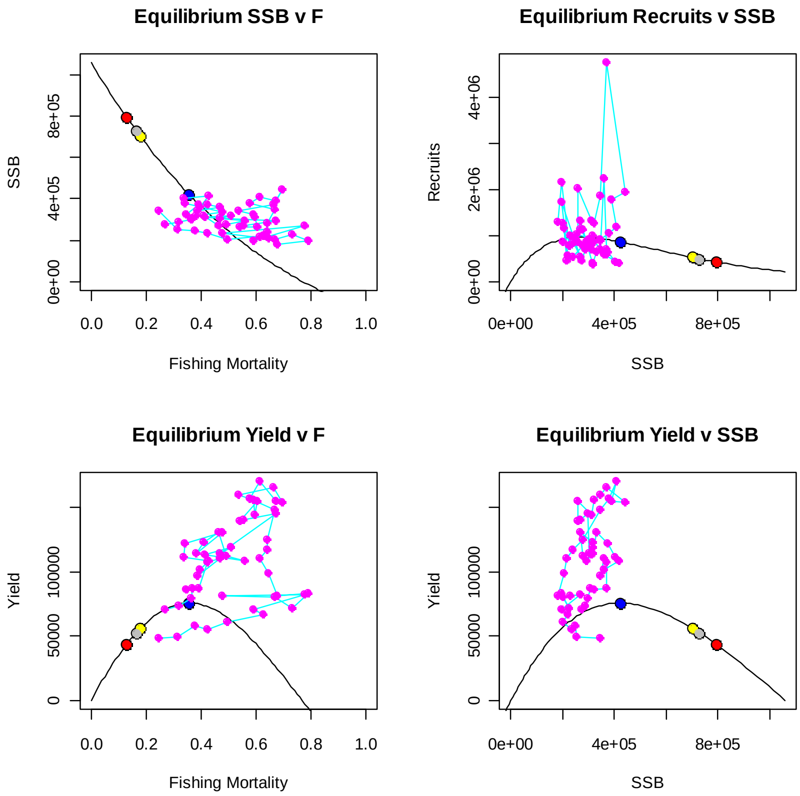


Figure 4.15. Results from equilibrium yield curve analysis for plaice in area IV, based on a Ricker S/R curve. Blue dot indicates F_{msy}, yellow dot indicates F_{max}, grey dot indicates spr30, and red dot indicates $F_{0.1}$. Purple dots indicate the historic observations and estimates.

When using the segmented regression to estimate a yield curve from the YPR and S/R data (Figure 4.14) the F_{msy} estimate is at the deterministic F_{max} (0.18 year^{-1}) estimate, simply because in the region of F_{max}, the S/R curve is completely flat. However, the historic estimates of F, SSB, and yield show little correspondence to the equilibrium curves. If a segmented regression S/R is used, the equilibrium SSB at F_{msy} is far outside of the range of SSBs observed during the last 60 years for this stock. The F_{msy} estimate is quite far from the F_{crash} estimate. It should be noted that this F_{crash} estimate depends entirely on the assumption for the breakpoint in the S/R relation, for which there is no information available in the assessment data. The discrepancy between the equilibrium curves resulting from the yield curve analysis and the historic observations and estimates is the result of changes in growth and recruitment, amongst others.

To show the sensitivity of the deterministic F_{msy} estimate from the YPR and S/R on the assumptions on the S/R curve, an estimate using a Ricker curve is presented in Figure 4.15. Here, F_{msy} is estimated at 0.36, and F_{crash} is estimated at approximately 0.8 year^{-1}.

In relation to the F target of 0.3 year^{-1} in the multiannual plan, it is clear that at the F target, the spawning stock biomass is expected to be within the range of 400 kt to 1000 kt, depending on the assumed stock and recruitment relation. This is well above the B_{lim} and B_{pa} reference point values calculated by ICES for these stocks. The corresponding landings are between 70 kt and 110 kt.

4.7.2 Sole

The historic recruitment series does not indicate a very strong effect of spawning stock biomass on recruitment in the observed ranges. When estimating a segmented regression S/R relation, no breakpoint is found within the observed biomass range (Figure 4.16). As a result the breakpoint is put at the lowest SSB estimate in the time series. A Ricker S/R model shows a dome shape, the maximum being within the range of SSB estimates (Figure 4.17). Because there are no SSB and recruitment estimates closer to the origin of the curve, there is no information in these data on the steepness of the curve in the origin. A Beverton and Holt curve was fitted to the data and showed an extremely steep origin, and a flat curve at the asymptote through all observations. However there appears to be no information in the data from the assessment that provides information on the actual slope in the origin.

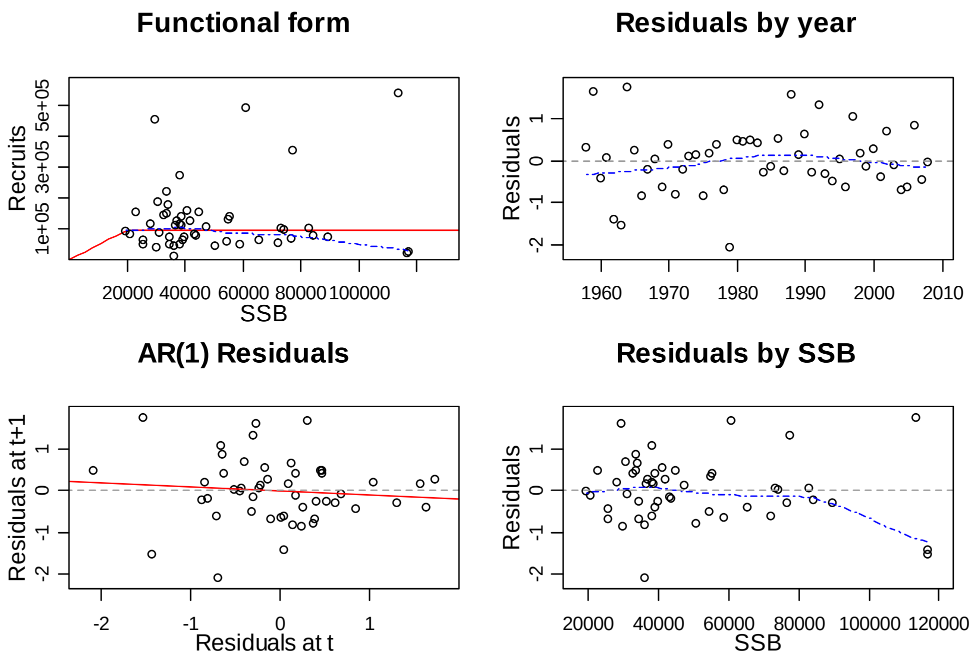


Figure 4.16. S/R analysis using a segmented regression model for sole in area IV.

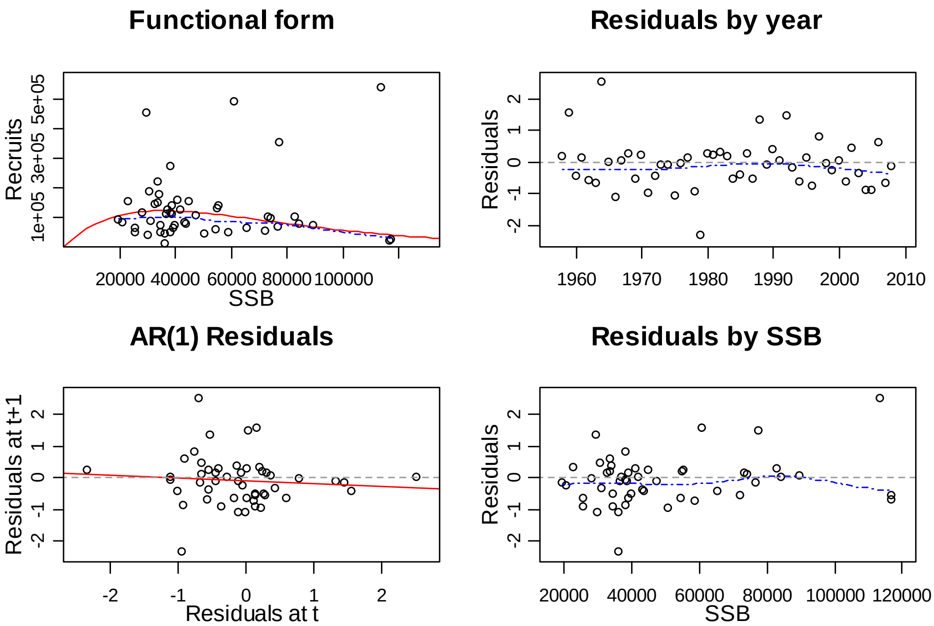


Figure 4.17. S/R analysis using a Ricker model for sole in area IV

One feature that all fits share is that there are positive residuals in the 1980s, but the effect is less pronounced as it is in plaice. This indicates that there was strong recruitment in those years that is not explained by the stock-recruitment relation.

When using the segmented regression to estimate a Yield curve from the YPR and S/R data (Figure 4.18), the F_{msy} estimate is close to the deterministic F_{max} (0.59 year^{-1}). However, the F_{msy} estimate is very close to the F_{crash} estimate. It should be noted that this F_{crash} estimate depends entirely on the assumption for the breakpoint in the S/R relation, for which there is no information available in the assessment data.

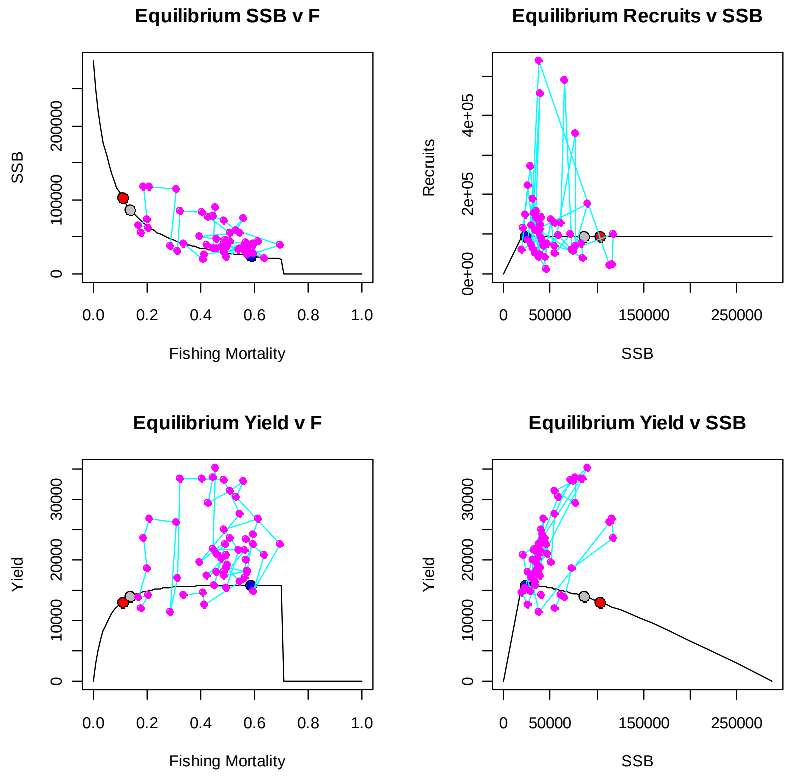


Figure 4.18. Results from equilibrium yield curve analysis sole in area IV, based , based on a segmented regression S/R curve. Blue dot indicates F_{msy}, grey dot indicates spr30, and red dot indicates $F_{0.1}$. Purple dots indicate the historic observations and estimates.

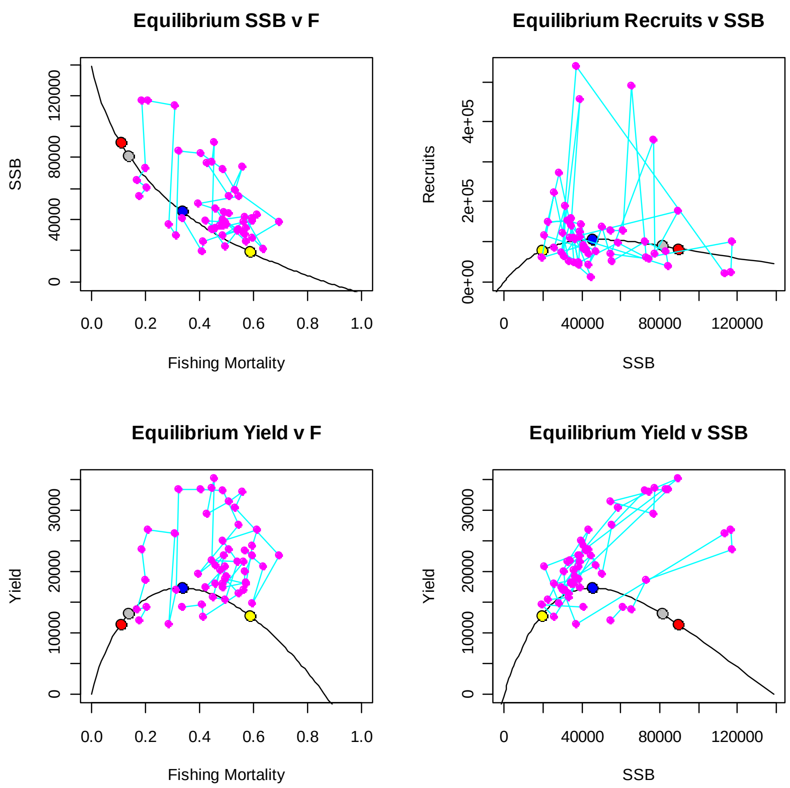


Figure 4.19 Results from equilibrium yield curve analysis sole in area IV, based on a Ricker S/R curve. Blue dot indicates F_{msy}, yellow dot indicates F_{max}, grey dot indicates spr30, and red dot indicates $F_{0.1}$. Purple dots indicate the historic observations and estimates.

The historic estimates of F, SSB, and yield show better correspondence to the equilibrium curves for the sole stock compared to the plaice stock. One of the reasons for this is probably that the equilibrium analysis here estimates the yield curve based on the average recruitment, while the historic estimates stem also from the period when recruitment was high in the 1980s. Also, growth has changed substantially over the entire time period.

To show the sensitivity of the deterministic F_{msy} estimate from the YPR and S/R on the assumptions on the S/R curve, an estimate using a Ricker curve is presented in Figure 4.19. Here, F_{msy} is estimated at 0.51, and F_{crash} is estimated to be higher than 1.0 year^{-1}.

In relation to the F target of 0.2 year^{-1} in the multiannual plan, it is clear that at the F target, the spawning stock biomass is expected to be approximately 60 kt. This is well above the B_{lim} and B_{pa} reference point values calculated by ICES for these stocks. The corresponding landings are approximately 15 kt.

4.8 Stock projections

4.8.1 Plaice

The results indicate that the SSB will likely increase (Figure 4.20a). The lower 95% confidence limit stays approximately at level at which SSB is now, being above 400 000 tonnes. This is substantially higher than B_{lim}. Thus, there is a <5% probability of SSB falling below B_{lim} before 2020. None of the 10 year simulation runs have years outside of safe biological limits.

The fishing mortalities that result from the plan are around the target F in the plan (0.3 year^{-1}; Figure 4.20b). The lower confidence interval is substantially lower, resulting from the 15% TAC change constraint and occasional large recruitments (Fig. 4.21a). These large recruitments are the result of drawing the exceptionally large 1986 year class in the sampling procedure. In that case, the TAC cannot increase fast enough to keep F at 0.3 year^{-1}.

(a)

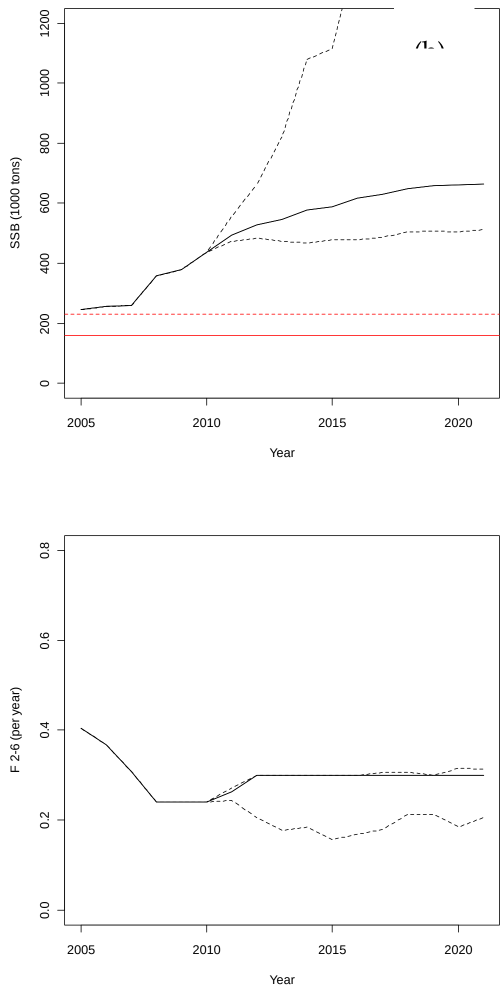


Figure 4.20. Time series of spawning stock biomass (a) and fishing mortality (b) for plaice in the North Sea. The time series comprise of the stock assessment results prior to 2010, and the projected 95% confidence intervals (- - -) and median (-----) after 2010. In the SSB panel, the red line drawn line indicates B_{lim}, and the red dashed line indicates B_{pa}.

The median landings in the projection of the plan increase to values in the range of 80-100 kt. (Figure 4.21b). However, the 95% confidence interval is very large. The increase in the upper confidence limit is defined entirely by the 15% TAC change constraint.

