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Evaluation of Proposed Amendments to the North Sea Flatfish Multiannual Plan

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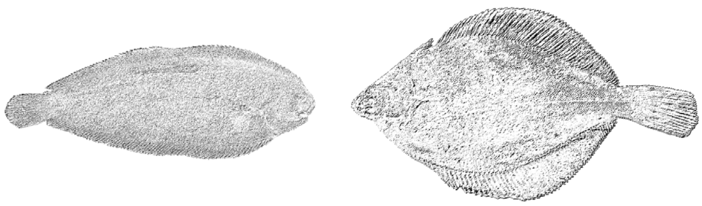

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Contents

Executive Summary

In 2007, the European Commission (EC) adopted Council Regulation No 676/2007, establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea. In 2010 IMARES provided a thorough simulation Management Strategy Evaluation (MSE) of the EU management plan for sole and plaice in the North Sea. This evaluation (Miller and Poos, 2010) as well as a subsequent STECF evaluation (Simmonds *et al*., 2010b) found the plan to be precautionary while providing high long term yields. In April 2012, IMARES, through ICES, received a special request from the Netherlands to evaluate whether a number of proposed amendments to the plan are in accordance with the precautionary principle and MSY approach. In summary, the proposed amendments comprise a change in the target fishing mortality for sole from 0.20 to 0.25 and ceasing reductions of the Maximum Allowable Effort. The current report provides the response to this special request.

The evaluation of the multiannual plan is carried out using a numerical simulation model to study the interplay between the biological dynamics of the stocks and the dynamics of the fleet. The biological operating model consists of age structured population models of the 'true' plaice and sole stocks in the North Sea, following current stock delineations (see WGNSSK, 2012). The effects of the fishery on the two stocks is modeled as the combined effect of three different fishing fleets: a BT2 Dutch beam trawl fleet (80mm mesh, targeting plaice and sole), a Dutch fleet with gears other than BT2 (targeting plaice) and a fleet for the other countries (targeting plaice).

A number of management strategies were tested under various scenarios, including differing assumptions on biology and fleet behavior. For the main purpose of responding to the special request a comparison is done between the current management plan ("CurMP") and the proposal for an amended management plan ("Proposal") under a "BaseCase" scenario. Subsequent scenarios examined sensitivity of the results to several assumptions incorporated in the biological operating model (alternative stock perception as a starting point and different levels of stock productivity: "WorstCase" and "BestCase") and in the fleet operating model (differences in effort deployment and inclusion of technological creep: "DepEffLeast","DepEffMost" and "TechCreep").

Under base case assumptions, the proposed amendments to the current management plan are in accordance with the precautionary approach and consistent with the principles of MSY. Further scenarios indicate that the proposed management plan is capable of prevent collapse of the stocks under very low productivity and of generating high yields under high productivity regimes.

1 The assignment

On 23 May 2012, ICES received a special request from the Dutch Ministry of Economic Affairs, Agriculture and Innovation to evaluate a number of amendments to the multi-annual plan for North Sea plaice and sole which is currently in force by means of Council Regulation EC676/2007 (Appendix A). This request stipulates "to assess whether two proposed changes to articles 4 and 9 of the multiannual plan are consistent with the precautionary and MSY approach in conformity with ICES criteria".

The proposed change to article 4 of the plan implies to change the target fishing mortality (to be applied in the second stage of the plan) for sole from 0.20 to 0.25 (while the target fishing mortality for plaice remains the same).

The proposed change to article 9 of the plan implies to freeze the maximum allowable fishing effort (kW days), while both the sole and plaice stocks are within safe biological limits. This was agreed with ministry representatives during the process of the current evaluation being conducted to interpret freezing as maintaining the effort level for the BT2 fleet from 2013 onward at the 2012 level. In other words, the TAC is used as the exclusive mechanism for meeting the plan's long term objectives. When one or both stocks fall back outside safe biological limits, than a reduction in maximum allowable fishing effort should be applied to help recover the stock(s) to within safe biological limits again.

On 20 April 2012 ICES received an unofficial, yet more elaborate, specification of the above mentioned request. The full text of this earlier request – as well as the official special request form received by ICES in May – are included in this report in Appendix B.

2 Background information

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. The objective of the multiannual 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 limitation of 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 implementation of 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.

TAC setting procedures are provided independent of the applicable stage of the plan (article 7) through a HCR which describes both a recovery process (reductions of F by 10% annually) and a stable plateau stage continuous application of an F of 0.3 when this level is reached (which at the time of developing the plan was the suggested value by ICES to approximate F_{MSY}). Where application of the previous would result in a TAC which differs from the TAC of the preceding year by more than 15 %, a TAC change of 15 % is applied. The multiannual plan furthermore prescribes the maximum allowable effort (kW-days) to be adjusted according to changes in fishing mortality (assuming a linear relationship between F and effort). The Council Regulation is included in this report in Appendix A.

The adopted plan is the main instrument for flatfish management in the North Sea. It should also 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 fishing mortality rate for plaice is to a great extent due to the 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 setting total allowable catches (TACs) for 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.

In 2010 IMARES provided a Management Strategy Evaluation (MSE) of the EU management plan for sole and plaice in the North Sea. This evaluation (Miller and Poos, 2010) as well as a subsequent STECF evaluation (Simmonds *et al*., 2010b) found the plan to be precautionary while providing high long term yields. Based on these simulations, ranges of F suitable as a basis for F_{MSY} were proposed to and accepted by ICES (WGNSSK 2011) as well. For plaice, an F range of 0.2-0.3 was considered appropriate as a basis for F_{MSY}. For sole, any F value on the range 0.20-0.25 was suggested to produce high yields while maintaining low risk to the stock.

The Council Regulation has been used as the basis for establishing TACs for North Sea plaice and sole since 2008. North Sea plaice F has been relatively stable and below the target F level since 2008 and consequently TAC has been increasing (at the maximum allowed 15% TAC change limit for the last 3 years). 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. A decrease in the F of North Sea sole can be observed over the same time period, although the current F remains above the plan's target. TACs have been relatively stable under the multiannual plan at a somewhat lower level as in the period preceding the implementation of the plan. In the future, they are likely to fluctuate depending on the strength of incoming year classes.

An *ex post* evaluation of the performance of the management plan over the first three years (Miller and Poos 2010) found it difficult to determine whether the current level of exploitation is to be regarded as a result of the TACs established under the plan, or the annual reductions in allowable effort. Moving into the second stage of the plan should see a stabilisation in F at or around the target values, which in turn should lead to more stable allowable effort each year. Consequently this should lead to TACs becoming the driving factor in determining the exploitation levels on the stocks in future.

ICES concluded in June 2011 that both North Sea plaice and sole stocks were within safe biological limits, for two consecutive years, and that the first stage of the plan was achieved. Upon entering the second stage of the plan the Commission should propose amendments to the plan in relation to the target fishing mortality for plaice and sole, and on fishing effort limitation, with a view to permit the exploitation in accordance with the principles of MSY (following article 5). IMARES, through ICES, received a special request from the Netherlands to evaluate whether a number of proposed amendments to the plan are in accordance with the precautionary principle and MSY approach. In summary, the proposed amendments comprise a change in the target fishing mortality for sole from 0.20 to 0.25 and ceasing reductions of the Maximum Allowable Effort.

2.1 Reference points

Reference points are utilised within the plan in two ways:

1) As indications of the condition of the stocks in relation to safe biological limits (SBL): set according to the principles of the precautionary approach. In case when either of the stocks are outside of SBL, more drastic management measures can be taken.

2) As target fishing mortalities for each stock: set according to the principles of F_{MSY}.

2.1.1 Precautionary approach reference points

North Sea plaice

The current precautionary approach reference points for this stock were established by WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock-recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks. Therefore, ICES considered that B_{lim} can be set at B_{loss}=160 000 t and that B_{pa} can then be set at 230 000 t using the multiplier of 1.4 (although the WG acknowledges that, since the noisy discards estimates have been included, the uncertainty of the estimates of stock status is much greater than that, see Kraak *et al*. 2008). F_{lim} was set at F_{loss} (0.74). F_{pa} was proposed to be set at 0.6 which is the 5^{th} percentile of F_{loss} and gave a 50% probability that SSB is around B_{pa} in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 t.

North Sea sole

The current reference points are B_{lim}= B_{loss}= 25 000 t and B_{pa} is set at 35 000 t using the default multiplier of 1.4. F_{pa} was proposed to be set at 0.4 which is the 5th percentile of F_{loss} and gave a 50% probability that SSB is around B_{pa} in the medium term. Equilibrium analysis suggests that F of 0.4 is consistent with an SSB of around 35 000 t.

2.1.2 MSY reference points

In 2010 ICES implemented the MSY framework for providing advice on the exploitation of stocks, aiming to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock. However, given the hierarchic rules for providing advice (following WKFRAME2), advice is provided on the basis of a management plan when this is available. The current fishing mortality targets for plaice and sole included in the management plan are 0.2 and 0.3 respectively. Hence, these values are used to provide advice (taking account of other constraints included within the management plan).

The STECF evaluation of the plan (Simmonds *et al*., 2010b) included an equilibrium analysis approach to determine FMSY, taking into account uncertainty in stock-recruitment relationships. In light of these analyses, revised MSY framework reference points and ranges, for both stocks were proposed to and accepted by ICES.

North Sea plaice

The MSE simulations conducted by IMARES (2010) indicated that alternative F targets in the 0.15 to 0.3 range lead to the stock stabilising at different levels of SSB, all above B_{pa} and were precautionary with regards to the limit reference points in the short and long term. In additional, long term yields for Fs over the range 0.2-0.3 showed negligible differences. An equilibrium analyses taking into account uncertainty in stock-recruitment relationships indicated that alternative F targets over the range 0.2-0.3 all lead to similar long term TAC values. The estimate of F_{MSY} from the long term equilibrium analysis method using 2010 assessment values, gave a value for North Sea plaice of F=0.25 (latest calculations; Simmonds, *et al*. 2010b). On the basis of these analyses an F range of 0.2-0.3 was considered appropriate as a basis for F_{MSY}.

It was considered that while MSY framework advice (which uses a point value and does not consider a range) should be provided on the basis of F_{MSY}=0.25, while the stock should be considered to be sustainably fished (e.g. in stock status tables) for any F on the range 0.2-0.3, which includes the management plan target value (F=0.3). This would ensure that ICES will not provide advice on this basis of the management plan while simultaneously stating that the stock is being unsustainably fished in relation to F_{MSY} at this level. While the analyses and discussions had focused on the appropriate exploitation rate for this stock, in addition, a biomass trigger point of 230 000t (MSY $B_{trigger}$ = B_{pa} = 230 000t) for plaice was considered to be appropriate.

North Sea sole

On the basis of the CEFAS ADMB analyses (ICES 2010b), an F target of 0.22, within the range 0.13-0.39 (based on stochastic equilibrium analysis), was considered appropriate as a basis for F_{MSY}. The MSE simulations conducted by IMARES in 2010 indicated that alternative F target values in the range 0.15 to 0.35 result in both short term and long term differences in TAC. An F target of 0.15 produced lower TACs in both the short and long term, while an F target of 0.30 provided higher short term TACs, slowly becoming more similar to the long term TACs from F targets in the 0.2-0.25

range. There was a short term difference between 0.20 and 0.25, though in the long term this was less substantial. However, for F values above 0.25 there was an increasing risk of driving the stock out of safe biological limits and exploitation levels greater than this were not considered to be precautionary. The equilibrium analyses taking into account uncertainty in stock-recruitment relationships using 2010 assessment values gave an F_{MSY} value for North Sea sole of F=0.32. However, it was considered that it was important to take the risk into account when setting the target F for sole. An increase in F target might lead to higher catches, but the risks associated with increase in target F above 0.3 are considered to be not precautionary, according to stochastic equilibrium analysis and simulation study results.

On the basis of these analyses ICES concluded that F=0.22 is an appropriate value for F_{MSY} for the North Sea sole stock as it results in a high long term yield, while maintaining the SSB above B_{lim} with a high probability. This finding is supported by all analyses including simulation tests, uncertainty in input parameters and uncertainty in stock-recruitment relationships. In addition, it seemed that any F value on the range 0.20-0.25 produces high yields while maintaining low risk SSB decreasing below B_{lim}. Therefore it is recommended that while MSY framework advice should be provided on the basis of F_{MSY}=0.22, the stock should be considered to be sustainably fished (e.g. in stock status tables) for any F on the range 0.2-0.25. This range also includes the management plan target value. While the analyses and discussions focussed on exploitation rates, a biomass trigger point (MSY $B_{trigger}$) of 35 000t for sole, corresponding to B_{pa} for the stock, was considered to be appropriate.

An overview of the different F and SSB reference points important for management of the two stocks is given in Table 2.1, as well as the proposed values evaluated in the current analysis.

Table 2.1. F and SSB reference points important for management of the two stocks

	B_{LIM}	B_{PA}	F_{PA}	F_{MSY}	$F_{MSY\ (RANGE)}$	$F_{TARGET(MP)}$	$F_{TARGET(PROPOSED)}$
Sole	25 000 t	35 000 t	0.40	0.22	0.20-0.25	0.20	0.25
Plaice	160 000 t	230 000 t	0.60	0.30	0.20-0.30	0.30	0.30

3 Methods

The evaluation of the multiannual plan is carried out using a numerical simulation model to study the interplay between the biological dynamics of the stocks and the dynamics of the fleet. Figure 3.1 provides a general overview of how the model operates in terms of linking fish stocks to management decisions to fleet behaviour. 'True' fish stocks (in the biological operating model) and fleets (in the fleets operating model) are simulated from the available information using simple population and fleet dynamics principles. In the model, the future fisheries management strictly follows the rules of the management measures to be evaluated. Observation uncertainty in the management system is modelled by assuming random noise for the landings, discards and surveys, based on historical estimates of uncertainty (2012 SCA results). This way, a "perceived stock" is created that is used for subsequent year's management decision.

The evaluation consists of a number of management strategies applied to a set of biological, fishery and implementation scenarios. Each strategy-scenario combination (consisting of one management strategy applied to one scenario, called a 'run') was simulated for a number of iterations to capture stochastic variability.

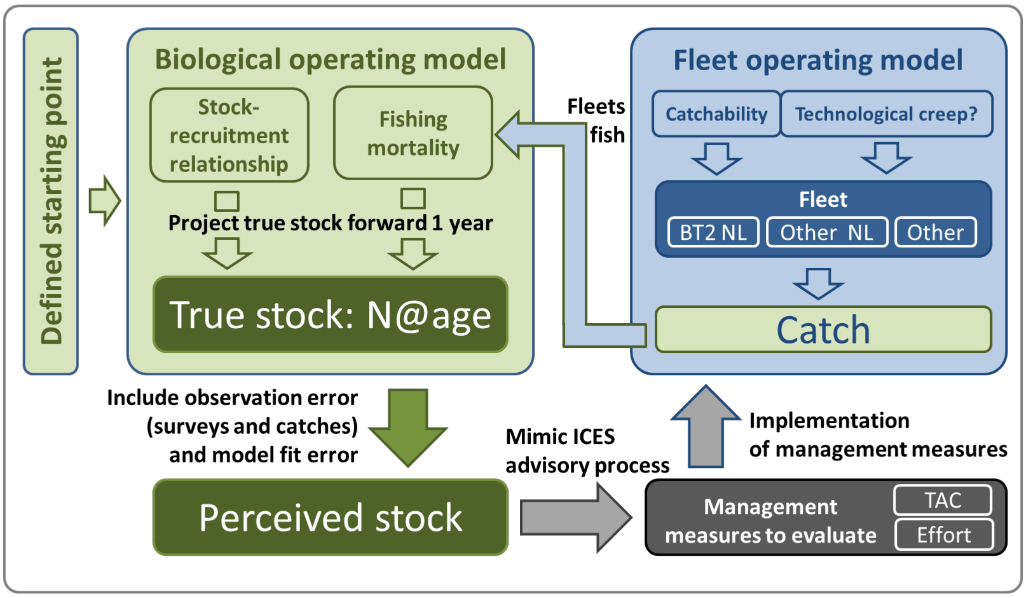


Figure 3.1. Schematic overview of how the biological and fleet operating models interact in each year of the simulations.

3.1 Simulation scenarios and management strategies

A number of management strategies were tested under various scenarios, including differing assumptions on biology and fleet behavior. For the main purpose of the special request a comparison is done between the current management plan ("CurMP") and the proposal for an amended management plan ("Proposal"). In addition, results are presented for assessing the effects of the two proposed changes individually (i.e. new sole Ftarget with effort management retained, "NewF"; and old sole Ftarget fixing the maximum allowable effort to the 2012 level, "EffCap"), i.e. for only amending article 4 or 9 respectively. These four strategies were conducted on the base case biological and fleet scenario.

Subsequent scenarios examined sensitivity of the results to several assumptions incorporated in the biological operating model (alternative stock perception as a starting point and different levels of stock productivity: “WorstCase” and “BestCase”) and in the fleet operating model (differences in effort deployment and inclusion of technological creep: “DepEffLeast”,“DepEffMost” and “TechCreep”).

3.1.1 Base Case Scenario Runs

The runs under the base case scenario were undertaken to assess the impact of introducing the proposed changes to article 4 and/or 9 of the management plan (focussing on the combined effect of both changes, with results of individual change runs presented in the appendices). In the four management strategies listed in Table 3.1 the F-target for plaice is 0.30 (no changes are proposed for plaice Ftarget), the maximal TAC change for both species is 15%, the maximal Maximum Allowable Effort (MAE) change is 10%, technological creep is assumed to not occur and deployed effort is assumed to be precisely partitioned between plaice and sole landings until both TACs are fully utilized and there are no over-quota catches. These runs are used to assess whether or not the plan subject to the proposed changes can be considered as precautionary and in agreement with the principles of F_{MSY}.

3.1.2 Best and Worst Case Scenario Runs

In the next 5 runs (see Table 3.1) a best and worst case scenario are investigated. The best case scenario (runs 5-7) is used to examine whether the proposed changes to the management plan allow for yield to be maximized under favourable conditions. The worst case scenario (runs 8-9) assume continuous recruitment throughout the projected time series of the lowest observed value without variation is aimed at gaining insights into how the proposed management plan compares to the current management plan under such extraordinary conditions. It should serve to assess whether the management measures (and their ability to adapt to the invoked biological changes) in such circumstances will lead to complete crashes of the stock(s) or whether the stocks can be expected to undergo such severe changes, possibly decrease to below B_{lim}, but recover and stabilize at a lower level of SSB. In addition, an alternative management strategy is included in this scenario (“ProposalHCR”) in which a biomass trigger is introduced at B_{pa}, below which the target F is linearly reduced to zero at an SSB of zero. Such biomass triggers are commonly included in multiannual plans, and should help prevent stocks from crashing when a substantial reduction in general productivity of the stock is observed.

In these five runs, F-target for plaice is 0.30, the maximal TAC change is 15%, the maximal MAE change is 10%, technological creep is assumed not to occur and implemented effort is assumed to be precisely partitioned between plaice and sole landings until both TACs are fully utilized and no over-quota catches are discarded.

3.1.3 Effort Deployment Scenario Runs

To test the robustness of the proposed management measures under different assumptions on how the fleet partitions effort between plaice and sole landings, the proposal was tested under two specific scenarios (number 10-11 in Table 3.1). Their results are presented in the results section together with run 2 under the base case scenario for comparison. The scenarios differ in how the NL BT2 fleet is assumed to deploy effort. The base case scenario assumes that the fleet is able to land its individual stock TACs independently of each other (*both*). Alternative scenarios were examined in which either the TAC requiring the *least* effort became limiting (i.e. the remainder of the other TAC goes uncaught) or the TAC requiring the *most* effort is limiting (i.e. fishing continues until the last TAC is landed and over-catch of the other stock is discarded). In all cases the effort cap (fixed MAE at the 2012 level) still applies, meaning that the MAE may become restrictive and the TAC is not fully landed.

In these scenarios the model is conditioned as in the base case scenarios, i.e. using the most recent XSA results as a starting point and using the combination of stock-recruitment functions (Ricker and segmented regression). The new target F for sole of 0.25 is used, TAC change is limited to a maximum of 15% and MAE changes are limited to 10%. The fleets cease their fishery when the TACs are fully utilized.

3.1.4 Technological Creep Scenario Run

Finally, a single scenario ("TechCreep") was run to investigate the effect of including the occurrence of technological creep. This was done to test whether the use of a fixed effort cap still performs in a precautionary manner under potentially realistic improvements in catchability of sole and plaice (i.e. while the Maximum Allowable Effort remains constant, the F associated with this level will increase as technological efficiency improves). Other than the technological creep assumption (of 1.6% and 2.8% for plaice and sole respectively) this run was conditioned the same as the proposal under the base case scenario.

Table 3.1. Runs used to investigate the effect of implementing the proposed amendments to the management plan in comparison to the current management plan under various scenarios. (For further details on scenario settings see the following sections.)

Number	Management Strategy	Scenario	Starting Point	SR Type	Sole Target F	Effort Cap	Deployed Effort	Technological Creep
1	CurMP	BaseCase	XSA	Bayesian	0.20	F	Both	0
2	Proposal	BaseCase	XSA	Bayesian	0.25	T	Both	0
3	NewF	BaseCase	XSA	Bayesian	0.25	F	Both	0
4	EffCap	BaseCase	XSA	Bayesian	0.20	T	Both	0
5	CurMP	WorstCase	worst	Lowest obs.	0.20	F	Both	0
6	Proposal	WorstCase	worst	Lowest obs.	0.25	T	Both	0
7	ProposalHCR	WorstCase	worst	Lowest obs.	HCR	T	Both	0
8	CurMP	BestCase	best	RecPer_srH	0.20	F	Both	0
9	Proposal	BestCase	best	RecPer_srH	0.25	T	Both	0
10	Proposal	DepEffLeast	XSA	Bayesian	0.25	T	Least	0
11	Proposal	DepEffMost	XSA	Bayesian	0.25	T	Most	0
12	Proposal	TechCreep	XSA	Baysian	0.25	T	Both	1.6% (plaice) 2.8% (sole)

3.2 The biological operating model

The biological operating model consists of simplified age structured population models of the 'true' plaice and sole stocks in the North Sea, following current stock delineations (see WGNSSK report, ICES 2012). The models are conditioned to reflect our current understanding of the states and dynamics of the two stocks. The base case comparisons are based on the most recent assessments of the stocks (ICES, 2012), using the XSA model (Darby and Flatman 1994) incorporating data up to 2011. In addition, a best and worst case scenario are included to assess the functionality of the management measures in a period of relatively high or a period of sustained low productivity (large or small incoming year classes), respectively. There is no variation in future weights at age (mean of the last five years), maturity ogives (constant annual ogives as used in the assessments of the stocks) or natural mortality (a value of 0.1 for all ages and years for both stocks). The starting year of the projections is 2012. The TACs for 2012 were taken as those agreed by the EU and Norway according to the current plan in 2011. From 2013 onwards TACs are set according to the management strategy being simulated. The historic numbers at age (starting point) and the future stock-recruitment relationship are considered to be the primary sources of biological variation in the evaluation.

3.2.1 Starting points

We use three distinct starting conditions (Table 3.2) rather than incorporating stochastic uncertainty in starting point values into all simulations. Spreading out the starting points of the iterations across the whole expected uncertainty range limits the confidence in estimation of upper and lower bounds of projections because the uncertainty limits in the future simulation period are then determined on the basis of only a few iterations near the lower and upper limits. By running 100 or 200 runs starting near the edges of the uncertainty range, the evaluation of performance at the likely upper and lower bounds in future projections is improved by incorporating fully the likely future variation from these initial starting conditions.

The runs in the base case scenario use starting values taken from the results of the XSA assessment done by WGNSSK in 2012. In the WorstCase scenario, a *pessimistic* starting point is used. To generate this relatively pessimistic stock status, the XSA was run using index values for which the most recent 6 cohorts (2006-2011) were arbitrarily decreased by applying a multiplication factor of 0.75 (with a variance of 0.1). Similarly, in the best case scenario an *optimistic* starting point was used by doing the same with a multiplication factor of 1.25. These three starting points are compared in Table 3.2 and Figure 3.2.

