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Report of the Working Group on balance between resources and their exploitation (SGBRE)

Northern hake long-term management plans (SGBRE-07-03)

Lisbon, 4-8 June 2007

Edited by Ernesto Jardim & Franz Hölker

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

STECF COMMENTS ON THE REPORT OF THE WORKING GROUP ON BALANCE BETWEEN RESOURCES AND THEIR EXPLOITATION (SGBRE)

NORTHERN HAKE LONG-TERM MANAGEMENT PLANS (SGBRE-07-03)

LISBON, 4-8 JUNE 2007

STECF OPINION EXPRESSED DURING THE PLENARY MEETING

OF 18-22 JUNE 2007 IN ISPRA

1. Background

In 2004, a recovery plan for the northern hake stock (EC Reg. No 811/2004) followed up a previous emergency plan (EC Reg. No 1162/2001, EC Reg. No 2602/2001 and EC Reg. No 494/2002). The recovery plan aimed at achieving a SSB of 140,000 t (Bpa), by limiting fishing mortality to 0.25, and by allowing a maximum change in TAC between consecutive years of 15%.

The recovery plan is foreseen to be replaced by a management plan when, in two consecutive years, the target level for the concerned stock has been reached, in accordance with Article 6 of EC Reg. No 2371/2002. ICES, with the agreement of Scientific Technical and Economic Committee for Fisheries (STECF), evaluate and advices if the targets set in the recovery plan have been reached.

Recent ICES assessments indicate that the northern hake SSB is close to the rebuilding target established in the recovery plan. The increase in SSB appears to be due to a combination of good recruitment and moderate fishing mortality. As stated above, a management plan should therefore be put into place to replace the recovery plan, to ensure a sustainable exploitation of this stock in the long-term.

The future management plan will be based on sound scientific advice and, therefore the European Commission has asked STECF to provided scientific advice regarding several possible scenarios to be considered in the future long-term management plan. The analysis should include both single-species management and multi-species management considerations. Furthermore, economic aspects should also be considered, to ensure that the biological modelling framework that is being used can also be applicable to an economic (bio-economic) analysis. The results of the economic analysis will in turn be used to assess the impact of the future management plan.

2. Subgroup Assumptions

S-R relationship is not well estimated for the northern stock of hake and the group decided to use an Ochkam model. Using the Ockham model in favour of other S-R gave a more conservative perspective of the stock development.

Due to the uncertainty on growth rates, the group decided to carry out simulations based on an alternative faster growth hypothesis consistent with available tagging data. Considering that a faster growth would also impact natural mortality, the group decided to use a higher value for M (0.4 instead of 0.2).

The current assessment for northern hake is conducted without accounting for discards as discards rates of several fleets are simply not known and even where data are available, it is not possible to incorporate them in a consistent way. The group considered that in aiming for an optimum long-term management of this stock the issue of discards should not be ignored. Hence, simulations based on an ad-hoc rebuilding of historical discards were also carried out.
Findings

Fmax (0.17) is well defined for this stock and was considered a good proxy for the target reference point Fmsy.
Decreasing F to Fmax will result in higher and more stable biomass and higher catch per unit effort compared to fishing at Fpa.
The faster the decrease in F the faster the SSB stabilizes. This leads however to larger losses in yields in the short term.
Reductions in F towards Fmax results in short term losses if the reductions in F are greater than 5% per year.
Ftarget will be achieved in all scenarios by 2015, except in the scenario that reduces F to 0.8*Fmax at a rate of 5% per year

A faster growth rate coupled with a higher M value gives somewhat lower absolute levels of abundance and higher F but similar trends. It should be noted however that under the alternative M assumptions, results might be quite different and the group felt that further sensitivity analyses are required to give a full evaluation of alternative assumption for M.

A decrease in F in the fleets catching hake will also affect the Fs on other species associated in the catch like monkfish and megrim. However, the magnitude of the decrease in F on such species will be lower.
Taking into account discards leads to larger expected gains in long-term yields but reductions in F to reach Fmax would then need to be larger. If the reduction in F is coupled with changes in the selection pattern (by decreasing F in younger ages), this would increase further the maximum expected yields and at the same time reduce the decrease in F needed to get to Fmax.

Decreasing current F to 0.8*Fmsy or 1.2*Fmsy would lead to similar yield at long-term but to different level of SSB.
An attempt was made to link fleet segments as defined in the DCR for the collection of economic data to Fishery Units used in the assessment. The resultant matrix could be used in further analysis to investigate the economical impact of alternative management measures.

3. STECF Comments and Conclusions

STECF considers that the Sub-Group dealt with the task well in the time available, achieved its objectives and provided valuable information about the ToRs.

STECF notes that there is little difference, in terms of long-term yields, between Fmax and Fsq (which is close to Fpa) scenarios. STECF notes however that reducing F to Fmsy as opposed to Fpa would lead to higher SSB and thus give the stock more stability, reducing the risk of getting back to an unsafe situation. This could also improve economic efficiency.

STECF notes that a 5% decrease in F would lead to Fmax before 2015 without significant loss in yields at short term.

STECF notes that inclusion of discard estimates in the analysis creates a stronger positive effect on yield and SSB when F is reduced. Furthermore, inclusion of discards in simulations where the selection pattern is changed to reduce F on younger ages produces positive benefits of similar magnitude to reductions in overall F. These analyses are based on preliminary and incomplete estimates of discards quantities, nevertheless, STECF is aware that discarding takes place and considers, therefore, that the output gives a better representation than when discards are excluded. STECF recommends that in any management plan involving a move towards an Fmax target, measures which improve the selection pattern should be included.

STECF recommends that the preliminary proposals presented by the group to link fleet segmentation used to collect economical data to Fishery Units used in the stock assessment model should be continued and further developed through a specific study. STECF also recommends that, following this specific study, another meeting, involving both biologist and economists should be planned, in order to carry out bio-economic impact assessments of alternative management plans for this stock. STECF recommends that some further sensitivity analysis should be conducted on the value of M when an alternative growth rate hypothesis is used.

STECF/SGBRE-07-03WORKING GROUP REPORT ON

NORTHERN HAKE LONG-TERM MANAGEMENT PLANS

Lisbon, 4-8 June 2007

This report does not necessarily reflect the view of the European Commission and in no way anticipates the Commission's future policy in this area

1. Introduction

1.1. Background of Northern hake long-term management plans

In 2004, a recovery plan for the northern hake stock (EC Reg. No 811/2004) followed up a previous emergency plan (EC Reg. No 1162/2001, EC Reg. No 2602/2001 and EC Reg. No 494/2002). The recovery plan aimed at achieving a SSB of 140,000 t (B_{pa}), by limiting fishing mortality to 0.25, and by allowing a maximum change in TAC between consecutive years of 15%.

The recovery plan is foreseen to be replaced by a management plan when, in two consecutive years, the target level for the concerned stock has been reached, in accordance with Article 6 of EC Reg. No 2371/2002. ICES, with the agreement of Scientific Technical and Economic Committee for Fisheries (STECF), evaluate and advices if the targets set in the recovery plan have been reached.

Recent ICES assessments indicate that the northern hake SSB is close to the rebuilding target established in the recovery plan. The increase in SSB appears to be due to a combination of good recruitment and moderate fishing mortality. As stated above, a management plan should therefore be put into place to replace the recovery plan, to ensure a sustainable exploitation of this stock in the long-term.

The future management plan will be based on sound scientific advice and, therefore the European Commission has asked STECF to provided scientific advice regarding several possible scenarios to be considered in the future long-term management plan. The analysis should include both single-species management and multi-species management considerations (see chapter 2.3). Furthermore, economic aspects should also be considered, to ensure that the biological modelling framework that is being used can also be applicable to an economic (bio-economic) analysis. The results of the economic analysis will in turn be used to assess the impact of the future management plan.

1.2. The stock and the fishery

Northern Hake is taken as components of catches in mixed demersal fisheries. Historically, a set of different Fishery Units (FU) was defined by the ICES Working Group on Fisheries Units in Sub-areas VII and VIII in 1985, in order to study the fishing activity related to demersal species (ICES, 1991). To take into account the hake catches from other areas, a new Fishery Unit was introduced in the beginning of the nineties (FU 16: Outsiders). This Fishery Unit was created on the basis of combination between mixed areas and mixed gears (trawl, seine, long line, and gill net). The FU have been defined as follows:

Table 2.2.1 – Northern Hake Fishery Units (FU)

Fishery Unit	Description	Sub-area

FU1	Long-line in medium to deep water	VII
FU2	Long-line in shallow water	VII
FU3	Gill nets	VII
FU4	Non-*Nephrops* trawling in medium to deep water	VII
FU5	Non-*Nephrops* trawling in shallow water	VII
FU6	Beam trawling in shallow water	VII
FU8	*Nephrops* trawling in medium to deep water	VII
FU9	*Nephrops* trawling in shallow to medium water	VIII
FU10	Trawling in shallow to medium water	VIII
FU12	Long-line in medium to deep water	VIII
FU13	Gill nets in shallow to medium water	VIII
FU14	Trawling in medium to deep water	VIII
FU15	Miscellaneous	VII & VIII
FU16	Outsiders	IIIa, IV, V & VI
FU00	French unknown	

The main part of the fishery (close to 90% of the total landings) is currently conducted in six Fishery Units, three of them from Sub-area VII: FU 1 (Long-line in medium to deep water in Sub-area VII), FU 3 (Gill nets in Sub-area VII) and FU 4 (Non-*Nephrops* trawling in medium to deep water in Sub-area VII), two from Sub-area VIII: FU 13 (Gill nets in shallow to medium water) and FU 14 (Trawling in medium to deep water in Sub-area VIII) and one in Sub-areas IIIa, IV, V and VI, representing respectively 22%, 13%, 20%, 8%, 13% and 15% of the total in 2006.