In the context of the plan being in line with the precautionary approach, the probability of the plan bringing the SSB < B_{lim} within the next 10 years is substantially smaller than 0.05, with none of the 500 simulations being below B_{lim}. The plan thus has a very small (<<5%) probability of bringing F above F_{pa} and F_{lim} in the period up to 2020 and SSB < B_{lim}.

(a)

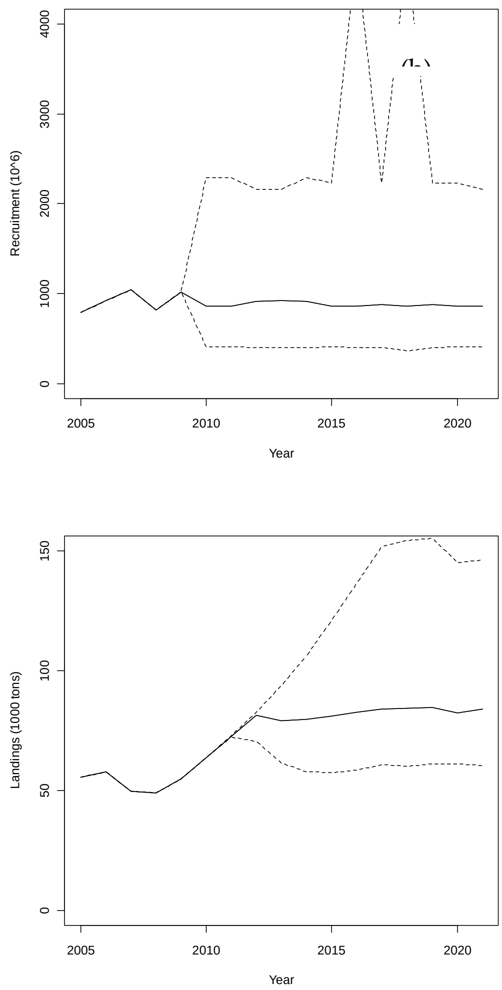


Figure 4.21. Time series of recruitment (a) and landings (b) for plaice in the North Sea. The time series comprise of the stock assessment results prior to 2010, and the projected 95% confidence intervals (- - -) and median (-----) after 2010.

4.8.2 Sole

The results indicate that the SSB will likely increase as a result of the rules in the plan (Figure 4.22a). The lower 95% confidence limit is approximately at B_{lim} for a number of years, mainly caused by those realizations where recruitment is low in the period 2010-2012. In those cases, the fishing mortality does not decrease by 10% per year because of the 15% TAC change limits. After the fishing mortality has successfully been decreased, the stock increases, and SSB becomes increasingly unaffected by recruitment strength. The lower confidence limit then increases to approximately B_{pa}, being 35 000 tonnes. Of the 500 realizations, only 22 bring the SSB below B_{lim}. Thus, there is a <5% probability of SSB falling below B_{lim} before 2020.

The fishing mortalities that result from the plan decrease to the target F in the plan (0.2 year^{-1}; Figure 4.22b). The lower confidence interval is substantially lower, resulting from the 15% TAC change constraint and occasional large recruitments. In that case, the TAC cannot increase fast enough to keep F at 0.2 year^{-1}. Finally, none of the realizations results in an F> F_{pa} after 2011. Thus, the plan has a very small (<<5%) probability of bringing F above F_{pa} in the period up to 2020.

(a)

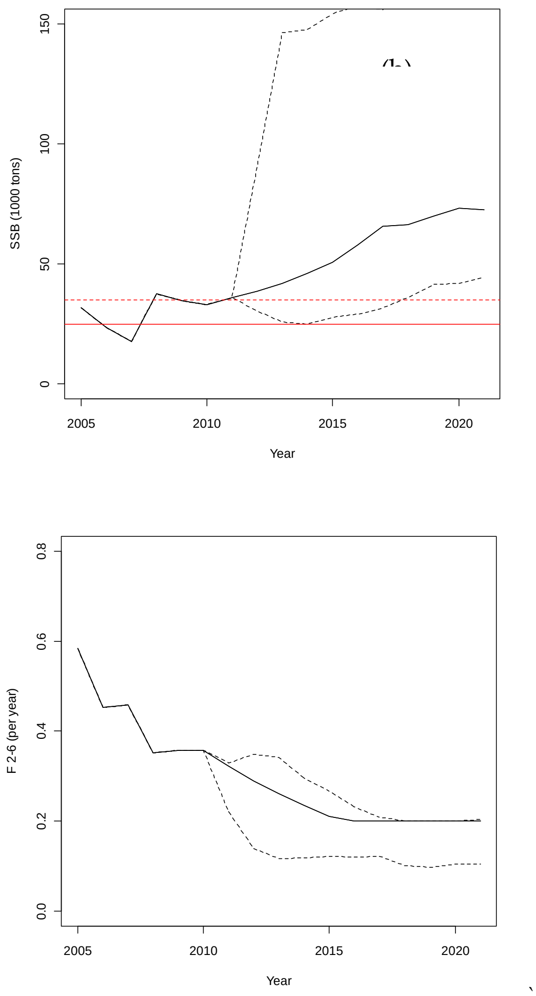


Figure 4.22. Time series of spawning stock biomass (a) and fishing mortality (b) for sole in the North Sea. The time series comprise of the stock assessment results prior to 2010, and the projected 95% confidence intervals (- - -) and median (-----) after 2010. In the SSB panel, the red line drawn line indicates B_{lim}, and the red dashed line indicates B_{pa}.

(a)

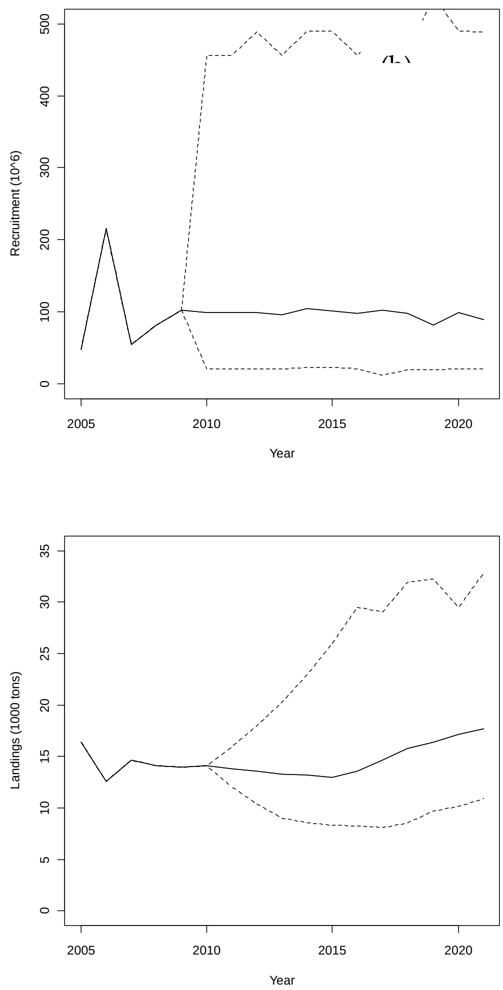


Figure 4.23. Time series of recruitment (a) and landings (b) for sole in the North Sea. The time series comprise of the stock assessment results prior to 2010, and the projected 95% confidence intervals (- - -) and median (-----) after 2010.

The median landings in the projection of the plan slightly decrease in the period up to 2013, as a result of the decrease in fishing mortality. The decrease is followed by an increase as the stock increases and fishing mortality is more or less constant at the target F. Then the median landings increase to values in the range of 15 to 20 kt. (Figure 4.23b). However, the 95% confidence interval is very large. The increase in the upper confidence limit is defined entirely by the 15% TAC change constraint.

4.9 Full management strategy evaluation

4.9.1 Base case and worst case scenarios

Under both scenarios an initial large reduction in effort is followed by a slowly decreasing trend in HP days (Figure 4.24). There is a greater initial reduction in effort observed in the base case scenario because of the reduction in F required for the sole stock. Effort does not subsequently increase as stock recovery means that less effort is required to land the TACs. Under the worst case scenario, poorer stock recovery means that more effort is required to land the TACs.

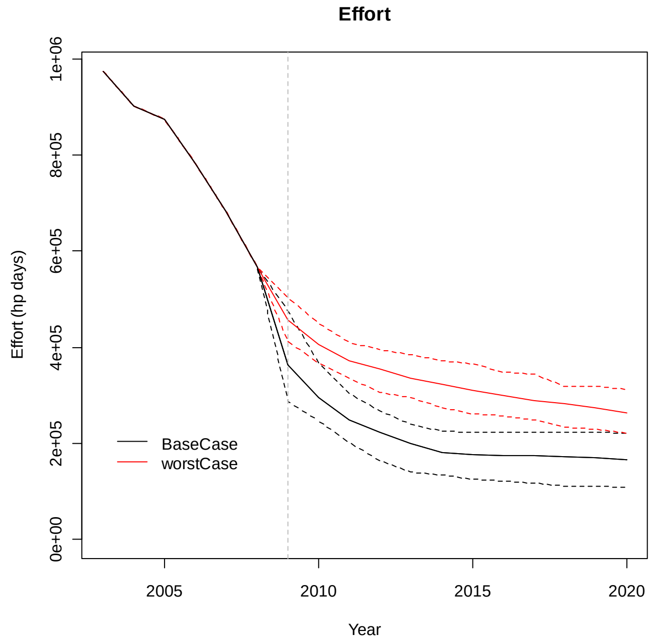


Figure 4.24. Total effort in HP days of the fleet fishing the North Sea sole and plaice stocks.

Plaice

Fishing mortality for plaice starts below the target level of 0.3 and decreases for about 5 years before stabilizing in the region of 0.2 (Figure 4.25). Under the multiannual plan, if current F is below the target level, F should increase towards the target. However in the simulations F initially decreases by more than 10%. This is because the already healthy stock continues to increase while the 15% limit prevents the TAC from increasing accordingly. In addition, restriction to the effort that can be applied on the sole stock impact on the ability of the fleet to utilize the full plaice quota (Figure 4.26). Discards decrease with the reduction in effort and remain stable at low levels. At these low F levels, SSB, which starts above Bpa, is likely to increase steadily. This is also the case under the minimum recruitment scenario.

Sole

For the sole stock, the initial stock status from the 5th percentile of the SCA distribution represents a stock in healthier condition than the XSA estimates it to be. However, the minimum recruitment scenario still represents a more pessimistic view of stock dynamics and can still be viewed as the worst case scenario. In both cases F continues the sharp decrease observed in the recent past reaching the target level before around 2013 (Figure 4.25). The decrease in F exceeds 10% for the first three years as a result of a mismatch between 'real' F and the perceived F used in the determination of the TAC. This, in combination with effort restrictions, is also the reason why F stabilizes slightly below the F target. SSB starts near Bpa and increases steadily under the base case scenario, though with larger uncertainty bounds. Yields increase slowly at first then quicker once target F is reached (Figure 4.26) and these are likely to increase further as the stock recovers. In the worst case scenario there is no increase in SSB, despite the stabilizing of F levels in the range of the target, suggesting at those low levels of recruitment the stock is near the equilibrium biomass and yield for the target F value.

Probability of achieving management goals/being precautionary

In the 10 years following 2010 (future simulation period) none of the 100 stochastic runs had SSB levels below B_{lim} or above F_{lim} for any of the years for both the plaice and sole stocks (Table 4.1). This was also true for the stock projection for plaice, but not for sole which had 4% of the simulations dropping below B_{lim} at one point. This implies that by ICES precautionary criteria, the management plan can be considered precautionary for both stocks.

Probability of achieving plan F_{msy} targets

The fishing mortality for plaice starts below the plan target and remains below in 2015. For sole, an initial decrease in *F* is required but in both the base case and worst case scenarios, the median *F* level is at or below the target by 2015.

Table 4.1. Performance of the multiannual plan for North Sea sole and plaice according to WKMOSE criteria for the stock projection and MSE results.

Stock	Analysis	*N* simulations	*N* simulations with B < B_{lim} for 1 or more years	% Risk level
Sole	Projection	500	22	<5%
	MSE	100	0	<1%
Plaice	Projection	500	0	<1%
	MSE	100	0	<1%

4.9.2 Sensitivity to stock recruit relationship

The alternative recruitment scenarios represent a greater range of future stock dynamics for the plaice stock than for the sole stock (Figure 4.27). For plaice, the Beverton and Holt scenario shows a massive increase is recruitment compared to the base case geometric mean function while the minimum recruitment scenario obviously represents a much lower potential future recruitment. The impact of this on future SSB and F values is as would be expected, with greater recruitment leading to greater recovery in SSB and, through reduction in effort required to land TACs, slightly lower F values. In all scenarios SSB increases and F decreases, but at different rates. For sole, the Beverton and Holt scenario is identical to the base case geometric mean scenario. This is because the Beverton and Holt curve for this stock is flat-topped as described above in section 4.1. In the minimum recruitment scenario, very poor recruitment leads initially to a slight decline in stock size, but this then stabilizes in the range of Bpa.

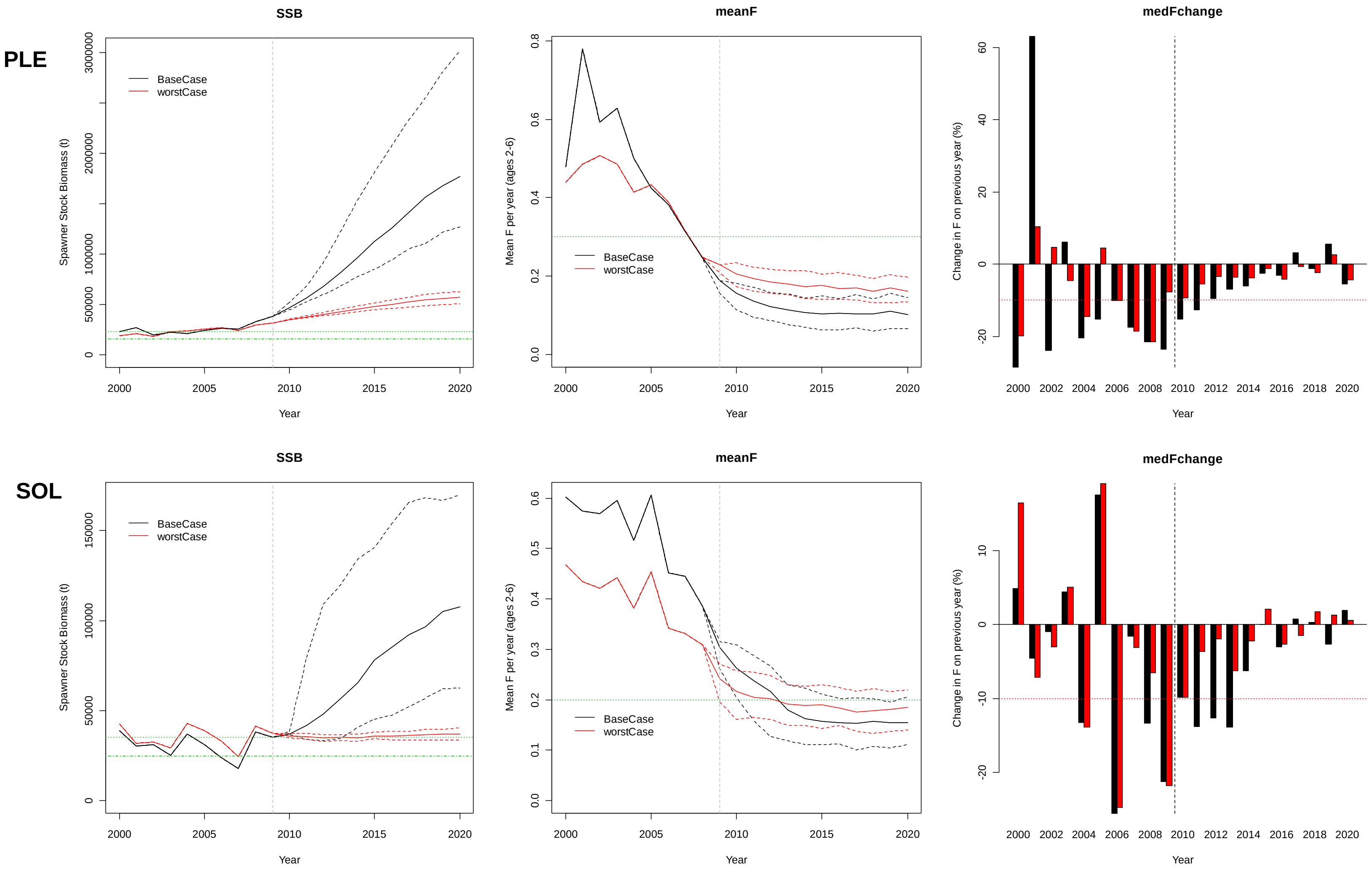


Figure 4.25. 'Base case' and 'worst case' scenarios: time series of SSB (left, with B_{lim} and B_{pa} marked), mean fishing mortality for ages 2-6 (centre, with target F marked) and median annual change in mean F (right) for the North Sea plaice (top) and sole (bottom) stocks. Time series comprise stock assessment results prior to 2010, and the 90% confidence intervals (- - -) and median (-----) thereafter.