Table 3.2. Starting point values for the given scenarios based on the XSA results

	Scenario set	Starting Point	F 2011	SSB 2011	Avg. Rec (2009-2011)
Plaice	BaseCase	XSA	0.23	468 861	1 258 796
	WorstCase	pessimistic	0.29	395 936	1 010 045
	BestCase	optimistic	0.17	570 850	1 516 933
Sole	BaseCase	XSA	0.29	34 990	93 963
	WorstCase	pessimistic	0.39	28 562	78 272
	BestCase	optimistic	0.22	44 039	109 364

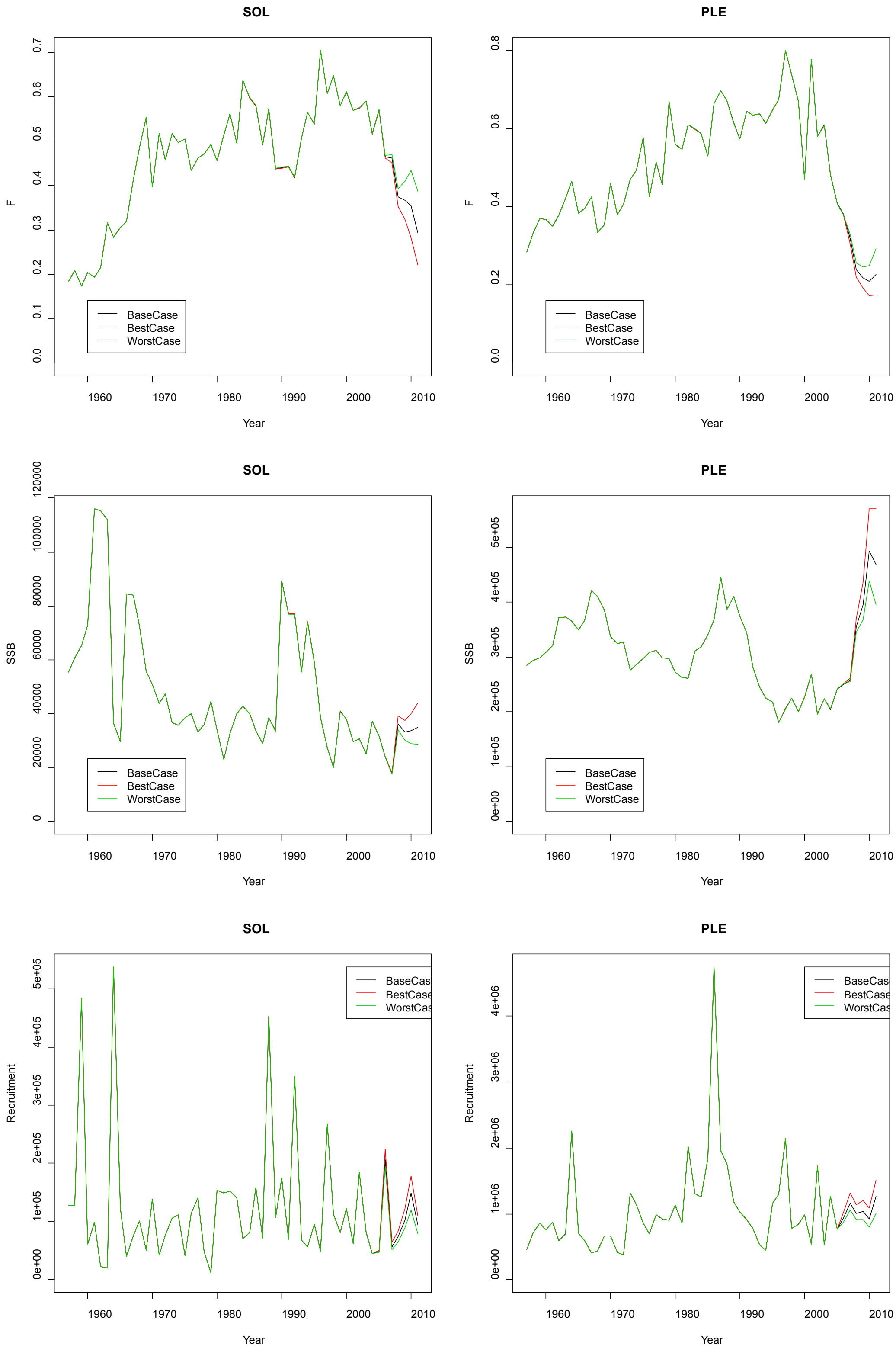
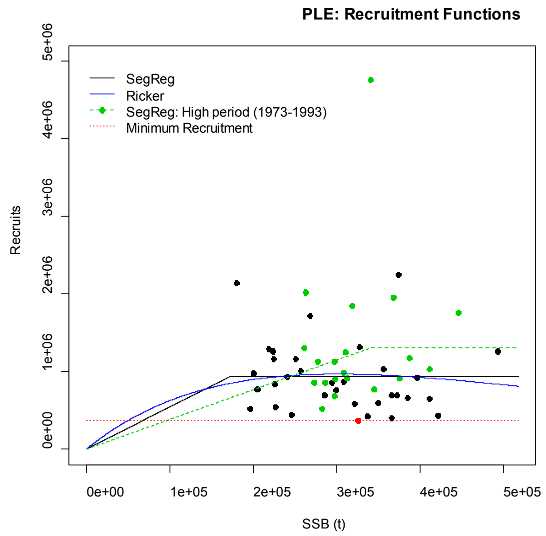


Figure 3.2. Comparison of BaseCase (black), WorstCase (green) and BestCase (red) scenario starting points. Top: Mean F (ages 2-6); middle: SSB; bottom: recruitment.

3.2.2 Stock-recruitment functions

Recruits are generated in the simulations from estimated stock-recruitment functions with random lognormal noise corresponding to the observed residual variation over the historic period (1957-2009). The spawning stock biomass (SBB), the biomass of the sexually mature part of the population, determines the number of potential recruits of the next year. Stock-recruitment relationships were examined over the historic period up to 2009 (excluding the most recent estimates of recruitment that are based on limited data) with SSB and recruitment estimates available from the XSA model (Figure 3.3).



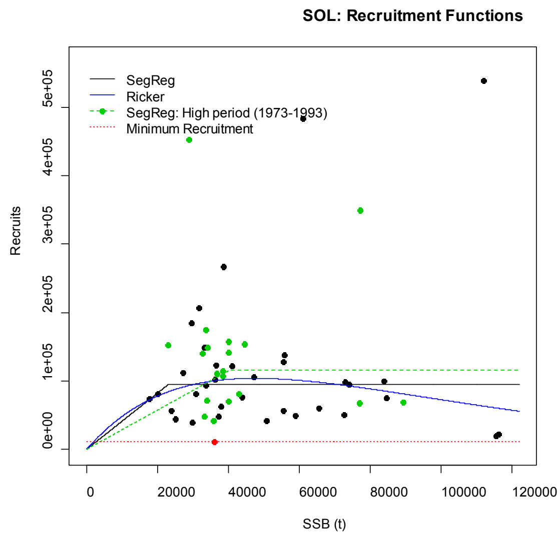


Figure 3.3. Stock-recruitment fits based on XSA estimates over the period 1957-2009. The red point in each graph indicates the lowest observed recruitment, green points indicate a consecutive period (1973-1993) where average recruitment was higher than in other periods and black dots are the remaining stock-recruit pairs.

In all except the "BestCase" and "WorstCase" scenarios, recruitment is modelled by using a combination of segmented regression and the Ricker SRRs. Here the S-R functions chosen are segmented regression and Ricker (see Simmonds *et al.* 2010b for further details).

Each iteration in a simulation chooses one of these two SRRs with a probability of drawing one or the other according to a predetermined weight. The weights were calculated according to the same procedure as used in the previous STECF evaluation conducted in 2010 (STECF SGMOS 10-06; Simmonds *et al.* 2010a, 2010b). Individual populations follow a single stock-recruitment function to define functional dependence of recruitment on SSB and a stochastic component (stock-recruitment function parameters) to mimic unpredictable environmental influences. The set of model parameters are based on Bayesian analysis to give a joint distribution of model coefficients (A,B and σ) for each functional type. The proportion of functional types is chosen using the method of Kass and Raftery (1995). This procedure is documented in more detail in Simmonds *et al*. (2011) for the example of NE Atlantic mackerel.

In the "WorstCase" scenario, for all future years recruitment is set to the lowest observed recruitment over the historic period (see red lines in Figure 3.3). The probability of this happening, given the statistical distribution of historic recruitment is extremely low. In the best case scenario, a segmented regression function was fit to a period of the historic time series which has shown higher than average recruitment (see green points in Figure 3.3). The period 1973-1993 was chosen as identified by STECF in the preparatory meeting for the 2010 impact assessment (Simmonds *et al*. 2010a).

3.3 The Fleet operating model

The effects of the fishery on the two stocks is modeled as the combined effect of three different fishing fleets: a BT2 Dutch beam trawl fleet (80mm mesh, targeting plaice and sole), a Dutch fleet with gears other than BT2 (targeting plaice) and a fleet for the other countries (targeting plaice). The Dutch BT2 fleet is used to model the impacts of effort management because it has a very high proportion of the North Sea sole and plaice landings (ICES 2012) and has suitable data available to do so. Also it is a data-rich component of the fishery, especially in terms of availability of effort data. Further division of the fleet was not possible because data availability limits the parameterizing of the sub-fleets.

3.3.1 Catchability and selectivity

The fleet operating model affects the number at age of the 'true' stock 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 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, catchability (q) and selectivity-at-age. This simplistically implies a linear relationship between F and fleet effort for each species. The historic selectivity-at-age (Figure 3.4) and catchability (Figure 3.5) were estimated from the landings at age for the different international fleets, the international discards data, and stock assessment results. These data are collected for the ICES demersal assessment working group and available at IMARES. The working group results 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. Catchability, relating F to fishing effort, varies from year to year and to reflect this, values are sampled from estimates in the period 1995-2011rather than using the mean over the whole period.

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 simulated 'true' landing values for the two species and discard values for the plaice stock. In the simulations, every year these catches, with observation error, were added to the catch-at-age matrix used in fitting the assessment model (XSA).

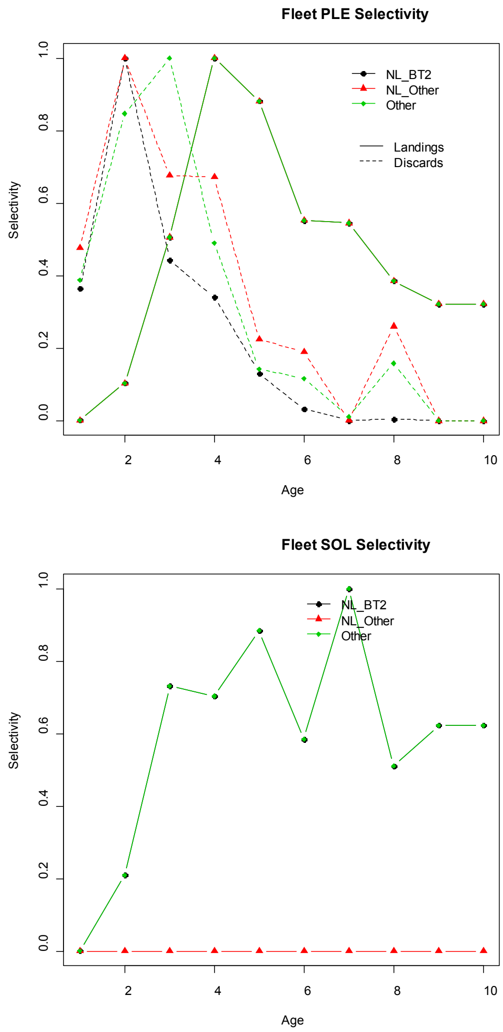
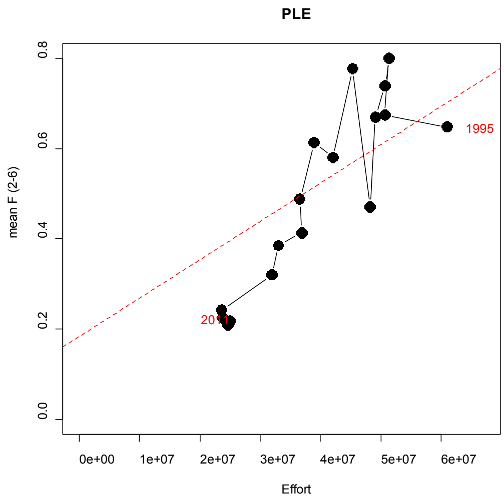


Figure 3.4. The selectivities by age (relative to the maximally selected age) of both species by the three fleets used in the MSE simulations. Landings selectivities for plaice and sole (left) all overlap with the exception of the NL_Other fleet, which catches no sole.



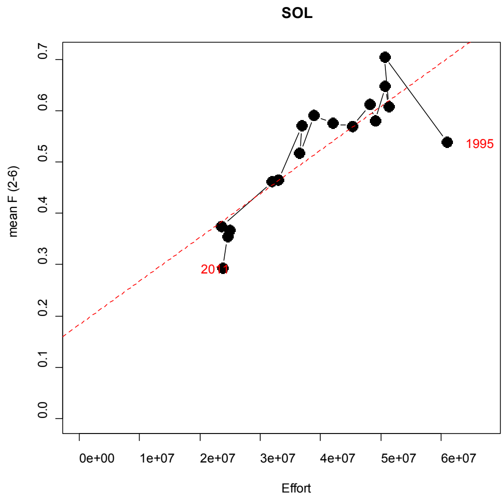


Figure 3.5. The relationship between effort deployed and mean F (ages 2-6) over the period 1995-2011 for both species for the NL_BT2 fleet used in the MSE simulations. Catchability is defined as the slope of the relationship between effort and F (here represented by the dashed red line).

3.3.2 Technological creep

One specific scenario is included to test robustness of the proposed amended management measures to increases in efficiency of the fleets over time. This scenario incorporates technological creep percentages based on Rijnsdorp *et al.*, 2006. In that study, 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 period prior to 2006. This positive trend was considered to result from an increase in skipper skills, investment in auxiliary equipment, the replacement of old vessels by new ones and, to a lesser extent, to engine upgrades. The technical creep percentages were used to incrementally increase the catchability of sole and plaice over the simulated period.

There are no trend changes in selectivity through time and future selectivity is based on the mean of the last 5 years as in previous scenarios. With new gears being introduced in recent years (such as pulse trawlers and sum wings) changes in catchability as well as selectivity may be expected for parts of the fleets, either increasing or decreasing their efficiency and changing catch composition. At present, no data is available to allow simulating scenarios that could take such changes into account when a large part of the fleet would change to these gears. However, since at present, these new gears are used on a very small scale, the impact on the results presented in the current report are probably negligible.

3.3.3 Mixed Fisheries considerations

Individual vessels in the Dutch beam trawl fleet differ broadly in terms of the proportion of plaice landings in their overall landings, though the high value of sole relative to plaice skews the economic importance in favour of sole (Figure 3.6). Certain vessel land plaice almost exclusively, while others land sole almost exclusively. This suggests that the fleet should have the potential to be adaptive to having TACs available in different ratios. For this reason, in the base case scenarios it is assumed that the fleets will fish up both TACs while avoiding catching over-quota fish. However, it is worth considering the possible impacts of mixed fishery dynamics on the performance of management measures, should the fleet not be as adaptive as suggested here.

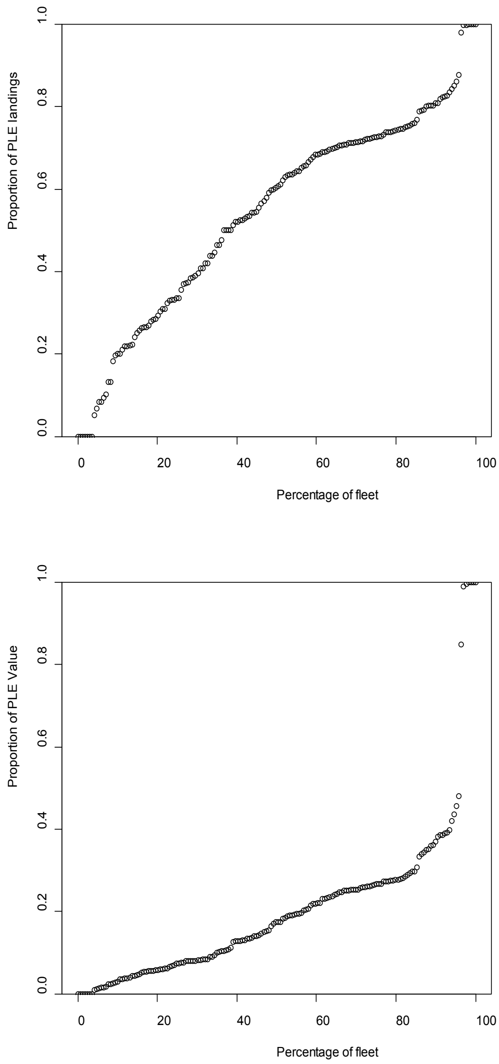


Figure 3.6. Proportion of plaice (out of the total for plaice and sole) landings (left) and value (right) by vessels of the Dutch beam trawl fleet in 2009 (Miller *et al.* 2010).

In order to examine the possible effect of the mixed fishery, a number of scenarios ("DepEffLeast","DepEffMost") are included in which different assumptions on the fishing effort deployment are tested. These scenarios differ in the reaction of the NL BT2 fleet to situations where the TAC of one stocks has been caught before the TAC of the other stock. Because sole is the 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 (1) there is a big discrepancy between the TACs and (2) plaice fishing alone is profitable, then plaice can be caught cleanly by spatial changes or technical restrictions, e.g. in the central and northern North Sea where there is less sole.

3.4 Applying management measures

The annual ICES advice process is mimicked as closely as possible. This implies that full-feedback simulations are conducted, including scientific surveys on the 'true' population, annual stock assessments and short term forecasts to calculate the Total Allowable Landings and subsequently, the TAC for each stock. Some assumptions were needed on the setting of Maximum Allowable Effort (MAE), including annual change restrictions and how a single value is determined for the mixed fishery. The resulting TACs and TAEs are then applied on the 'true' stocks in the following year (under a number of effort deployment scenarios).

Survey Indices

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 indicative of the state of the stocks. Survey indices used as input to the assessments in future years were generated from the "real" population on the basis of model estimated catchability at age (from the most recent ICES assessments) with error coefficients to simulate observation error. Variance estimates for observations by age (Table 33) 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.

3.4.1 Assessment and Forecast

The information or perception of the status of the stocks is generated through the explicit inclusion of a stock assessment in the simulation. In order to set a management measure for year *y*, assessment data will be available up to year *y*-2, with the assessment itself carried out in year *y*-1. Catches (discards and landings) of the fleets are "recorded" in the model. Three surveys sample the plaice and sole stocks. Catches per unit of effort are assumed to be linearly related to stock abundance.

The stock assessment process results in perceived 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 'true' population characteristics as modeled in the biological operating model because of the introduction of observation error (in the generation of abundance indices) and model error (the fit of the XSA model to these indices).

The perceived fishing mortality (F) and SSB 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 selection pattern of the previous three years (*y-3 to y*-1) rescaled to the F of the most recent year (*y-1*). There has been some discussion as to whether it would be preferable to assume F_{sq} to be at the level associated with the TAC set for the intermediate year. In principle, especially for sole, this could make a difference because F recently has been on a downward trend (in line with annual 10% reductions in accordance with the plan). To test sensitivity of the results to this assumption, a scenario run was conducted in which F_{sq} each year is calculated to correspond with the TAC of the intermediate year (results not shown here). Since no significant differences could be observed, all presented scenarios apply F_{y-1} rescaled in the intermediate year, corresponding to the way that it has been calculated in practice in WGNSSK in recent years.

To simulate observation error, the assessment input data (surveys and catches) were generated from the 'true' population with error coefficients. Variance estimates for observations by age (Table 3.3) 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 which do not treat catch proportions at age as exact (Appendix C). Biological parameters of the stocks in the assessment process are assumed to be equal to the biological parameters set in the operating model.

Table 3.3. 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 as derived from the SCA output).

	Plaice					Sole				
	Catch		Surveys			Catch			Surveys	
	Lan	Dis	BTS-Isis	BTS-Tridens	SNS		Lan	Dis	BTS-ISIS	SNS
1	1.25	0.23	0.2	0.84	0.26	1	2.14	NA	0.08	0.07
2	0.27	0.08	0.25	0.53	0.68	2	0.11	NA	0.19	0.31
3	0.05	0.18	0.22	0.12	1.01	3	0.01	NA	0.28	0.25
4	0.03	0.32	0.1	0.1	NA	4	0.01	NA	0.16	0.34
5	0.02	0.75	0.21	0.09	NA	5	0.02	NA	0.45	NA
6	0.02	1.11	0.26	0.09	NA	6	0.02	NA	0.47	NA
7	0.02	2.14	0.35	0.09	NA	7	0.03	NA	0.52	NA
8	0.02	10.17	0.7	0.09	NA	8	0.07	NA	0.54	NA
9	0.05	NA	NA	0.12	NA	9	0.16	NA	0.69	NA
10	0.05	NA	NA	NA	NA	10	0.16	NA	NA	NA
Min	0.02	0.08	0.1	0.09	0.26	Min	0.01	NA	0.08	0.07
Max	1.25	10.17	0.7	0.84	1.01	Max	2.14	NA	0.69	0.34
Mean	0.18	1.87	0.29	0.23	0.65	Mean	0.27	NA	0.38	0.24

3.4.2 Setting TACs and Maximum Allowable Effort (MAE)

The HCR formulates the advice for setting the Total Allowable Catches (TACs) according to the intended fishing mortality and the Maximum Allowable Effort[1] (MAE). For each stock annual reductions in F of 10% are applied until the target F is reached, after which the target F is applied continuously. Where this would result in a TAC which differs from the TAC of the preceding year by more than 15 %, a TAC chance of 15 % only is applied. Article 18 of the management plan allows for a greater reduction in TAC or MAE should the SSB of either stock be found to be suffering from reduced reproductive capacity, i.e. when SSB is perceived to be below B_{lim}. The management plan does not specify how much greater reductions will be allowed. In the simulation model, it is assumed that in such cases, TAC reductions of maximally 25% would be allowed.

In all management strategies that are based on the current management plan, Maximum Allowable Effort (in KwDays) made available to the NL BT2 fleet is calculated as the minimum of the amounts needed to land the full TAC of each species. In other words, the MAE in these management strategies is recalculated each year as an appropriate limit based on changes in the 'true' populations while assuming a linear relationship between F and effort: the MAE. This may lead to the TACs not been fully caught in some years if the MAE becomes restrictive to the fishery. The two other fleets in the fleets operating model are left to operate unrestrained by MAE limitations, and instead seize their fishery when their TACs are fully utilized. The reason for not restraining these fleets is that there is not sufficient data to estimate the relationship between effort and F. However, because the BT2 fleets catches the major share of the TACs, the effect of the MAE will be noticeable in the results.

An alternative management strategy ("EffCap") is based on the proposed amended management plan and fixes the MAE for the NL BT2 fleet at 2012 level. In this case, MAE is applied as laid down in the TAC and quota regulation (e.g. 44/2012). Swaps (e.g. within the Netherlands between the BT2 and TR1 fleets) are not taken into account: a limit of 28.3 million kilowatt days was assumed for the NL BT2 fleet throughout the projection period.

3.5 Projection model

The MSE is a full feedback stochastic projection model in which in addition to the biology, the fisheries system is modelled with simple fleet dynamic rules for three different fleets targeting the two species. Each iteration runs from 2012 to 2026 (i.e. fishing mortality estimates out to 2025). For the base case scenarios for the purpose of the comparison of the different management measures, 200 iterations were run, projecting the stock and the fishery forward until the year 2026. The scenarios for sensitivity testing used 100 iterations. The analyses were carried out using the FLR package (FLCore v2.4; Kell *et al*. 2007), a collection of data types and methods written in the R language (v2.13.1; R Development Core Team 2008). All code, data and additional sources for checking, validating and evaluation are freely available upon request.

[1] In some places in the report and in figure captions this is referred to as **Total** Allowable Effort (TAE).