Spain accounts for the main part of the landings with 59% of the total in 2006. France is taking 26% of the total, UK 6%, Denmark 3%, Ireland 3% and other countries (Norway, Belgium, Netherlands, Germany, and Sweden) contributing small amounts.

Total landings from the Northern stock of hake by area for the period 1961-2006 as used by the WG are given in Table 2.2.2. They include landings from Divisions IIIa and IVa,c, Sub-areas IV, VI and VII, and Divisions VIIIa,b,d, as reported to ICES. Except in 1995, landings decreased steadily from 66 500 t in 1989 to 35 000 t in 1998. Up to 2003, landings have fluctuated around 40 000 t. In 2004 and 2005, an important increase in landings had been observed with 47 123 t and 46 300 t of hake landed respectively. In 2006, the total landings decreased to 41,810 t.

The assessment

The XSA assessment of this stock is based on estimates of landings at age and trends in abundance given by commercial CPUE data and four series of French, UK and Spanish trawl survey data. Data on discards are presently inadequate for inclusion in the assessment. Due to low confidence in the estimate of age 0 in the landings because of inconsistencies in the data for this age group in recent years, age 0 was removed from the catch at age matrix (replaced with 0 landings) and from the commercial fleet data. However, age 0 is still used in the assessment because indices for age 0 are available from surveys in age 0.

There are several sources of uncertainties for this stock:

- CPUE indices on the earlier year of the series.
- Non validated ageing criteria.
- Substantial uncertainty associated with total catches, particularly on small ages.
- Estimation of recruitment in recent years due mainly to inconsistencies in younger age indices from the FR-EVHOES survey. As this survey is thought to provide a reliable age 0 index, this may reveals an ageing problem

Alternative runs conducted by the ICES working group in 2006 (ICES, 2006) indicated that results are very sensitive to each of this uncertainties.

This group decided to conduct an update of the ICES 2006 assessment using the available input data for year 2006. The assessment summary is presented in Figure 2.2.1. SSB appears to have been very close to $\mathbf{B}_{pa}$ over the last 3 years, and F has been around $\mathbf{F}_{pa}$ since 2001. The increase in SSB since the low values estimated in the 90s appears to be due to a combination of good recruitment and moderate fishing mortality. As the growth rate and thus the age determination and productivity of northern hake stocks are uncertain, absolute estimates of SSB and F have to be considered with caution.

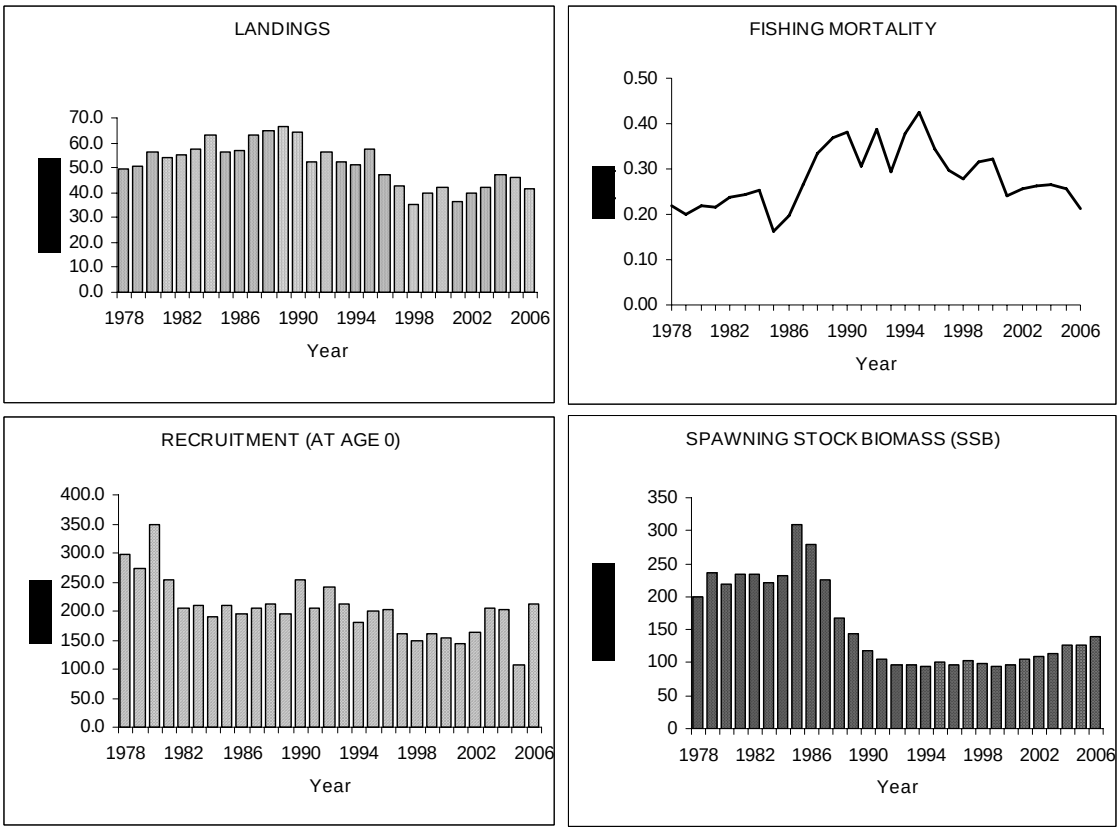


Figure 2.2.1. Summary plots for Northern hake stock as obtained from the XSA assessment.

Management

Following concerns in the late 1990s about the low level of the stock biomass and the possibility of recruitment failure a range of technical measures were introduced (Council Regulations N°1162/2001, 2602/2001 and 494/2002) aimed at improving the selection pattern and protecting juveniles. Subsequently a recovery plan was introduced (Council regulation EC Reg. No 811/2004).

The technical measures comprise a 100 mm minimum mesh size for otter-trawlers when hake comprises more than 20% of the total amount of marine organisms retained onboard, with a dispensation for those vessels less than 12 m in length and which return to port within 24 hours of their most recent departure. Further, two areas have been defined, one in Sub area VII and the other in Sub area VIII, where a 100 mm minimum mesh size is required for all otter-trawlers, irrespective of the proportion of hake caught.

The recovery plan consists of setting a TAC equivalent to a target F of 0.25 (Fpa), or a lower F to prevent decline in SSB, and with the constraint that annual change in TAC should not exceed 15%.

Since the end of 2005, the French vessels involved in the *Nephrops* fishery in the Bay of Biscay are regulated by licence. This licence is given only for vessels using a square mesh panel allowing 20-30% escapement of undersized hake.

Table 2.2.2. Estimates of catches ('000 t) for the Northern Hake by area for 1961–2006.

	Landings (1)					Discards (2)	Catches (3)
Year	IVa+VI	VII	VIIIa,b	Unallocated	Total	VIIIa,b	Total
1961	-	-	-	95.6	95.6	-	95.6
1962	-	-	-	86.3	86.3	-	86.3
1963	-	-	-	86.2	86.2	-	86.2
1964	-	-	-	76.8	76.8	-	76.8
1965	-	-	-	64.7	64.7	-	64.7
1966	-	-	-	60.9	60.9	-	60.9
1967	-	-	-	62.1	62.1	-	62.1
1968	-	-	-	62.0	62.0	-	62.0
1969	-	-	-	54.9	54.9	-	54.9
1970	-	-	-	64.9	64.9	-	64.9
1971	8.5	19.4	23.4	0	51.3	-	51.3
1972	9.4	14.9	41.2	0	65.5	-	65.5
1973	9.5	31.2	37.6	0	78.3	-	78.3
1974	9.7	28.9	34.5	0	73.1	-	73.1
1975	11.0	29.2	32.5	0	72.7	-	72.7
1976	12.9	26.7	28.5	0	68.1	-	68.1
1977	8.5	21.0	24.7	0	54.2	-	54.2
1978	8.0	20.3	24.5	-2.2	50.6	2.4	52.9
1979	8.7	17.6	27.2	-2.4	51.1	2.7	53.8
1980	9.7	22.0	28.4	-2.8	57.3	3.2	60.5
1981	8.8	25.6	22.3	-2.8	53.9	2.3	56.3
1982	5.9	25.2	26.2	-2.3	55.0	3.1	58.1
1983	6.2	26.3	27.1	-2.1	57.5	2.6	60.1
1984	9.5	33.0	22.9	-2.1	63.3	1.9	65.1
1985	9.2	27.5	21.0	-1.6	56.1	3.8	59.9
1986	7.3	27.4	23.9	-1.5	57.1	3.0	60.1
1987	7.8	32.9	24.7	-2.0	63.4	2.0	65.3
1988	8.8	30.9	26.6	-1.5	64.8	2.0	66.8
1989	7.4	26.9	32.0	0.2	66.5	2.3	68.8
1990	6.7	23.0	34.4	-4.2	59.9	1.5	61.4
1991	8.3	21.5	31.6	-3.9	57.6	1.7	59.3
1992	8.6	22.5	23.5	2.1	56.6	1.7	58.3
1993	8.5	20.5	19.8	3.3	52.1	1.5	53.6
1994	5.4	21.1	24.7	0	51.3	1.9	53.1
1995	5.3	24.1	28.1	0	57.6	1.2	58.9
1996	4.4	24.7	18.0	0	47.2	1.5	48.8
1997	3.3	18.9	20.3	0	42.6	1.8	44.4
1998	3.2	18.7	13.1	0	35.0	0.8	35.8
1999	4.3	24.0	11.6	0	39.8	0.8	40.6
2000	4.0	26.0	12.0	0	42.0	0.6	42.6
2001	4.4	23.1	9.2	0	36.7	0.5	37.2
2002	2.9	21.1	15.9	0	40.1	0.3	40.4
2003	2.8	23.7	15.3	0	41.9	-	41.9
2004	4.4	27.2	15.5	0	47.1	-	47.1
2005	5.3	26.7	14.4	0	46.4	-	46.4
2006	6.1	24.9	10.8	0	41.8	-	41.8

(1) Spanish data for 1961–1972 not revised, data for Subarea VIII for 1973–1978 include data for Divisions VIIIa,b only. Data for 1979–1981 are revised based on French surveillance data.
Includes Divisions IIIa, IVb,c from 1976.
There are some unallocated landings moreover for the period 1961–1970.