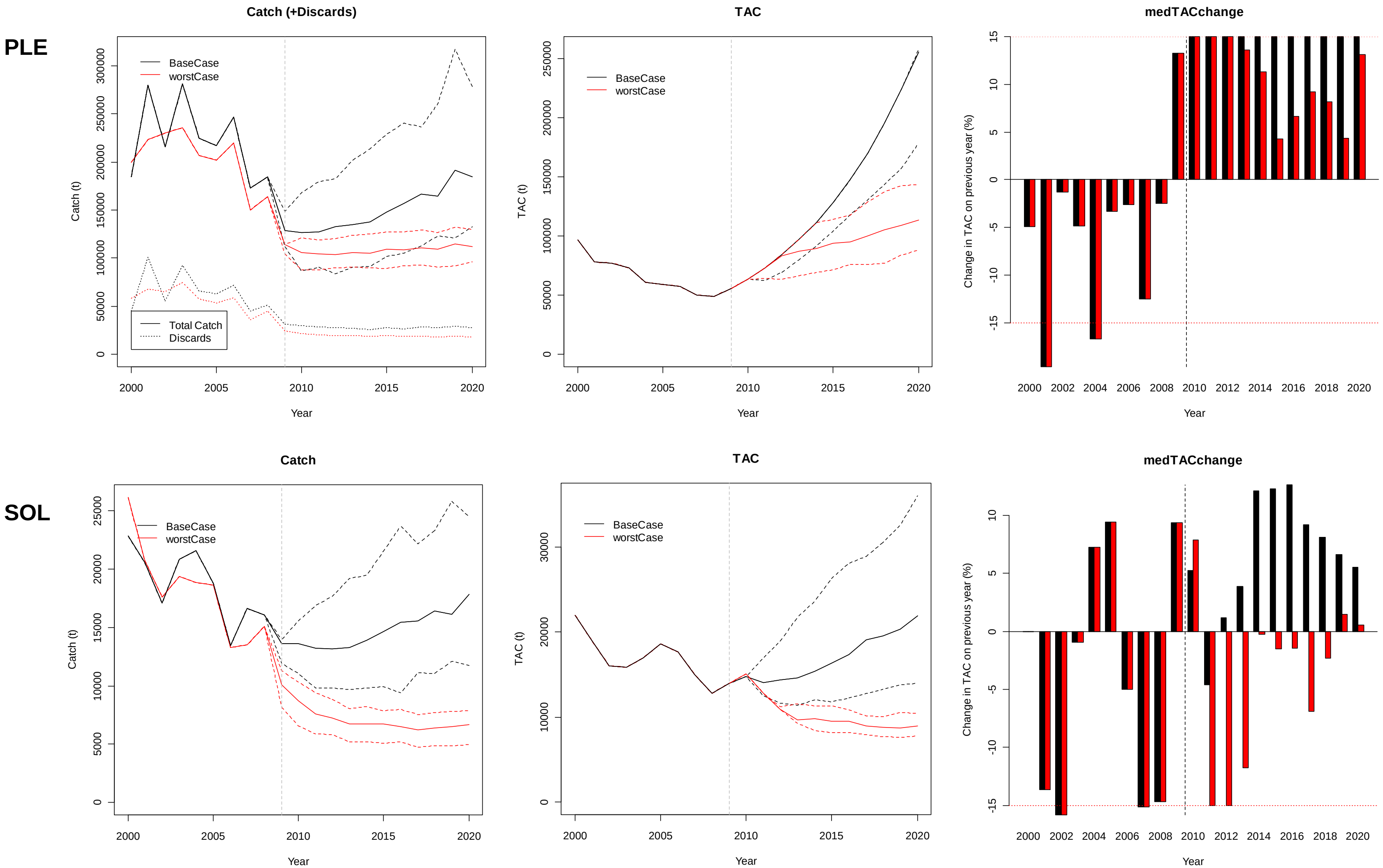


Figure 4.26. 'Base case' and 'worst case' scenarios: time series of Catch (left), TAC (centre) and median annual TAC change (right) for the North Sea plaice (top) and sole (bottom) stocks. Time series of catch and TAC comprise stock assessment results prior to 2010, and the 90% confidence intervals (- - -) and median (-----) thereafter.

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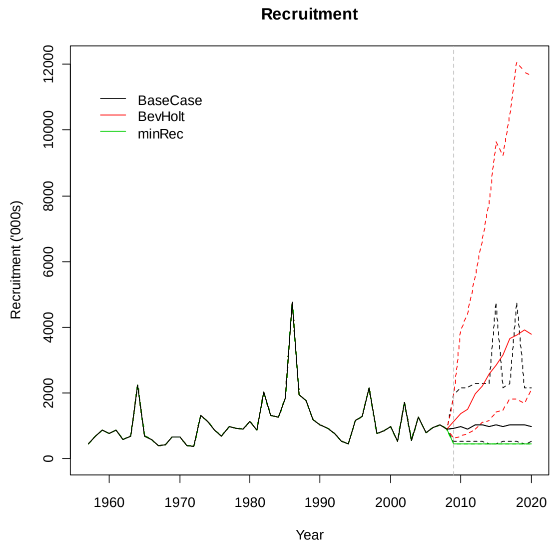
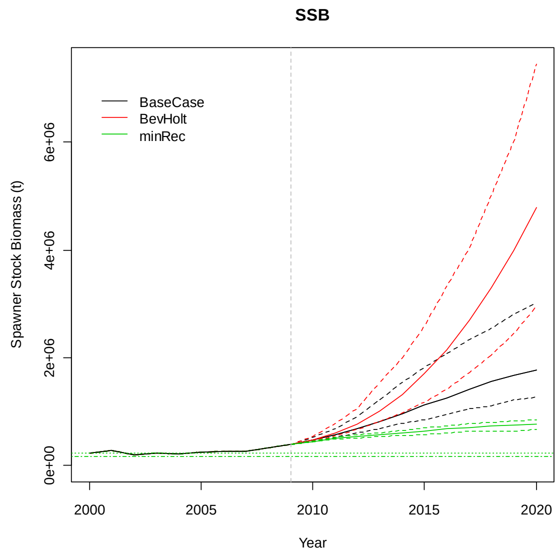
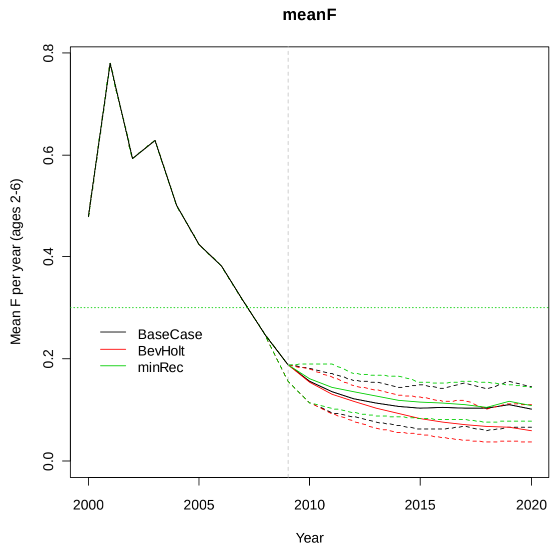

Recruitment
BaseCase
BevHolt
minRec
Recruitment ('000s)
0
2000
4000
6000
8000
10000
12000
1960
1970
1980
1990
2000
2010
2020
Year


SSB
BaseCase
BevHolt
minRec
Spawner Stock Biomass (t)
0e+00
2e+06
4e+06
6e+06
2000
2005
2010
2015
2020
Year


meanF
BaseCase
BevHolt
minRec
Mean F per year (ages 2-6)
0.0
0.2
0.4
0.6
0.8
2000
2005
2010
2015
2020
Year

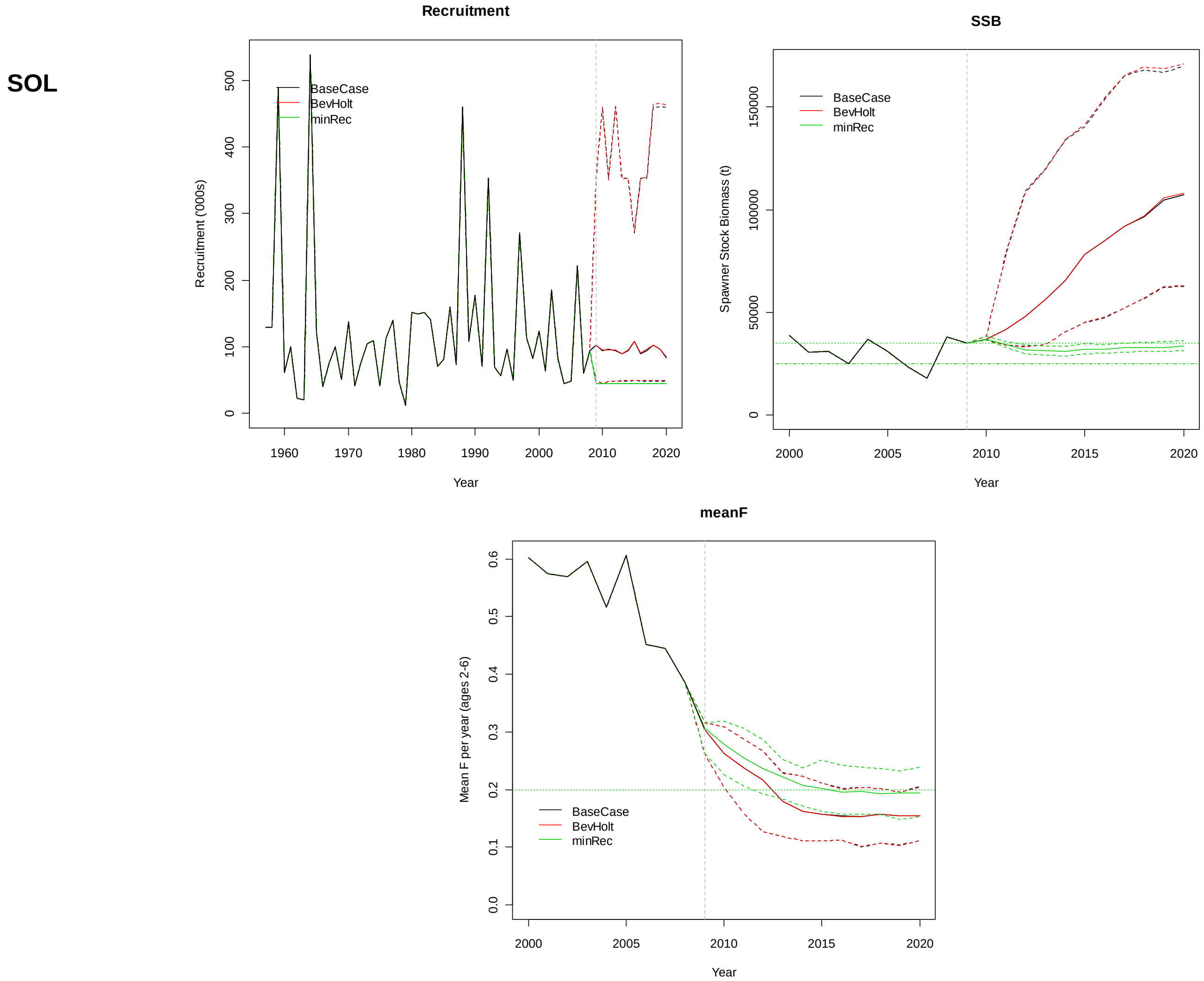


Figure 4.27. Alternative stock-recruitment relationship scenarios: time series of recruitment (left), SSB (centre, with B_{lim} and B_{pa} marked) and mean fishing mortality for ages 2-6 (right, with target F marked) for the North Sea plaice (top) and sole (bottom) stocks. Time series comprise stock assessment results prior to 2010, and the 90% confidence intervals (- - -) and median (-----) thereafter.

4.9.3 Sensitivity to starting point

Both the rate of recovery (increase in SSB and decrease in F) as well as the pattern of recovery over time relative to the initial starting conditions are very similar across the range of starting points for both stocks. The ‘poorer’ starting points show a greater degree of recovery at a slightly more rapid rate (Figure 4.28).

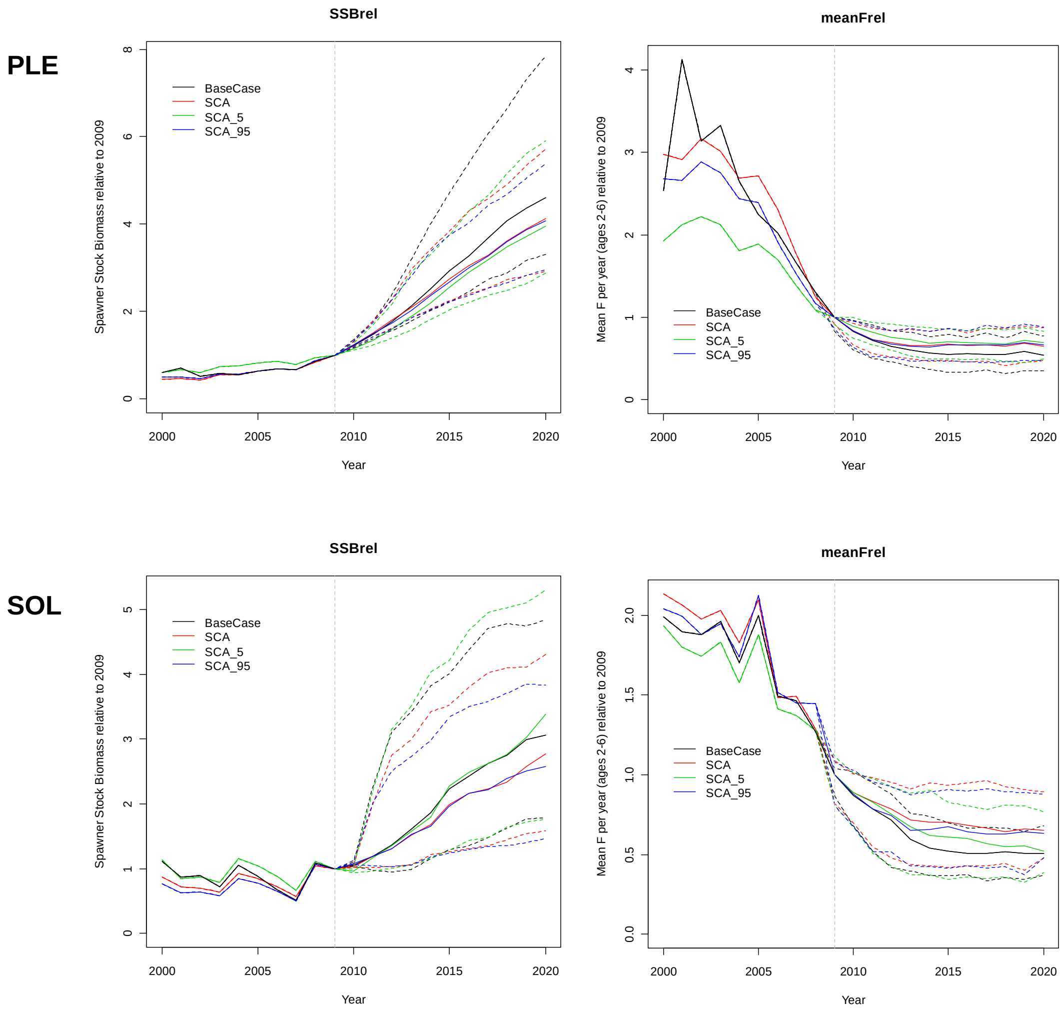


Figure 4.28. Alternative starting point scenarios: time series of SSB (left) and mean fishing mortality for ages 2-6 (right) relative to the median value in 2009 for the North Sea plaice (top) and sole (bottom) stocks. Time series comprise stock assessment results prior to 2010, and the 90% confidence intervals (- - -) and median (-----) thereafter.

4.9.4 Fleet dynamics and fishery

The trends of total effort by fleet, and the resultant *F* levels by stock, under the three mixed fishing scenarios are presented in Figure 4.29. The fishing effort for plaice and sole is identical under the *Least_Eff* and *MostSOL_Eff* scenarios, effort only differs in the *Both_Eff* scenario, where TACs are caught independently. Initially more effort is required to land the sole TAC than the plaice TAC but this reverses after as sole *F* decreases and plaice *F* increases according to the plan. If effort is limited in the plaice fishery, *F* remains at a low level, at or slightly above current *F*. If the plaice TAC is always caught, F increases slowly, the median level not reaching the target *F* before 2030. For sole, limiting effort allows for *F* to drop more rapidly to the target level, but in all cases the median *F* value reaches the target level by 2015. Thereafter *F* increases slowly, due to application error in setting TACS (i.e. imperfect perception of stock size and *F* when applying the HCR, and technical creep in the efficiency of the fleets).