3.6 Performance Statistics

A number of standard biological and fishery indicators were retained from the simulations to analyse the outcomes. These are divided into fishery and stock metrics. For all metrics, means and percentile values (median, 5-95) are calculated for each year of the projections. The first ten iterations of the stochastic runs are also retained to illustrate individual run trajectories of SSB, catch and recruitment (‘worm plots’). The metrics are evaluated at the following specific years and time horizons:

- 2015 (initial target year for F_{MSY})
- 2025 (final year of the long term evaluation)
- 2016-2025 (ten year medium-term period)

For certain performance statistics other relevant time periods were also considered.

Plots are produced of time series of metrics showing median values and 90% confidence limits. ‘Worm plots’ of the first ten iterations of the stochastic simulations are produced as well as box plots (median, interquartile range and 90% confidence limits) of the metric values at the year 2015 and 2025 and the averages over the long-term period (2016-2025).

3.6.1 Effects on the fishery

Metrics examined include:

- Mean F (true and perceived)
- TAC
- TAC variability (inter annual change calculated as average % change from year to year).
- Yield (focussing on landings, but also total catch and discards)
- MAE (Maximum Allowable Effort)
- Deployed effort

3.6.2 Effects on the stock

Metrics examined include:

- SSB
- Recruitment
- Precautionary risk measures of SSB in relation to B_{lim} (proportion of iterations that drop below B_{lim} at least once over the examined time period)

Additional ways of calculating risk in relation to B_{lim} were also explored, though these were not used in the evaluation of the performance of the proposed management plan.

4 Results

Detailed results of all of the runs in Table 3.3 are presented in Appendix D. Unless specified otherwise, statements made in this results section are based on median trajectories. Individual iterations could be different from the median trajectory. Some plots showing the first ten iterations for each management strategy are included in appendix D to provide some insight in the possible dynamics of individual iterations.

4.1 The current plan versus the proposal (BaseCase)

Comparing the strategy runs for the current plan and the proposed plan provides for the opportunity to assess the impact of introducing the proposed changes to article 4 and 9 of the management plan. Table 4.1 provides a summary of results for comparison of the current management plan with the proposal. Note that plots showing individual effects of changing either one of the articles are included in Appendix D, Section D.2.

4.2 Effects on the stocks

Figure 4.1 shows that in both strategies (the current plan as well as the proposed plan), the risk of SSB going below B_{lim} is less than 5%, for either stock in any given year, meaning that the evaluated management strategies are in conformity with the precautionary approach. The SSB of plaice stabilises around 800 kt in both strategies. In comparison to the current management plan, the SSB of sole stabilises at a slightly lower level (around 70 kt) under the proposal, which is still with high probability well above B_{pa}.

Realised fishing mortality of plaice under both strategies increases until it reaches the target F in the medium term after which it stabilises at a level just below the target. Under the current management plan, the level of the plateau where F stabilises is slightly lower, in part because the fishery will be restricted in some cases by the MAE and is not able to utilise the full TAC. This is the case more often in the longer term. Under the proposed plan the MAE set at the 2012 level is less likely to become restrictive and hence F stabilises at a slightly higher level. In neither strategy does F go above F_{pa} in any of the simulation runs. Fishing mortality on sole stabilises just below the target level, i.e. just below 0.20 under the current plan and just below 0.25 in the runs for the proposal. This is partly because of TAC change limits keeping F below the target in some years and partly due to differences between perceived F and true F. Figure 4.2 shows the distribution of the realised fishing mortality for both stocks in relation to defined F_{MSY} ranges as expected under the current management plan and the proposal. For plaice, the peak of the distribution of realised fishing mortality falls within the ICES defined F_{MSY} range under both strategies. In relation to the ICES defined sole F_{MSY} range, the realised F under the proposal is more probable to be within the range, while with the current plan with a lower target F, the peak of the distribution of realised F lies just below the range.

Long term landings in plaice are similar under both strategies. Sole landings are higher under the proposal in comparison to the current plan. Because the target F for plaice is the same in both strategies, plaice landings are the same, i.e. reaching a plateau by 2015 and fluctuate around from then onwards. Plaice discard levels appear to be influenced mostly by MAE restrictions, considering that in the strategies where the MAE is kept at the 2012 level, the fleet is less often restricted by the MAE and discards may be slightly higher in the longer term (see Figure 4.3). However, considering that discard rates are highly uncertain in the future, it is difficult to draw any conclusions regarding catches including discards, hence landings is probably the most appropriate measure for assessing the relative performance (in terms of yield) of the management strategy under consideration.

Figure 4.4 shows that in the current plan, where the MAE is not frozen at the 2012 level, the MAE will decrease for the first number of years, because fishing mortality on sole needs to be brought down to the target still before it stabilises. When the MAE is fixed at the 2012 level, a decrease in the MAE is observed only on rare occasions, when the sole stock goes outside of safe biological limits. In the initial period when the MAE is not limiting, it requires less effort to land the TAC for plaice than for sole (due to lower F and higher SSB). This implies that discarding rates for plaice could be high if the fleet is not able to partition effort between stocks successfully. Given that it is more difficult to catch sole cleanly (i.e. without catching plaice) than it is to catch plaice cleanly, it is possible that the assumption of no plaice over-catch may be violated in this case. However, the extremely high levels of SSB for plaice over this period suggest that any potential extra discarding would not impact on the sustainability of the proposed management plan.

Table 4.1. Summary of results for the comparison of the current management plan with the proposal.

	North Sea plaice		**North Sea sole**	
	Current plan	Proposal	Current plan	Proposal
Effect on the stocks				
P(SSB<Blim); 2013-2015	0	0	0	0
P(SSB<Blim); 2015-2020	0	0	0.005	0.005
P(SSB<Blim); 2016-2025	0	0	0.015	0.015
P(SSB<Bpa); 2013-2015	0	0	0.007	0.005
P(SSB<Bpa); 2015-2020	0	0	0.022	0.033
P(SSB<Bpa); 2016-2025	0	0.002	0.016	0.041
Effect on the fishery				
Mean landings; 2013-2015	104830	105900	14227	15095
Mean landings; 2015-2020	112101	115198	16179	17887
Mean landings; 2016-2025	112952	117239	17385	19063
P(MAE constrains effort); 2016-2025	0.62	0.21	0.31	0.11

***See Appendix E for further discussion of risk definitions.**

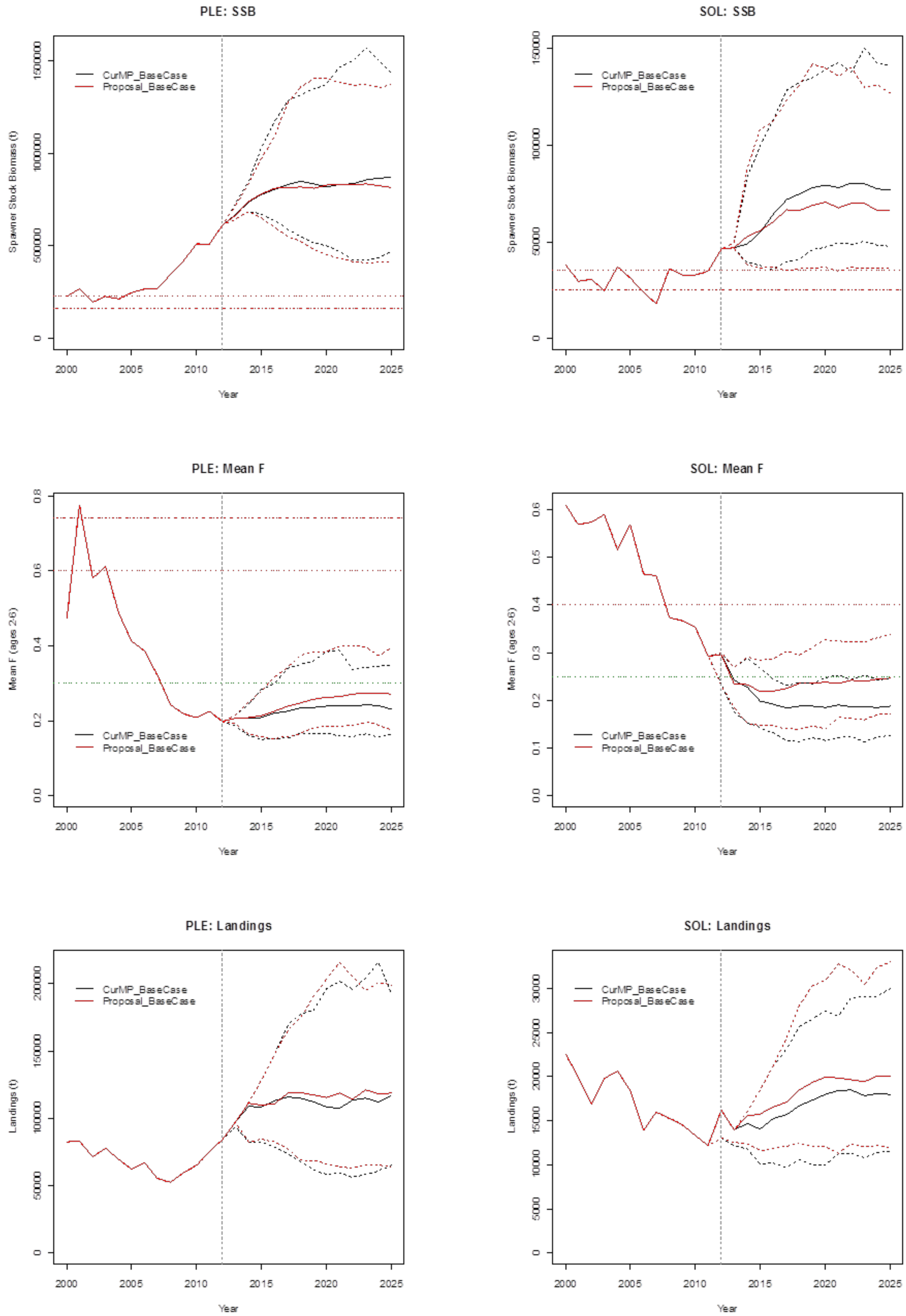


Figure 4.1. Projections of the median as well as the 90% confidence interval for SSB (top), fishing mortality (middle, Flim (for plaice) and Fpa included as dashed red horizontal lines) and landings (bottom) for plaice and sole stocks under the current and proposed management plans.

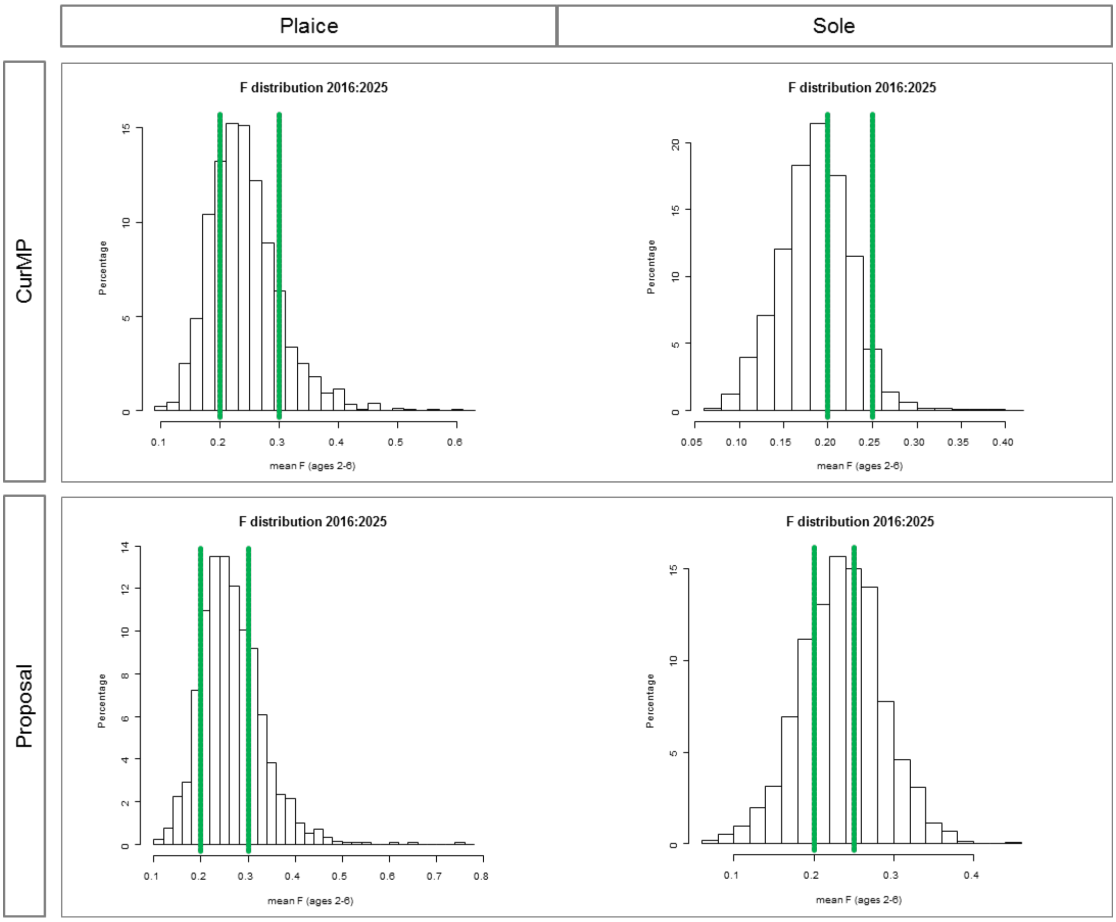


Figure 4.2. Distribution of 'true' fishing mortality under different scenarios in relation to F_{MSY} ranges as defined by ICES.

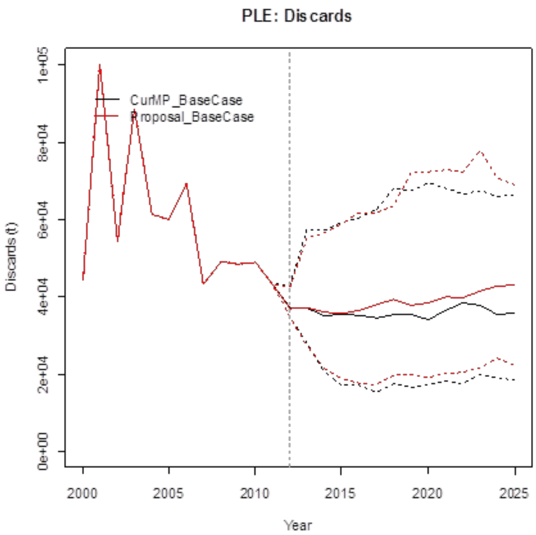


Figure 4.3. Projections of the median as well as the 90% confidence interval for discards of plaice under the current and proposed management plans.

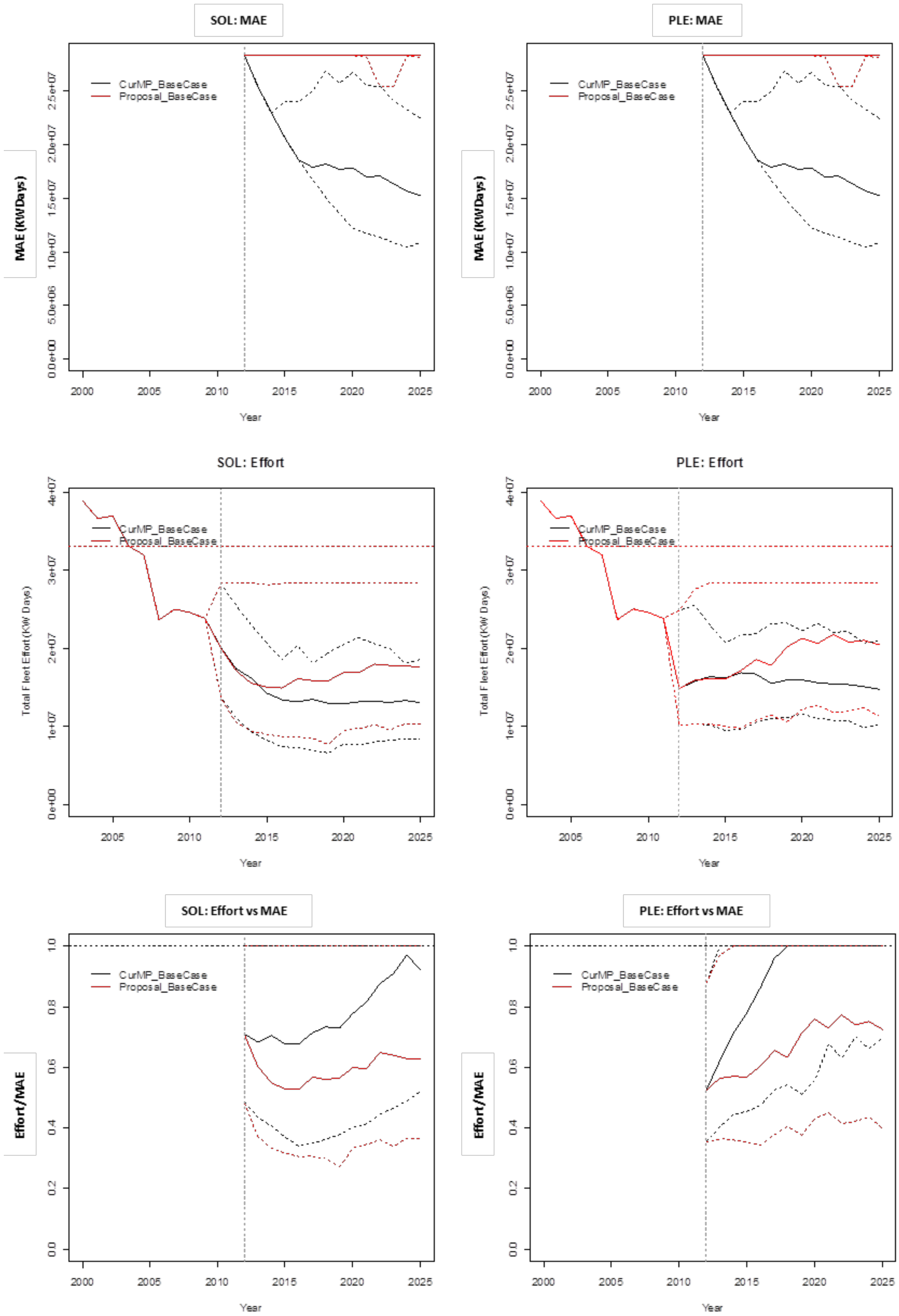


Figure 4.4. Developments in Maximum Allowable Effort (MAE; top), deployed effort (effort needed by the fleet to land the TACs; middle) and the proportion of MAE used (bottom) under the current and proposed management plans.

4.3 Best case scenario

Figure 4.5 shows how the current management plan and the proposal perform under an optimistic productivity scenario. The main purpose of this run was to assess whether the management strategy is able to maximise yield under improved stock conditions. In relation to plaice, the results are nearly identical when comparing the current management plan and the proposal. In the case of sole however, some differences are visible. SSB increases to a higher level under the current proposal, since a lower fishing mortality is applied than in the proposal.

Figure 4.6 shows that the TAC will generally be higher under the proposal and long term yields thus are allowed to increase more with the proposal under favourable productivity circumstances in comparison to the current management plan.

Figure 4.7 shows how Maximum Allowable Effort (MAE) could be expected to fluctuate over time if it is related to F (as under the current management plan) in comparison to the fixed level as in the proposal. It shows that under optimistic circumstances there is a substantial chance that the MAE would be set at a level considerably higher than the 2012 level. In other words, effort limitations may become more often restrictive to the fishery under the proposal than with the current management plan.

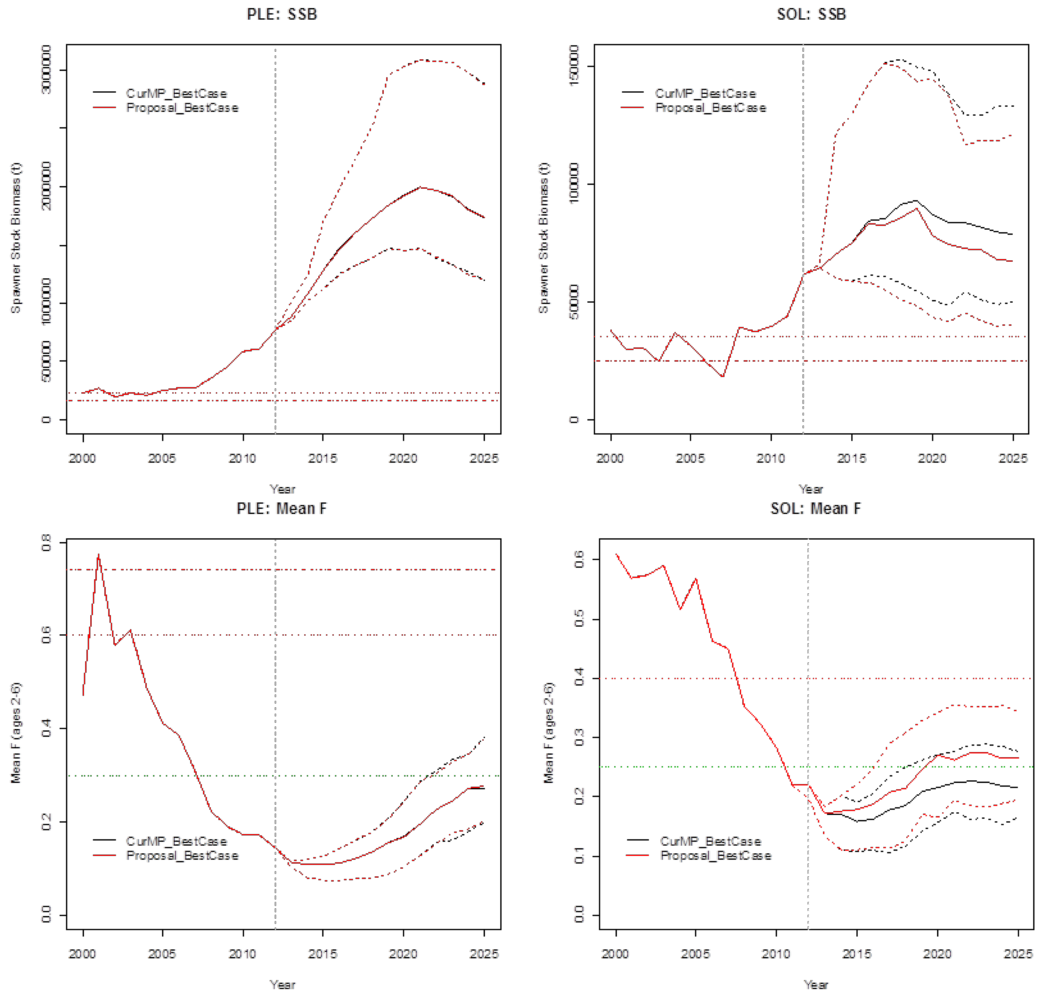


Figure 4.5. Projections of the median as well as the 90% confidence interval for SSB and fishing mortality for the two stocks under the BestCase biological scenario.