(2) Discards have been estimated from 1978 and only for Divisions VIIII a,b.
(3) From 1978 total catches used for the Working Group.

1.3. Terms of reference (ToRs)

The terms of reference for this meeting were:

PART 1. SINGLE-SPECIES MANAGEMENT
(1) Determine a measure of fishing mortality corresponding to exploitation of the northern stocks of hake at maximum sustainable yield (=Fmsy).
(2) Establish by simulation the comparative benefits of gradually changing the current level of fishing mortality on northern hake to Fmsy in steps of (a) 5% per year (b) 10% per year (c) 15%per year.
(3) The exercise in para. 2 should be repeated for moving to Fmsy * 1.2 and Fmsy * 0.8.
(4) Measures of performance should be calculated including the mean, median, 25th. and 75th. percentiles of the following:

- Inter-year variability in (a) catches (b) TACs (c) discards
- Level of (d) annual catches (e) TACs
- Level of (f) fishing mortality
- Level of (g) SSB
- Level of (h) fishing effort (disaggregated by gear types as appropriate), in kW-days at sea needed to take the TAC.

and the annual risk of SSB falling under Bpa.
Measures should be calculated in comparison with setting TACs at a level corresponding to Fpa.

PART 2. MULTISPECIES MANAGEMENT
In parallel with the scenarios calculated in part 1, STECF is requested to calculate (for selected relevant scenarios, but including the strategy of moving to Fmsy in 10% annual changes) the effects on yields and stock sizes of the principal commercial species caught together with northern hake.

PART 3. OTHER SCENARIOS
STECF is invited to investigate on its own initiative other scenarios that may be comparable with the objectives of fishing a high and stable yield from the stock.

PART 4. ECONOMIC ANALYSIS
The simulations calculated here will at a later stage form the basis of an economic impact analysis. The implementing methods for this have not yet been developed.
(1) Identify the data needed for economic analysis purposes - fleets, aggregation, variables
(2) Ensure compatibility between "economic" and "biological" fleet segments
(3) Consider the application of the FLR programming approach (incorporating economic components)
(4) Identify problem areas/potential solutions in applying bio-economic modelling in impact assessment (using North Sea flatfish experience).

1.4. Starting conditions

First, a XSA was run with the available catch at age data from 1978 to 2005 updated to 2006, 8 abundance indices, and the settings used in WGHMM. The output of this model was used as a basis to parameterize the models.

An initial random population and fishing mortality at age were generated iterating the XSA 100 times. In each of the iterations a multiplicative lognormal error was added to each abundance index, with

mean equal 1 and standard deviation equal to the residual variance of the index in the base XSA. The catch at age matrix was maintained constant along iterations.

In the projections the mean of the observed last three years, 2004-2006, were used for maturity at age and weight at age. Regarding natural mortality 0.2 was used for all ages and years, except in one scenario, the faster growth scenario, in which a natural mortality of 0.4 was used.

The different stock recruitment S/R models used in the simulations were parameterized using the numbers at age obtained in the base XSA, the estimates of 2005 and 2006 were discarded from the fit because they are normally considered unreliable in the assessment working group.

All the scenarios were run for 100 iterations until 2040.

1.5. Simulation algorithms

Two algorithms, both integrated in FLR (Kell et al. 2007), were used to simulate all the scenarios, a simple projection algorithm and an algorithm which uses the Management Strategy Evaluation (MSE) approach to simulate the proposed Harvest Control Rule (HCR).

The simple projection algorithm, referred as 'proj' in this document, simulates an age structured population using a predefined S/R relationship, the survival equation and the Baranov catch equation to project the population forward. In 2007, the first year of the simulation, it assumes that the fishery catches exactly the TAC, and the corresponding fishing mortality is calculated according to the biomass and the selection pattern. From 2008 onwards the reference F is decreased in a 5, 10 or 15 % depending in the scenario until an F equal to Ftarget is obtained. Once Ftarget is reached the fishing mortality is maintained constant along years. The only uncertainty considered in the simulation is a lognormal multiplicative error around the S/R curve and the uncertainty in the initial population and fishing mortality.

The MSE approach consists in considering the main uncertainties arising in the management process within the simulation. The main uncertainties arising in management process can be classified in 5 main groups according to Kell et al. (2007), which are process, observation, estimation, model and implementation uncertainties. In the simulations carried out during the meeting some specific forms of the first four groups were considered. Process uncertainty was introduced in the S/R process adding a multiplicative lognormal error to the recruitment. Observation error was inserted in the abundance indices adding also a multiplicative lognormal error. Estimation error arose automatically in the simulation as the assessment model did never estimate exactly the true population. And model uncertainty comes out in the HCR when in the year of application it is assumed that the recruitment of this year is equal to the geometric mean of the previous year recruitment estimates.

The MSE algorithm models the interplay between the biological dynamics of the stocks the dynamics of the fleet, the perception of the stock status via an assessment and a management measure resulting in the HCR that acts on the fishery. A relational diagram of the -full feedback- model is given in Figure 2.5.1.

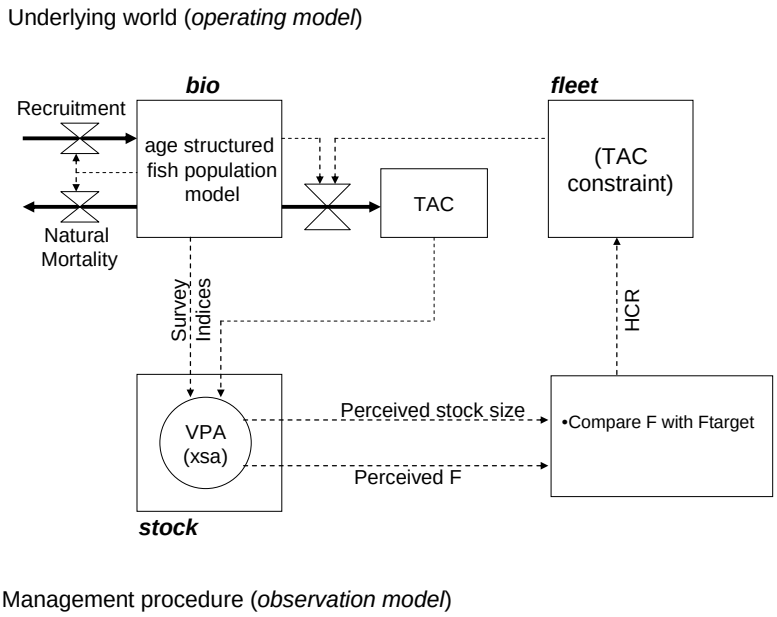


Figure 2.5.1. Relational diagram of the MSE algorithm.

Biological operating model

The biological operating model consisted of an age structured population state of a 'real' stock, including the population dynamics of this stock. The spawning stock biomass (SSB) determines the number of recruits of the next year class via the S/R model. The stock numbers at age are affected by natural mortality set for every age class, and fishing mortality. The simulation was initiated in 2007. Catch and survivors of the stocks were then calculated for the successive years using the survival and Baranov catch equations. From 2007 onwards the recruits are sampled from the stock-recruitment relationship, given the stock sizes.

Fleet operating model

The simulated fishery consists in a single fleet harvesting the population. Implementation error is not considered so the fishery catches exactly the TAC obtained in the HCR and the selection pattern is maintained constant along the years.

Observation model

The "perceived" stocks status is generated through the explicit inclusion of a stock assessment in the simulation. The assessment method used was XSA based on the catch at age taken without error from the fleet and some simulated abundance indices. The abundance indices are simulated using a linear catchability model and an observation error is introduced in them though a lognormal multiplicative error with mean equal one and standard deviation equal to the residual variance of the index in the initial XSA fit. Biological parameters of the stock in the assessment process were assumed to be equal to the biological parameters set in the operating model, i.e. they were assumed to be constant and known without error.

Management action model

In order to set a TAC for year y, assessment data were available up to year y-2 and the assessment itself is carried out in year y-1. The stock assessment produced fishing mortality estimates up to year y-2, and beginning of year population estimates up to year y-1. The recruitment used for projections was the geometric mean recruitment computed over the "observed" time period. The assumption to estimate the fishing mortality of year y-1, is that the fleet catches exactly the TAC set in year y-2 for year y-1. This fishing mortality is then compared with the Ftarget, if they are not equal the fishing mortality is changed in a 5, 10 or 15% and the corresponding TAC is calculated according to this obtained fishing mortality and the estimated stock numbers for 1st January of year y. Under the assumption of no implementation error, this TAC is the catch that the fleet will catch in year y.

To carry out the simulations for alternative scenarios (Section 5) the CS5 software (Patterson, 2002) was used.

1.6. Statistical stability

The exercise presented in this section tests the consistency of the statistical properties of our simulations with regards to the number of iterations used. We increase the iterations number from 100, used in all our simulations, until 300 hundred, in this particular simulation and present some comments about the stability of our results. Note that a sensitivity test about the number of iterations should be presented on further analysis. We expected to progress towards the stability of our results when the number of iterations increase i.e. if we repeat our simulation we should expect to get the same (or similar) results. Perfect theoretical stability is only achieved at infinitum iterations; this is obviously impossible and not needed for practical purposes. However, it should be expected to get a practical stability at a reasonable number of iterations.