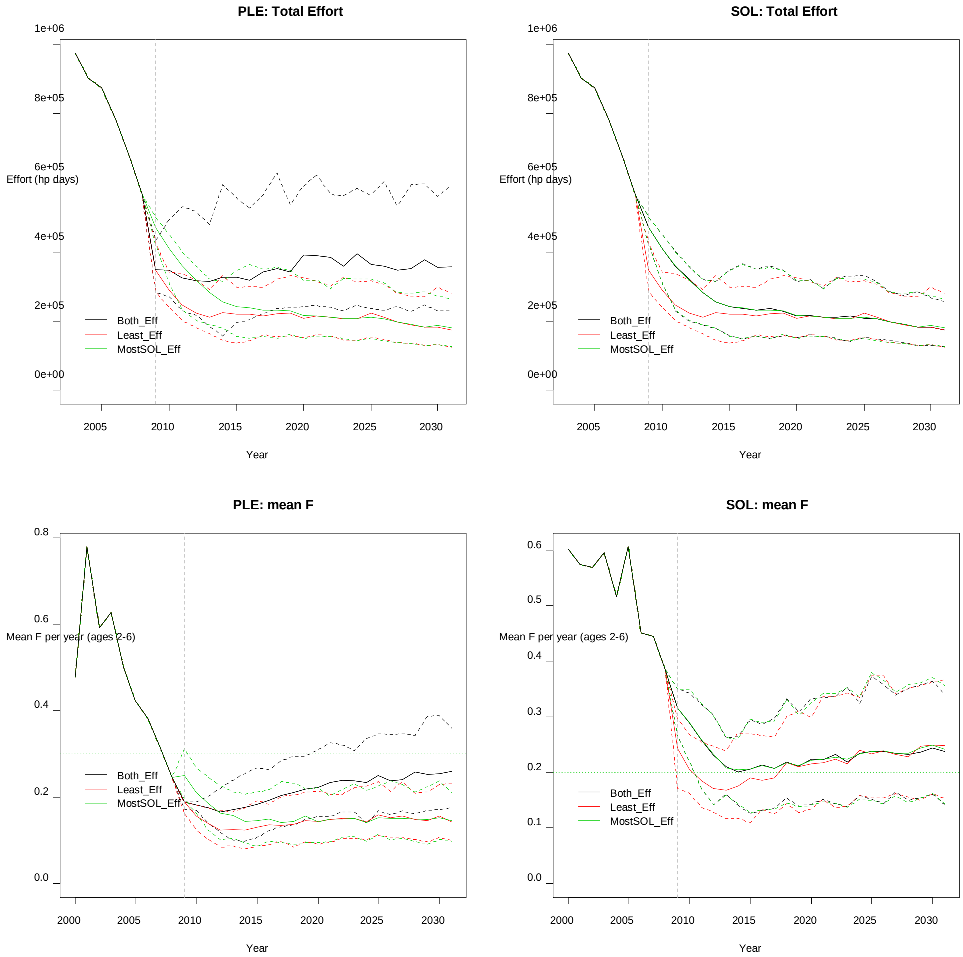


Figure 4.29. Total effort and resultant mean F values for the plaice and sole stocks under different assumptions of mixed fishery behaviour.

Effort by fleet is presented in Figure 4.30. Patterns of change over time are similar for all three fleets, with a gradual decline following initial large declines prior to the simulation period. Only the *Other_BT1* fleet remains unaffected by sole effort restrictions (as this fleet catches only plaice due to large mesh size), but this fleet contributes very little to the overall catch. Landing the plaice TAC over the period examined require a gradual increase in effort by the BT2 fleets (NL and other) while landing the sole TAC require a gradual decrease. This follows naturally from the increase in F required for plaice (below the F target) and the decrease required for sole (above the *F* target).

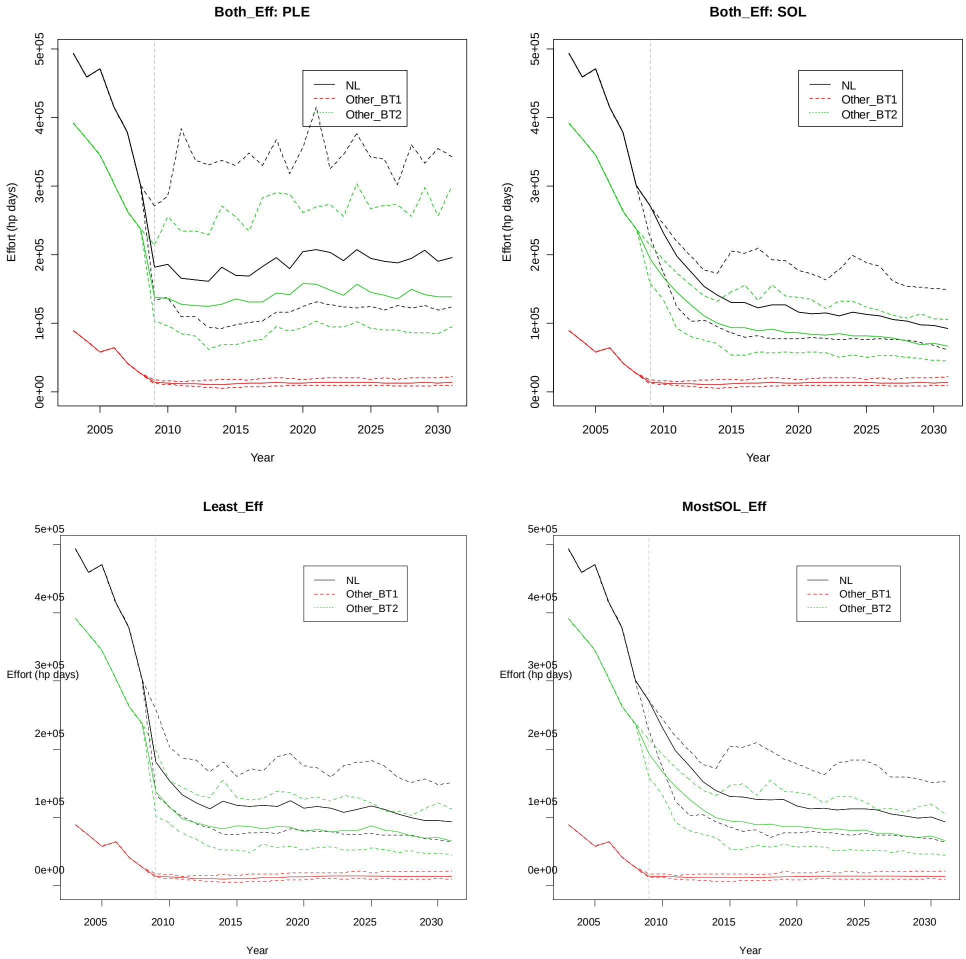


Figure 4.30. Effort by fleet for the plaice and sole stocks under different assumptions of mixed fishery behaviour. Note; under the *Least_Eff* and *MostSOL_Eff* scenarios the effort by fleet for each stock is the same.

Trends in yield for the plaice and sole stocks are shown in Figures 4.31 and 4.32. For plaice, in all cases the TAC continues to increase initially constrained by the 15% TAC change limit. Overquota is only caught in the case of the *MostSOL_Eff* scenario, and this is only in the first few years when more effort is required to land the sole TAC. The proportion of discards in the catch decreases steadily in all cases, but this proportion is less in the scenarios where effort becomes limiting. For sole, TAC increases initially at a slower rate than that of plaice until levelling off after approximately 10 years. In all cases, except initially under the *Least_Eff* scenario TACs are very similar. Overquota landings in some years are made under all scenarios due to the banking and borrowing which is included in the management for sole (i.e. if the full TAC is not landed in one year, up to 10% can be carried over to the next year).

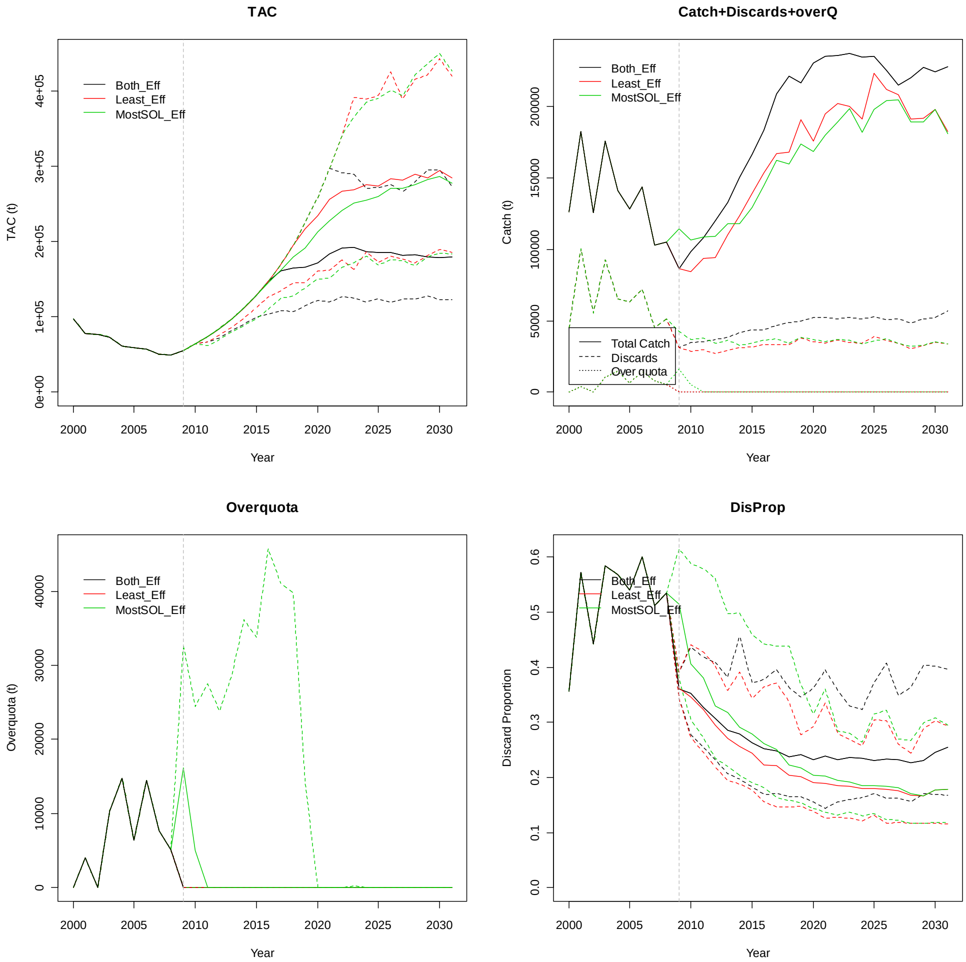


Figure 4.31. Yield from the plaice stock under different assumptions of mixed fishery behaviour: TAC; Catch, Discards and Overquota; Overquota; and Discards proportion in the catch (assuming overquota is discarded) . Medians and 5/95%iles are plotted in all cases except for the catch plot which shows only the median values.

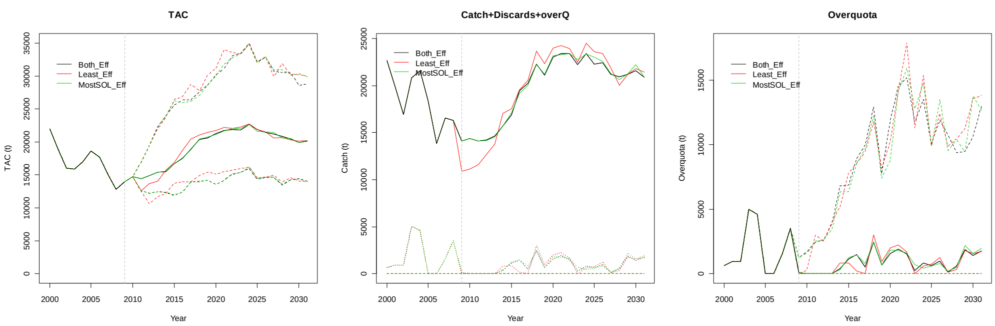


Figure 4.32. Yield from the sole stock under different assumptions of mixed fishery behaviour: TAC; Catch and Overquota; and Overquota. Medians and 5/95%iles are plotted in all cases except for the Catch plot which shows only the median values.

The trends in stock growth under the different mixed fishery assumptions are given in Figure 4.33. When effort is restrictive, greater growth in stock size occurs initially, stock size levels off at similar levels in the long term. In the case of the plaice stock, higher catch over most of the period in the *Both_Eff* scenario (in which effort is not limiting) leads to a low long term biomass. However, this is still well above Bpa . In all case for both stocks the risk of failing to be precautionary according to the WKOMSE criterion was less than 5%.

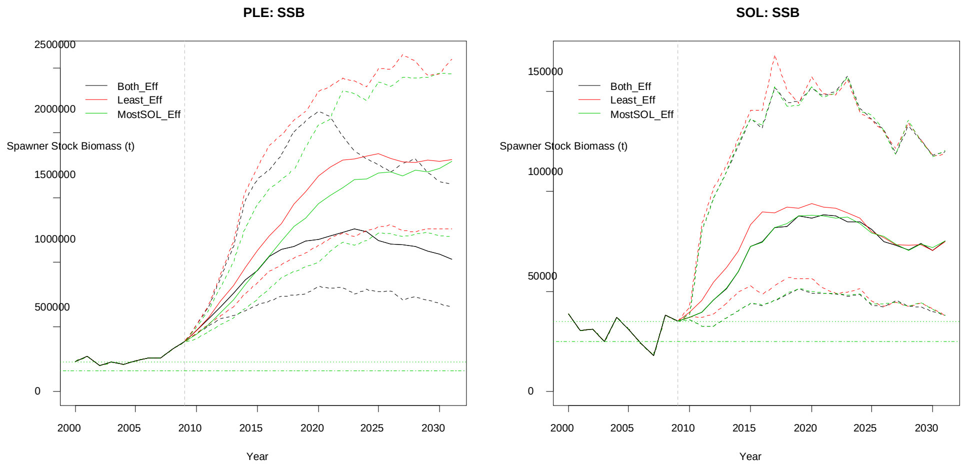


Figure 4.33. SSB of the plaice and sole stocks under different assumptions of mixed fishery behaviour.

5 Discussion

The multiannual plan through its two stage process leads to a change in management strategy from a risk avoidance strategy (to get within safe biological limits) to a strategy of optimal harvesting of the resource. The aims of stage two of the plan are in accordance with the commitments made at the World Summit on Sustainable Development at Johannesburg (2002), the approach that is currently being implemented by ICES for the provision of advice for the management of fish stocks. The proposed management means a change from conservation or limit reference points to target reference points that are intended to meet management objectives. The primary driver for management advice under the multiannual plan is the estimated fishing mortality, but this output control is also complemented by effort restrictions. The fishing mortality targets have been chosen such that they will ensure that the biomass of the two stocks is kept at a high level within safe limits without the need for specific reactionary measures to the biomass status of the stocks. However, included within the plan is a clause that allows for more reactionary management measures should the stocks be found to be suffering from reduced reproductive potential that may result from insufficient biomass levels.

We used three different approaches to study the effects of the long term management plan for sole and plaice. Each of these approaches has pros and cons in terms of the level of complexity and the assumptions made in the analysis. In general, the three different approaches lead to similar conclusions about the effects of the plan on the spawning stock biomasses and yields.

The results presented here suggest that the multiannual plan can be considered to be precautionary for both of the managed stocks according to the criteria described by WKOMSE (ICES 2009a) for the evaluation of multiannual plans. The plan allows for increases in yield in the long term while reducing the current levels of F. There is a very high likelihood of stock growth in terms of SSB for both stocks. Both the simple stock projections and full feedback MSE analysis showed that F is likely to remain at low levels allowing for increases in stock biomass. The fact that the projections incorporated no effort control and therefore allowed for the full utilisation of both TACs lead to some slight differences in future stock status. For the sole stock, some of the projected runs allowed for a slight increase in F in the first few years of the simulation causing 2 of the 50 iterations to drop below B_{lim} for a short period before full recovery began. This did not occur in the MSE simulations, where none of the iterations dropped below B_{lim}, because the reductions in effort applied by the HCR prevented any increases from the initial starting F value thereby allowing for more immediate stock recovery.

Caution needs to be taken in the interpretation of the MSE, and stock projection, results because future projections take the stock to outside the range of historic observations. It is likely that in reality such changes in stock status would not proceed unchecked. Density-dependent growth or mortality would impact on the stock at such sizes and fishing patterns and selectivity would likely change. This evaluation does not aim to predict exactly what would happen if the multiannual plan continues to be implemented in the long term. The evaluation aims to assess whether the plan is robust to future process error and various assumptions of stock dynamics. It further aims to assess the degree of certainty with which we can accept that it is likely to be both precautionary and allow for the high long term yields while maintaining healthy stocks. The models should be used as indications more than absolute projections into the future. By examining the performance of the plan at the lower ends of the simulation ranges and considering 'worst case' recruitment scenarios the likely risk of a management failure can be assessed. This is embodied in the WKOMSE criteria used to evaluate the results.

A number of simplifying assumptions were required for the implementation of the MSE. For both plaice and sole stocks it has been assumed that productivity of the marine ecosystem in the projected period will remain within the same range as has been observed in the past 50 years. Though this assumption is likely to be flawed, it is the most reasonable assumption to make given the availability of data and the fact that incorporating potential future regime shifts would be largely speculative. Observations of changes in the species composition in the North Sea towards more southern species and observation on changes in stock dynamics of some other stocks may indicate that external factors, such as climate change, do also affect the ecosystem. In the evaluation, it has also been assumed that annual decisions will be made using certain assessment methods (the present assessment procedures) with their associated uncertainties. It can be envisaged that other methods may be used in the future and this may affect (improve or deteriorate) the effect of the measures. In the current model spatial variation in fish abundance and fishing effort is not included. Conditioning of a model with spatial differentiation is complicated (Pastoors *et al*. 2006; Poos *et al*. 2006) and the (XSA) observation model to which the results are compared don't include spatial variation either. When evaluating the model, assumptions had to be made at different levels in the process. If these assumptions are very different from the true situation, the effect of the measures may be different than indicated by the evaluation. Two major assumptions that were identified for this analysis were the initial starting condition of the two stocks and the form of the stock recruit relationship. By assessing ranges of these two factors in different scenarios it was possible to determine the plan is sensitive to assumptions about them. The present results suggest that the multiannual plan is effective across a broad range of stock conditions, as simulated in the 7 scenarios (Table 3.5.2), for both plaice and sole, maintaining a healthy stock while keeping F levels low in all cases. It also performed effectively at even the lowest likely future recruitment. These results show the multiannual plan to be robust to uncertainty in initial starting condition and future recruitment.