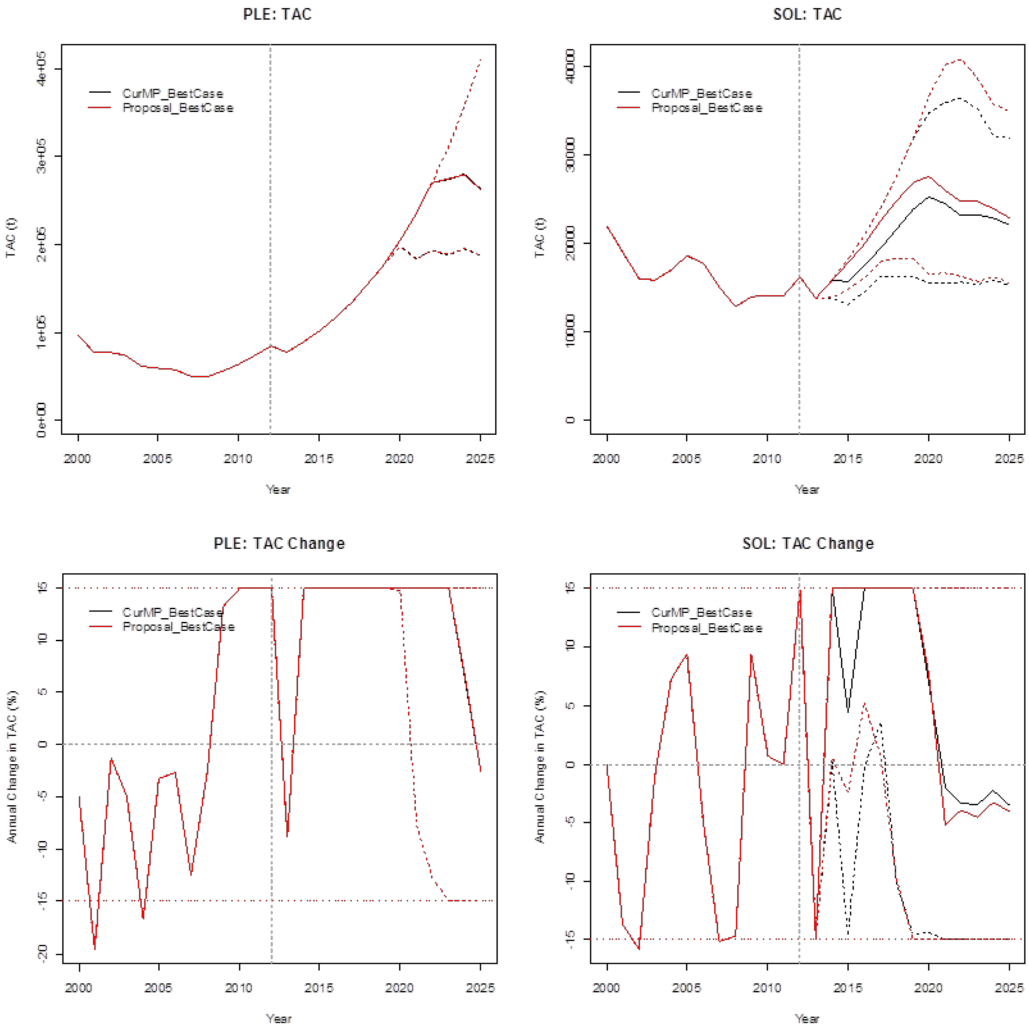


Figure 4.6. Projections of the median as well as the 90% confidence interval for TAC and annual TAC change under the BestCase biological scenario.

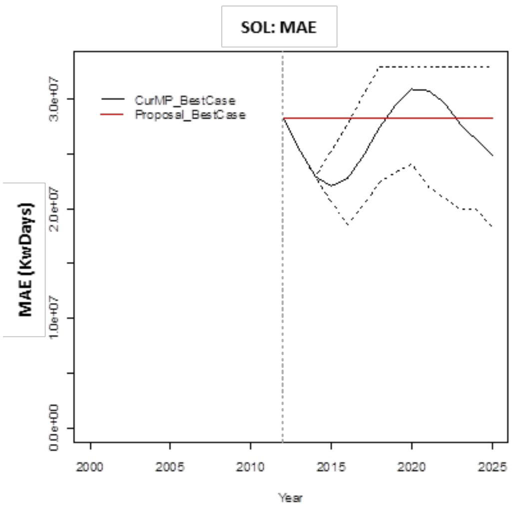


Figure 4.7. Projections of the median as well as the 90% confidence interval for TAC and annual TAC change under the BestCase biological scenario.

4.4 Worst case scenario

The worst case scenario provides the opportunity to assess what will happen to the stock under relatively low productivity conditions, while comparing how the current management plan and the amended plan would perform under such conditions. In addition, a third management strategy (ProposalHCR_WorstCase) was run under this scenario, in which an extra 'safety option' (reduced F at low biomass) is included in the proposed management plan to assess whether this would make a difference in terms of stock performance (see scenario section for more details). Figure 4.8 shows how the stocks develop when recruitment would fall to the respective lowest observed values in their historic time periods. Under all three strategies SSB of plaice decreases under such circumstances, while under the base case scenario SSB consistently increased to a substantially higher level than at present. However, even under these extraordinary conditions, the stock never goes outside safe biological limits within the considered time period. Consequently, the extra safety option included in the ProposalHCR_WorstCase is never invoked and there is no difference to be observed for this particular strategy.

The sole stock, under this scenario goes outside safe biological limits for all three strategies, dropping below B_{lim} in the majority of the cases as well. This is not surprising given that the recruitment generated in this scenario is at the lowest observed value for every year. This creates a situation that is unlikely to be found in reality. Still, in none of runs does the stock crash completely. Instead, the stock slowly appears to recover towards the end of the simulation period in most cases. This suggests that the management plan provides advice capable of adapting to such an extreme change in productivity. It allows for recovery of the stock under these extreme conditions, even though the performance of the management strategies under this scenario cannot be said to be in accordance with the precautionary approach. Neither the rate of decline of the stock, nor the recovery rate, appear substantially different under the different strategies.

In general, the differences under this scenario among the strategies are small because TAC reductions (Figure 4.9) in all cases are often limited to 15% (when SSB is between B_{pa} and B_{lim}) or 25% (when SSB is below B_{lim}). However, the MAE reductions as a consequence of the bad performance of the sole stock have the effect that the plaice TAC in many cases cannot be fully landed because not enough allowable effort is available to the fleet to do so.

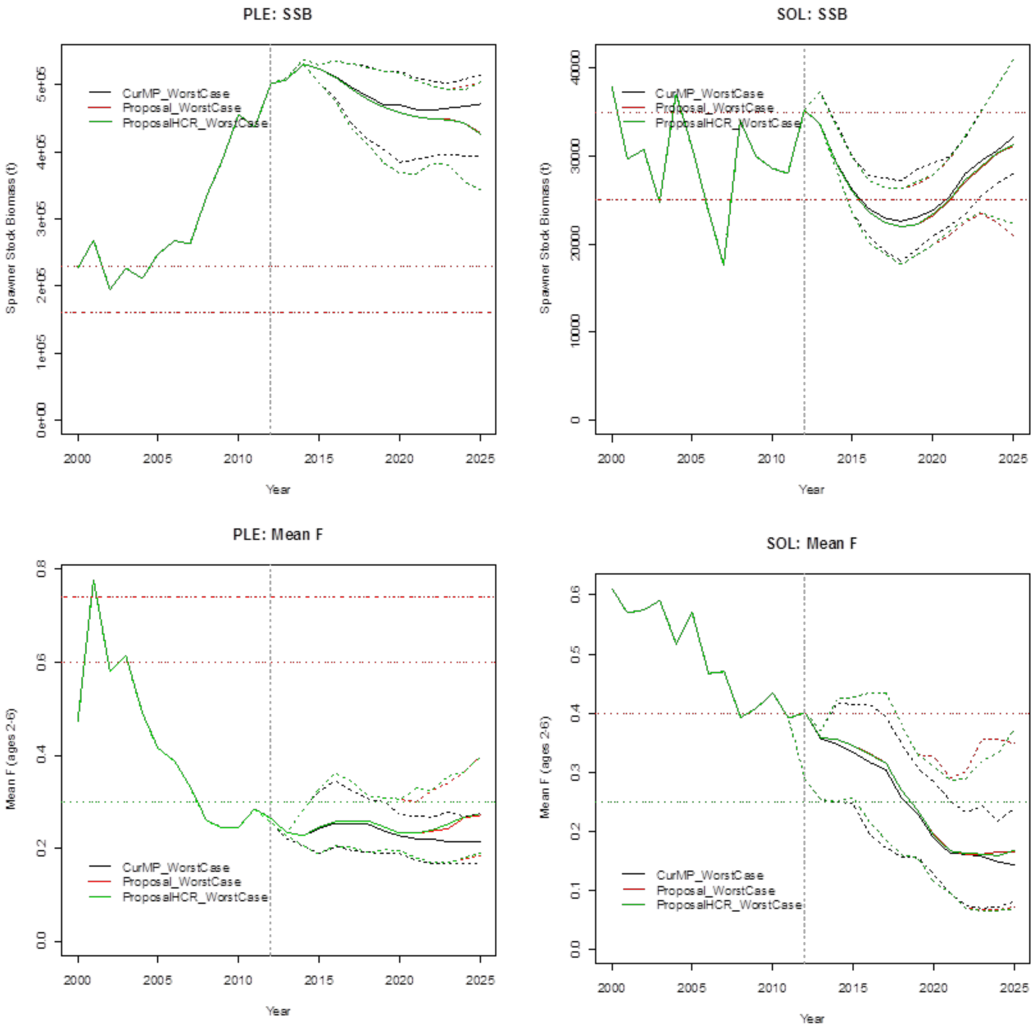


Figure 4.8. Projections of the median as well as the 90% confidence interval for SSB and fishing mortality for the two stocks under the WorstCase biological scenario.

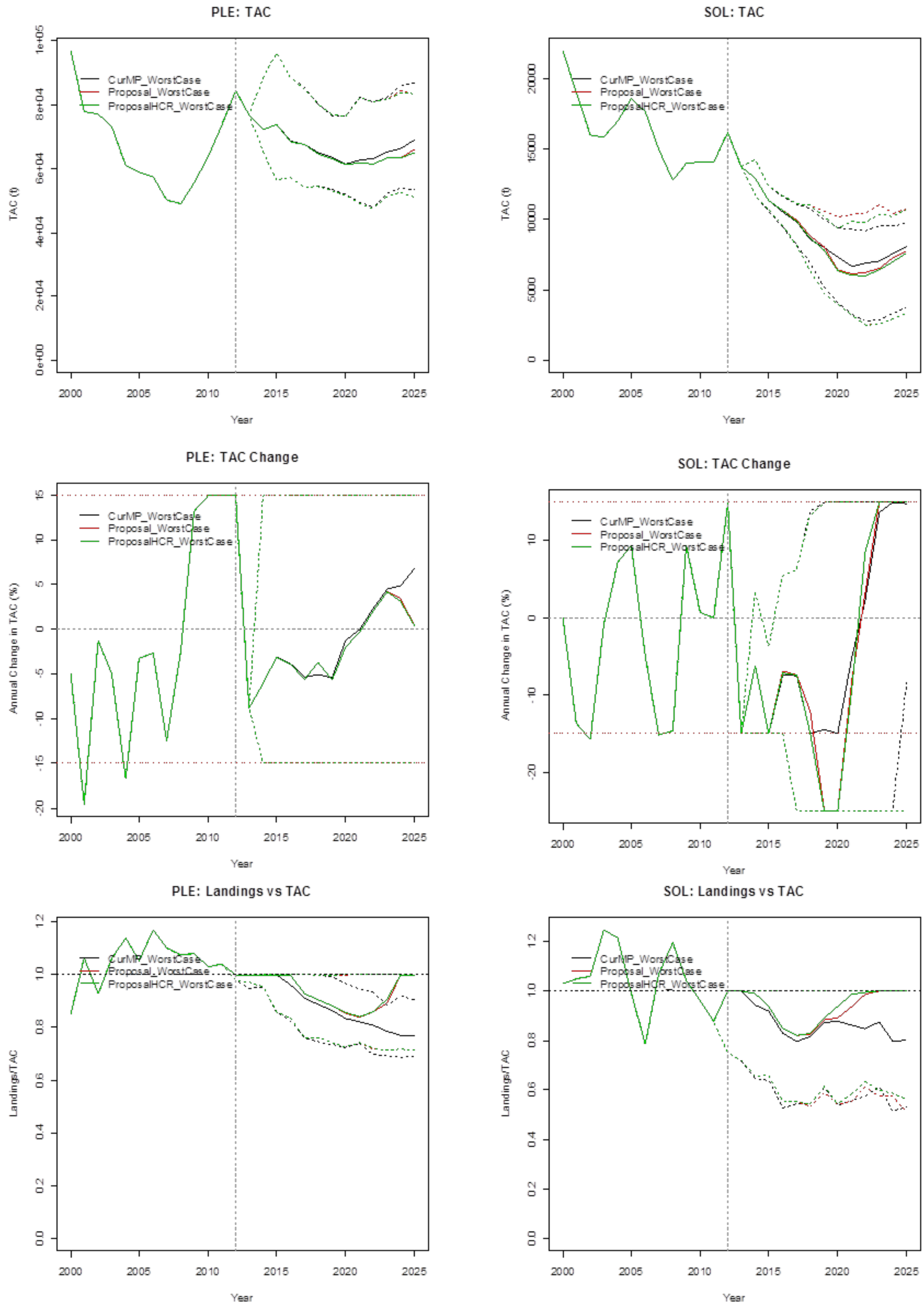


Figure 4.9. Projections of the median as well as the 90% confidence interval for TAC, annual TAC change and landings vs TAC under the WorstCase biological scenario.

4.5 Deployment of effort scenario

Three scenarios of how effort is deployed were examined. These do not result in significantly different stock trajectories and in all cases the proposed management plan remains precautionary (see Figure 4.10). From the start of the simulations up until 2017 more effort is required to land the sole TAC than the plaice TAC. Therefore, under the DepEffLeast scenario the effort deployed is restricted to that required to land the plaice TAC and the landings for sole are below the TAC. Conversely in the DepEffMost scenario, the plaice TAC is exceeded as fishing continues after the plaice TAC has been reached and the sole TAC still needs to be caught. After 2017 as F for sole has decreased and F for plaice has increased towards the respective targets, the situation reverses. Over this period it requires more effort to land the plaice TAC than the sole TAC. Therefore in the DepEffLeast scenario the plaice TAC is not landed fully over this period. In the DepEffMost scenario the sole TAC is exceeded over this period as sole continues to be caught as fishing for plaice continues after the sole TAC has been reached.

The proposed management plan did not perform significantly differently under this scenario compared to the BaseCase scenario. However, in practice the implementation of such an effort control regime is likely to be complicated by changes in catchability over time (e.g. new gears, changes in fishing location etc.) as well as potentially providing an incentive for accelerated technological creep.

4.6 Technological creep

The results from the scenario including technological creep do not differ significantly from the base case scenario (no technological creep). The only difference is that under a scenario where technological creep occurs, the effort cap is less likely to be limiting at the end of the time period because each unit of effort results in higher F and landings. In the case of plaice, the likelihood of MAE being limiting over the period 2016-2025 decreased from 22% in the base case scenario to 15% when technological creep occurs. For sole the decrease was from 19% to 9%. Results from this scenario are shown in Appendix D, section D.6.

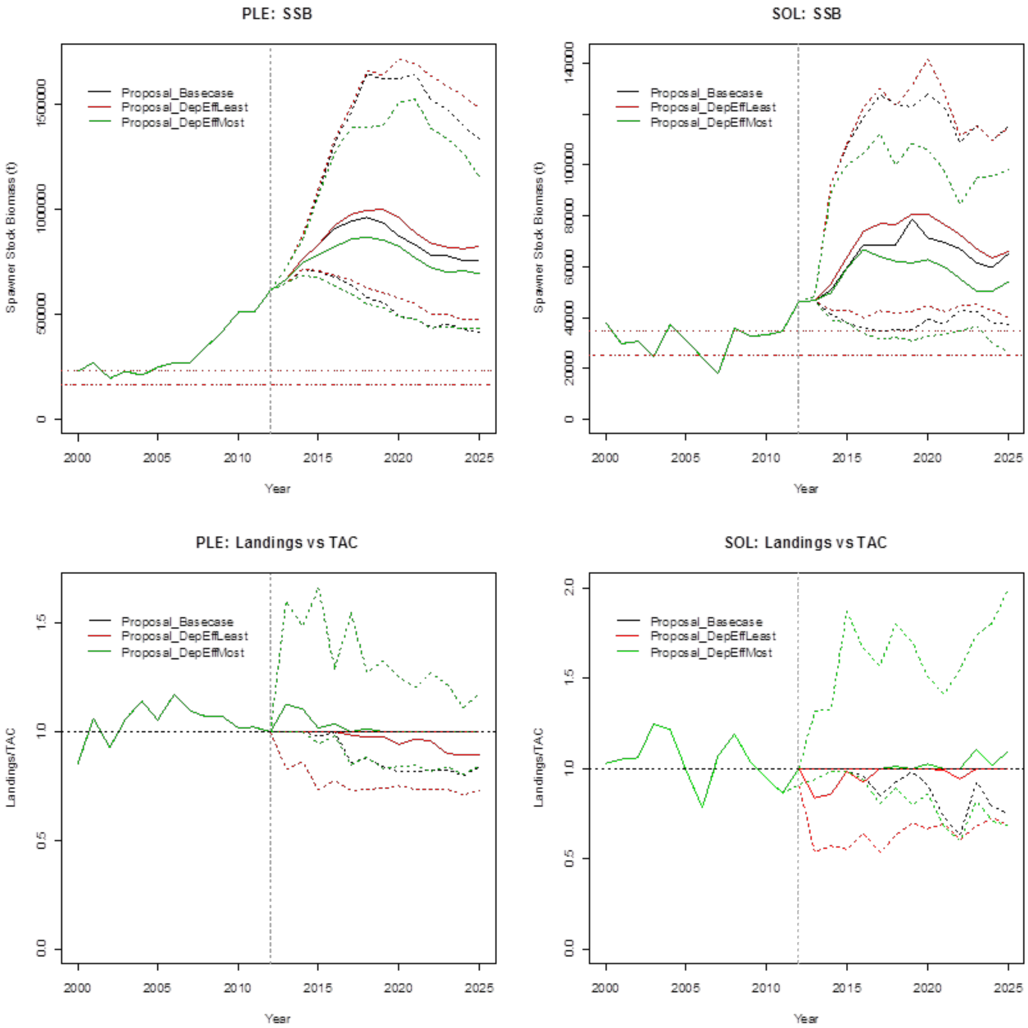


Figure 4.10. Projections of the median as well as the 90% confidence interval for SSB (left) and landings as a proportion of TAC (right) for the two stocks under the TechCreep fleet scenario.

5 Discussion

The present study focuses on evaluating one particular proposal for a specific set of management measures. In this sense, a true Management Strategy Evaluation is conducted, considering that this particular set of management measures is tested under various assumptions incorporated in the biological and fleet operating models. One could question whether the various scenarios investigated provide an exhaustive overview of different potentially encountered circumstances. The HCR evaluations conducted have not been tested against exceptional variations in biology which are beyond the variation observed in history. The analyses, however, can be viewed as appropriate given the uncertainty in the current population size and provide the basis for answering the request fully. The current exercise did not aim at investigating a range of target-F values as this was not included in the request. However, work relating to this has been conducted at various times over the last 3 years (e.g. ICES 2010, Simmonds *et al*. 2011) and the current study shows that the proposed F target values are within the range of values that are in conformity with the principles of F_{MSY}.

At the start of the simulation period the plaice stock was at record high levels of SSB. In the future projection period SSB continues to increase, taking the stock to outside the range of historic observations. Caution needs to be taken in the interpretation of the simulation results because it is likely that in reality such changes in stock status would not proceed unchecked. Density-dependent growth or mortality would be expected to 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. In practice management plans are reviewed every few years (the present evaluation being an example of this) to ensure they remain viable given the updated state of knowledge on the stocks. The projected period beyond this is examined to assess whether the plan is robust to future process error and various assumptions of stock dynamics, not to measure precisely what performance will be. 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. Hence, the simulation results should be used as indications more than absolute projections into the future. As thus they can be used to compare relative performance of proposed management strategies.

A number of simplifying assumptions were required for the implementation of the MSE. For both stocks it has been assumed that productivity (in terms of potential recruitment) 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 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. This is not accounted for in these simulations. 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 does not include spatial variation either. Finally, in the evaluation it has also been assumed that annual decisions will be made using certain assessment methods (the present ICES XSA assessment procedures) with their associated uncertainties. It can be envisaged that if other methods are applied in future, both the perception of the current and historical states of the stock could change. This in turn could impact on the values of reference points, potentially requiring a re-evaluation of the plan.

When evaluating the model, assumptions had to be made regarding stock productivity. 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-recruitment relationship. With regards to starting condition, best and worst case scenarios were examined to check sensitivity to this. For stock-recruitment relationships, the base case scenario considered both of the two best fitting functional forms (in proportions related to the probabilities of these). The best and worst case scenarios also considered more extreme productivity regimes, likely encapsulating the range of future recruitments.

Stock structure, particularly for plaice, is not fully understood within the North Sea and surrounding waters. In 2012, the ICES working group WKPESTO (ICES 2012) met to examine potential links between the North Sea plaice and other adjoining stocks, focusing on the Skagerrak. The group concluded that it was likely that plaice in Skagerrak (Division 20) is closely associated with plaice in the North Sea. They suggested that this area could be included in the North Sea plaice stock assessment, but recognised that local populations are present in the area requiring separate management to assure the preservation of these local populations. Similarly, following the benchmark of the eastern channel (VIId) plaice (WKFLAT; ICES 2010a), the assessment for the North Sea stock now includes 50% of the quarter 1 landings from area VIId, as these are assumed to be migrant fish, temporarily found in this area. In both cases, the levels of catches in the surrounding waters are much lower than the catches taken in the North Sea. Hence including these areas does not have a major impact on the perception of the stock or the perceived dynamics. Given that both the current and proposed management plans apply to the predefined plaice and sole stocks found in the North Sea, this evaluation was limited to simulations of the North Sea stock alone.

Assuming current productivity levels (BaseCase scenario), it can be expected that due to the generally higher level of deployed effort under the proposed management plan, catches of associated species (i.e. bycatch species) in this mixed fishery will be higher with the implementation of the proposed plan. This could imply for instance that cod catches will be higher under the proposed management plan, in comparison to the current management plan, leading to an increased probability of the cod recovery plan becoming applicable to this fishery, and consequent reductions of MAE. However, under improved productivity levels (BestCase) the MAE as set based on the current management plan can be expected to increase to substantially higher levels than the 2012 level. In other words, under such circumstances, the proposed management plan would be more conservative in terms of setting MAE levels and effort could be expected to become restrictive more often than with the current plan

Generally, in relation to effort becoming restrictive to the fishery or not, it should be noted that transfers of sea days within the Netherlands among different metiers are not taken into account in the present study. However, the fact that they included a transfer of just over 6 million kWdays (between 20-25% of the 2012 MAE level) from the BT2 fleet to the TR1 fleet in most recent years, shows that these transfers can be quite substantial and if continued obviously implies that in practice, effort may become restrictive to the BT2 fleet sooner than indicated in the present study. While this falls outside of the ambit of the management plan, as this is something unique to a particular member state, it could nevertheless impact on the deployed effort of the fleet fishing sole and plaice in the North Sea (i.e. deployed effort < MAE).

For future purposes it would be interesting to be able to distinguish traditional beam trawlers from vessels using new gears that have been introduced in the fishery in recent years, such as pulse trawlers and sum wings. At present, however, no specific information in relation to the catchability and selectivity of vessels with such gears is available to make such distinctions. However, in terms of effects of different levels of deployed effort, also for instance on the bycatch of associated species, this would probably be a useful exercise.

6 Conclusions

The evaluation shows that the proposed changes to the management plan are acceptable. Performance compared to the current management plan is very similar with regards to plaice, and likely an improvement for sole (in terms of yield). The plaice stock is currently in a very healthy state and hence even much higher levels of F are likely to be sustainable in the short to medium term. For sole, the higher F proposed does result in slightly less growth in SSB, but this is still precautionary in relation to B_{lim} under all examined risk criteria. The proposed management plan maintains F within or near the defined F_{MSY} range in the medium term and keeps F well below precautionary F reference limits. Average yield for sole is expected to be slightly higher under the proposed management plan while still being sustainable, suggesting that the proposed changes are more in line with the principles of F_{MSY} than the current plan.

The proposed management plan also performed successfully under the various other possible scenarios of stock productivity, effort deployment, TAC setting procedure (results not shown here), and future fleet dynamics. Passing these sensitivity tests shows that the proposal is robust to some of the major assumptions made in the base case scenario runs. Importantly, the results show that under periods of sustained low productivity the management plan is able to prevent the collapse of any of the stocks while under periods of increased productivity yield increases as well. The HCR including a reduction in F below B_{lim} does not seem to be necessary to ensure sustainability of the stock because the proposed plan successfully keeps the stock above B_{lim} in most iterations, years and scenarios.