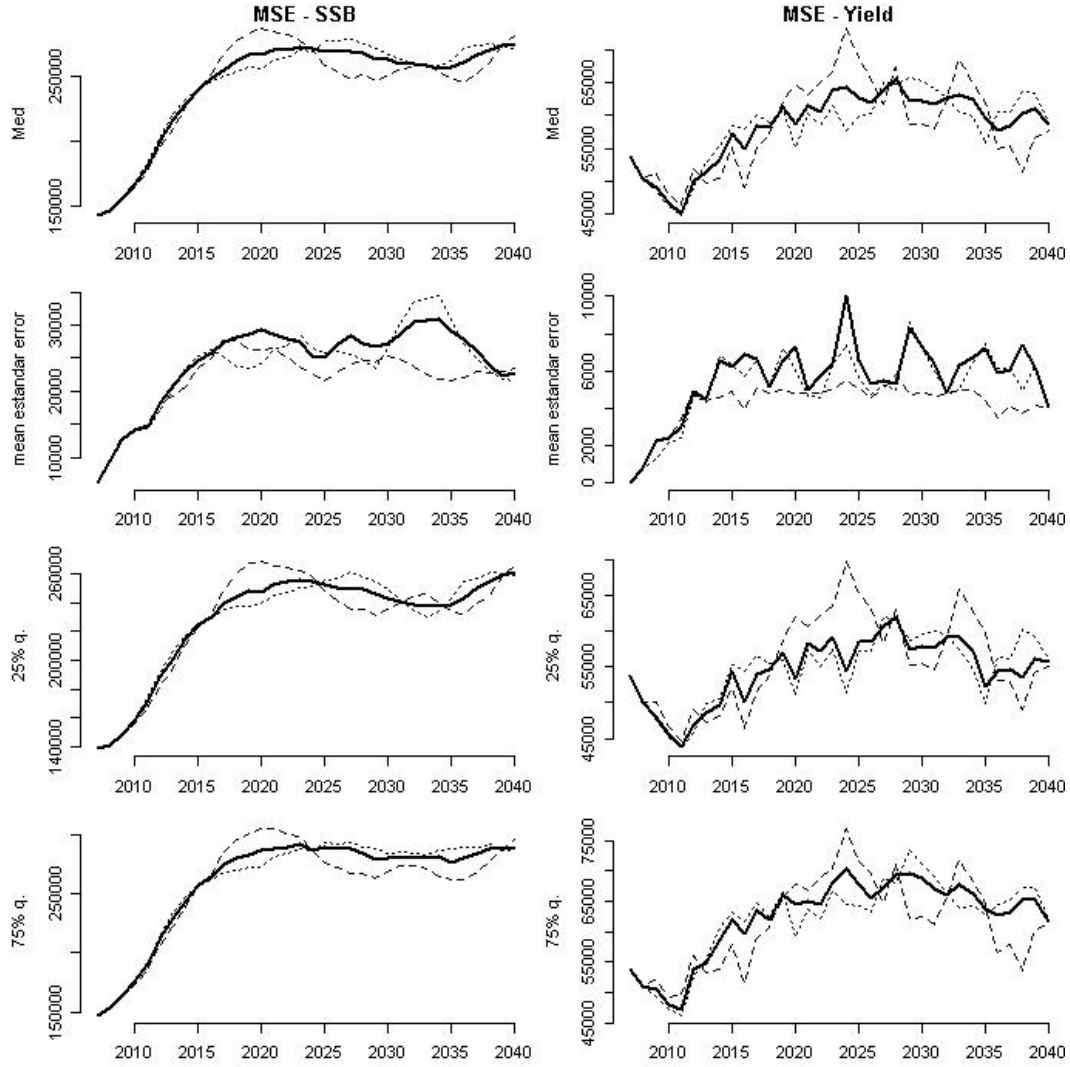


Figure 2.6.1. Analysis of statistical stability for SSB and Yield in the performed simulations in MSE method. 100 iterations (dashed line); 200 iterations (dotted line) and 300 iterations (continuous line).

In all the plots in Figure 2.6.1 (MSE simulations) we can see that 200 and 300 iterations are more similar among them than 100 iterations, this is a sign of progress towards the expected stability showing that 300 hundred iterations could be near a practical stability, although more simulations should be performed to identify clearly the gains and loses of doing more iterations. In all the cases we can see that 100 iterations (dashed line) differ clearly to 300 (continuous line); 100 iterations seems to be not enough to achieve statistical convergence in this simulation.

Percentiles (median, 25 and 75) show a trend towards dynamic stability when the number of iterations increases and this trend is faster in SSB than in yield. By dynamic stability we mean the year to year variability. Since our system are driven by variable dynamic processes, we should expect a progress towards any kind of dynamic stability when the number of iterations increase and that is what we can see in the percentile (median, 25 and 75) plots.

Projection simulations (Figure 2.6.2) show a faster convergence towards statistical stability than MSE simulations showing that this kind of simulations needs less iterations than MSE to achieve stability. Projections are also more stable than MSE in dynamic terms; this is something expected due to the absence of year to year assessment and the consequent application of a Harvest Control Rule (HCR) to set a new TAC based on the assessment results.

From this analysis we may conclude that:

MSE simulations are quite unstable with 100 iterations and the trends obtained are partially caused by the lack of statistical convergence.

When we compare MSE simulations among them, as we can see in the "Traffic light plot" (Figure 3.6.1), the results are consistent showing a clear trend in the violation of 15% rule or the SSB stability when we modify the %F reduction or the F target. Although this may seem odd given the lack of statistical stability, it is explained by the use of the same initial pseudorandom number ("seed") in all simulations.

Further work should be done to set a more consistent number of iterations for this kind of statistical analyses quantifying the level of stability achieved.

Although the median trends in MSE seems to be noisy and far from stability with 100 iterations, the use of the same "seed" partially overcome this problem for comparative purposes of different scenarios.

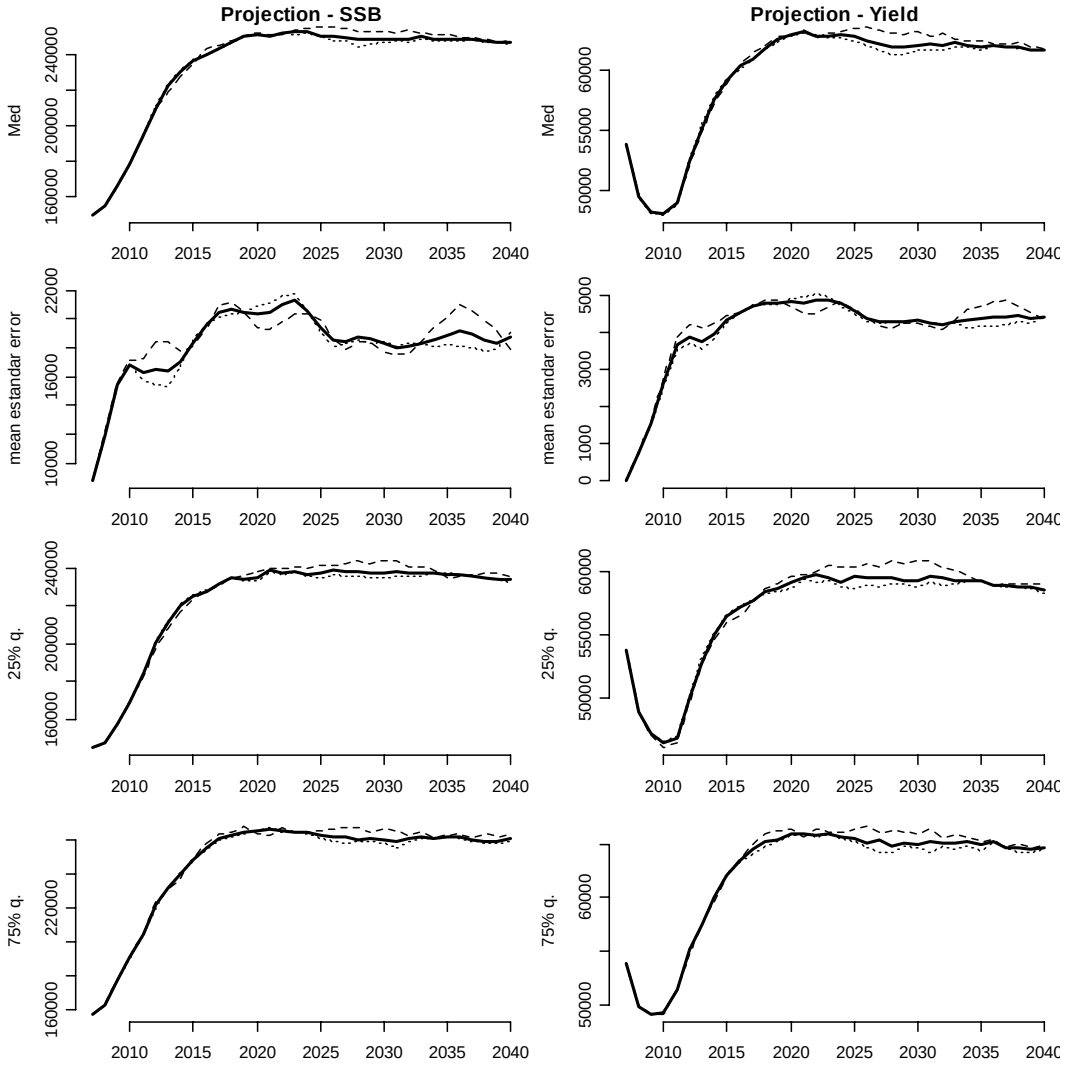


Figure 2.6.2. Analysis of statistical stability for SSB and Yield in the performed simulations in projections method. 100 iterations (dashed line); 200 iterations (dotted line) and 300 iterations (continuous line).