In the simulations the link between plaice and sole fishery in the initial evaluations was limited. This lead to an evaluation of how different assumptions on mixed fisheries behaviour are likely to impact on the stock. The effort required to land the sole TAC is initially higher than that for the plaice TAC due to high levels of F in the sole fishery compared to low levels in the plaice fishery. As plaice TACs increase more rapidly than those of sole, accompanying opposite trends in F (decrease in sole and increase in plaice), this leads to the TAC of plaice requiring more effort to land in the long run. This is a more tractable and favourable situation for the mixed fishery to be in because overquota of sole can be more easily avoided than that of plaice. None of the assumptions of mixed fisheries behaviour invalidated any of the previous conclusions, in fact suggesting that for plaice the management plan is likely to be more precautionary.

The current MSE implementation has addressed a number of the main concerns addressed by the previous ICES reviewers: for example (i) the issue of unrealistic uncertainty estimates for surveys, landings and discards has been dealt with by using estimates from the most recent stock assessments, (ii) the model does not generate systematic, large overestimates of plaice landings in the conditioning period compared with observed landings, (iii) the evaluation correctly simulates the forecasting procedure necessary for implementation of the plan. Because the multiannual plan has been applied for a number of years now, less interpretation was required in devising the HCR to be used in accordance with the plan. The current implementation of the plan in the simulations is believed to be in strict accordance with the regulations detailed in the multiannual plan. Some assumptions still needed to be made for the incorporation of Article 18 (actions to be taken when the stocks show reduced reproductive potential), though in none of the simulations did this clause ever come into affect (plaice remained within safe biological limits, and the runs of sole that left safe biological limits did not require >15% change in TAC to recover). Fleet dynamics have been improved, though still in a simplified form due to limitations in data available for all métiers of the fleet. The estimation of observation error in landings and discards has also improved by using the outputs from the SCA model. Additionally, improved criteria to evaluate the precautionary nature of the plan were used. By assessing performance against the WKOMSE criteria, the evaluation of results is in accordance with both ICES and STECF standards.

The results presented show that the plan is very likely to be precautionary but it is more difficult to assess whether it achieves the goals of long term yields and sustained healthy populations. This is essentially a question over whether the F targets specified for the two stocks are reasonable and whether in practice they can be achieved simultaneously. The Yield curve analyses presented show that F_{msy} for plaice should be in the region of 0.18-0.36 and sole from 0.51-0.59, depending on the assumption of stock recruit relationship. In the case of sole, these high F values are close to F_{crash} in the segmented regression case. Also, the F_{msy} estimate using the Ricker functional form differs substantially from the estimates in the demersal assessment working group report. While the target for plaice lies within the bounds indicated by the different yield curves, the target F for sole is substantially lower. However, because of the lack of any clear functional form in stock-recruit data of either of the two stocks these values have a high degree of uncertainty attached to them. In 2005, the ICES ad hoc Group on Long Term Advice (AGLTA; ICES CM 2005/ACFM:25) concluded that with regards to plaice "*if the objective is to obtain a high* *long term yield in combination with a low risk to B_{lim}, the preferred level of human consumption fishing mortality could be in the area of Ft=0.2 to Ft=0.3.*". It is also stated within the EU multiannual plan that "*advice from a committee of experts examining multiannual management strategies indicates that the highest yield of sole can be taken at a fishing mortality rate of 0,2 on ages two to six years.*" Hence, given the uncertainty associated in the estimation of F_{msy} reference points and that expert opinion has been incorporated into the determination of possible target F points, the targets as they stand seem plausible. Whether or not the two targets can be achieved simultaneously depends on future fisheries behaviour and gear selection. The results suggest greater and more rapid recovery of the plaice stock compared to the sole stock. This will open up greater opportunities in the plaice fishery in future that would require potential shifts in fishing location (to grounds further north) and gear (to more 100mm trawls). However, economic reasons such as fuel prices and market prices of sole and plaice are likely to have an impact on future fishery behaviour and this is not easy to predict in simulations. Regardless, it is clear that both stock growth and long term increases in yield levels are likely should the multiannual plan be implemented.

6 Conclusions

Following the implementation of the management regulations on 1st July 2007, as described in Council Regulation (EC) No 676/2007, only two years of *SSB* estimates, and one year of *F* estimates are available for the North Sea plaice and sole stocks. As a result, long term trends in the population dynamics following the implementation of the management plan cannot be described. However these preliminary results do indicate certain trends in stock and fleet dynamics and several conclusions can be drawn from this *ex post* evaluation of the stock and fleet dynamics. The results also highlight issues regarding the actual implementation of the management regulations.

The management regulations in Council Regulation (EC) No 676/2007 have been used as the basis for establishing TACs for North Sea plaice and sole for the last two years. However, the regulations by themselves lack transparency and the details of how these regulations are to actually be applied has required a degree of interpretation by those trying to implement them. In particular there is no specification of how F_{sq} is to be calculated. At present F_{sq} in year *y* has been calculated as the mean *F* of the previous three years (*y-3 to y*-1) rescaled to the selection pattern of the most recent year. Considering that the regulations call for a annual decrease in *F*, assuming the current *F* to be equal to the three years preceding it seems to be an unreasonable assumption likely to slow progress towards the objectives. In the most recent years ICES has provided advice based on the management plan that considers F_{sq} to be equal to the most recent *F* estimate, rescaled to the mean selection pattern of the last three years. It is likely that this interpretation of the implementation of the plan will be used in the *ex ante* evaluation although alternative interpretations of how to implement the regulations could be considered. For example, it could be assumed that the TAC will be caught exactly in the intermediate year and the *F* associated with this TAC, re-scaled, could be used as F_{sq} in the projection. Basing TAC calculations on *F* is also sensitive to any retrospective changes in perceived *F* and may in certain years lead to an increase in *F* from one year to the next (e.g. from 2008 to 2009 for sole). Furthermore, the regulations do not state how the achievement of objectives is to be assessed, neither in terms of the model used to specify this, nor in the level of uncertainty that is acceptable. In terms of evaluating the success of the management plan, the North Sea sole stock could be considered to be within the stock size safe biological limit if the level of uncertainty required is less than 20%. However, if it is required to be less than 5% this is not the case. A clear specification is required of the level of risk to be tolerated.

The multiannual plan without further specifications than the regulations alone can appear to lack direction. A simple 10% reduction from an ill-defined F_{sq} does not necessarily steer the stock towards the objectives. A stepwise decrease in the 'distance' between current *F* and the target *F*, while potentially invoking the 15% TAC change more often, may be more successful in assuring progress towards the objectives and prevent issues such as the projected increase in sole *F* from 2008 to 2009. Conversely, difficulties in application can lead to a greater than specified *F* reduction, as has been observed for plaice (19%). This is exacerbated by the retrospective problems in the North Sea plaice and sole stock assessments. One possible way to attempt to moderate these inconsistencies would be a mid-year review of how our perception of the stocks have changed following the provision of advice in June of each year. In this way the TAC for the second half of the year could be adjusted slightly in line to account for potential changes in the perception of stock size. Such a scenario could be included within the *ex ante* evaluation.

The rationale for the target fishing mortality reference points in the long term management plan is not given in Council Regulation No EC 676/2007. The objective *F* for the North Sea plaice stock is similar to, though slightly higher than, the current proxy of F_{MSY} for this stock as given by ICES. In the case of North Sea sole, the management objective *F* lies within the broad range of potential proxies for F_{MSY} for the stock. However, before fishing mortality rates of the two stocks can be reconciled to the target F_{plaice}:F_{sole} ratio of 1.5, the fishing patterns in the fleets will likely have to change, given the current values. North Sea plaice *F* is likely to increase slowly (due to TAC increase constraints) and then fluctuate around the 0.3 per year level. Meanwhile, a significant decrease in the *F* of North Sea sole is required to bring about a ratio of 1.5, yet the current management *F* for the stock is likely to represent an increase in *F* from 2008 to 2009. In this context, the long term management plan will steer towards a further decrease in fishing effort by the main fleets targeting sole and plaice. The likely long term ratio in the *F*s of the two stocks could be examined in the *ex ante* evaluation, however any outcomes are likely to be largely dependent on assumptions made about the fleet behaviour, with regards to fishing location.

Under the multiannual plan, the North Sea plaice TAC has been increasing. This increase is likely to continue as long as the stock continues to recover because fishing in the near future should fluctuate around what is considered to be the optimum *F* for long term sustainable yields. Discarding levels remain high, but currently they are near the lowest level of the past ten years and show a downward trend. Assuming *F* remains at the current lower level, it is assumed that the discards to landings ratio will decrease further, potentially decreasing the quantity of discards even further. North Sea sole TACs have stabilised to a degree under the multiannual plan in the most recent years, but these are likely to continue to fluctuate depending on the strength of incoming year classes.

The data available to analyse the stock dynamics under the multiannual plan reveal a few conclusions. With respect to the chosen reference points and the safe biological limits of the stock it appears that:

- SSBs of both species have increased since the implementation of the plan. The XSA assessment for plaice (giving only point estimates), indicates that SSB has been larger than B_{pa} for two consecutive years. The SCA assessment (following Aarts and Poos 2009) indicates that plaice indeed has a larger than 95% probability of having reached a stage where the SSB is above B_{pa} for two consecutive years. For sole, the XSA stock assessment indicates that SSB has been above B_{pa} for two consecutive years. An alternative assessment including uncertainty estimates indicate that the probability of being above B_{pa} in not yet larger than 95%.

- The annual fishing mortality rates of the two stocks have been on a declining trend in recent years. The North Sea plaice stock is now fished at a level below the management regulation target for this stock (<0.3 per year). The annual rate of *F* for the North Sea sole stock remains above the management regulation target for this stock (>0.2 per year).
- According to the latest assessment results, both stocks appear to be within the precautionary zone in 2008, with both SSB and *F* trajectories being indicative of rebuilding stocks and a move towards more sustainable fishing levels.

Hence, despite a lack of clarity in the implementation of the management regulations, the multiannual plan, given the current perception of the stock, appears to be resulting in stock trajectories and fishing levels moving towards the desired objectives and in line with the principles of the precautionary approach.

In the first year of its implementation (2008), it appears that the effort regulations defined for the multiannual plan appear to be having the desired effect. Overall fishing effort has declined along with a decrease in the size of the main fishing fleets utilising these resources. These changes in effort seem to be making up for issues with the practical application of management regulations on setting of TAC. The reduction in effort appears to have brought about the desired changes in actual *F* as required by the regulation.

Most importantly. despite the known limitations of the approaches applied in this evaluation to assess the effectiveness of the multiannual plan for sole and plaice in the North Sea, it appears that the plan is in line with the ICES precautionary approach.

7 References

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Appendix A. Council Regulation EC No 676/2007

19.6.2007 EN Official Journal of the European Union L 157/1

I

(Acts adopted under the EC Treaty/Euratom Treaty whose publication is obligatory)

REGULATIONS

COUNCIL REGULATION (EC) No 676/2007

of 11 June 2007

establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 37 thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Parliament (1),

Whereas:

(1) Recent scientific advice from the International Council for the Exploration of the Sea (ICES) has indicated that the stocks of plaice and of sole in the North Sea have been subjected to levels of mortality by fishing which have exceeded the level determined by ICES as being consistent with the precautionary approach, and the stocks are at risk of being harvested unsustainably.

(2) Advice from a committee of experts examining multi-annual management strategies indicates that the highest yield of sole can be taken at a fishing mortality rate of 0,2 on ages two to six years.

(3) The Scientific, Technical and Economic Committee for Fisheries (STECF) has advised that the precautionary biomass for the stock of plaice in the North Sea should be 230 000 tonnes, that the fishing mortality rate necessary to produce the highest yield from the stock of plaice in the North Sea in the long term is 0,3 and that the precautionary biomass for the stock of sole in the North Sea should be 35 000 tonnes.

(4) Measures need to be taken to establish a multiannual plan for fisheries management of the stocks of plaice and sole in the North Sea. Such measures, where they concern the stock of plaice in the North Sea, are to be established in the light of consultations with Norway.

(5) The objective of the plan is to ensure, in a first stage, that stocks of plaice and sole in the North Sea are brought within safe biological limits, and in a second stage and after due consideration by the Council on the implementing methods for doing so that those stocks, are exploited on the basis of maximum sustainable yield and under sustainable economic, environmental and social conditions.

(6) Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy (2) requires, *inter alia*, that to achieve that objective, the Community is to apply the precautionary approach in taking measures to protect and conserve the stock, to provide for its sustainable exploitation and to reduce to a minimum the impact of fishing on marine ecosystems.

(1) Opinion of the European Parliament delivered on 28 September 2006 (not yet published in the Official Journal).

(2) OJ L 358, 31.12.2002, p. 59.

19.6.2007 EN Official Journal of the European Union L 157/1

I

(Acts adopted under the EC Treaty/Euratom Treaty whose publication is obligatory)

REGULATIONS

COUNCIL REGULATION (EC) No 676/2007

of 11 June 2007

establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 37 thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Parliament [1],

Whereas:

(1) Recent scientific advice from the International Council for the Exploration of the Sea (ICES) has indicated that the stocks of plaice and of sole in the North Sea have been subjected to levels of mortality by fishing which have exceeded the level determined by ICES as being consistent with the precautionary approach, and the stocks are at risk of being harvested unsustainably.

(2) Advice from a committee of experts examining multi-annual management strategies indicates that the highest yield of sole can be taken at a fishing mortality rate of 0,2 on ages two to six years.

(3) The Scientific, Technical and Economic Committee for Fisheries (STECF) has advised that the precautionary biomass for the stock of plaice in the North Sea should be 230 000 tonnes, that the fishing mortality rate necessary to produce the highest yield from the stock of plaice in the North Sea in the long term is 0,3 and that the precautionary biomass for the stock of sole in the North Sea should be 35 000 tonnes.

(4) Measures need to be taken to establish a multiannual plan for fisheries management of the stocks of plaice and sole in the North Sea. Such measures, where they concern the stock of plaice in the North Sea, are to be established in the light of consultations with Norway.

(5) The objective of the plan is to ensure, in a first stage, that stocks of plaice and sole in the North Sea are brought within safe biological limits, and in a second stage and after due consideration by the Council on the implementing methods for doing so that those stocks, are exploited on the basis of maximum sustainable yield and under sustainable economic, environmental and social conditions.

(6) Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy [2] requires, *inter alia*, that to achieve that objective, the Community is to apply the precautionary approach in taking measures to protect and conserve the stock, to provide for its sustainable exploitation and to reduce to a minimum the impact of fishing on marine ecosystems.

[1] Opinion of the European Parliament delivered on 28 September 2006 (not yet published in the Official Journal).

[2] OJ L 358, 31.12.2002, p. 59.

(7) This Regulation should aim at a progressive implementation of an ecosystem-based approach to fisheries management, and should contribute to efficient fishing activities within an economically viable and competitive fisheries industry, providing a fair standard of living for those who depend on fishing North Sea plaice and sole and taking into account the interest of consumers. The Community bases its policy partly on the policy recommended by the appropriate Regional Advisory Council (RAC). A large part of the catches of plaice in the North Sea are taken together with catches of sole. The management of plaice cannot be addressed independently of the management of sole.

(8) Consequently, in drawing up the multiannual plan, account should also be taken of the fact that the high fishing mortality rate for plaice is due to a great extent to the large discards from beam-trawl sole fishing with 80mm nets in the southern North Sea.

(9) Such control of the fishing mortality rates can be achieved by establishing an appropriate method for the establishment of the level of total allowable catches (TACs) of the stocks concerned, and a system including limitations on permissible days at sea whereby fishing efforts on those stocks are restricted to levels at which the TACs and planned fishing mortality rates are unlikely to be exceeded, but are sufficient to catch the TAC allowed on the basis of the fishing mortality rates established in the plan.

(10) The plan should cover all flatfish fisheries having a significant impact on the fishing mortality of the plaice and sole stocks concerned. However, Member States whose quotas for either stock are less than 5 % of the European Community's share of the TAC should be exempted from the provisions of the plan concerning effort management.

(11) This plan should be the main instrument for flatfish management in the North Sea, and should contribute to the recovery of other stocks such as cod.

(12) Control measures in addition to those laid down in Council Regulation (EEC) No 2847/93 of 12 October 1993 establishing a control system applicable to the Common Fisheries Policy [1] need to be included in order to ensure compliance with the measures laid down in this Regulation.

[1] OJ L 261, 20.10.1993, p. 1. Regulation as last amended by Regulation (EC) No 1967/2006 (OJ L 409, 30.12.2006, p. 11).

(13) In 2006 the Commission initiated a debate concerning a Community strategy for a gradual reduction in fishing mortality in all major fisheries by means of a communication concerning the attainment of the maximum sustainable yield objective by 2015. The Commission has submitted this communication to the RACs for their opinion.

(14) The Commission has requested STECF to report on key aspects of impact assessment in relation to the management of plaice and sole, which should be based on accurate, objective and comprehensive biological and financial information. That impact assessment will be annexed to the Commission's proposal concerning the second stage of the multiannual plan.

(15) The multiannual plan should be deemed to be a recovery plan during its first stage and a management plan during its second stage, within the meaning of Articles 5 and 6 of Regulation (EC) No 2371/2002,

HAS ADOPTED THIS REGULATION:

CHAPTER I

SUBJECT-MATTER AND OBJECTIVE

Article 1

Subject-matter

1. This Regulation establishes a multiannual plan for the fisheries exploiting the stocks of plaice and sole that inhabit the North Sea.

2. For the purposes of this Regulation, 'North Sea' means the area of the sea delineated by the International Council for the Exploration of the Sea as Sub-area IV.