The proposed amendments to the current management plan are in accordance with the precautionary approach and consistent with the principles of MSY.

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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 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.

(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.

L 157/2 EN Official Journal of the European Union 19.6.2007

(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;

(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.

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.

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. Evaluation Request

B.1. Evaluation request (pre-announcement)

Introduction

ICES concluded in June 2011 that both North Sea plaice and sole stocks were within safe biological limits, for two consecutive years, and that the first phase of the plan was achieved. WGNSSK 2012 may come back on that conclusion, in light of the reassessment of the 2010 sole stock, but at least the objective is met for 2011 and 2012.

Following article 5 of the multi annual plan on the management of North Sea plaice and sole (EC 676 / 2007), the Commission should propose amendments to article 4(2) and 4(3) on the target fishing mortality for plaice and sole, article 7 and 8 for setting the TACs for plaice and sole and article 9 on fishing effort limitation, with a view to permit the exploitation at MSY.

ICES has already stated that in the absence of a proposal for review, their advice on North Sea plaice and sole, which is due for June 2012 will not be based on the plan. It is put in their so-called “table 3: Management plans that ICES does not consider appropriate as a basis for advice”

The Netherlands consider this situation as highly unfortunate. We propose amendments to the named articles (below) and invite ICES to review and assess whether they are in accordance with the precautionary principle and MSY approach. If positive, we invite ACOM to include this proposal in its 2012 advice.

Proposed amendments:

Article 4

Objectives of the multiannual plan in the second stage

2) The objective specified in paragraph 1 shall be attained by maintaining the fishing mortality on plaice at a rate equal to or no lower than 0.30 on ages two to six years.

3) The objective specified in paragraph 1 shall be attained by maintaining the fishing mortality on sole at a rate equal to or no lower than 0.25 on ages two to six years.

<u>Clarification to the proposed amendments in article 4.</u>

Ad 2. Little is known on the stock-recruitment relationships of both stocks. Taking into account a number of stock–recruitment relationships for plaice, ACOM of ICES generated a range of values between 0.2 and 0.3 for plaice (ICES, June 2011). This is in line with the evaluation of the plan done by STECF (November 2010). F targets examined over the range from 0.2 to 0.3 all lead to similar long term TAC values (because these values lie on the flat top of the F_{MSY} distribution), yet F targets above 0.3 were not found to be precautionary over any time period. The risk of stocks falling below B_{lim} or B_{pa} with targets lower than 0.3 are considered very small (see table below, taken from the STECF 10-06b Vigo meeting report, 2010). This coincides with the evaluation of the plan done by ICES in November 2010 (special request). It should be noted that these levels are lower than the possible range (see figure C5 below, taken from STECF 2010), but this is due to the fact that STECF has also taken into account the mixed nature of the fisheries, the effects on sole catches and discards.

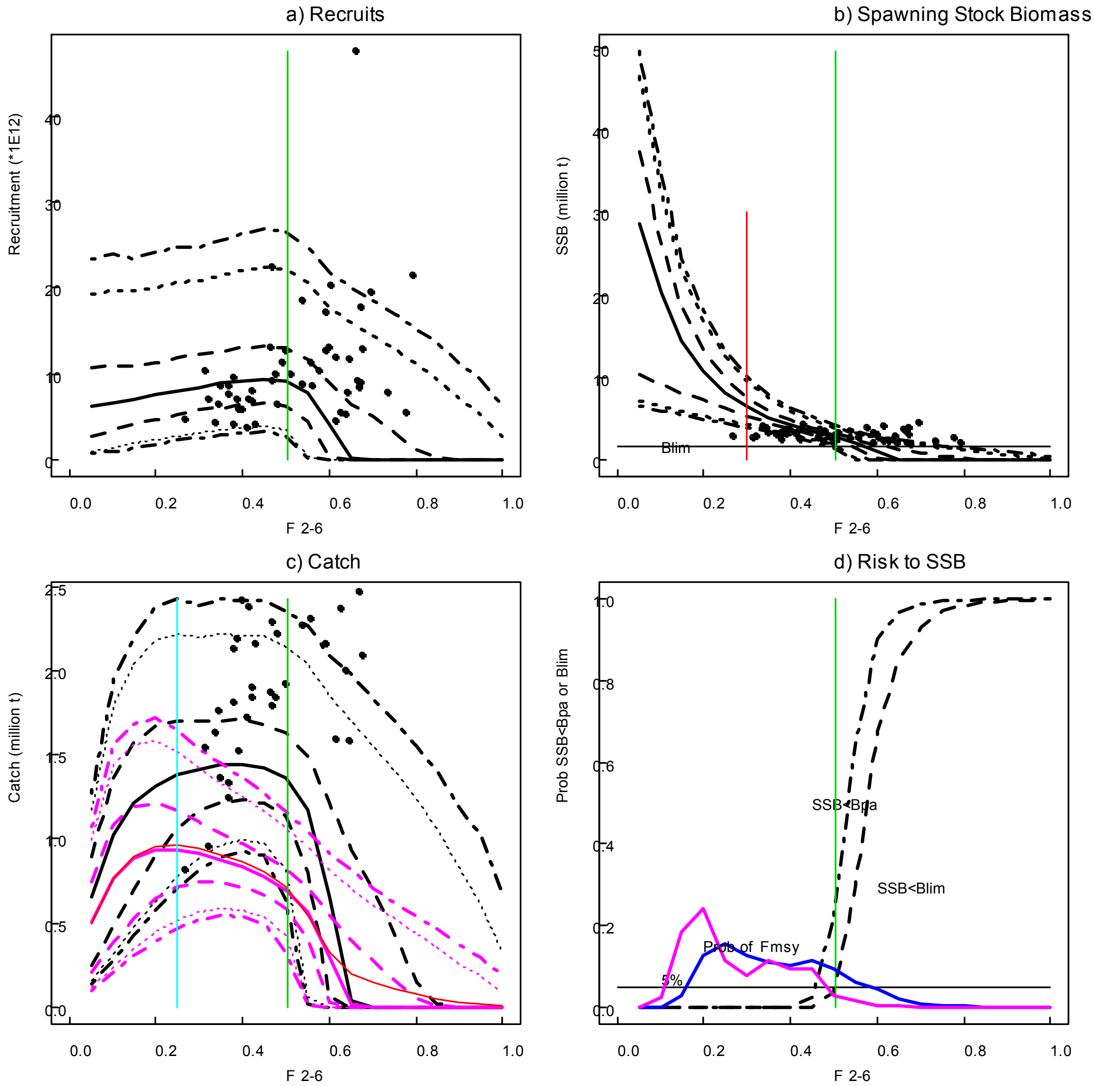

Figure C5 Equilibrium exploitation of NS plaice against target F from F=0.05 to 1.0. Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch (axes values incorrect – should be divided by 10): black lines and Landings pink lines. Historic Recruits, SSB and Catch: black dots. c) mean landings: red line. d) probability of SSB below Blim and Bpa: black lines and 5% probability of SSB below Blim green line in all panels. d) distribution of F for maximum catch, blue line, and maximum landings, pink line. F for maximum Landings: cyan line, based on 50% point on the distribution of F panel (d) and maximum mean Landings panel (c). The red line in panel b shows the current management plan target F.

<u>MSE analyses (first few columns) and equilibrium analyses from the 'combined' SR results (above)</u>

Table 8.3. Plaice yields and likelihoods of meeting WKOMSE precautionary criteria (risk to stock) under different targets Fs in the multi-annual plan and from the equilibrium analysis (Annex c). (For scenarios that were run with less than 100 iterations, it is not possible to adequately estimate the risk to the stock, so NA values are given.)

	Yield		Risk			Bayesian equilibrium values		
F	ST (2011-2015)	MT (2016-2025)	ST (2011-2020)	MT (2016-2025)	LT (2021-2030)	Yield	Risk <Blim	Risk <Bpa
0.15§	**69357**	**97825**	**NA**	**NA**	**NA**	80345	0.00	0.00
0.2§	**73307**	**112434**	**NA**	**NA**	**NA**	85997	0.00	0.00
0.22	*	*	*	*	*	86691	0.00	0.00
0.23	79190	124038	0	0	0	87038	0.00	0.00
0.25	82168	124938	0	0	0	87732	0.00	0.00
0.3	93044	130710	0	0	0	86734	0.00	0.00
0.35	*	*	*	*	*	83743	0.00	0.00

§ based on only 21 replicates (too few to estimate risk) * Not run for this stock.

Ad 3. Similarly, targets for FMSY for sole within a range a range of 0.2-0.25 are considered by ICES to be produce high yields while maintaining a low risk to the stock and therefore sustainable. However, for F values above 0.25 there was an increasing risk of driving the stock out of safe biological limits and exploitation levels greater than this were not considered to be precautionary. These values lie well within the range given by STECF in their evaluation of the plan in November 2010 (see figure C4 below, taken from STECF). The risk of the stock falling below B_{pa} with a F_{MSY} of 0.25 is still very low (see table below).

In addition is should be noted that the ratio of the proposed F_{MSY} for plaice (0.3) and sole (0.25) are consistent with the average long term ratio of 1.18 (F_{MSY} plaice/ F_{MSY} sole), see Figure 11.1 from evaluation STECF (November 2010)

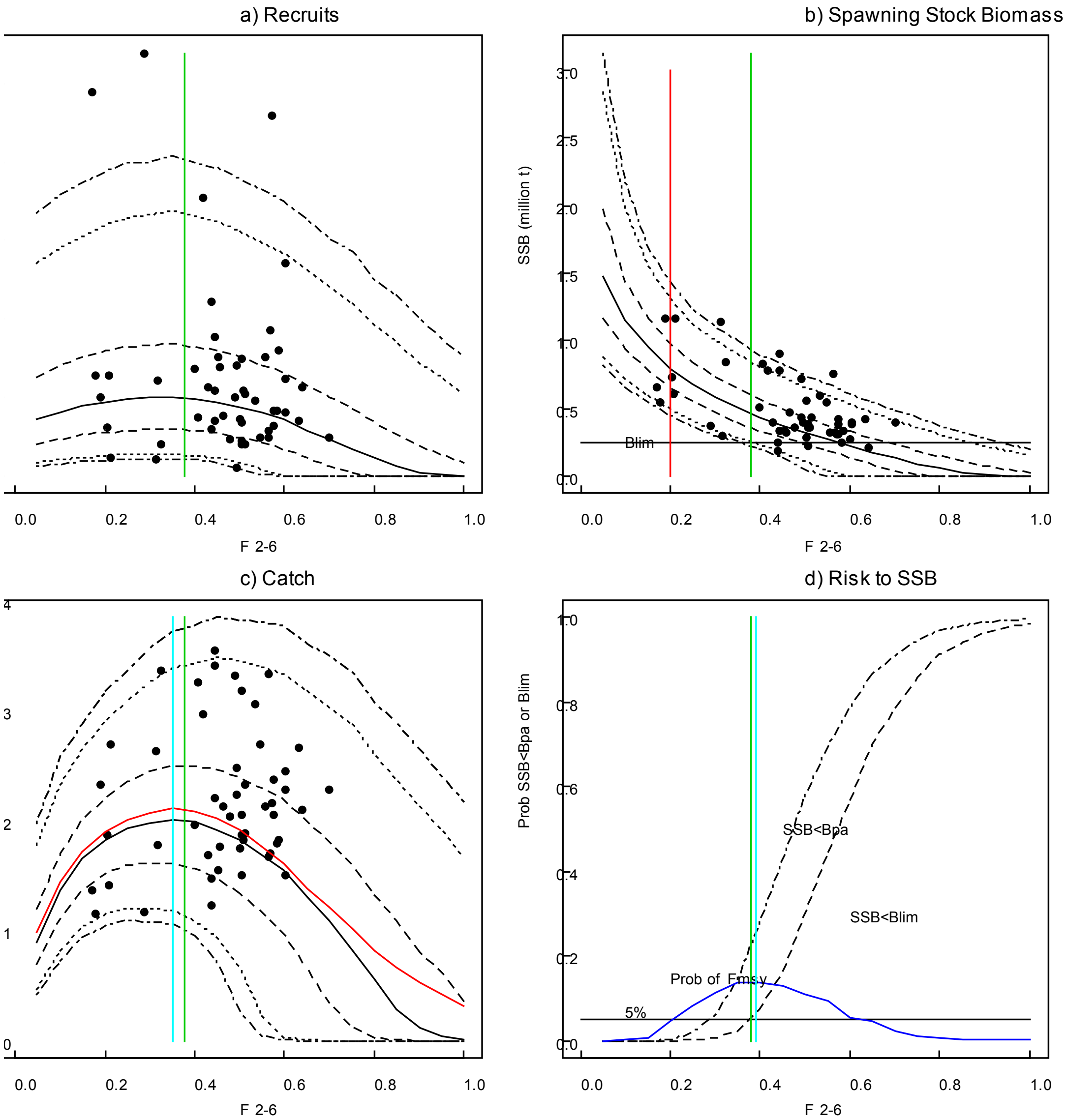

Figure C4 Equilibrium exploitation of NS sole against target F from F=0.05 to 1.0. Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch/Landings (axes values incorrect – should be divided by 10): black lines. Historic Recruits, SSB and Catch/Landings black dots. c) mean catch/landings: red line. d) probability of SSB below Blim and Bpa: black lines and 5% probability of SSB below Blim green line in all panels. d) distribution of F for maximum catch/landings blue line. F for maximum catch/landings: cyan line, based on 50% point on distribution of F panel (d) and maximum mean catch/landings panel (c) The red line in panel b shows the current management plan target F.

<u>MSE analyses (first few columns) and equilibrium analyses from the 'combined' SR results:</u>

Table 8.4. Sole yields and likelihoods of meeting WKOMSE precautionary criteria (risk to stock) under different targets Fs in the multi-annual plan(Annex B and from the equilibrium analysis (Annex c). (For scenarios that were run with less than 100 iterations, it is not possible to adequately estimate the risk to the stock, so NA values are given.)

F	Yield		Risk			Bayesian equilibrium values		
	ST (2011-2015)	MT (2016-2025)	ST (2011-2020)	MT (2016-2025)	LT (2021-2030)	Yield	Risk <Blim	Risk <Bpa
0.15§	**14365**	**15904**	**NA**	**NA**	**NA**	16644	0.00	0.00
0.2	14512	17687	0.1	0.05	0.02	18202	0.00	0.00
0.22	14531	18215	0.1	0.05	0.02	18595	0.00	0.01
0.23	*	*	*	*	*	18792	0.00	0.01
0.25	14615	19151	0.1	0.06	0.06	19185	0.00	0.02
0.3	14645	20236	0.14	0.14	0.19	19694	0.01	0.08
0.35§	**15886**	**20568**	**NA**	**NA**	**NA**	19608	0.04	0.19

§ based on only 21 replicates (too few to estimate risk) * Not run for this stock.

Article 7

Procedure for setting the TAC for plaice

No amendments

Article 8

Procedure for setting the TAC for sole

No amendments

CHAPTER III

FISHING EFFORT LIMITATION

Article 9

Fishing effort limitation

4) The Commission shall request from STECF a forecast of the average maximum level of fishing effort that is 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, effort transfers between member states and transfers of quota between gear categories in the framework of the cod recovery plan EC 1342 /2008 in the North Sea.

5) 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 taking into account the reduction of fishing mortality that is achieved following to article 6.

Clarification on the proposed amendments:

The current management plan provides little guidance on how STECF should provide advice on the appropriate effort level. As a consequence both TAC and effort restrictions are used equally to reduce the fishing mortality to the smallest denominator (in this case sole). Since the entry of enforcement of the plaice and sole management plan, the number of days at sea (or kWdays) have been reduced with some 10% every year. However, looking back, the overall effort remained more or less stable. On the other hand, the fishing mortality dropped dramatically. The F for plaice is already at F_{MSY} level for a number of years, F_{MSY} for sole is near. It seems logical to conclude that TAC restrictions have been more effective in reducing the fishing mortality. A second observation refers to the composition of the flatfish fleet, which has changed dramatically over the past number of years. A lot of beam trawl cutters have been decommissioned and many fishermen have changed to other demersal trawls, targeting only plaice. Restrictions on the basis of sole is no longer appropriate it seems. Therefore we suggest to shift to an approach which should address both fisheries, by means of an average of the effort required.

B.2. Evaluation request (official ICES form)

Request from (organisation)	Ministry of Economic Affairs, Agriculture and Innovation, Netherlands
Contact within organisation: Name/ Email/ Telephone	Henk Offringa Tel.: +31 70 3784048 / gsm +31 6 48131244 email address: h.r.offringa@mineleni.nl
Content contact person: Name/ Email/ Telephone	Henk Offringa or Lianne Kersbergen: +31 70 3784154, m.c.kersbergen@mineleni.nl
Request announced	23 April 2012
Request received	23 April 2012
Answer deadline client	Mid October 2012
Request code (client)	
Request code (ICES)	
Request	Request to assess whether the proposed changes to articles 4 and 9 of the multi annual plan on the management of North Sea plaice and sole (EC 676 / 2007) are consistent with the precautionary and MSY approach (in conformity with the ICES criteria). This would require a Management Strategy Evaluation. A summary of the proposal: Art 4: change Fmp (second phase) for sole to 0.25 (plaice remains the same) Art 9: freeze the effort when the stocks are within safe biological limits and use TAC/quota restraints to reach the long term objectives (Fmp seconds phase). When one or both stocks fall back outside safe limits (i.e. F>Fpa and SSB<Bpa), than a reduction in effort (kW days) should help to recover the stock(s).
Planning ICES	
Request (budget) accepted	Date:
ICES contact person Name/ Email/ Telephone	
WG(s) involved	
Preparation timing	
Review group	
Advice drafting group	
ACOM Webex	
Release date	

Appendix C. 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

$$F_{a,t} = qe_t f_{a,t}.$$

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 modeling 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.

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 likelihoodfunction 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 modeled 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.

Appendix D. Full Scenario Results

D1. Current management plan (CurMP) and proposed plan (Proposal), BaseCase scenario

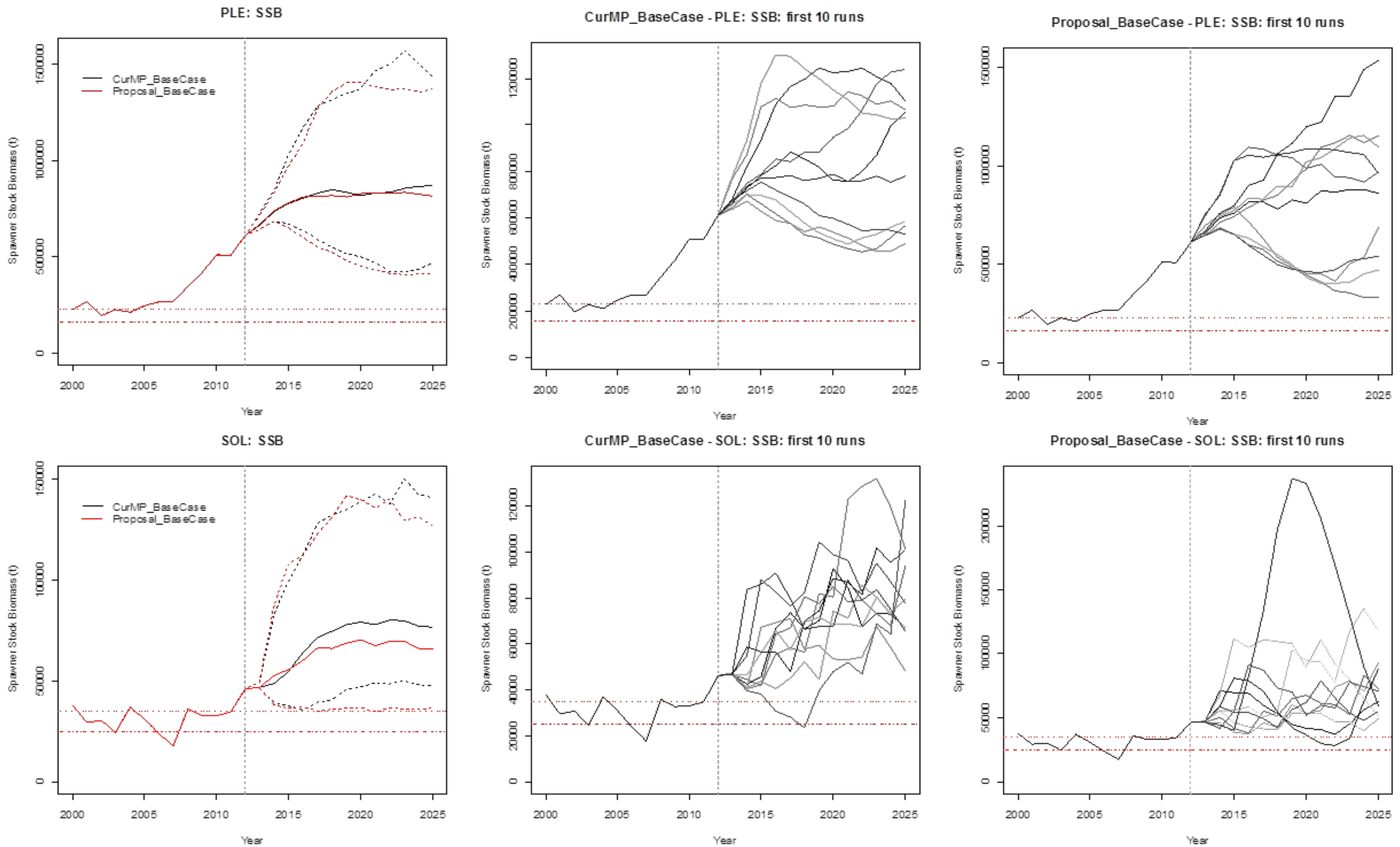

Figure D1.1. BaseCase scenario, CurMP and Proposal. SSB of plaice (PLE, top) and sole (SOL, bottom): median and 5th and 95th percentiles (left), and first ten iterations for the CurMP (middle) and Proposal (right) strategies.

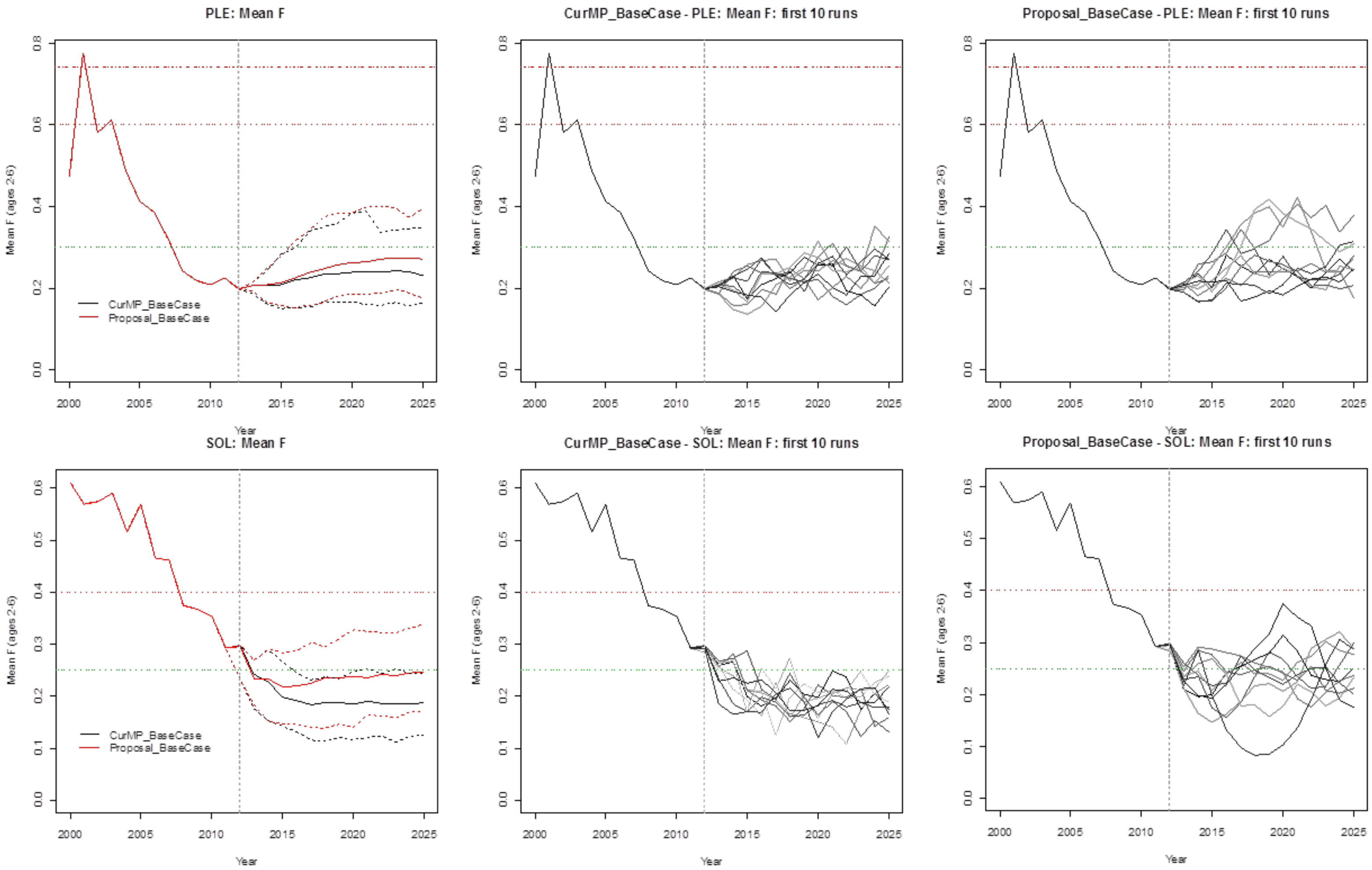

Figure D1.2. BaseCase scenario, CurMP and Proposal. Mean F (ages 2-6) of plaice (PLE, top) and sole (SOL, bottom): median and 5th and 95th percentiles (left), and first ten iterations for the CurMP (middle) and Proposal (right) strategies.