1.7. General Comments

The group agreed that the analysis of long term management plans should not be done in a single meeting but should be subject to extensive analysis, *e.g.* to overcome the drawbacks identified during this exercise (see section 7). It is also the group's opinion that a monitoring system should be created to update the analysis and explore new scenarios.

The ToR for this meeting were quite extensive and requested an high level of interaction between different fields like marine biology, fisheries, statistical modelling, economics and computer science. Nevertheless, the ToR were clear and together with the scientists' open minded attitude largely contributed to the meeting's success.

It's important to note that the work carried out during this meeting was only possible because data, software (R/FLR), computer resources and expertise were available before the meeting. It would have been impossible to decide on scenarios, write code and run all the simulations requested during the meeting.

1.8. Participants

STECF Members:
Michel Bertignac (IFREMER, France)

Invited experts:
Ernesto Jardim (chair; IPIMAR, Portugal)
Marina Santurtun (AZTI, Spain)
Dorleta García (AZTI, Spain)
Alain Biseau (IFREMER, France)
Santiago Cerviño (IEO, Spain)
Manuela Azevedo (IPIMAR, Portugal)
Jesper Levring Andersen (FOI, Denmark)
Raul Prellezo Iguaran (AZTI, Spain)
José María Da Rocha (University of Vigo, Spain)
Sarah Walmsley (CEFAS, UK)

European Commission:
Lisa Borges (DG FISH)
Angel Calvo (DG FISH)
Franz Hoelker (JRC, STECF secretariat)

2. ToR 1. Single species management

2.1. Long term management strategy evaluation – choice of F_{MSY}

Limit and precautionary reference points
In 2003, ACFM updated precautionary reference points following a revision of the assessment model and input data in recent years. The new points are presented in the table below (Table 3.1.1.)

Table 3.1.1. Precautionary reference points as defined by ACFM

	ACFM 2003
$\mathbf{F}_{lim}$	0.35(= $\mathbf{F}_{loss}$ WG 03)
$\mathbf{F}_{pa}$	0.25(= $\mathbf{F}_{lim}$*$e^{-1.645*0.2}$)
$\mathbf{B}_{lim}$	100 000t(~ $\mathbf{B}_{loss}$= B_{94})
$\mathbf{B}_{pa}$	140 000t(= $\mathbf{B}_{lim}$*$e^{1.645*0.2}$)

Target reference points

From this group update to ICES (2006), the F_{max} was estimated to be 0.17 (Table 3.1.2). F_{max} is well defined for this stock, with a low variability between years. Moreover, since the determination of F_{max} does not require the adoption of a S-R relationship, which is not well estimated for the northern stock of hake (see Figure 3.1.1 below), the value of 0.17 was thus used as a proxy for the target reference point F_{msy} in the simulations.

Table 3.1.2. Recent Estimated F_{max} for Northern hake

Assessment year	**Fmax**
2002	0.17
2003	0.16
2004	0.18
2005	0.17
2006	0.17
2007*	0.17
Average	**0.17 ± 0.01**

* From this group update

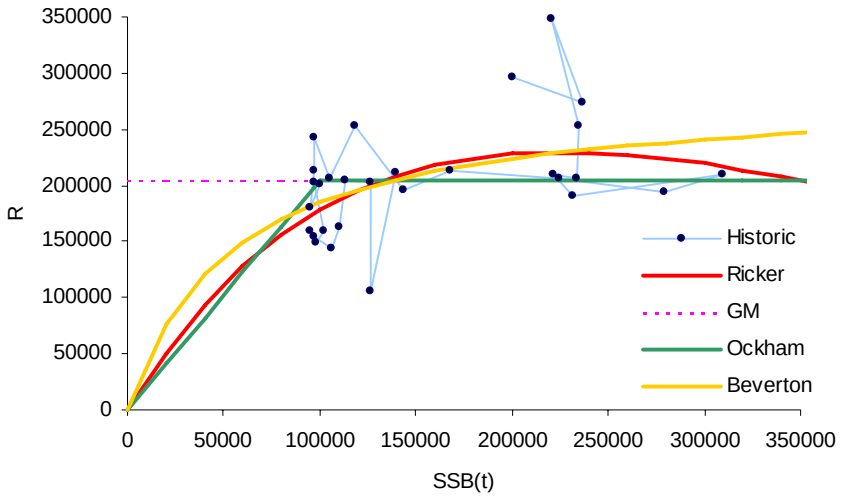


Figure 3.1.1. Stock recruitment relationships estimated for Northern hake

2.2. Comparison of F strategies (F_{max}, Ockham)

In all simulations, SSB increases to 250,000t, a value well above B_{pa} and then stabilises at that value. Changing the rate of F decrease will only impact on the rate at which this high value is reached. In all simulation, yields increase to the long-term equilibrium value (62,000t) which is above the current yield. At short term however, there is a decrease in landings. The strength of the decrease, very small when a 5% decrease rate in F is applied, will be larger when a higher rate of reduction in F is used. In the MSE simulations, some oscillations are observed in all those variables and are due to biases in estimates of population abundance and F obtained from the assessment model as compared to the underlying population model.

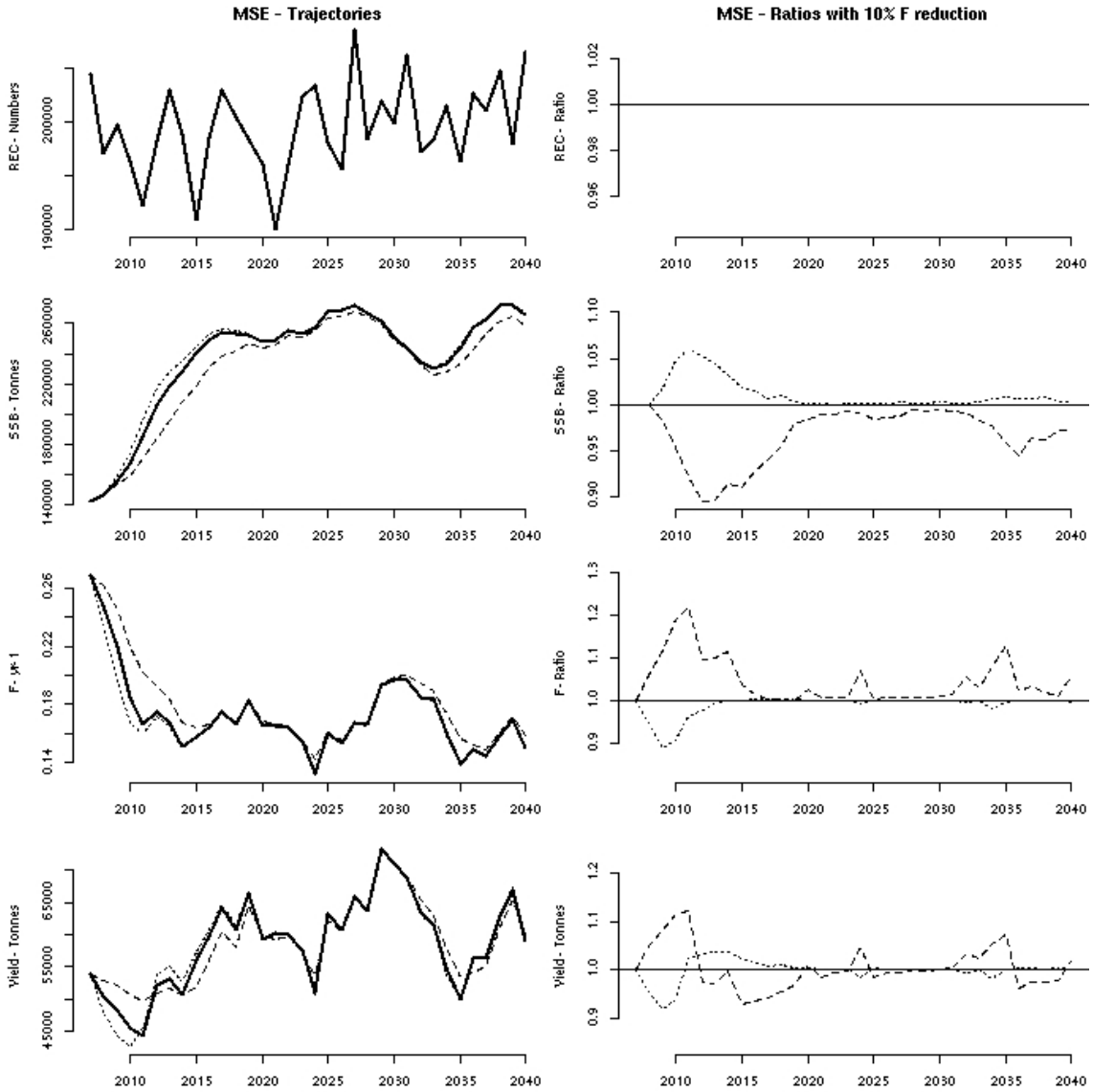


Fig 3.2.1. Comparison of F strategies towards Fmax with MSE algorithm. Solid line = 10% reduction, dashed line = 15% reduction, dotted line = 5% reduction.