Article 2

Safe biological limits

1. For the purposes of this Regulation, the stocks of plaice and sole shall be deemed to be within safe biological limits in those years in which, according to the opinion of the Scientific, Technical, and Economic Committee for Fisheries (STECF), all of the following conditions are fulfilled:

(a) the spawning biomass of the stock of plaice exceeds 230 000 tonnes;

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(b) the average fishing mortality rate on ages two to six years experienced by the stock of plaice is less than 0,6 per year;

(c) the spawning biomass of the stock of sole exceeds 35 000 tonnes;

(d) the average fishing mortality rate on ages two to six years experienced by the stock of sole is less than 0,4 per year.

2. If the STECF advises that other levels of biomass and fishing mortality should be used to define safe biological limits, the Commission shall propose to amend paragraph 1.

Article 3

Objectives of the multiannual plan in the first stage

1. The multiannual plan shall, in its first stage, ensure the return of the stocks of plaice and of sole to within safe biological limits.

2. The objective specified in paragraph 1 shall be attained by reducing the fishing mortality rate on plaice and sole by 10 % each year, with a maximum TAC variation of 15 % per year until safe biological limits are reached for both stocks.

Article 4

Objectives of the multiannual plan in the second stage

1. The multiannual plan shall, in its second stage, ensure the exploitation of the stocks of plaice and sole on the basis of maximum sustainable yield.

2. The objective specified in paragraph 1 shall be attained while maintaining the fishing mortality on plaice at a rate equal to or no lower than 0,3 on ages two to six years.

3. The objective specified in paragraph 1 shall be attained while maintaining the fishing mortality on sole at a rate equal to or no lower than 0,2 on ages two to six years.

Article 5

Transitional arrangements

1. When the stocks of plaice and sole have been found for two years in succession to have returned to within safe biological limits the Council shall decide on the basis of a proposal from the Commission on the amendment of Articles 4(2) and 4(3) and the amendment of Articles 7, 8 and 9 that will, in the light of the latest scientific advice from the STECF, permit the exploitation of the stocks at a fishing mortality rate compatible with maximum sustainable yield.

2. The Commission's proposal for review shall be accompanied by a full impact assessment and shall take into account the opinion of the North Sea Regional Advisory Council.

CHAPTER II

TOTAL ALLOWABLE CATCHES

Article 6

Setting of total allowable catches (TACs)

Each year, the Council shall decide, by qualified majority on the basis of a proposal from the Commission, on the TACs for the following year for the plaice and sole stocks in the North Sea in accordance with Articles 7 and 8 of this Regulation.

Article 7

Procedure for setting the TAC for plaice

1. The Council shall adopt the TAC for plaice at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:

(a) that TAC the application of which will result in a 10 % reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year;

(b) that TAC the application of which will result in the level of fishing mortality rate of 0,3 on ages two to six years in its year of application.

2. Where application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15 %, the Council shall adopt a TAC which is 15 % greater than the TAC of that year.

3. Where application of paragraph 1 would result in a TAC which is more than 15 % less than the TAC of the preceding year, the Council shall adopt a TAC which is 15 % less than the TAC of that year.

Article 8

Procedure for setting the TAC for sole

1. The Council shall adopt a TAC for sole at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:

(a) that TAC the application of which will result in the level of fishing mortality rate of 0,2 on ages two to six years in its year of application;

(b) that TAC the application of which will result in a 10 % reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year.

2. Where the application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15 %, the Council shall adopt a TAC which is 15 % greater than the TAC of that year.

3. Where the application of paragraph 1 would result in a TAC which is more than 15 % less than the TAC of the preceding year, the Council shall adopt a TAC which is 15 % less than the TAC of that year.

CHAPTER III

FISHING EFFORT LIMITATION

Article 9

Fishing effort limitation

1. The TACs referred to in Chapter II shall be complemented by a system of fishing effort limitation established in Community legislation.

2. Each year, the Council shall decide by a qualified majority, on the basis of a proposal from the Commission, on an adjustment to the maximum level of fishing effort available for fleets where either or both plaice and sole comprise an important part of the landings or where substantial discards are made and subject to the system of fishing effort limitation referred to in paragraph 1.

3. The Commission shall request from STECF a forecast of the maximum level of fishing effort necessary to take catches of plaice and sole equal to the European Community's share of the TACs established according to Article 6. This request shall be formulated taking account of other relevant Community legislation governing the conditions under which quotas may be fished.

4. The annual adjustment of the maximum level of fishing effort referred to in paragraph 2 shall be made with regard to the opinion of STECF provided according to paragraph 3.

5. The Commission shall each year request the STECF to report on the annual level of fishing effort deployed by vessels catching plaice and sole, and to report on the types of fishing gear used in such fisheries.

6. Notwithstanding paragraph 4, fishing effort shall not increase above the level allocated in 2006.

7. Member States whose quotas are less than 5 % of the European Community's share of the TACs of both plaice and sole shall be exempted from the effort management regime.

8. A Member State concerned by the provisions of paragraph 7 and engaging in any quota exchange of sole or plaice on the basis of Article 20(5) of Regulation (EC) No 2371/2002 that would result in the sum of the quota allocated to that Member State and the quantity of sole or plaice transferred being in excess of 5 % of the European Community's share of the TAC shall be subject to the effort management regime.

9. The fishing effort deployed by vessels in which plaice or sole are an important part of the catch and which fly the flag of a Member State concerned by the provisions of paragraph 7 shall not increase above the level authorised in 2006.

CHAPTER IV

MONITORING, INSPECTION AND SURVEILLANCE

Article 10

Fishing effort messages

1. Articles 19b, 19c, 19d, 19e and 19k of Regulation (EEC) No 2847/93 shall apply for vessels operating in the area. Vessels equipped with monitoring systems in accordance with Articles 5 and 6 of Commission Regulation (EC) No 2244/2003 of 18 December 2003 laying down detailed provisions regarding satellite-based vessel monitoring systems [1] shall be excluded from hailing requirements.

2. Member States may implement alternative control measures to ensure compliance with the obligation referred to in paragraph 1 which are as effective and transparent as these reporting obligations. Such measures shall be notified to the Commission before being implemented.

(1) OJ L 333, 20.12.2003, p. 17.

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Article 11

Margin of tolerance

1. By way of derogation from Article 5(2) of Commission Regulation (EEC) No 2807/83 of 22 September 1983 laying down detailed rules for recording information on Member States' catches of fish [1], the permitted margin of tolerance, in estimation of quantities in kilograms live weight of each of plaice and sole retained on board of vessels that have been present in the North Sea shall be 8 % of the logbook figure. In the event that no conversion factor is laid down in Community legislation, the conversion factor adopted by the Member State whose flag the vessel is flying shall apply.

2. Paragraph 1 shall not apply concerning a species of aquatic organism if the quantity of that species retained on board is less than 50 kg.

Article 12

Weighing of landings

The competent authorities of a Member State shall ensure that any quantity of sole exceeding 300 kg or of plaice exceeding 500 kg, caught in the North Sea shall be weighed before sale using scales that have been certified as accurate.

Article 13

Prior notification

The master of a Community fishing vessel that has been present in the North Sea and who wishes to land any quantity of plaice or sole in a port or a landing location of a third country shall inform the competent authorities of the flag Member State at least 24 hours prior to landing in a third country, of the following information:

(a) the name of the port or landing location;

(b) the estimated time of arrival at that port or landing location;

(c) the quantities in kilograms live weight of all species of which more than 50 kg is retained on board.

The notification may also be made by a representative of the master of the fishing vessel.

[1] OJ L 276, 10.10.1983, p. 1. Regulation as last amended by Regulation (EC) No 1804/2005 (OJ L 290, 4.11.2005, p. 10).

Article 14

Separate stowage of plaice and sole

1. It shall be prohibited to retain on board a Community fishing vessel in any individual container any quantity of plaice or any quantity of sole mixed with any other species of marine organisms.

2. The masters of Community fishing vessels shall give inspectors of Member States such assistance as will enable the quantities declared in the logbook and the catches of plaice and of sole retained on board to be cross-checked.

Article 15

Transport of sole and plaice

1. The competent authorities of a Member State may require that any quantity of plaice exceeding 500 kg or any quantity of sole exceeding 300 kg caught in the geographical area referred in Article 1(2) and first landed in that Member State is weighed before being transported elsewhere from the port of first landing using scales that have been certified as accurate.

2. By way of derogation from Article 13 of Regulation (EEC) No 2847/93, quantities of plaice exceeding 500 kg and quantities of sole exceeding 300 kg which are transported to a place other than that of landing shall be accompanied by the declaration provided for in Article 8(1) of that Regulation. The exemption provided for in Article 13(4)(b) of Regulation (EEC) No 2847/93 shall not apply.

Article 16

Prohibition of transhipments of sole and plaice

A Community fishing vessel that is present in the North Sea shall not tranship any quantity of plaice or sole to any other vessel.

CHAPTER V

FOLLOW-UP

Article 17

Evaluation of management measures

1. The Commission shall, on the basis of advice from STECF, evaluate the impact of the management measures on the stocks concerned and the fisheries on those stocks, in the second year of application of this Regulation and in each of the following years.

2. The Commission shall seek scientific advice from the STECF on the rate of progress towards the objectives of the multiannual plan in the third year of application of this Regulation and each third successive year of application of this Regulation. The Commission shall, if appropriate, propose relevant measures, and the Council shall decide by qualified majority on alternative measures to achieve the objectives set out in Articles 3 and 4.

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Article 18

Special circumstances

In the event that STECF advises that the spawning stock size of either or both plaice or of sole is suffering reduced reproductive capacity, the Council shall decide by qualified majority on the basis of a proposal from the Commission on a TAC for plaice that is lower than that provided for in Article 7, on a TAC for sole that is lower than that provided for in Article 8, and on levels of fishing effort that are lower than those provided for in Article 9.

CHAPTER VI

FINAL PROVISIONS

Article 19

Assistance under the European Fisheries Fund

1. During the first stage foreseen in Article 3 of this Regulation, the multiannual plan shall be deemed to be a recovery plan within the meaning of Article 5 of Regulation (EC) No 2371/2002, and for the purposes of Article 21(a)(i) of Council Regulation (EC) No 1198/2006 of 27 July 2006 on the European Fisheries Fund ([1]).

2. During the second stage foreseen in Article 4 of this Regulation, the multiannual plan shall be deemed to be a management plan within the meaning of Article 6 of Regulation (EC) No 2371/2002, and for the purposes of Article 21(a)(iv) of Regulation (EC) No 1198/2006.

Article 20

Entry into force

This Regulation shall enter into force on the 20th day following its publication in the *Official Journal of the European Union*.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Luxembourg, 11 June 2007.

For the Council

The President

H. SEEHOFER

([1]) OJ L 223, 15.8.2006, p. 1.

Appendix B. The Statistical Catch at Age (SCA) model

Model description

The model is elaborately described in Aarts and Poos (2009). Here we present the text from Aarts and Poos (2009), changing parts to make the text more concise, and to describe the differences between the sole and plaice assessment. For an in-depth description we refer to Aarts and Poos (2009). In short, the model is a traditional discrete-time age-structured population dynamics model

$$N_{a+1,t+1} = N_{a,t}\mathrm{e}^{-Z_{a,t}},$$

where $N_{a,t}$ are the numbers at age a at time t, and $Z_{a,t}$ the total mortality, which is composed of the instantaneous natural mortality rate M and the fishing mortality rate $F_{a,t}$.

Natural and fishing mortality

Natural mortality is assumed to be constant (0.1) in time and equal for all ages. Fishing mortality $F_{a,t}$ is the result of catchability q, annual fishing effort e_t, and the selectivity pattern $f_{a,t}$, such that

$$F_{a,t} = qe_tf_{a,t}.$$

Catchability q is the extent to which a stock is susceptible to fishing. The fishing effort e_t is the total amount of fishing in a year. With the available data, it is only possible to estimate the product of these two. The selectivity pattern $f_{a,t}$ defines the relative likelihood that an individual of age a in the population is caught and is constrained to have a maximum of 1. A smooth function of age is used, constructed using four b-spline basis functions $h_k(a)$. Each b-spline basis function is a cubic polynomial of the explanatory variable, but it is only non-zero within a certain range (defined by so-called knots) of the explanatory variable. Next, each basis function $h_k(a)$ is weighted by a constant $b_{k,t}$. Summing these weighted functions results in the complex smooth function of age:

$$f_{a,t} = \mathrm{logit}^{-1}\left(\sum_{k=1}^{4} b_{k,t}h_k(a)\right).$$

In this function, logit^{-1} is exp(·)/(1 + exp(·)) and ensures that $f_{a,t}$ takes values between 0 and 1. Because of the local nature of the basis function, the fit of the smooth function in one range of the data (e.g. at low ages) is independent of its fit at the other extreme (e.g. at high ages). Similar to many other assessment techniques, we assume that the fishing mortality of the last age class is equal to the fishing mortality of the preceding age. Temporal changes in the spatial overlap between fishing effort and the different age classes of the fish population can result in changes in the selectivity pattern. This is captured by modelling the weighting constants as a function of time, hence the subscript t in $b_{k,t}$. To prevent overparameterization, only a linear function for the temporal changes in selectivity was inspected, i.e.

$$b_{k,t} = \beta_{0,k} + \beta_{1,k}t.$$

Discards and landings

The expected catch $C_{a,t}$ for age a and year t is calculated from

$$C_{a,t} = \frac{F_{a,t}}{Z_{a,t}} N_{a,t}(1 - e^{-Z_{a,t}}).$$

For plaice, the catch consist of discards $D_{a,t}$ and landings $L_{a,t}$.We assume that an age-dependent fraction $d_{a,t}$ of the catch is discarded, such that

$$D_{a,t} = d_{a,t} C_{a,t},$$

$$L_{a,t} = (1 - d_{a,t}) C_{a,t}.$$

Although landings data are generally available, discard data are often lacking or, as in our study, only available for the most

recent years. For sole, we assume that the landings are equal to the catches, and there in no discarding. For plaice, we assume that the discard fraction $d_{a,t}$ is a smooth function of age where each smooth parameter is modeled as a second-order orthogonal polynomial function of time.

7.1.1 Tuning series

The tuning series data for plaice are collected over a short period (August–September) of each year. Because the survey vessel catches are a very small part of the population, it is assumed that these catches do not affect the mortality of the population as a whole. The population size $N_{a,t}$ represents the population size on 1 January of year t. When the scientific survey takes place later in the year, the population size may be reduced considerably by fishing and natural mortality. To correct for this, the mean population size during the time of the survey is estimated as

$$N^U_{a,t} = N_{a,t} \frac{e^{-\kappa Z_{a,t}} - e^{-\lambda Z_{a,t}}}{(\lambda - \kappa) Z_{a,t}},$$

where κ and λ are the start and end, respectively, of each survey expressed as a fraction of a year. Consequently, the catch of survey $U_{a,t}$ of age a in year t can easily be calculated as

$$U_{a,t} = s_{u,a} N^U_{a,t} q_u,$$

where q_u is the efficiency, which is survey vessel u-specific, and $s_{u,a}$ the age-specific selectivity of the survey vessel u. Again, we model $s_{u,a}$ as a smooth function of age. Survey selectivity $s_{u,a}$ is assumed to remain constant in time. It should be noted that for sole, the commercial LPUE series of the Dutch beam trawl fleet is used in the assessment (similar to the ICES WGNSSK assessment). Here, the assumption of constant q_u may be violated. Because the LPUE series span the entire year, κ and λ are set to 0 and 1, respectively

Likelihood function

The available datasets for parameter estimation are (i) landings-at-age, (ii) discards-at-age, and (iii) tuning series from three surveys. Conforming with most other statistical catch-at-age assessment, the data are assumed to be lognormally distributed, with means and age-specific standard deviations predicted by the model. Zero values were replaced by half of the lowest value observed in the dataset where each occurred. This approach guards against zeros in the likelihood function by taking account of the scale of the data. The total log-likelihood is then:

$$\ell = \ell_D + \ell_L + \ell_U,$$
$$\text{where } \ell_D = \sum_{a,t} \mathrm{n}(\log(D_{a,t}); \log(\hat{D}_{a,t}), \sigma_a^D),$$
$$\ell_L = \sum_{a,t} \mathrm{n}(\log(L_{a,t}); \log(\hat{L}_{a,t}), \sigma_a^L),$$
$$\ell_U = \sum_{a,t} \mathrm{n}(\log(U_{a,t}); \log(\hat{U}_{a,t}), \sigma_a^U).$$

The values of σ_a are modelled as the exponent of an orthogonal polynomial function of age, with 2 d.f. The standard deviations are constrained to be at least 0.05, to facilitate convergence of the minimizer used to find the maximum likelihood. For sole, the likelihood function for the discards observations is removed from the total likelihood function, because we assume there are no discards.

Parameter estimation and model selection

All model fitting was done using the FLR package. The negative of the likelihood function was minimized using the BFGS quasi-Newton or variable metric algorithm. Several starting values were selected randomly from a uniform distribution within appropriate boundaries, leading to different parameter estimates. This suggests that the likelihood function had several local maxima. We therefore selected the parameter estimates corresponding to the highest maximum likelihood among >50 runs. The model often converged to these parameter estimates, and we assumed that these correspond to the global maximum. Also, all eigenvalues of the numerically differentiated Hessian matrix at the parameter values presented here were positive, indicating that the parameter values indeed represented a maximum of the log-likelihood function.

Quantifying uncertainty

Maximizing the log-likelihood function results in maximum likelihood parameter estimates and the variance–covariance matrix that is derived from the inverse of the Hessian. For estimating parameter uncertainty, we selected 10 000 random values from a multivariate normal distribution with those parameter means and variance–covariances. The resulting random realizations are then used to estimate 95% confidence intervals for population and fisheries characteristics of interest, using the percentile method.