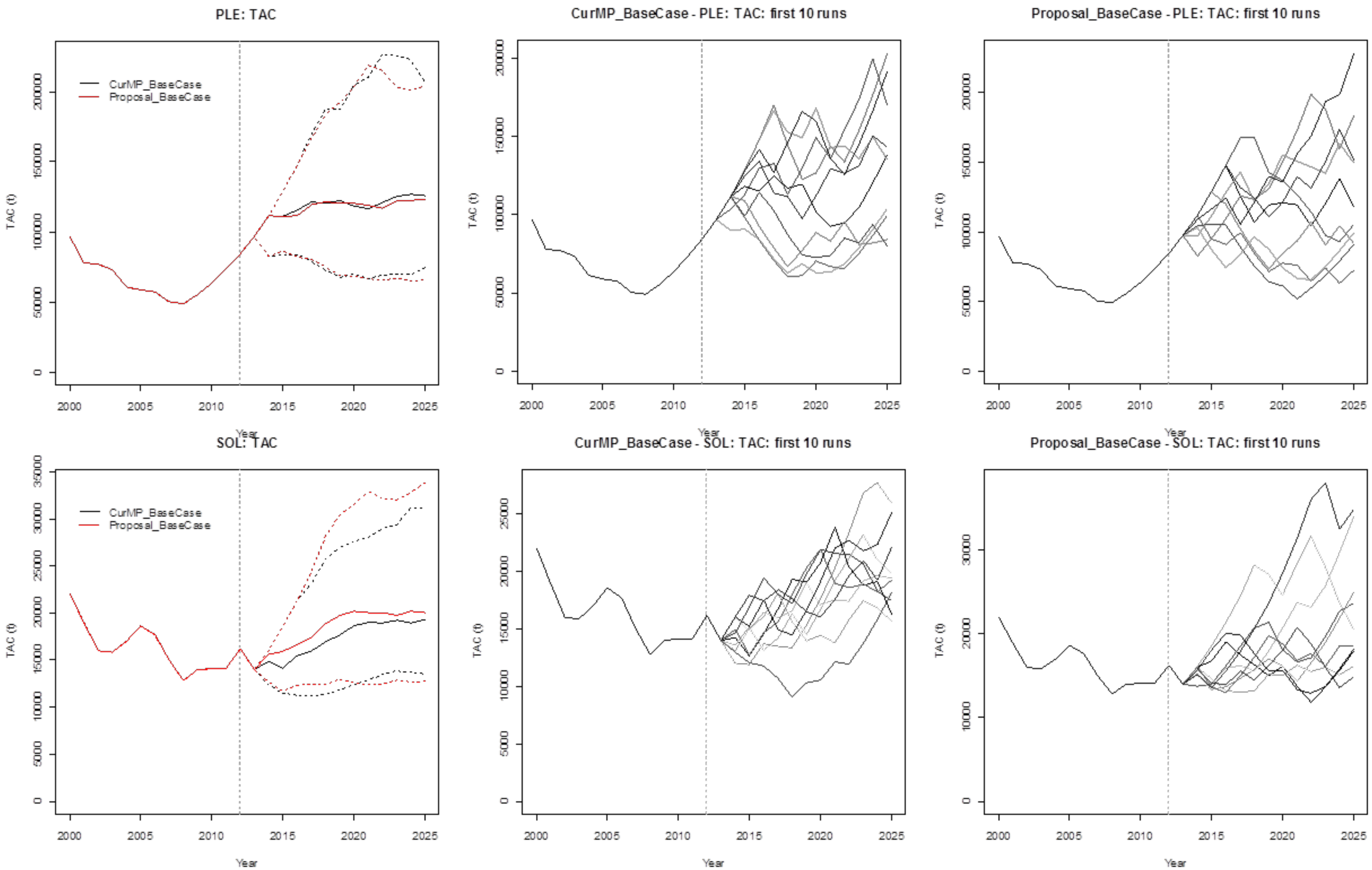

Figure D1.3. BaseCase scenario, CurMP and Proposal. TAC for plaice (PLE, top) and sole (SOL, bottom): median and 5th and 95th percentiles (left), and first ten iterations for the CurMP (middle) and Proposal (right) strategies.

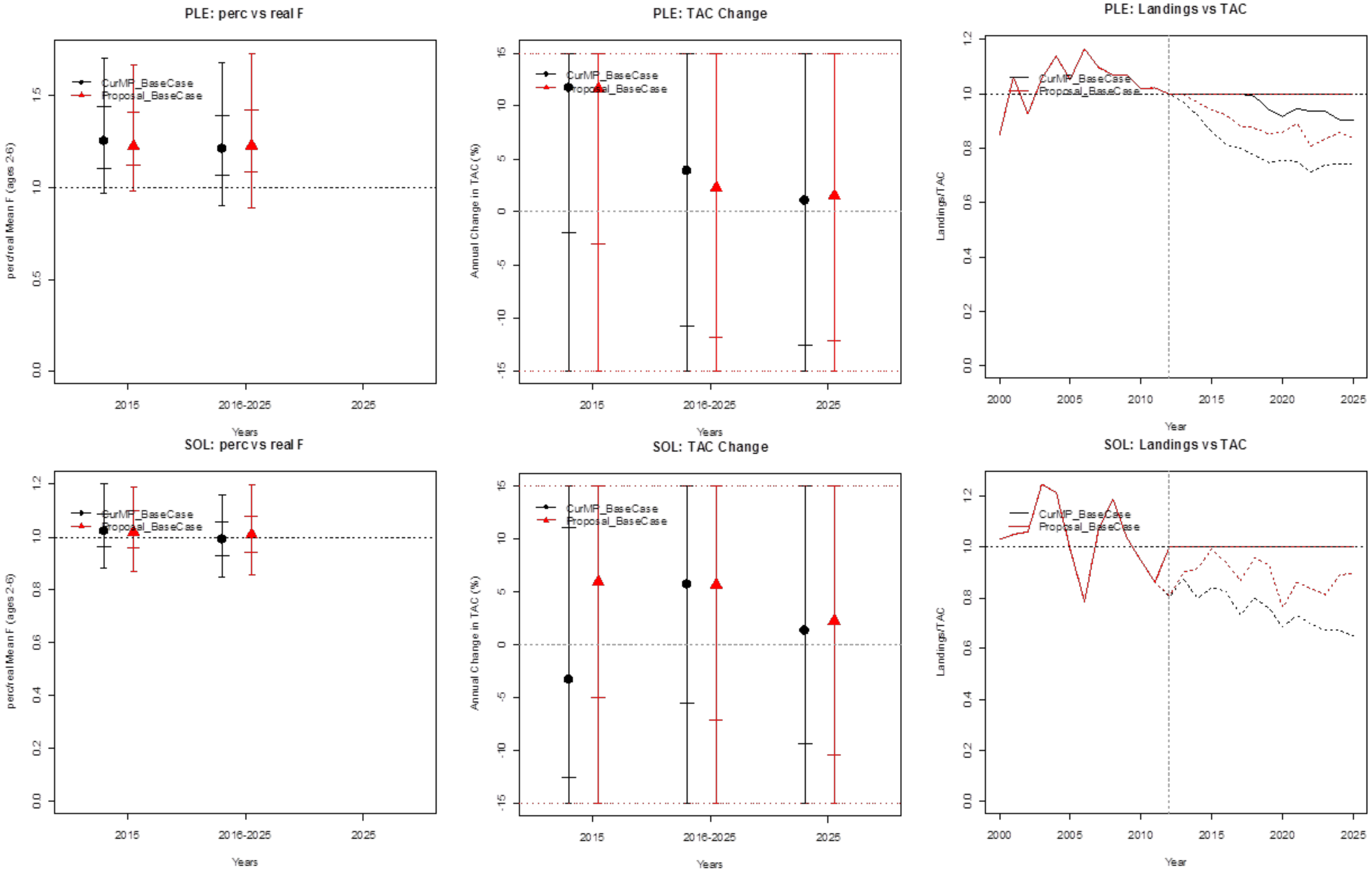

Figure D1.4. BaseCase scenario, CurMP and Proposal. Perceived vs Real mean F (left), average annual TAC change (middle) and landings vs TAC (right) of plaice (PLE, top) and sole (SOL, bottom).

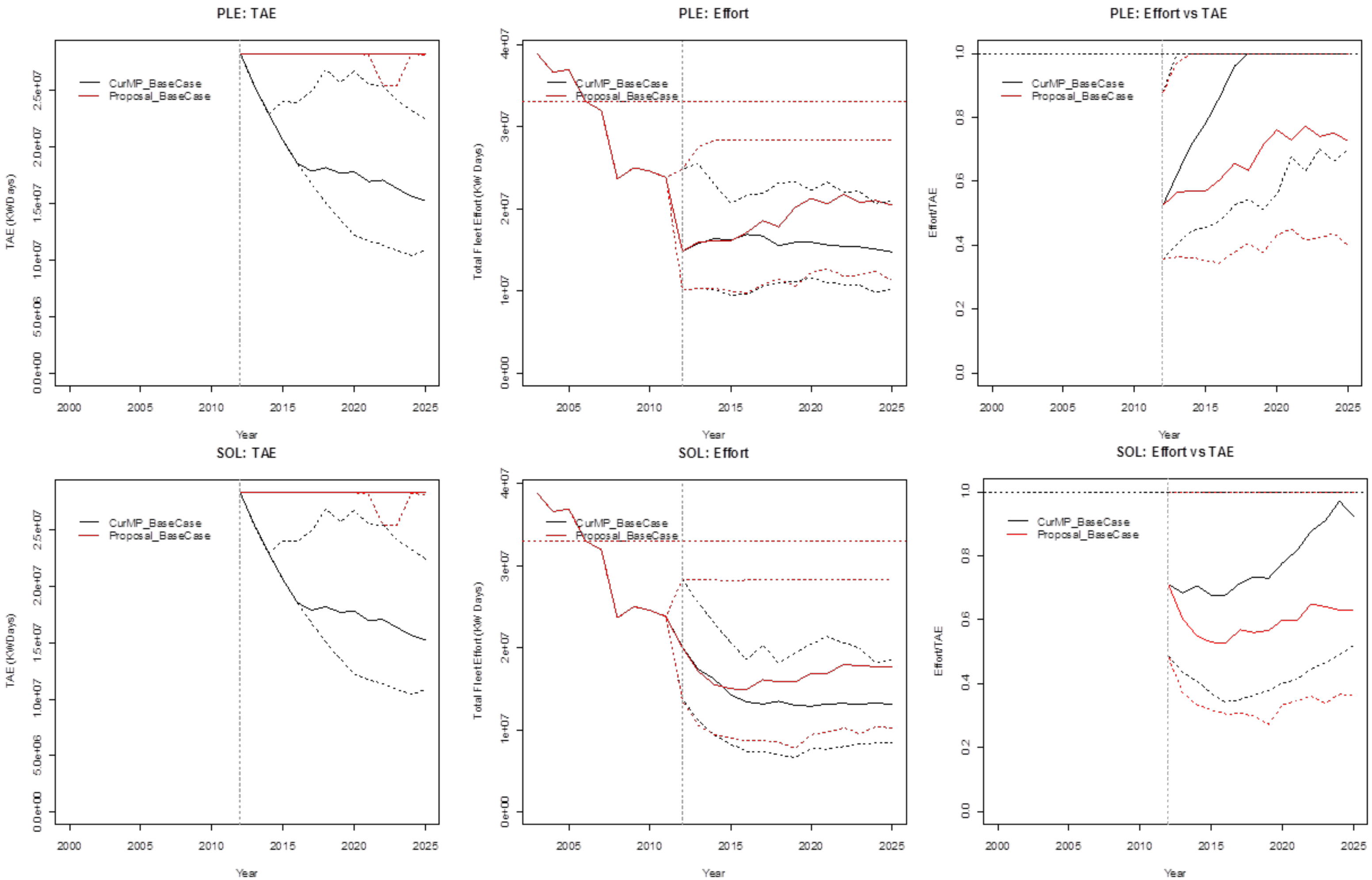

Figure D1.5. BaseCase scenario, CurMP and Proposal. Maximum Allowable Effort (here 'TAE' – Total Allowable Effort; left), effort (middle) and effort vs TAE (right) of plaice (PLE, top) and sole (SOL, bottom).

D2. Current management plan (CurMP), New sole F target (NewF), effort cap (EffCap) and proposed plan (Proposal), BaseCase scenario

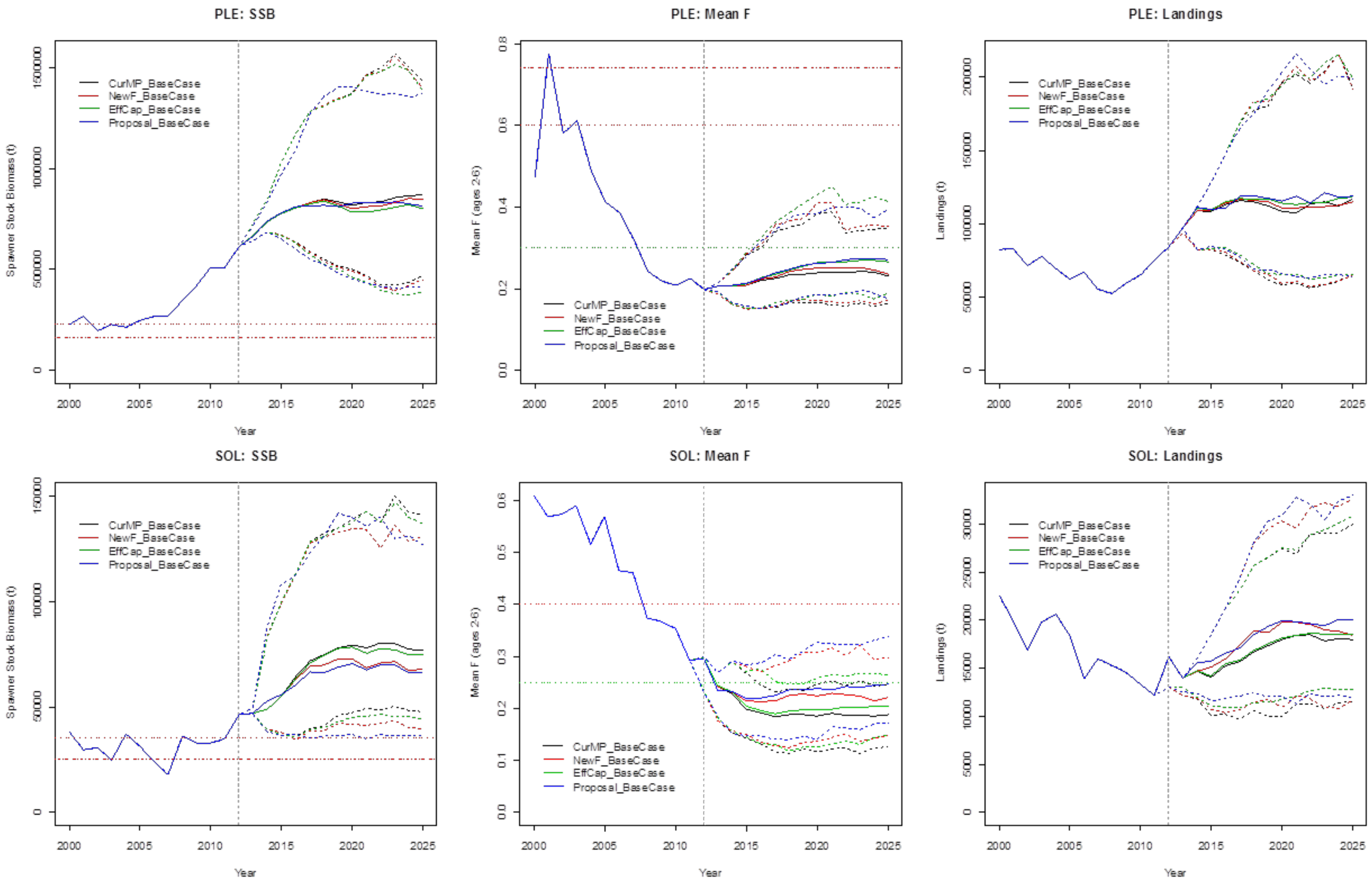

Figure D2.1. BaseCase scenario, CurMP, NewF, EffCap and Proposal. SSB (left), Mean F ages 2-6 (middle) and landings (right) of plaice (PLE, top) and sole (SOL, bottom).

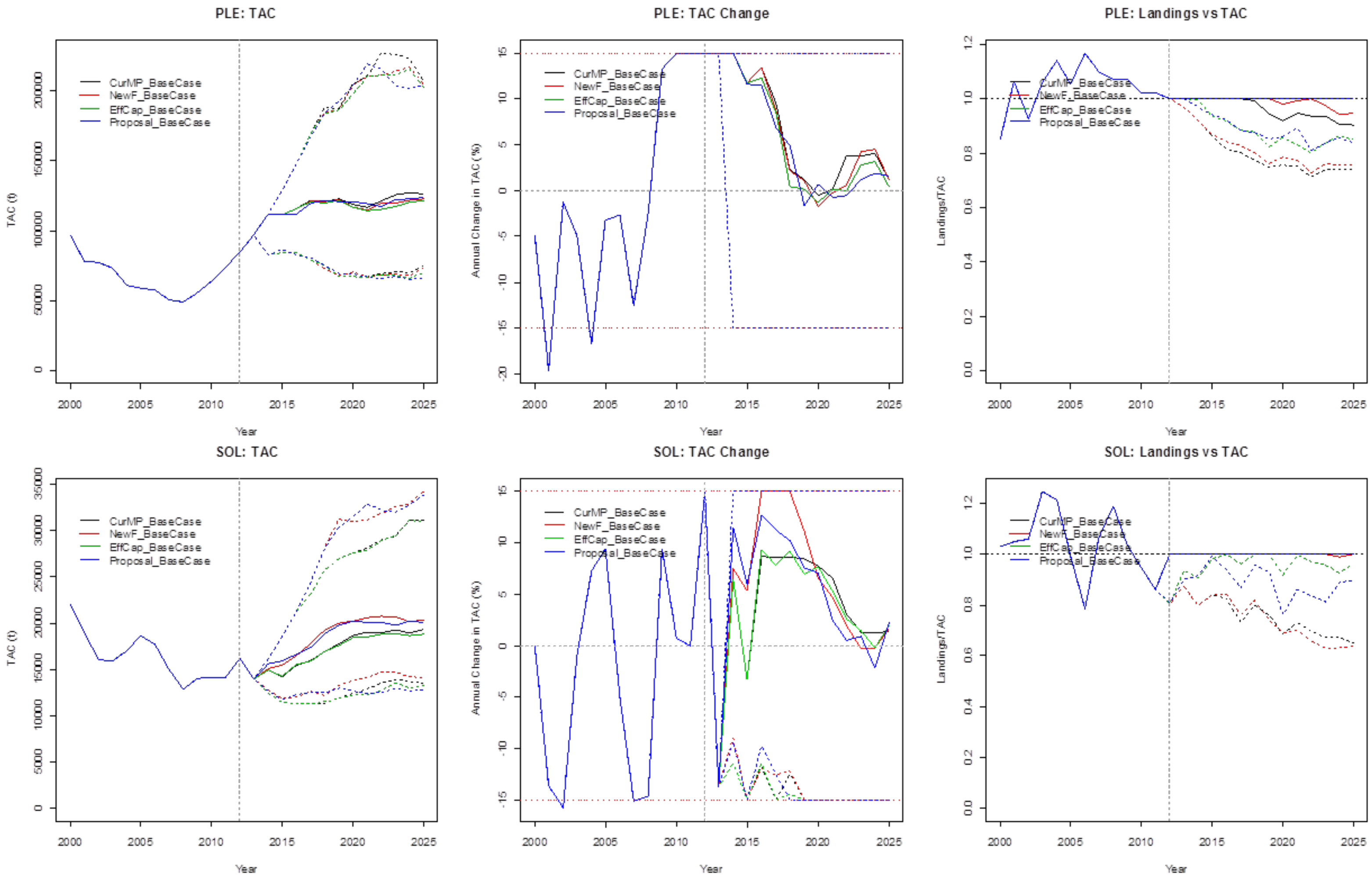

Figure D2.2. BaseCase scenario, CurMP, NewF, EffCap and Proposal. TAC (left), annual TAC change (middle) and landings vs TAC (right) of plaice (PLE, top) and sole (SOL, bottom).