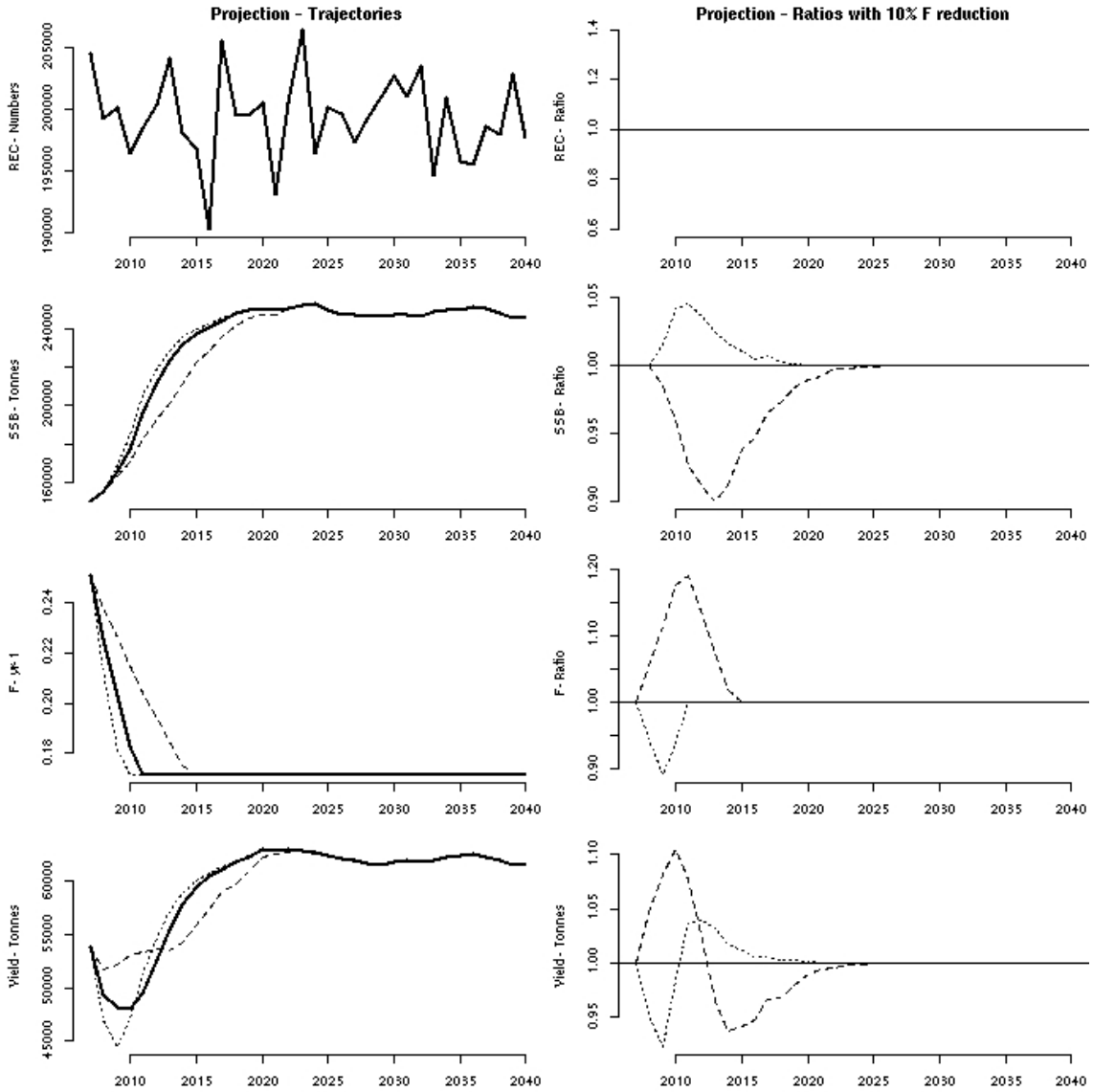


Fig 3.2.2. Comparison of F strategies towards Fmax with projection algorithm. Solid line = 10% reduction, dashed line = 15% reduction, dotted line = 5% reduction.

2.3. Comparison of F targets ($0.8F_{max}$, $1.2F_{max}$, Ockham)

When at a given rate of F decrease, the target is modified to 0.8*Fmax and 1.2*Fmax, yield at equilibrium are not modified substantially: they are estimated around 61 000t instead of 62 000t. However, larger changes in SSB level are observed (300,000t when the target is set at 0.8*Fmax and 220 000t when it is set at 1.2*Fmax but with sharp a drop. Furthermore, when the target is closer to the current situation, i.e. 1.2*Fmax, the differences observed between the different decreasing rate scenario are smaller. Concluding it can be said that with different target of Fs, very similar yields are reached. However, SSB vary considerably and it will be desirable to check whether levels reached are significantly different between them.

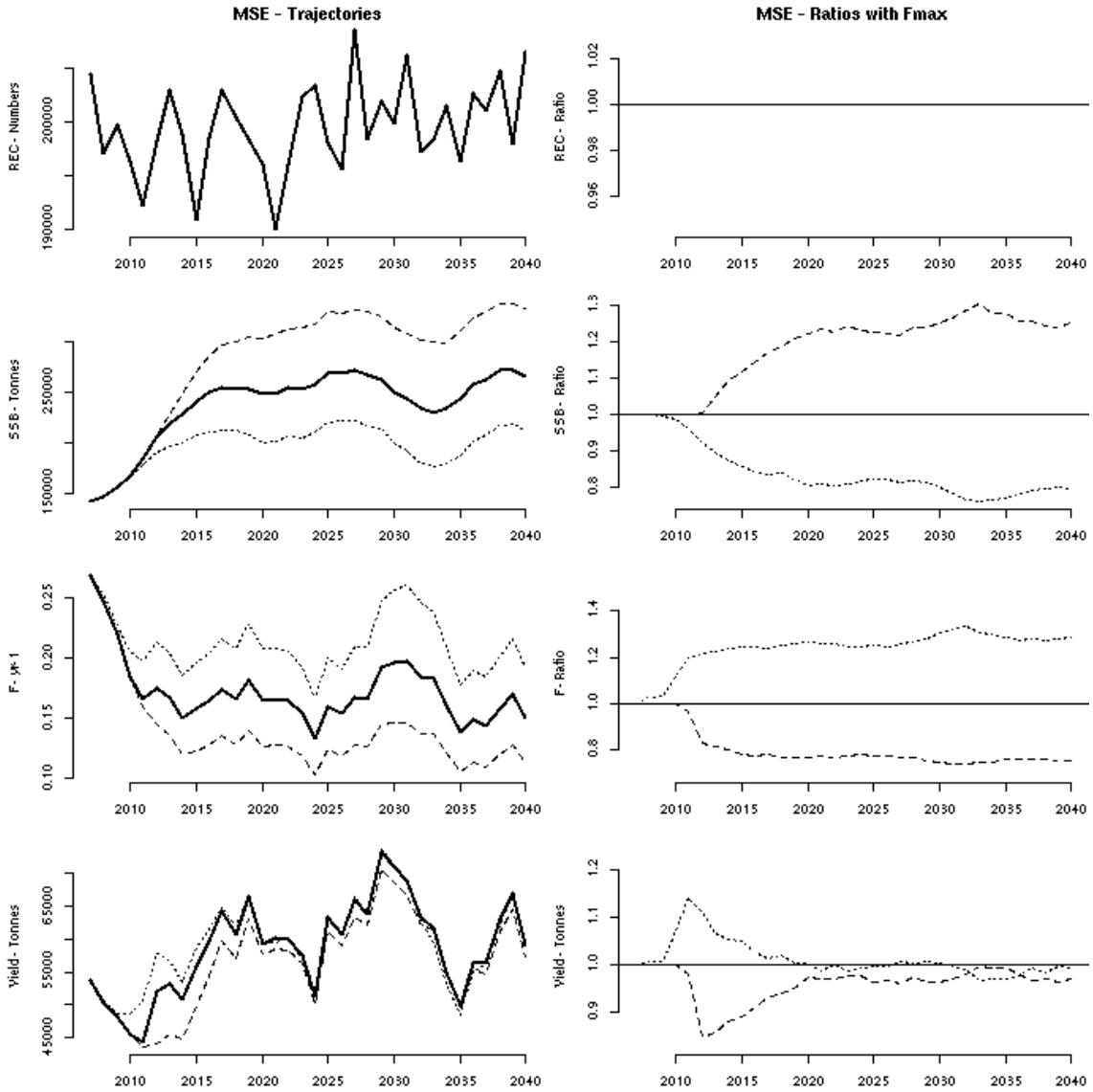


Fig 3.3.1. Comparison of F targets (F_{max}, $0.8F_{max}$ & $1.2\ F_{max}$) with 10% F reduction and MSE algorithm. Solid line = Fmax, dashed line = 0.8Fmax, dotted line = 1.2Fmax.