First round of reviews performed on Report

"Miller. C.M; J. J Poos 2010. Ex post and ex ante evaluation of the long term management plan for sole and plaice in the North Sea (part 2): ex ante. Working document to ACOM, August 2010

Reviewer 1: Paul Marchal (IFREMER, France)

OVERVIEW

This report presents the outcomes of an evaluation of the North Sea flatfish (plaice and sole) management plan incepted by the EU in 2007. It consists of two parts, one being a retrospective (*ex post*) evaluation of the plan's past conservation performances, and another one being an impact assessment (*ex ante*) of that plan in the future. The stock assessment required in Part 1 are performed using standard XSA, and also the new Statistical Catch at Age model (SCA), which offers an alternative way of estimating discards, and which is described in some details in an appendix. The stock, fishing mortality and catch projections required in Part 2 have been carried out using three methods of increasing complexity, building on, (1) equilibrium yield curve analyses, (2) individual stock projections and, (3) a full MSE. The results obtained in these reports suggest that the EU management plan has had desired effects since its inception, and that it is consistent with the ICES precautionary standards expressed by the WKOMSE.

The authors of this report provided useful work to evaluate the North Sea flatfish management plan. I did not find major flaws in the methods used and analyses carried out in Part 1, or in the equilibrium yield curve analysis performed in Part 2. However, I have two concerns with some of the other *ex ante* analyses. One is related to how the (N) starting points scenarios have been set in both the individual stock projections and in the MSE, and more particularly how these accounted for the North Sea plaice retrospective pattern. My other concern is dealing with how fleet dynamics have been designed and subsequently simulated in the MSE. As it stands now, the fleet dynamics module implemented by the authors is simple, but not necessarily realistic or robust, and it may provide an over-optimistic view of the performance of the management plan being evaluated.

PART 1: *EX POST* EVALUATION

p. 8, bottom. A lot of F-based reference points (F_{plan}, F_{max}, F_{pa}) are presented in the text. It would help to have these information gathered in one table for both stocks, along with F_{sq}.

p. 9. What is exactly the point of analysing F_{plaice}/F_{sole}? Were the calculations of the expert group, whatever it is, that provided the target-F of 0.3 and 0.2 for both stocks respectively included considerations about the ratio between the two Fs? If so, this would better be introduced. If not, I don't think this section is really useful, as it is not used anywhere else in the report.

p. 11-12. In Figures 4.1 & 4.2, the SSB retrospective pattern obtained with the XSA should be shown as in Figures 4.3 & 4.3. This is particularly important for plaice, the XSA assessment of which is subject to a strong retrospective pattern, and for which the derived 2009 N values are used to feed in the *ex ante* evaluation in Part 2.

p. 12, bottom. "*The increase from 2008 to 2009 is the result of the retrospective increase in the F estimates*". Are we talking about the difference in F(2007) obtained by running an XSA with or without the 2008 data? If so, the difference is quite small.

p. 13, legend of Figures 4.3 & 4.4. Is F_{mgt} calculated based on "TAC advice", as indicated in the legends, or rather on the TAC actually incepted by the EU?

PART 2: *EX ANTE* EVALUATION

p. 8, Table 3.2.1. The BRP against which the conservation performance of the flatfish management plan are evaluated are B_{lim} and F_{lim}. I appreciate, this is driven from the ICES WKOMSE guidelines. However, another objective should be that some MSY-based reference point is achieved (or exceeded) by 2015, with a high probability, which does not appear explicitly in the WKOMSE table. It is important to include this target (or limit) here, given the MSY objective is explicit in both the Johannesburg Declaration and in the second stage of the EU management plan.

p. 9, stock projections. Only one starting point seems to have been considered, which does not account for the plaice retrospective pattern. This may cause problems. The authors have attempted to account for the plaice retrospective pattern in the subsequent MSE by setting several starting points, so why not here?

p. 10, starting points. It would be useful to have a table with the actual numbers used in the four scenarios, so these could be compared with the values obtained in Part 1 (Figures 4.3 & 4.4). A point which worries me a bit is that the four starting points do not necessarily cover the range of likely N values. I am not concerned with the 3 points derived from SCA, which cover a reasonable range of possible values estimated with that method, but more with the fact that only 1 point covers the XSA-estimated SSB. We know that the plaice XSA assessment is subject to strong retrospective patterns. This was shown in Part 1 (Figure 4.3) for F estimates, and probably applies to SSB estimates (please show the SSB retrospective pattern in Part 1 – Figures 4.1 & 4.2). As stated several times in the report, this XSA retrospective pattern is problematic, and should be dealt with adequately. The way the authors are dealing with it here is by assuming that the SSB(2009) revised by future XSA assessments will lie within the 5-95% boundaries of the current SCA estimate. I would like to be convinced that this is realistic and adequate, and that updated SSB estimated by subsequent XSA assessments will not infringe the range of plausible SCA values. This could be checked by examining how successive XSA assessment values have historically lied relative to SCA percentiles. Should these XSA estimates fall occasionally beyond the SCA range, then alternative starting point ranges may need to be considered.

p. 10, fleet dynamics and the fishery, first paragraph. What is the difference between BT1 and BT2? Is one of them an otter trawl fleet from other countries and the other one a beam trawl fleet from other countries? Please clarify.

p. 11, bottom. "*All of the scenarios assume that the fleet will fish up both TACs while avoiding catching overquota*". If it is so, then we don't really have a fleet dynamics model. This assumption means that every year, fishers' catch allocation matches exactly their catch composition. However, it is generally admitted that this is not possible in a mixed fishery, even if that is regulated by an ITQ system like in the Netherlands. Either one species' quota will be underfished, or exceeded, leading to overquota discards and/or unreported landings. This has apparently applied to the North Sea flatfish fishery in the past, where catch-quota balancing has historically been poor for North Sea sole (Part 1, Figure 4.6). This unbalance means that it will not be possible to derive a common fishing effort metrics that matches the TAC of both sole and plaice, which is problematic (see next comment). I think the authors should have simulated a range of plausible fishers' behaviour scenarios, which could typically have been developed as a joint task with fisheries economists. It is a shame economist experts (e.g. from LEI) did not contribute to the development of this MSE, in collaboration with IMARES, as they might have provided useful inputs and expertise to the development of a more realistic fleet dynamics model.

p. 12, simulation of the multi-annual plan management measures. Because it is not possible to achieve a common metric to achieve the TAC of both plaice and sole, the authors implemented the maximum out of the two. This may lead to overquota landings for the species the targeted effort of which was lowest. The problem here is that the authors do not subtract those landings from the biomass, which impacts adversely the linkage between F and N for that species. We do not know the extent of these overquota landings (it would be useful to have them in a figure, as well as the simulated fishing effort trends), but if these are large, the procedure adopted by the authors here could seriously bias the results of the MSE, and provide an over-optimistic view of the conservation performances of the management plan.

p. 15, Figure 4.1.3. The legend indicates that this figure builds on the Ricker S/R curve, while it should refer to the segmented S/R curve

p. 24, Table 4.3.1. Table 4.3.1. (and more generally the results) could also show the performance of the plan with respect to achieving plausible target reference points, e.g. Pr(SSB_{2015} > B_{MSY}). The results may need to be revisited in the light of the concerns expressed above in relation to the design of the stock projection and MSE analyses.

Reviewer 2: Dorleta Garcia (AZTI - Marine Research Division, Spain)

Review of*: Ex post* and *ex ante* evaluation of the long term management plan for sole and plaice in the North Sea (part 2): *ex ante*

According to the criteria used, the scenarios run and the assumptions made, within the scenarios, it can be conclude that the plan is precautionary. However, there are some points that need clarification or that could be improve and lead to different conclusions.

In the introduction the report says that,

> *"… Plaice has a larger than 95% probability of having reached a stage where the SSB is above Bpa for two consecutive years. The XSA stock assessment indicates that this is also the case for sole…"*

Someone not familiar with the XSA could understand that sole has also a larger than 95% probability of having reached a stage where the SSB is above Bpa for two consecutive years, but XSA gives only point estimates so I suppose that what is only true is that the XSA SSB estimates have been above Bpa for two consecutive years.

Stock projections

- It would be interesting to consider here the scenarios with different starting points considered in the MSE approach. Further, when the more pessimistic results are obtained using this simple projection. It seems that better results are obtained under MSE approach because the assessment procedure within MSE overestimates F and because TAC is not always fully catch.

- Given that the approach is relatively simple, in principle not very time consuming and the variability in recruitment could be high it seems that 50 iterations are not enough. This fact is especially critical in the case of sole that 2 of the iterations bring the SSB below Blim. In the case of 50 iterations this represents a 4% of the iterations but if the number of iterations were increased this percentage will surely change. Thus, from only 50 iterations you can not assure that the probability of falling below Blim is less than 5%, at most you can say that this probability is low.

Full management strategy evaluation

- What is the reason to start the simulation in 2003? After I understand that the different starting points are taken in 2009, I don't understand the congruence between these two choices.

- In the description of the biological operating model it is not described how survival of existing age groups is modelled, the common way of doing it, in an age structured model, is using an exponential decay equation however in page 11 it says that the relationship between catch and effort is linear, which is incompatible with an exponential survival. The combination of both exponential survival with linear catch effort relationship will invalidate the analysis, so a clarification on this is needed. I assume that the exercise is correct, so

I assume that exponential survival and linear catch effort relationships have not been used simultaneously.

- Although the exploitation is divided into 3 fleets, in the results nothing is said about the performance of different fleets under the management plan. It would be interesting to assess the suitability of the plan from the point of view of the fleets; for example, does it affect the 3 fleets in the same degree?
- The '*part 1 ex post*' report refers to lack of proper specification of how the regulations are to be implemented for example in relation to how Fsq is calculated, however in page 12 *(part 2 ex ante)* it is not described how Fsq (F in year y-1) is calculated. Given that this is one uncertainty derived from the regulation, maybe it should be interesting to assess the performance of the management plan under different assumptions about Fsq.
- It seems not sensible to model the effort as the maximum of the amount needed to land the full TAC of each species and then do not removed the overquota landings from the population. For the population is the same as assuming that the regulation is fully fulfilled but for the fleets is like assuming that sometimes the catchability or selectivity decrease. This way of modelling could be valid for the biological populations but it seems somewhat meaningless for the fleets. (page 13).
- In the paragraph 3.5.4 it says that there is probably uncertainty in mortality rates, once it has been mentioned, a clarification on the importance of this uncertainty, the source of it, and an explanation of why it has not been included would be convenient. The same with the next sentence about simplifications and assumptions, which are the most important ones? What is the expected impact of these simplifications or assumptions in the results?
- Why consider SCA, SCA_5 and SCA_95 scenarios if you can consider the SCA results as an initial random population and then project the iterations in 1 single scenario?

In the discussion it says that the article 18 never come into effect within the simulations, but the SSB of sole fell below Blim in 2 iterations so in these iterations the article should come into effect, should not?

Reviewer 3: Stuart Reeves (Cefas Lowestoft Laboratory, UK)

A Review of Miller & Poos, 2010 "*Ex post* and *ex ante* evaluation of the long term management plan for sole and plaice in the North Sea (part 2): *ex ante*."

The Dutch ministry of Agriculture, Nature and Food Quality commissioned David Miller and Jan Jaap Poos of IMARES to extend their earlier evaluation of the multi-annual management plan for plaice and sole in the North Sea. That work was summarised in two reports: part 1, an *ex post* evaluation covering the implementation of the plan to date, and part2, an *ex ante* evaluation where simulation testing was used to evaluate whether the management plan could be considered to be precautionary. Subsequently, The Dutch ministry made a special request to ICES to review part 2 of the report, the ex ante evaluation, and to assess whether the EU multi-annual plan for management of sole and plaice in the North Sea is precautionary or not. This document is intended as one of a number of reviews made in response to the special request to ICES.

Methodology

The work uses a number of approaches of increasing complexity from yield curve analyses through to a full MSE approach. This is a useful and illuminating approach which is helpful for the comprehension of the results. For this reason I would also like to have seen an even simpler approach giving yield-per recruit curves and deterministic without stock-recruitment relationships, but that is a personal preference which does not affect the validity or utility of the work that is presented.

One point which emerges from the yield-curve analyses for sole is the F_{MSY} is estimated to be relatively high, in the range 0.51 to 0.59. From Figure 4.1.7 this appears to result from the yield-per recruit curve being almost flat, and not from the poorly-determined stock-recruitment relationship. One consequence of this is that the equilibrium yield associated with the current F-target (0.2) is only marginally smaller than that associated with the estimated F_{MSY}. In turn, the conclusion that the yield-per-recruit curve is flat results from the fixed weights at age and exploitation pattern assumed in the yield curves. While the authors do not propose changing the F-target on the basis of their analyses, it would nonetheless be useful to look at the impact of using other exploitation patterns and weights at age, perhaps selected from earlier in the stock history, on the estimates of F_{MSY}. Similar comments also apply in the case of the stock projections; there is a tendency to assume that the future stock trajectories will be driven only by recruitment whereas as abundance increases in response to low Fs, growth rate will be of increasing importance in determining stock biomass. While as yet there may be no basis for modelling density dependence in growth it would at least be useful to know how the weights at age used in the projections relate to past trends in these quantities. If the projection weights are low compared to historic trends then the overall conclusions from the analysis are likely to be more robust than if they are at the high end of observed values.

Figure 4.1.3 is incorrectly captioned; the results presented appear to use a segmented regression rather than a Ricker curve. In general the captions of Figure 4.1.3, 4.1.4, 4.1.7 and 4.1.8 are a little unhelpful. Specifically the "different reference points" shown by the grey dots, should either be individually identified (which reference points are they?) or only the MSY reference points should be retained.

I have difficulty in interpreting the comment relating to the yield curve analysis for both stocks that "the equilibrium SSB is far outside the range of SSBs observed during the last 60 years for the stock". It is unclear which SSB is meant, i.e. the equilibrium SSB at which F? Further, for plaice, while some of the unidentified grey dot reference points are outside of the observed range of SSB values, this is not the case at MSY, or for any of the sole reference points.

With regard to the MSE, the use of a 'worst case' scenario using both low starting populations and low recruitment is very helpful, and gives considerable confidence that conclusions about precautionarity are likely to be robust. I do have the slight caveat that the worst case should also have taken account of growth rates over the simulation period.

Different aspects of the work were conducted using different versions of R and the relevant FLR packages. While this is unlikely to have influenced the results, it does place an element of doubt in the reviewer's mind. It would be desirable to ensure consistency in R-version use for future work. Alternatively, details of R and package versions used should be listed in the same place within the document along with a comment to the effect that the use of different versions has been demonstrated not to affect results.

Conclusions

The EC flatfish management plan makes explicit reference to the linkages between the plaice and sole fisheries through the statement that: "A large part of the catches of plaice in the North Sea are taken together with catches of sole. The management of plaice cannot be addressed independently of sole" . However, in large part the management plan consists of rules for setting TACs for the two stocks independently of each other. The linkage only comes in the effort limitations which in principle are intended to complement the TACs. The way in which effort limits are derived is not clearly specified in the regulation but my interpretation would be the same as the authors, i.e. the effort will be set to the higher of the two values required to take either the sole or the plaice TAC. It could be argued that in practice this does not represent a limitation in effort; if vessels are fishing only for plaice and sole then they are likely to stop fishing once their quotas for both species are exhausted, hence capping effort at that level would not impose any additional restrictions. If this is the case then what is specified in the regulation is arguably better regarded as two single stock management plans rather than a combined flatfish management plan. Admittedly the regulation also allows for the possibility of more interventionist management actions under the "special circumstances" of either stock falling below its biomass limit, but these actions are not explicitly specified.

If there is a large difference between the level of effort corresponding to the TACs for the two stocks, then this is likely to lead to over-quota catches of the more restrictive species. Thus, under some circumstances, over-quota catches are an implicit consequence of the management plan. The authors explicitly acknowledge this and explicitly disregard the effect. Hence they are effectively also treating the plan as two separate, single stock management plans, and their conclusions need to be interpreted in that light.

For both stocks the results of the analyses indicate that the harvest control rules contained within the flatfish management plan have a very low probability of leading to the stocks declining below their biomass limit reference points over the time periods considered. This conclusion holds for both stocks even under a 'worst case' scenario of low starting population and subsequent recruitment. As a result, the two harvest control rules individually meet the criteria to be considered precautionary.

Final comments

In general I support the conclusion from the work that the management plan is in line with the ICES precautionary approach. However, I would like to highlight two areas which it would be useful to address in future evaluations:

- There is more to productivity than recruitment. Under conditions of sustained low fishing mortalities as are likely to be encountered if the apparent success of the management plan is continued, the influence of annual recruitment on stock size and yield is reduced and the importance of individual growth increases. There is a need to take more explicit account of this, particularly with regard to density dependence which may become apparent as the stock sizes increase.
- The management plan appears to have been effective so far in reducing fishing mortality towards the target values for both stocks. Nonetheless, there is a hypothetical possibility that linkages between the fisheries on the two stocks could cause problems if one stock falls to a low level while the other is high. This is a potential problem with the plan that should be explored further, e.g. through more explicit evaluation of the linkages and the possible implications in terms of over-quota catches.

Summary of responses/actions to address reviewer´s comments and concerns

The report was updated with responses to reviewers and including further analysis to address the mixed fishery issue "Miller. C.M; J. J Poos 2010. Combined *Ex post* and ex ante evaluation of the long term management plan for sole and plaice, including responses to ICES reviews

We appreciate the fact that all three reviewers concluded that the plan in essence appears in line with the precautionary approach. They had some concerns about possible mixed species fishery effects. We have tackled these concerns by adding analyses in the MSE framework that assume that the fishery will discard overquota plaice while ensuring the sole quota is completely taken. This has limited effect on the outlook for the plaice and sole SSBs. Thus the mixed fisheries concerns do not invalidate the conclusions from our reports, in that the plan is in line with the precautionary approach according to the WKOMSE criterion set up by ICES.