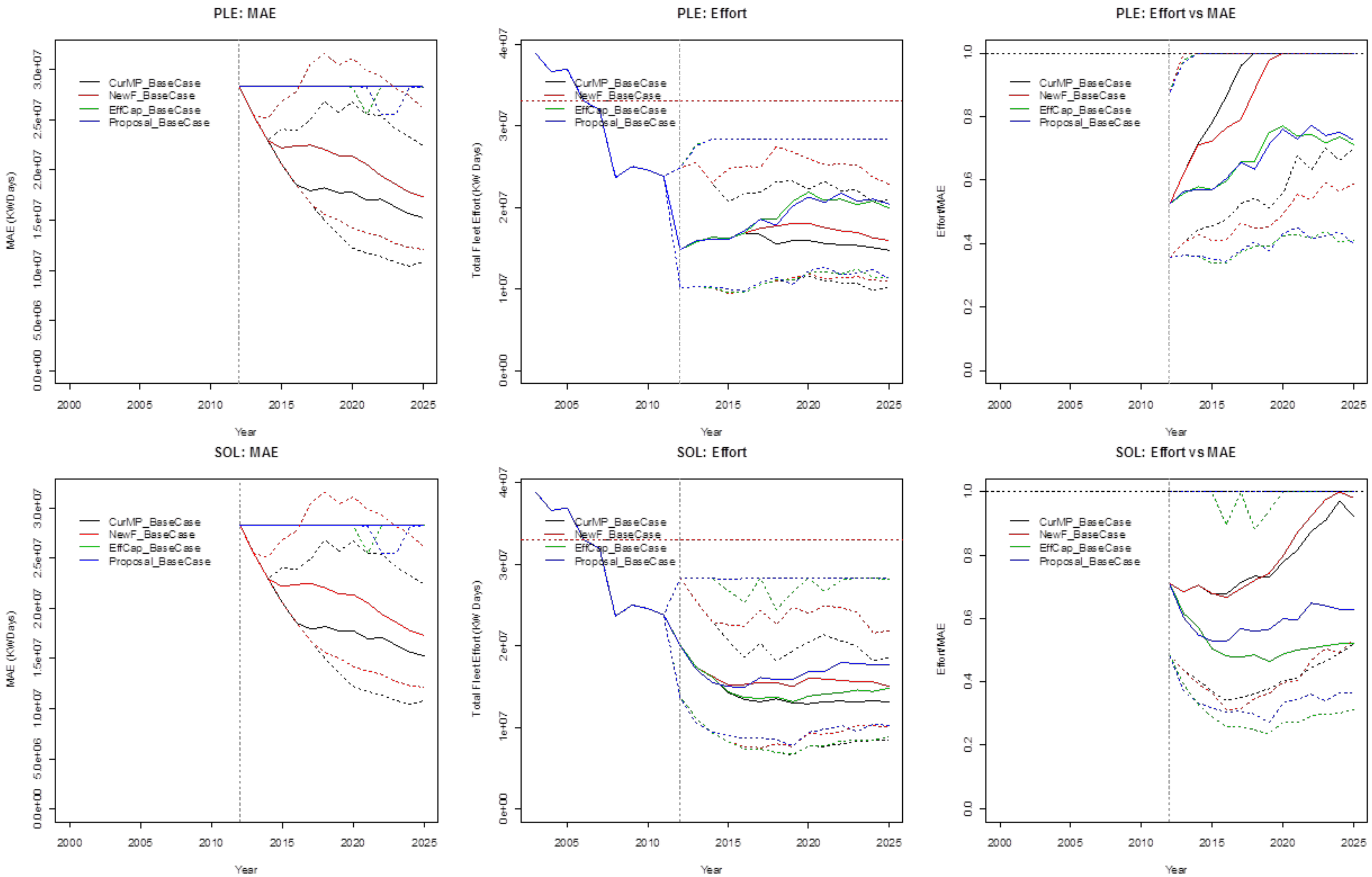

Figure D2.3. BaseCase scenario, CurMP, NewF, EffCap and Proposal. MAE (left), effort (middle) and effort vs MAE (right) of plaice (PLE, top) and sole (SOL, bottom).

D3. Current management plan (CurMP), proposed plan (Proposal) and proposed plan with HCR (Proposal_HCR), WorstCase scenario

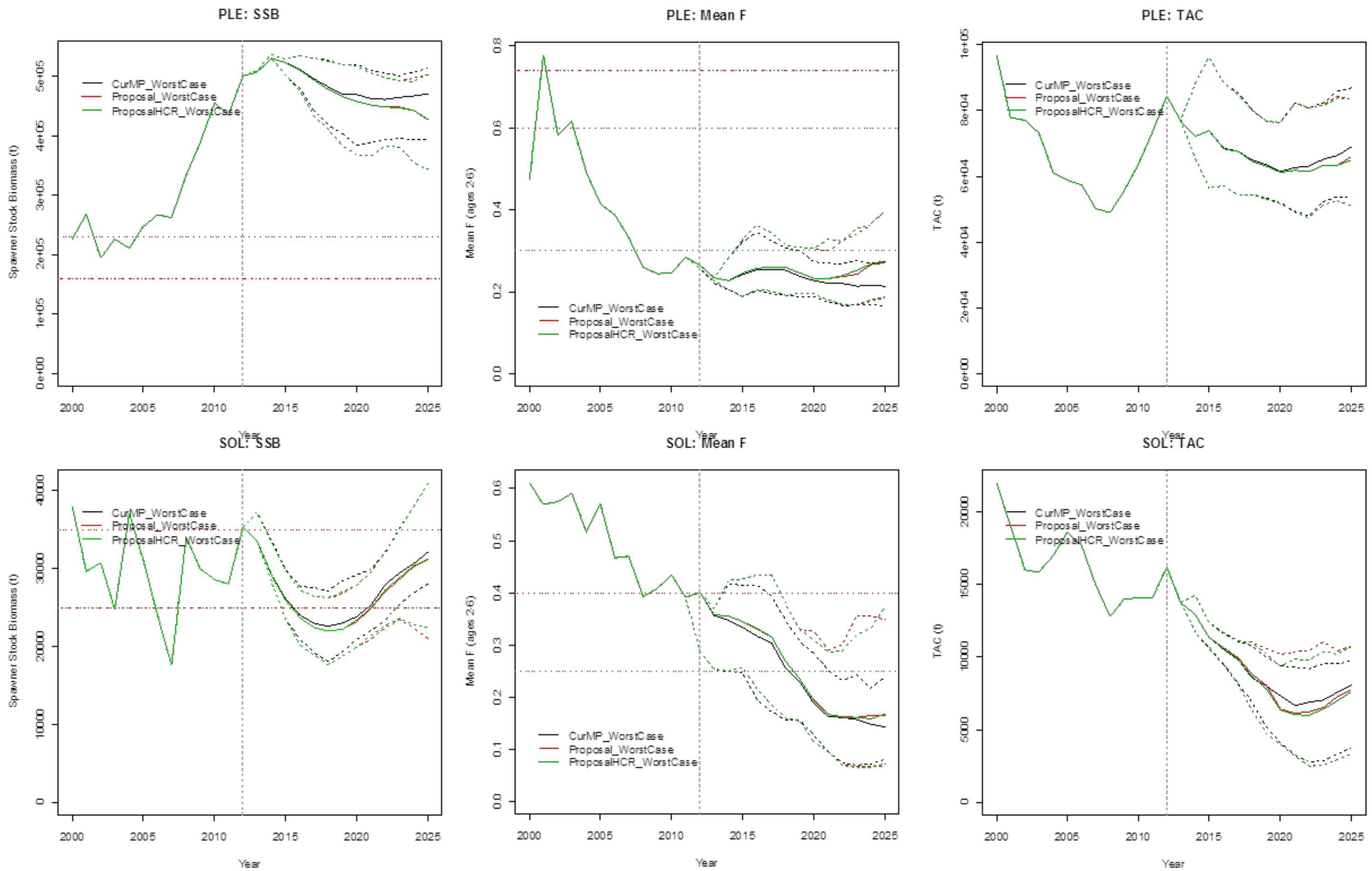

Figure D3.1. WorstCase scenario, CurMP, Proposal and Proposal_HCR. SSB (left), Mean F ages 2-6 (middle) and landings (right) of plaice (PLE, top) and sole (SOL, bottom).

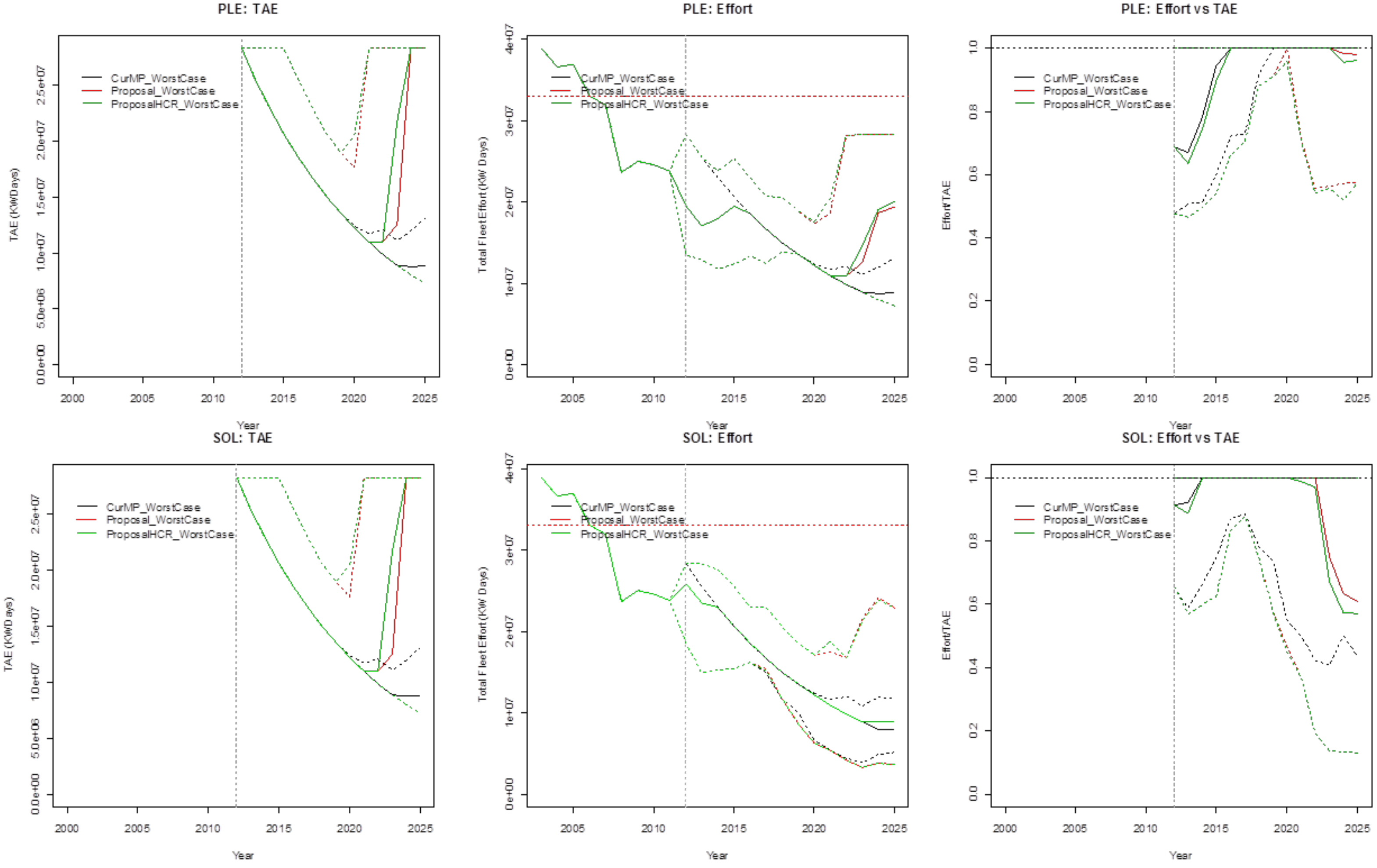

Figure D3.2. WorstCase scenario, CurMP, Proposal and Proposal_HCR. Maximum Allowable Effort (here 'TAE' – Total Allowable Effort; left), effort (middle) and effort vs TAE (right) of plaice (PLE, top) and sole (SOL, bottom).

D4. Current management plan (CurMP) and proposed plan (Proposal), BestCase scenario

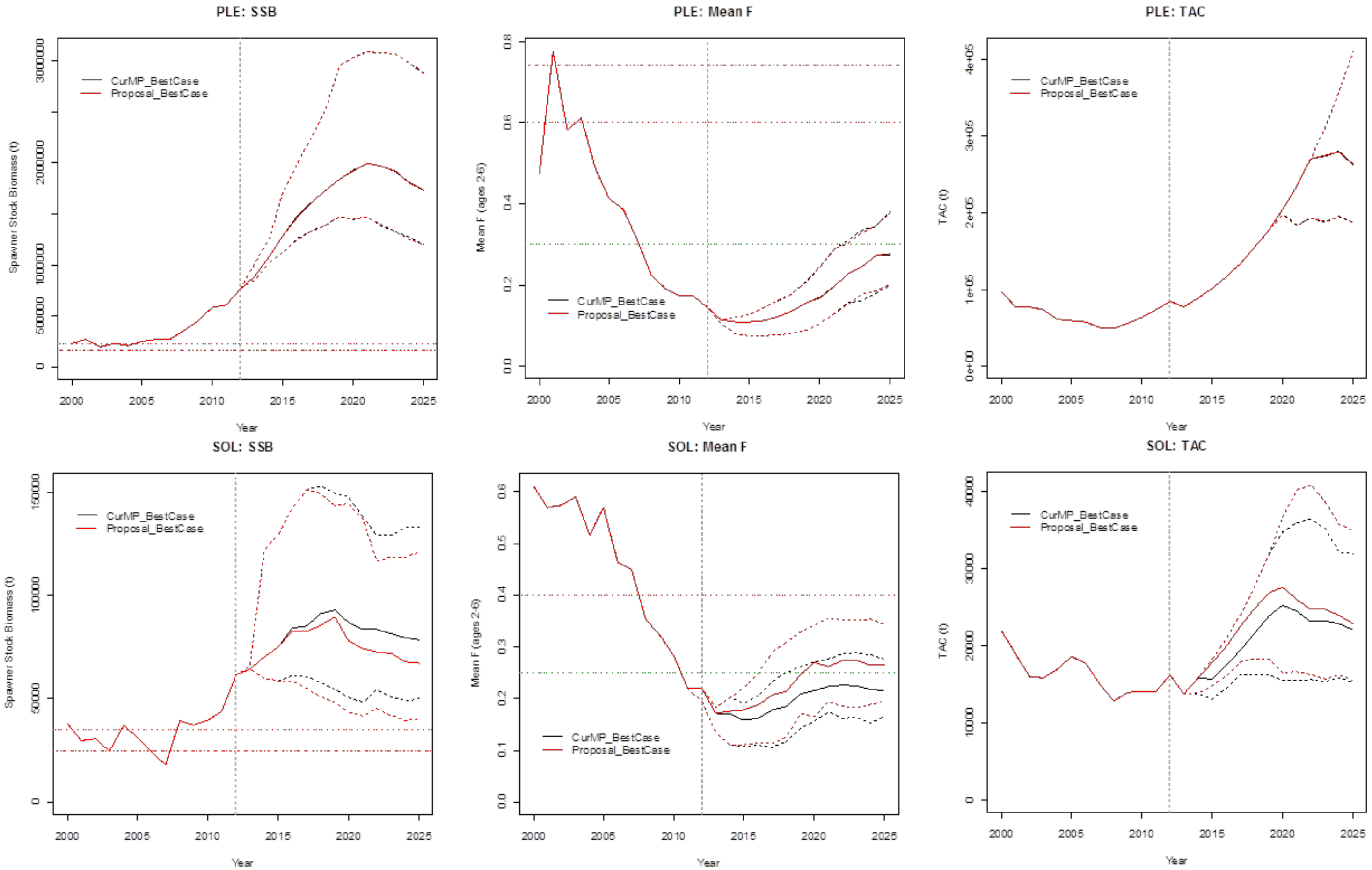

Figure D4.1. WorstCase scenario, CurMP and Proposal. SSB (left), Mean F ages 2-6 (middle) and landings (right) of plaice (PLE, top) and sole (SOL, bottom).

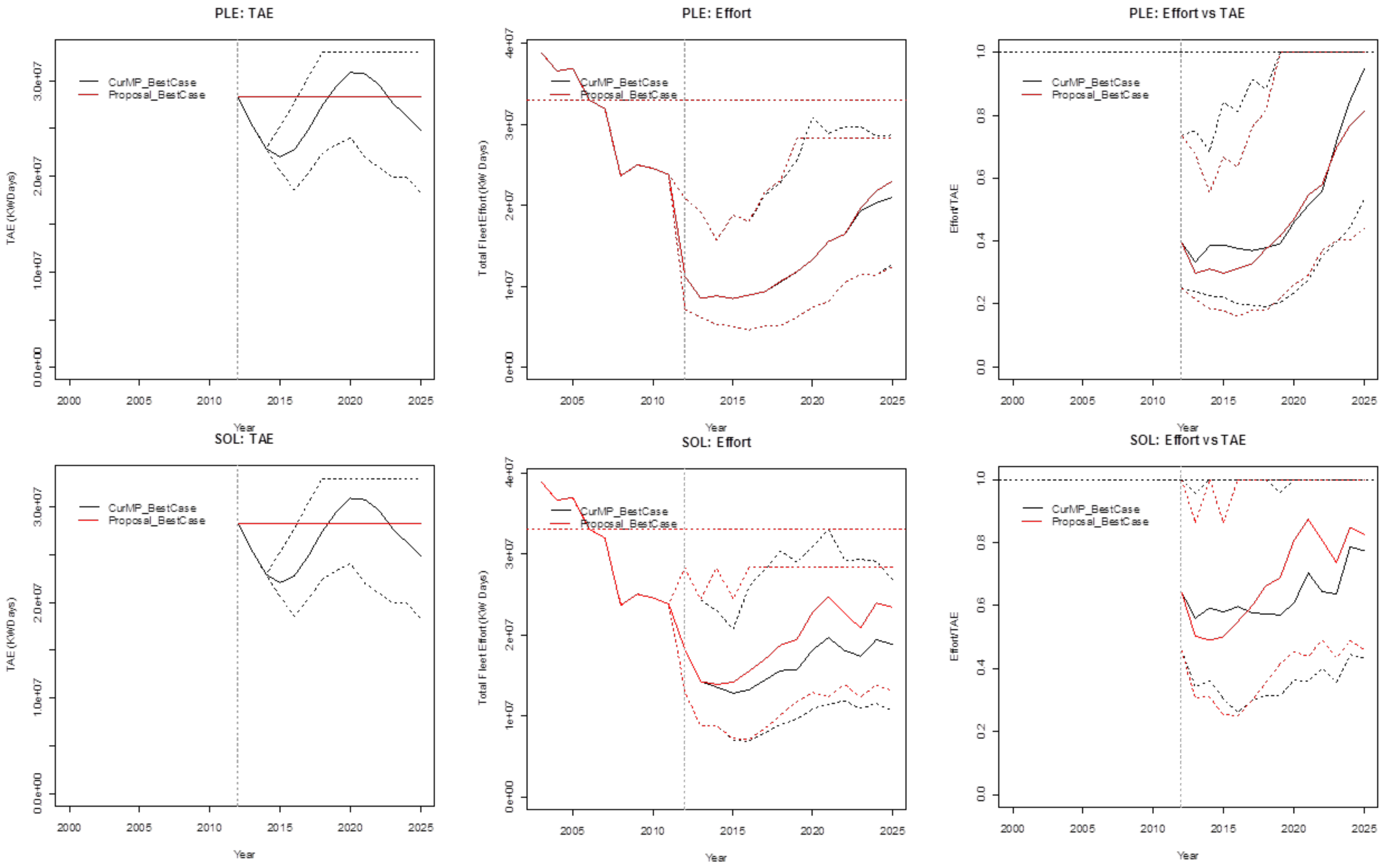

Figure D4.2. BestCase scenario, CurMP and Proposal. Maximum Allowable Effort (here 'TAE' – Total Allowable Effort; left), effort (middle) and effort vs TAE (right) of plaice (PLE, top) and sole (SOL, bottom).

D5. Proposed plan (Proposal), deployed effort scenarios (DepEffLeast, DepEffMost and 'both')

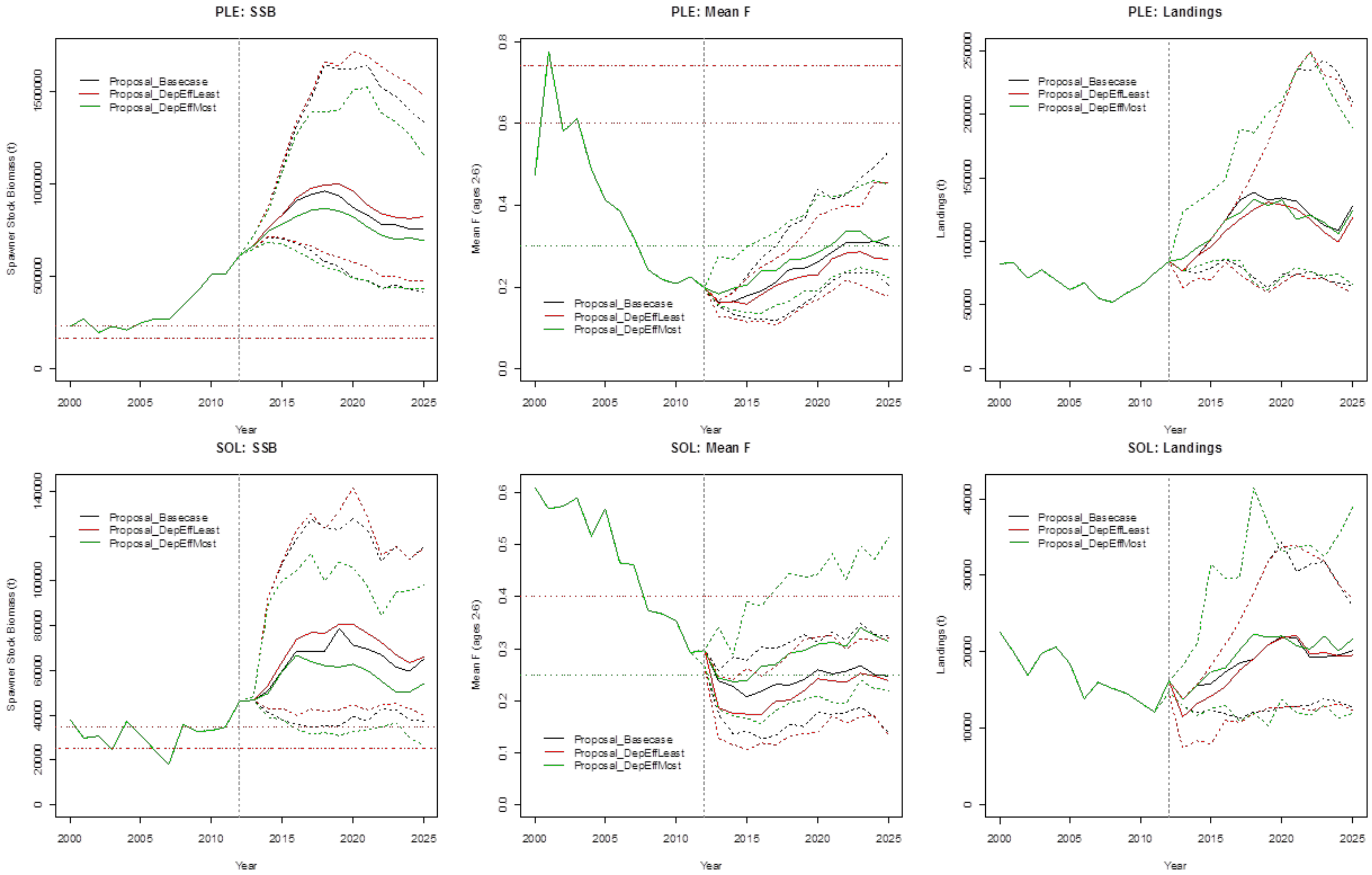

Figure D5.1. Deployed effort scenarios (DepEffLeast, DepEffMost and 'both'), Proposal. SSB (left), Mean F ages 2-6 (middle) and landings (right) of plaice (PLE, top) and sole (SOL, bottom).