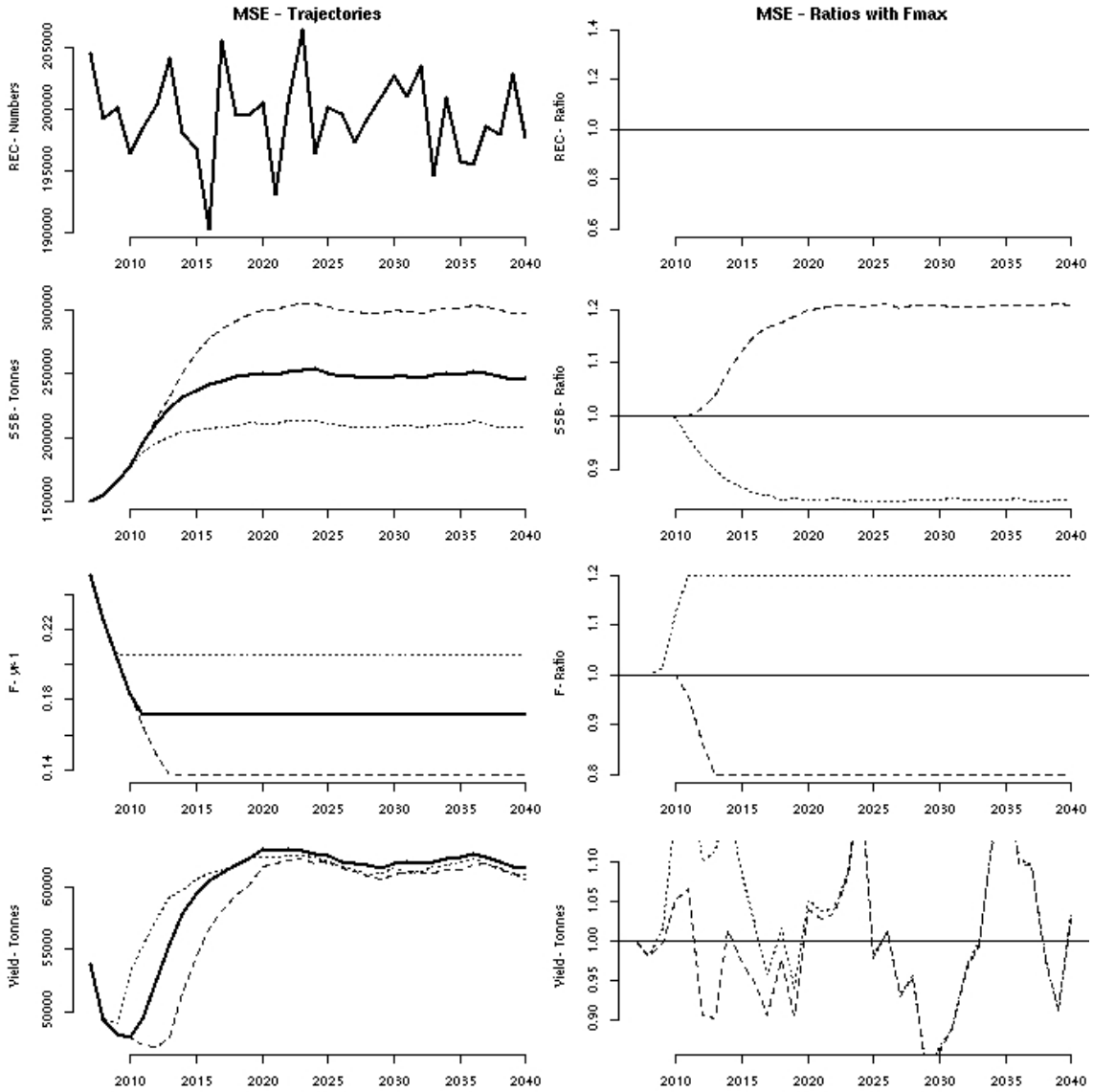


Fig 3.3.2. Comparison of F targets (F_{max}, $0.8F_{max}$ & $1.2\ F_{max}$) with 10% F reduction and projection algorithm. Solid line = Fmax, dashed line = 0.8Fmax, dotted line = 1.2Fmax.

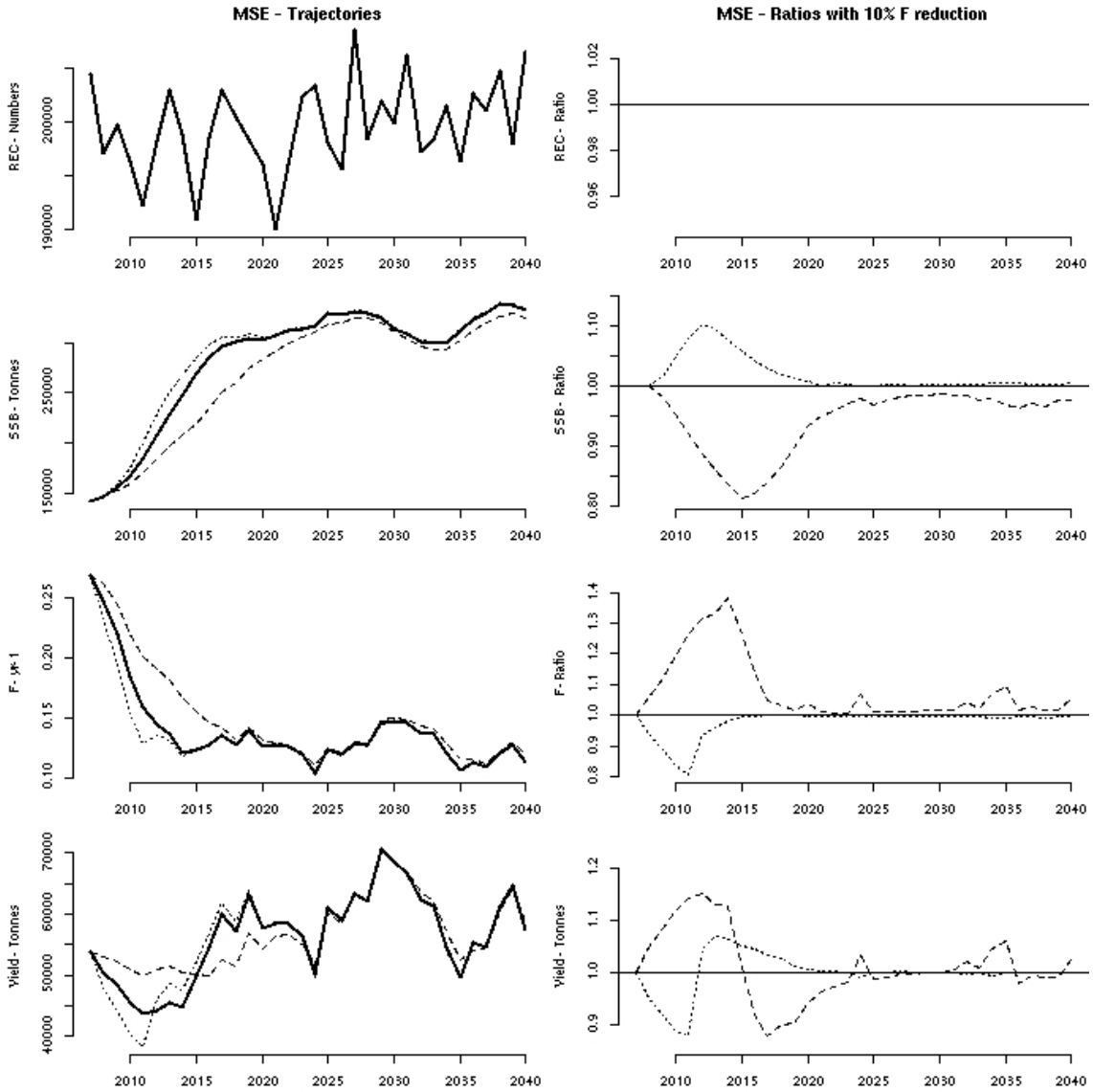


Fig 3.3.3. Comparison of F strategies towards 0.8Fmax with MSE algorithm. Solid line = 10% reduction, dashed line = 15% reduction, dotted line = 5% reduction.

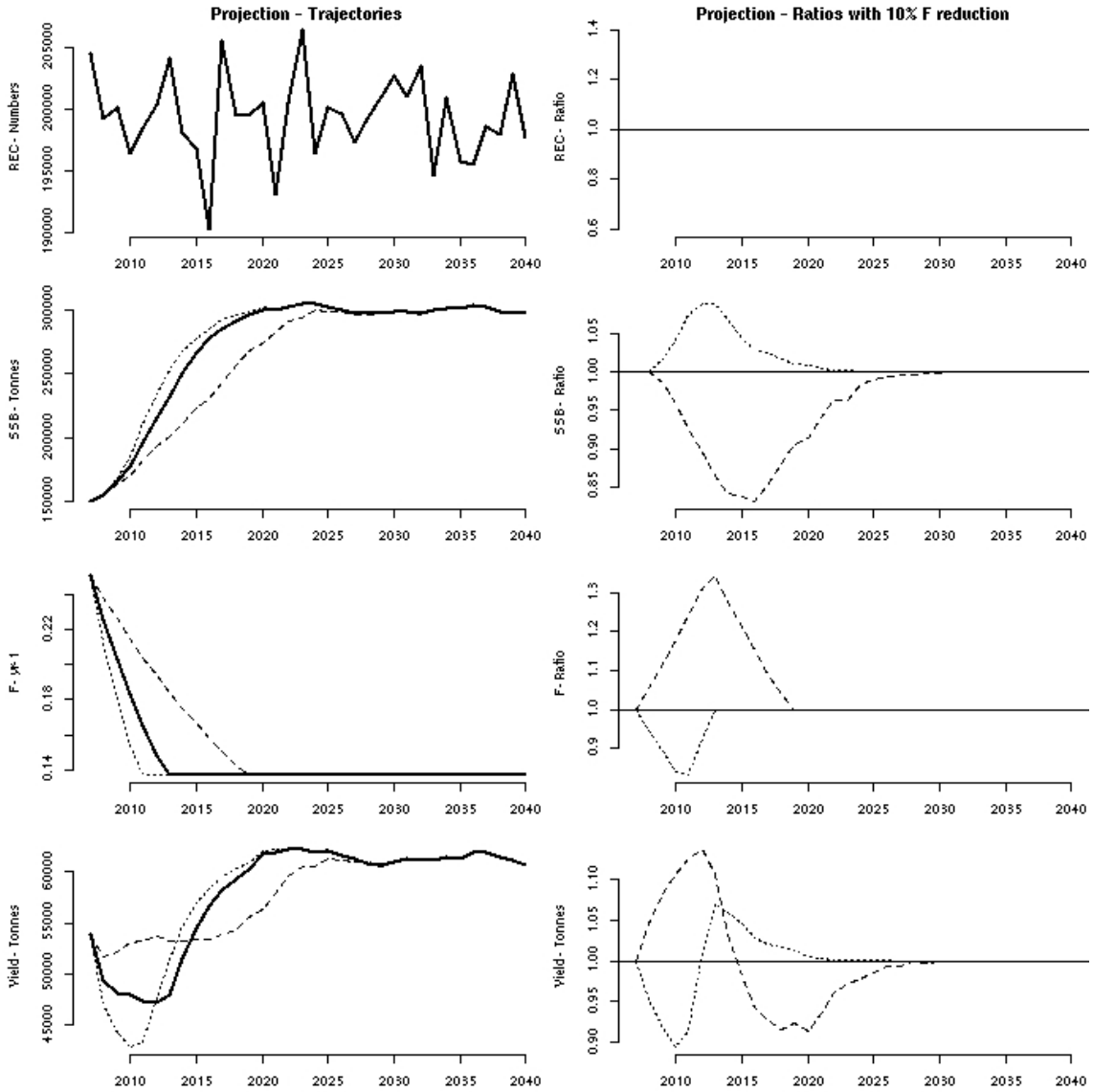


Fig 3.3.4. Comparison of F strategies towards 0.8Fmax with projection algorithm. Solid line = 10% reduction, dashed line = 15% reduction, dotted line = 5% reduction.