We are grateful that the three reviewers took the time to give their input to the review process. Below, we address the comments in more detail. The responses to the comments required additional analyses and improved text. We attach a report that combines the texts of the two earlier reports and addresses the comments, as indicated below.

	Comment	Response
	Dr. Garcia	
A1	In the introduction the report says that, "… Plaice has a larger than 95% probability of having reached a stage where the SSB is above Bpa for two consecutive years. The XSA stock assessment indicates that this is also the case for sole…" Someone not familiar with the XSA could understand that sole has also a larger than 95% probability of having reached a stage where the SSB is above Bpa for two consecutive years, but XSA gives only point estimates so I suppose that what is only true is that the XSA SSB estimates have been above Bpa for two consecutive years.	Although technically correct in the original document, this was phrased awkwardly. The text has been changed to clarify what is meant (summary section, conclusions section)
A2	It would be interesting to consider here the scenarios with different starting points considered in the MSE approach. Further, when the more pessimistic results are obtained using this simple projection. It seems that better results are obtained under MSE approach because the assessment procedure within MSE overestimates F and because TAC is not always fully catch.	The MSE is the most comprehensive exercise in the original reports. We feel that that is the more appropriate form for doing such exploratory analyses. Moreover, The WKOMSE requirements state that only the most recent assessment needs to be used.
A3	Given that the approach is relatively simple, in principle not very time consuming and the variability in recruitment could be high it seems that 50 iterations are not enough. This fact is especially critical in the case of sole that 2 of the iterations bring the SSB below Blim. In the case of 50 iterations this represents a 4% of the iterations but if the number of iterations were increased this percentage will surely change. Thus, from only 50 iterations you can not assure that the probability of falling below Blim is less than 5%, at most you can	This is a very valid point. We have redone the analyses, using 500 iterations. The results do not change the conclusions of the original reports: For sole, of the 500 iterations, only 22 bring the SSB below Blim. This is less than 5%, and a more robust estimate given the uncertainty of the outcomes (sections 3.7 and 4.8).

	say that this probability is low.	
A4	What is the reason to start the simulation in 2003? After I understand that the different starting points are taken in 2009, I don't understand the congruence between these two choices.	Text has been added to the document explaining this. In short, it was done to test the appropriateness of the catcahability estimates in the future, by comparing the model results to current observations.
A5	In the description of the biological operating model it is not described how survival of existing age groups is modelled, the common way of doing it, in an age structured model, is using an exponential decay equation however in page 11 it says that the relationship between catch and effort is linear, which is incompatible with an exponential survival. The combination of both exponential survival with linear catch effort relationship will invalidate the analysis, so a clarification on this is needed. I assume that the exercise is correct, so I assume that exponential survival and linear catch effort relationships have not been used simultaneously.	The reviewer is correct. This was an unfortunate error in the text of the report. Of course, the text should have stated that there is a linear relationship between fishing effort and fishing mortality, according to the classical population dynamics theory. This was what has been used in the actual calculations. This has been fixed in the text (section 3.8)
A6	Although the exploitation is divided into 3 fleets, in the results nothing is said about the performance of different fleets under the management plan. It would be interesting to assess the suitability of the plan from the point of view of the fleets; for example, does it affect the 3 fleets in the same degree?	There are differences in the outcomes for the different fleets. However, the data to parameterize the model in this respect is limited, and model results probably underestimate true differences.
A7	The 'part 1 ex post' report refers to lack of proper specification of how the regulations are to be implemented for example in relation to how Fsq is calculated, however in page 12 (part 2 ex ante) it is not described how Fsq (F in year y-1) is calculated. Given that this is one uncertainty derived from the regulation, maybe it should be interesting to assess the performance of the management plan under different assumptions about Fsq.	Indeed, the procedure is not described in the text of the council regulation. However, since the implementation, there is agreement between ICES and STECF on how this should be calculated. The analyses in the report are done accordingly.
A8	It seems not sensible to model the effort as the maximum of the amount needed to land the full TAC of each species and then do not removed the overquota landings from the population. For the population is the same as assuming that the regulation is fully fulfilled but for the fleets is like assuming that sometimes the catchability or selectivity decrease. This way of modelling could be valid for the biological populations but it seems somewhat meaningless for the fleets. (page 13).	New scenarios making assumptions about mixed fisheries behaviour have been run and added to the results (see section 4.9). In short, the conclusions about the plan being in line with the WKOMSE criteria does not change. It should be noted that it is difficult to capture the dynamics of the fleets in a mechanistic way in these MSEs. Using overly simplified assumptions about the fleet behaviour and overquota discarding may lead to false conclusions. As can be seen in Figure 3.1, the fleet has historically been able to adapt its catchability for the two species.
A9	In the paragraph 3.5.4 it says that there is probably uncertainty in mortality rates, once it has been mentioned, a clarification on the importance of this uncertainty, the source of it, and an explanation of why it has not been included would be convenient. The same with the next sentence about simplifications and assumptions, which are the most important ones? What is the expected impact of these simplifications or assumptions in the results?	To our knowledge, almost all forward projections make assumptions about fixed natural mortalities, despite the realisation that there must be (unknown) variability in time. Even the majority of the ICES stock assessments make crude (and often unjustifiable) assumptions about M. We do discuss the likely impact of various assumptions in the discussion section.

A10	Why consider SCA, SCA_5 and SCA_95 scenarios if you can consider the SCA results as an initial random population and then project the iterations in 1 single scenario	Indeed the suggestions of the reviewer is valid, and was considered. However, our interest was in seeing the outcomes in "good" and "bad" starting points. The approach in the report estimates those at low computational costs. Text was added to the report explaining this.
A11	In the discussion it says that the article 18 never come into effect within the simulations, but the SSB of sole fell below Blim in 2 iterations so in these iterations the article should come into effect, should not?	Text was added to the document discussing this comment. Although the stock did go out of safe biological limits, theoretically allowing article 18 to be applied, no further action was needed to return the stock to within safe biological limits in the next year. Our results could be interpreted as being precautionary in not assuming strong measures that would not be taken in reality (section).
	Dr Reeves	
B1	there is a tendency to assume that the future stock trajectories will be driven only by recruitment whereas as abundance increases in response to low Fs, growth rate will be of increasing importance in determining stock biomass. While as yet there may be no basis for modelling density dependence in growth it would at least be useful to know how the weights at age used in the projections relate to past trends in these quantities. There is more to productivity than recruitment. Under conditions of sustained low fishing mortalities as are likely to be encountered if the apparent success of the management plan is continued, the influence of annual recruitment on stock size and yield is reduced and the importance of individual growth increases. There is a need to take more explicit account of this, particularly with regard to density dependence which may become apparent as the stock sizes increase.	There are several issues raised here. In response to this point, indeed we cannot parameterize the density dependent growth and mortality. In the new report, we now show the weights used (the average of the last five years, or a resampling of the last five years; Figure 4.11). There it becomes evident that those last five years are the lower end of the statistical distribution of the historic weights.
B2	Figure 4.1.3 is incorrectly captioned; the results presented appear to use a segmented regression rather than a Ricker curve. In general the captions of Figure 4.1.3, 4.1.4, 4.1.7 and 4.1.8 are a little unhelpful. Specifically the "different reference points" shown by the grey dots, should either be individually identified (which reference points are they?) or only the MSY reference points should be retained.	This has been corrected. Also, the different reference points have been colour coded to aid the reader (Figures 4.14, 4.15, 4.18, 4.19)
B3	I have difficulty in interpreting the comment relating to the yield curve analysis for both stocks that "the equilibrium SSB is far outside the range of SSBs observed during the last 60 years for the stock". It is unclear which SSB is meant, i.e. the equilibrium SSB at which F?	This should be equilibrium SSB at Fmsy. The text has been changed to reflect the fact that is only the case for plaice (sections 3.6 and 4.7).
B4	With regard to the MSE, the use of a 'worst case' scenario using both low starting populations and low recruitment is very helpful, and gives considerable confidence that conclusions about precautionarity are likely to be robust. I do have the slight caveat that the worst case should also	As we explained in response B1, the chosen weights are already at the lower end of the statistical distribution of the historic observations (see also Figure 4.11). Additionally increased growth at lower abundances (as a result of density

	have taken account of growth rates over the simulation period.	dependent growth) would not make for a worse case scenario than our current assumptions.
B5	Different aspects of the work were conducted using different versions of R and the relevant FLR packages.	Newer versions of FLR have better methods for fitting S/R curves. Therefore different versions of FLR have been used. Each group of analyses was done in the same version of FLR.
B6	However, in large part the management plan consists of rules for setting TACs for the two stocks independently of each other. The linkage only comes in the effort limitations which in principle are intended to complement the TACs. The management plan appears to have been effective so far in reducing fishing mortality towards the target values for both stocks. Nonetheless, there is a hypothetical possibility that linkages between the fisheries on the two stocks could cause problems if one stock falls to a low level while the other is high. This is a potential problem with the plan that should be explored further, e.g. through more explicit evaluation of the linkages and the possible implications in terms of over-quota catches.	We have addressed this question, see response A8
	Dr Marchal	
C1	p. 8, bottom. A lot of F-based reference points (Fplan, Fmax, Fpa…) are presented in the text. It would help to have these information gathered in one table for both stocks, along with Fsq.	Table 3.1 was added, listing the important F and SSB reference points
C2	p. 9. What is exactly the point of analysing Fplaice/Fsole? Were the calculations of the expert group, whatever it is, that provided the target-F of 0.3 and 0.2 for both stocks respectively included considerations about the ratio between the two Fs? If so, this would better be introduced. If not, I don't think this section is really useful, as it is not used anywhere else in the report.	This was done to show the changes in relative catchability between the two stocks, and to give an indication if the target F values are reconcilable.
C3	p. 11-12. In Figures 4.1 & 4.2, the SSB retrospective pattern obtained with the XSA should be shown as in Figures 4.3 & 4.3. This is particularly important for plaice, the XSA assessment of which is subject to a strong retrospective pattern, and for which the derived 2009 N values are used to feed in the ex ante evaluation in Part 2.	Figures taken from the advice sheets were added as Fig 4.1c and 4.2c. These show the retrospective pattern in the ICES stock assessments. See also the text of section 4.2.
C4	p. 12, bottom. "The increase from 2008 to 2009 is the result of the retrospective increase in the F estimates". Are we talking about the difference in F(2007) obtained by running an XSA with or without the 2008 data? If so, the difference is quite small.	The difference is indeed small
C5	p. 13, legend of Figures 4.3 & 4.4. Is Fmgt calculated based on "TAC advice", as indicated in the legends, or rather on the TAC actually incepted by the EU?	Because ICES has advised according to the management plan, these values are the same
C6	p. 8, Table 3.2.1. The BRP against which the conservation performance of the flatfish management plan are evaluated are Blim and Flim. I appreciate, this is driven from the ICES WKOMSE guidelines. However, another objective should be that some MSY-based reference point is achieved (or exceeded) by 2015, with a high probability,	A section is added in the methods describing the (lack of) Fmsy targets for these stocks. In the absence of accepted Fmsy values, the targets set in the multi-annual plan (which were initially conceived on the basis of high long term yields) can be used in their stead. In the

	which does not appear explicitly in the WKOMSE table. It is important to include this target (or limit) here, given the MSY objective is explicit in both the Johannesburg Declaration and in the second stage of the EU management plan.	results section it was noted whether or not the F targets were reached by 2015.
C7	p. 9, stock projections. Only one starting point seems to have been considered, which does not account for the plaice retrospective pattern. This may cause problems. The authors have attempted to account for the plaice retrospective pattern in the subsequent MSE by setting several starting points, so why not here?	Here, we like to refer to response A2
C8	p. 10, starting points. It would be useful to have a table with the actual numbers used in the four scenarios, so these could be compared with the values obtained in Part 1 (Figures 4.3 & 4.4). A point which worries me a bit is that the four starting points do not necessarily cover the range of likely N values. I am not concerned with the 3 points derived from SCA, which cover a reasonable range of possible values estimated with that method, but more with the fact that only 1 point covers the XSA-estimated SSB.	A table (Table 3.3) was added to the report (in section 3.8). Also, text was added to the report justifying our choices. Finally, we also want to point out that our scenario testing already exceeds the requirements drafted by WKOMSE.
C9	p. 10, fleet dynamics and the fishery, first paragraph. What is the difference between BT1 and BT2? Is one of them an otter trawl fleet from other countries and the other one a beam trawl fleet from other countries? Please clarify.	This has been clarified in the text of section 3.8
C10	p. 11, bottom. "All of the scenarios assume that the fleet will fish up both TACs while avoiding catching overquota". If it is so, then we don't really have a fleet dynamics model. This assumption means that every year, fishers' catch allocation matches exactly their catch composition. We do not know the extent of these overquota landings (it would be useful to have them in a figure, as well as the simulated fishing	We have addressed this question, see response A8
C11	p. 15, Figure 4.1.3. The legend indicates that this figure builds on the Ricker S/R curve, while it should refer to the segmented S/R curve	We have addressed this question, see response B2
C12	p. 24, Table 4.3.1. Table 4.3.1. (and more generally the results) could also show the performance of the plan with respect to achieving plausible target reference points, e.g. Pr(SSB2015 > BMSY). The results may need to be revisited in the light of the concerns expressed above in relation to the design of the stock projection and MSE analyses.	The ICES MSY framework does not incorporate Bmsy targets. The question addressed in the same section as for C6.

Reviews performed on the updated report

i) Dorleta Garcia:

The comments have been addressed properly in general in the last report. Regarding mixed fisheries, the new scenarios gave similar results to those obtained previously, i.e, the management plan is in line with the precautionary approach given these scenarios. However, I find a bit strange the justification for considering only scenario where the effort is limited by sole's TAC. Being sole the more profitable, would not be sensible (from fishermen point of view) to continue fishing until plaice quota is exhausted and misreport sole catches?

The authors say that when sole quota is exhausted the fishermen could move further north to avoid catching sole, but this will imply higher variable cost (fuel, time…) and given plaice is less profitable than sole, misreporting or discarding sole would be, in principle, more profitable.

ii) Stuart A. Reeves:

In a previous document I reviewed an evaluation of the long term management plan for sole and plaice in the North Sea by Dr David Miller & Dr Jan Jaap Poos. Subsequently, the authors have provided a revised evaluation which addresses comments made by myself and two other ICES reviewers. This document summarises my comments on their revised evaluation.

The revised analyses have addressed both my concerns about growth and mixed fishery effects. With regard to growth, the authors illustrate that the weights at age used in the projections are towards the lower end of the observed values. This gives additional confidence that the conclusions from the analyses are robust.

The authors now account for potential mixed fishery effects by modelling a number of possible fleet effort scenarios in response to the quotas for the two stocks. These include the possibility that vessels might continue fishing for sole even though the plaice quota is exhausted but not the converse. This is justified on the basis that fishing for plaice alone is generally not economically worthwhile, and that anyway vessels change the spatial allocation of effort in response to quota availability. The latter is a relatively strong assumption, but I note that it has been demonstrated to occur in this case, for the Dutch fleet at least (Quirijns *et al*, 2008; Poos *et al*, 2010), hence it is a reasonable assumption to make.

I am confident that the additional analyses performed by Drs. Miller & Poos support their earlier conclusion that the flatfish plan can be considered precautionary. I would also like to thank the authors for their quick and thorough response to the referees comments.

References

Poos, J J, Bogaards J A, Quirijns, F J, Gillis, D M, and Rijnsdorp, A D (2010) Individual quotas, fishing effort allocation, and over-quota discarding in mixed fisheries. ICES Journal of Marine Science 67:323- 333.

Quirijns, F J, Poos,, J J & Rijnsdorp, A D (2008) Standardising commercial CPUE data in monitoring stock dynamics: accounting for targeting behaviour in mixed fisheries. Fisheries Research 89: 1-8.

iii) Paul Marchal:

1) The starting points (N) used to run the MSE. Because of its retrospective pattern (tendency to underestimate N and to overestimate F in recent years), I was concerned that the plaice SSB derived from XSA could lie well outside of the SCA estimates. The new Fig. 4.1 indicates that the newly estimated SSBplaice(2008) was about 350 kt, while it had been estimated at around 250 kt in the previous year's assessment. The correction factor is of 350/250 = 1.4. If we apply the same correction factor to SSB(2009), which is estimated to around 385 kt in the most up-to-date assessment (Table 3.3), then the SSBplaice(2009) estimated in the next year's assessment would be of 1.4*385 kt = 540 kt, which is quite beyond the SCA percentiles range indicated in Table 3.3. I do not suggest the authors run extra simulations using SSBplaice(2009)=540 kt as a starting value, because this value is the most optimistic of all, and would therefore not contradict the main conclusion that the plan is overall precautionary. Still, if a similar MSE had been carried out in a situation where the retrospective pattern was the other way round (tendency to overestimate N and to underestimate F), which happened for NS plaice only a few years ago when the stock was on the down side, then the situation would have been quite different, and alternative starting points may have been needed. This could be accounted for by adding a few words of caution in the discussion.

2) The fleet dynamics model. I'm quite happy with the way the authors have coped with my comment. They have added two extreme scenarios, alla Fcube, which do not contradict the main conclusion of that work. This is acceptable to me.

Overall, I'm happy with the revisions made by the authors. Adding one or two sentences in the discussion to account for my first point could be helpful.