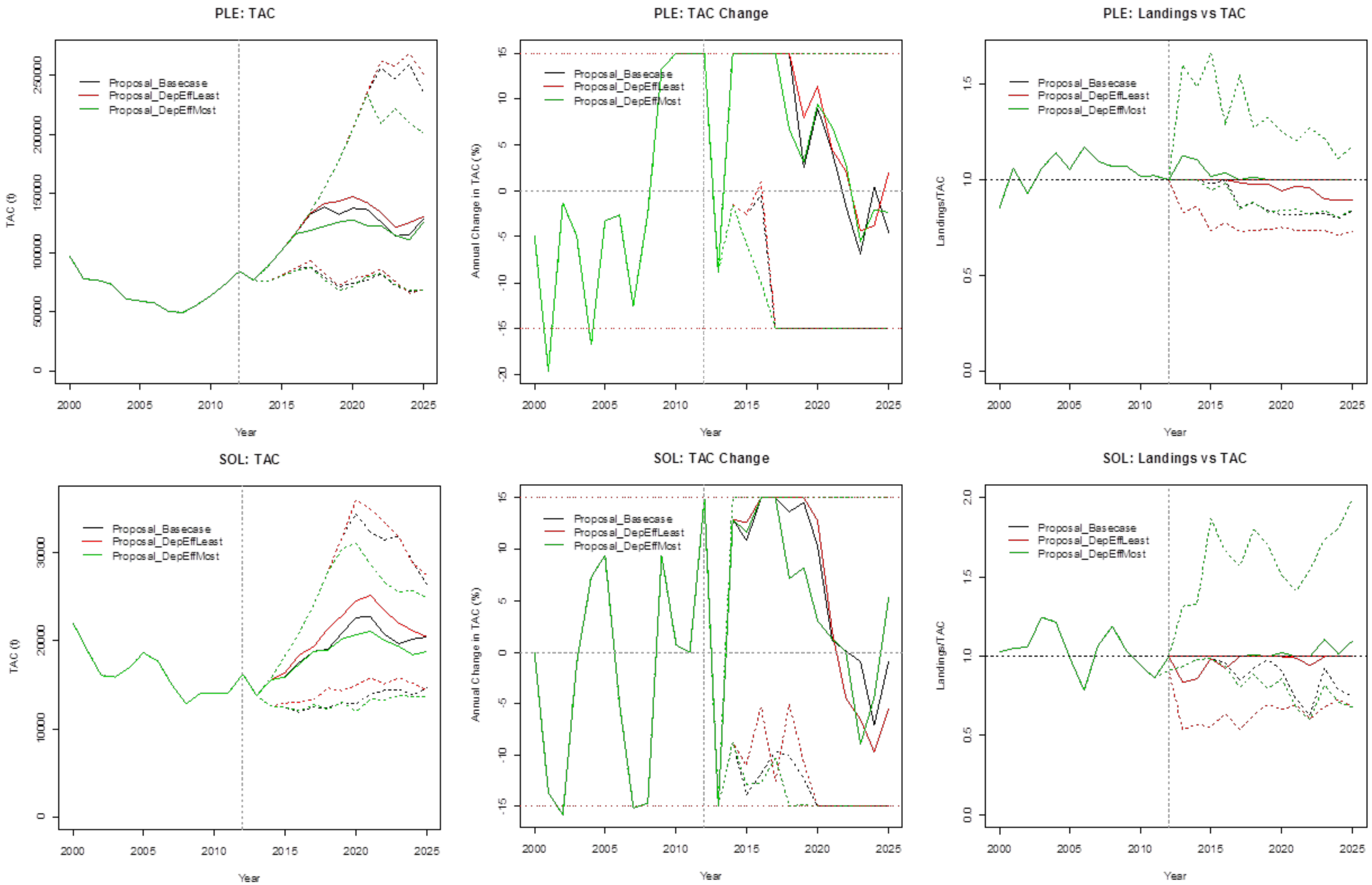

Figure D5.2. Deployed effort scenarios (DepEffLeast, DepEffMost and 'both'), Proposal. TAC (left), annual TAC change (middle) and landings vs TAC (right) of plaice (PLE, top) and sole (SOL, bottom).

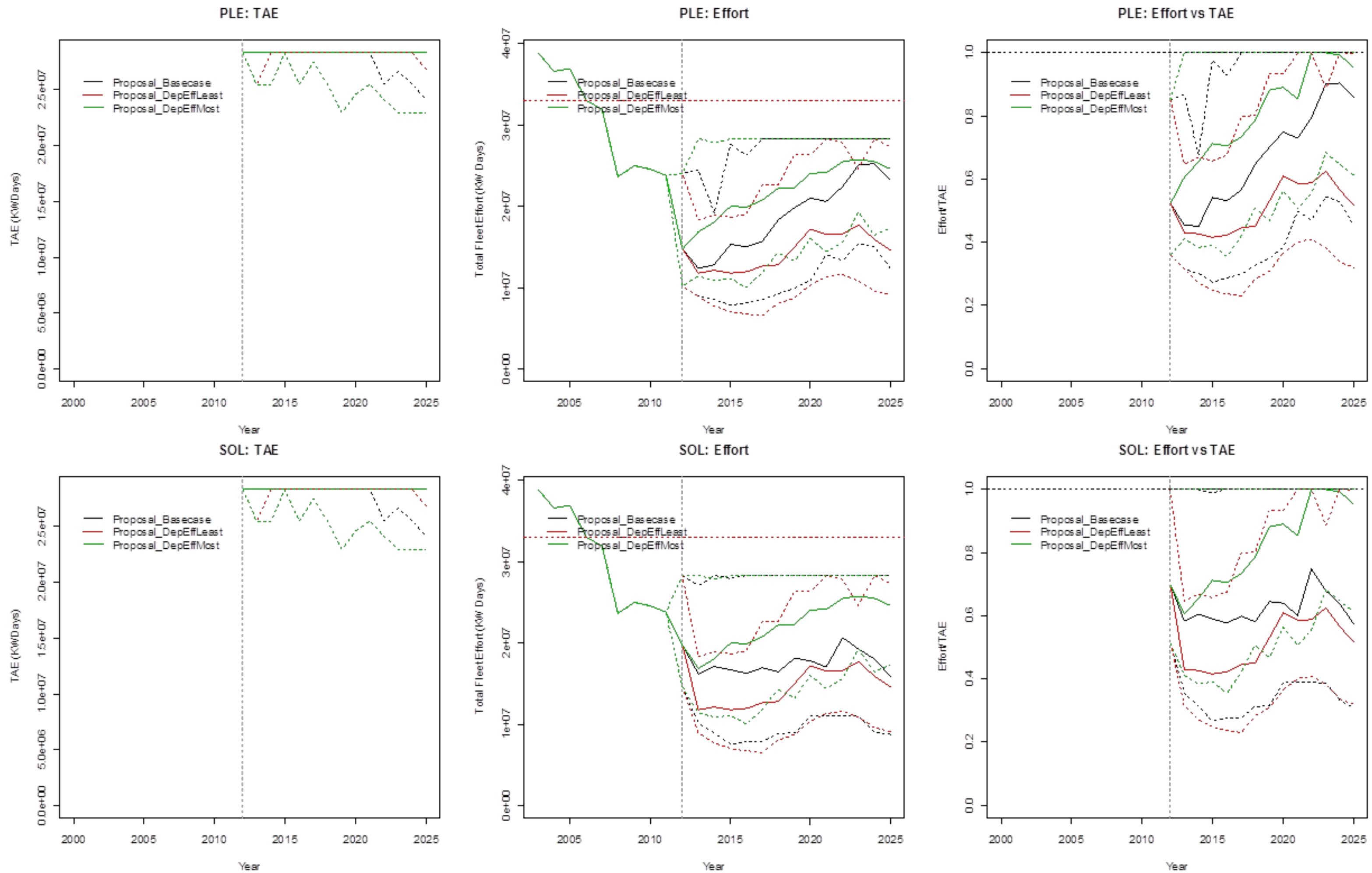

Figure D5.3. Deployed effort scenarios (DepEffLeast, DepEffMost and 'both'), Proposal. Maximum Allowable Effort (here 'TAE' – Total Allowable Effort; left), effort (middle) and effort vs TAE (right) of plaice (PLE, top) and sole (SOL, bottom).

D6. Proposed plan (Proposal), technological creep scenarios (TechCreep and ‘none’)

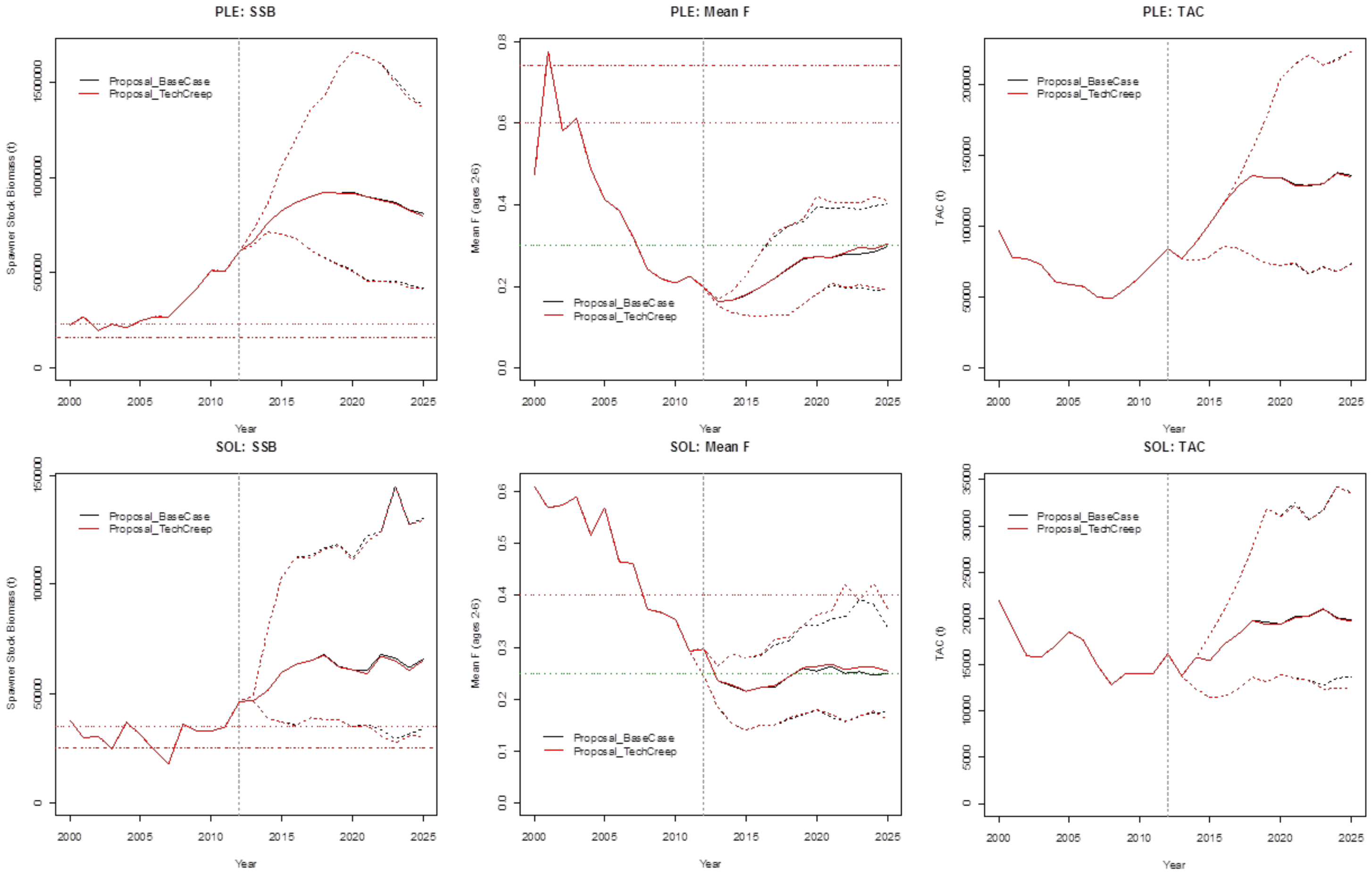

Figure D6.1. Technological creep scenario (TechCreep and ‘none’), Proposal. SSB (left), Mean F ages 2-6 (middle) and landings (right) of plaice (PLE, top) and sole (SOL, bottom).

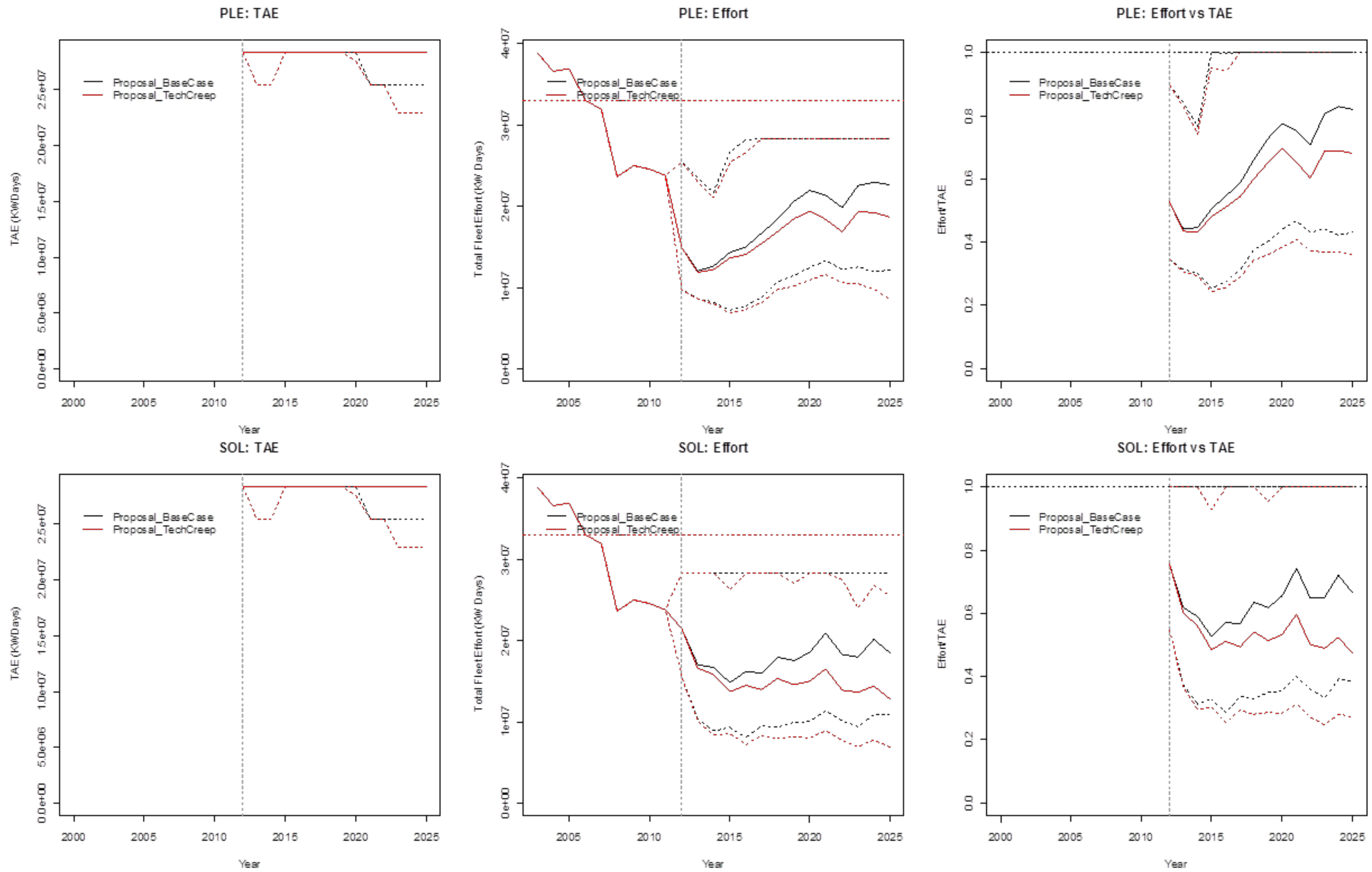

Figure D6.2. Technological creep scenario (TechCreep and 'none'), Proposal. Maximum Allowable Effort (here 'TAE' – Total Allowable Effort; left), effort (middle) and effort vs TAE (right) of plaice (PLE, top) and sole (SOL, bottom).

Appendix E: Risk Definitions

Risk definitions

Recently, some discussion has taken place in ICES on the definition of risk, for the purpose of determining whether a management plan is in conformity with the precautionary approach. Despite the fact that consensus was reached among a group of ICES and STECF scientists during the WKOMSE meeting in 2009 for using one specific definition (ICES 2009a), current practice shows that one of three different risk definitions are being applied in different long term management plan evaluations under the auspices of ICES:

- Risk1 = average probability that SSB is below B_{lim}, where the average is taken across the ny years.
- Risk2 = probability that SSB is below B_{lim} at least once during the ny years.
- Risk3 = maximum probability that SSB is below B_{lim}, where the maximum is taken over the ny years.

The results presented in the current report are based on risk definition number 2. This definition was chosen as the most appropriate one, amongst others because it was also used in previous evaluations of the management plan in 2007 and 2010. Furthermore, it became clear from the discussion that definition number 2 presents the most conservative results, i.e. in comparison to the other two definitions, it will provide a higher risk outcome. Figure E.1 below illustrates how the different risk definitions compare to each other (pers comm. Morten Vinther, DTU Aqua, DK).

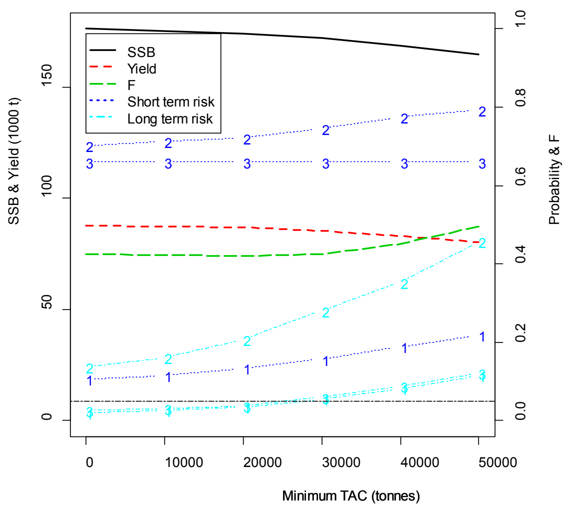

Figure E.1. A theoretical comparison of the different risk measurements under different levels of fishing pressure.

For the purpose of further discussion in ICES on choosing risk definitions, Table 5.1 below shows the specific outcomes in terms of risk calculated based on the three different definitions.

Table E.1. Overview of risk percentages when based on different definitions.

	North Sea plaice		North Sea sole	
	Current plan	Proposal	Current plan	Proposal
P(SSB<Blim); 2013-2015				
Risk 1	0	0	0	0
Risk 2	0	0	0	0
Risk 3	0	0	0	0
P(SSB<Blim); 2015-2020				
Risk 1	0	0	0.001	0.001
Risk 2	0	0	0.005	0.005
Risk 3	0	0	0.005	0.005
P(SSB<Blim); 2016-2025				
Risk 1	0	0	0.002	0.002
Risk 2	0	0	0.015	0.015
Risk 3	0	0	0.005	0.010

Appendix F: Technical Minutes

Review of the ICES Ad Hoc Group on Flatfish report 2012.

4 - 5 October 2012

Reviewers:	Alberto Murta (chair)
	Carl O'Brien
	John Simmonds (by correspondance – review annexed)
Chair Ad-Hoc Group:	Aukje Coers
Secretariat:	Mette Bertelsen

The RG acknowledges the huge effort expended by the ad-hoc group to produce the report with very tight deadlines, and also the quality of the scientific work on which the evaluation of the management plan is based.

The work carried out was not limited to reply to the question posed by the Dutch Administration: whether the proposed changes would still keep the management plan precautionary and in agreement with the MSY framework. The management plan evaluation also considered a wide range of scenarios that included situations of high and low productivity regimes, technological creep and variable ability to select target species. Although those scenarios are not immediately relevant to address the request, they may be useful in the future, depending on the future direction of the management.

The assessment model and the simulations set-up for the MP evaluation were based on previous work on the same stocks that was carried out in 2008 and 2010 and used in ICES advice. Therefore, most of the options taken had been previously reviewed, and the present review focus mainly on the aspects that are different from those previous simulations.

One of the most influential factors when simulating the application of a management plan is the choice of the stock-recruitment relationship (SRR). In this case, both species have a poorly defined SRR that is usually modeled using a segmented regression. However, the authors decided to have a segmented regression and the Ricker SSR as competing models with different a priori weights, and choose randomly (according to their weight) one of those to be used for each simulation run. How those weights were attributed to each model is poorly described in the draft report. Also, the choice of the Ricker model as a candidate SRR for flatfish is not well explained. Nevertheless, it was noted that the SSB levels above which the density dependence starts to be noticed in the Ricker model were never achieved in the simulations, and therefore the use of the Ricker SRR should be similar to the segmented regression.

The current MP states that if SSB falls below B_{lim}, effort must be decreased to rebuild the stock to healthy levels. However, the process and by how much the effort should be reduced is not described in the management plan. Therefore, the authors decided to apply a 25% reduction in effort in each year SSB was below B_{lim} in the simulations. However that situation never took place, thus the rule of 25% effort reduction was, in fact, not simulated.

Each simulation run covered a time period from 2012 to 2025. Given the foresighted changes in fishing technology (e.g. introduction of pulse trawling) and the naturally high uncertainty in the future dynamics of fish stocks, maybe simulating a shorter time period could have been enough to fulfill the objectives. Also, the remaining computational time could have been used to increase the number of runs in the simulations, given that with just 200 replicates it is difficult to have good estimates of the associated uncertainty.

Review by E J Simmonds

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- **Model conditioning**

The numerical simulation model used to evaluate the management targets which simulated populations and management changes from the available information using simple population and fleet dynamics principles is an effective way using currently accepted practice for the evaluation.

Observation uncertainty in the management system is modelled simply. There is some concern that the approach may be too cumbersome as the number of scenarios that can be run was limited making the estimates of risk rather uncertain. Some consideration could be given to characterizing the variability with random/correlated variability to mimic the response.

- *The biological operating model*

The biological models are considered to be adequate for the purpose, some minor improvements could be included, some variation in mean weight and maturation which were taken as fixed. The major uncertainties of S-R modelling was modelled well for the base case. The addition of the low recruitment option ('Worst Case') is not used to evaluate the normal performance of the plan rather to evaluate the response to abnormal runs of low recruitment. The choice of starting points is an approach that allows illustration of the influence of different conditions, but may under some circumstances make it difficult to assess short term risks. However, a both these stocks are currently above biomass reference points short term risks are low anyway.

- *The fishery operating model*

The fleet structure used substantively covers the fisheries. The use of sampled draws by year to reflect variability in fishery selectivity is an appropriate method for including variability in the age structure of the fishery it is unclear from the description if variable or fixed selection was used in the simulations. Separating landings and discards for plaice is considered to adequately address discarding for this fishery. For sole it is assumed that all catches are landed. However, there has been some evidence of small numbers of discards in this fishery recently. An additional test for robustness of the proposed management measures was carried out to simulate an increase in efficiency of the fleets over time. It is acknowledged that some gear changes are occurring and the changes in selectivity may be greater than those simulated. Mixed fishery considerations are assumed to be negligible in the main runs. It is acknowledged that potentially this not be acceptable and may influence the plaice mortality more than sole.

- *Assessment and forecast*

The setting of catches for the next year relies on an XSA assessment, implementing this is a good way to mimic the process of setting the TACs into the future. However the improvements in mimicking error structure in the method comes at a cost. The problem with this approach is that this methodology is that it is very time consuming and limits the utility of the overall approach. Consideration should be given to using the assessment based loop to develop an error model that describes the errors in setting the TAC. If this can be adequately characterized an autocorrelated random error process this could be implemented much more rapidly and facilitate better understanding of the risks.

In managing effort the limitation is that only one of the three fleets ids controlled as there is not sufficient data to estimate the relationship between effort and F for the other two fleets.

- **Simulation scenarios and management strategies**

Four management strategies were tested under different biological and fleet behavior assumptions in all options:

the F-target for plaice is 0.30 (no change)

Target F for sole =0.2 or 0.25

the maximum TAC change for both species is 15%,

the maximum allowable effort change is 10%, These scenarios are used to assess whether or not the plan subject to the proposed changes can be considered as precautionary and in agreement with the principles of Fmsy.

The evaluation was designed primarily to assess the precautionary nature of the plan with the old and new plans compared. The evaluation did not explore a wide range of options, but assumed that the selected plans options were close enough to MSY. Part of the reason for this was the difficulty in running the options quickly due to the time taken for each population simulation.

Overall the simulations were acceptable for the job. In particular the equilibrium biomass for plaice was sufficiently far above B_{lim} for all normal risks to be considered negligible. The same is not true for sole. The inclusion of the 'worst case' scenario was of particular help in deciding that the plans were precautionary, demonstrating that though the SSB might decline below B_{lim} in exceptional circumstances the plan would still deliver recovery.

However, some improvements should be considered. The biological variability in terms of growth, maturation and natural mortality was not included. The fishery variability may not be sufficient to encompass the real range of variability expected.

Replacing the assessment and TAC setting algorithm with a simple autocorrelated error generator may be sufficient to capture the precision of the assessment. By using the runs developed so far these can be used to test the error structure to see if such an approximation is acceptable. Then a far greater range of possibilities could be tested more easily, the tails of the distributions better established. Once a particular operating point has been selected it would always be possible to confirm it was being correctly evaluated by testing with the assessment reinserted in the model.