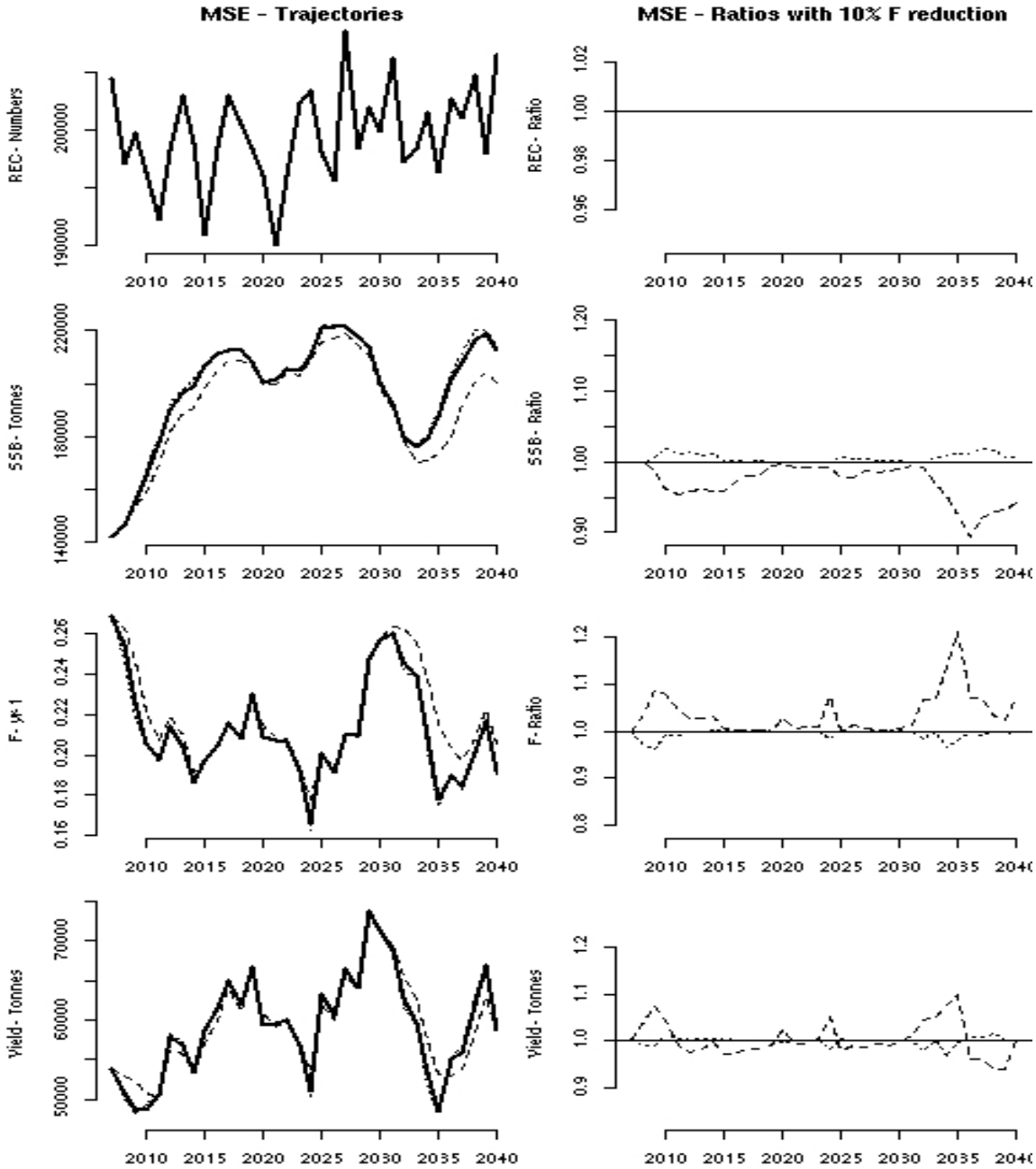


Fig 3.3.5. Comparison of F strategies towards 1.2Fmax with MSE algorithm. Solid line = 10% reduction, dashed line = 15% reduction, dotted line = 5% reduction.

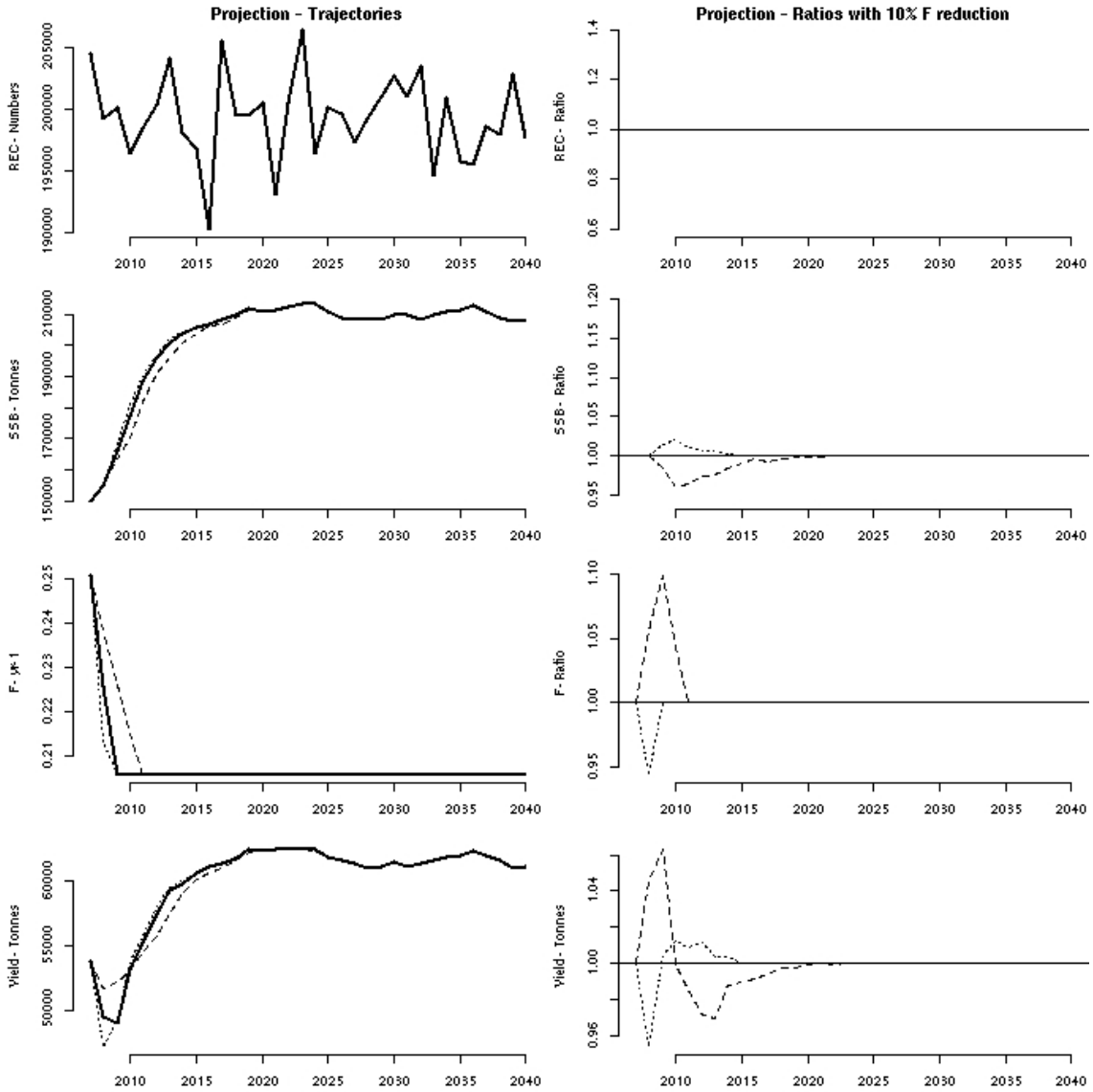


Fig 3.3.6. Comparison of F strategies towards 1.2Fmax with projection algorithm. Solid line = 10% reduction, dashed line = 15% reduction, dotted line = 5% reduction.

2.4. Robustness of models to SR relationships

The Ockham scenario is the more conservative scenario as it produces the lowest yields, around 60,000t for Ockham, 65,000t for Ricker and 75,000t for Beverton and Holt. The SSB starts increasing similarly in all the scenarios in the short term, but when the year classes generated with the S/R models mature, year classes from 2007 onwards, the SSB level stabilize at different level, 250,000t for Ockham, 275,000t for Ricker and 290000 for Beverton and Holt,. In the MSE algorithm the SSB is subestimated in Ricker and Beverton & Holt scenarios and the F is overestimated which result in a real F lower than the target F = 0.17, specially in the Ricker scenario in which from 2011 the F is always below 0.17. Due to this mismatch between F target and real F in MSE scenarios, the SSB levels obtained in these simulations are higher than those obtained in projection simulations, whereas the Yields are lower. The SSB in all the scenarios is maintained well above Bpa and quite stable in the long term, so in terms of biological robustness, this simulations suggest that a harvest control rule based in Ftarget = 0.17 is robust to the simulated stock-recruitment models.

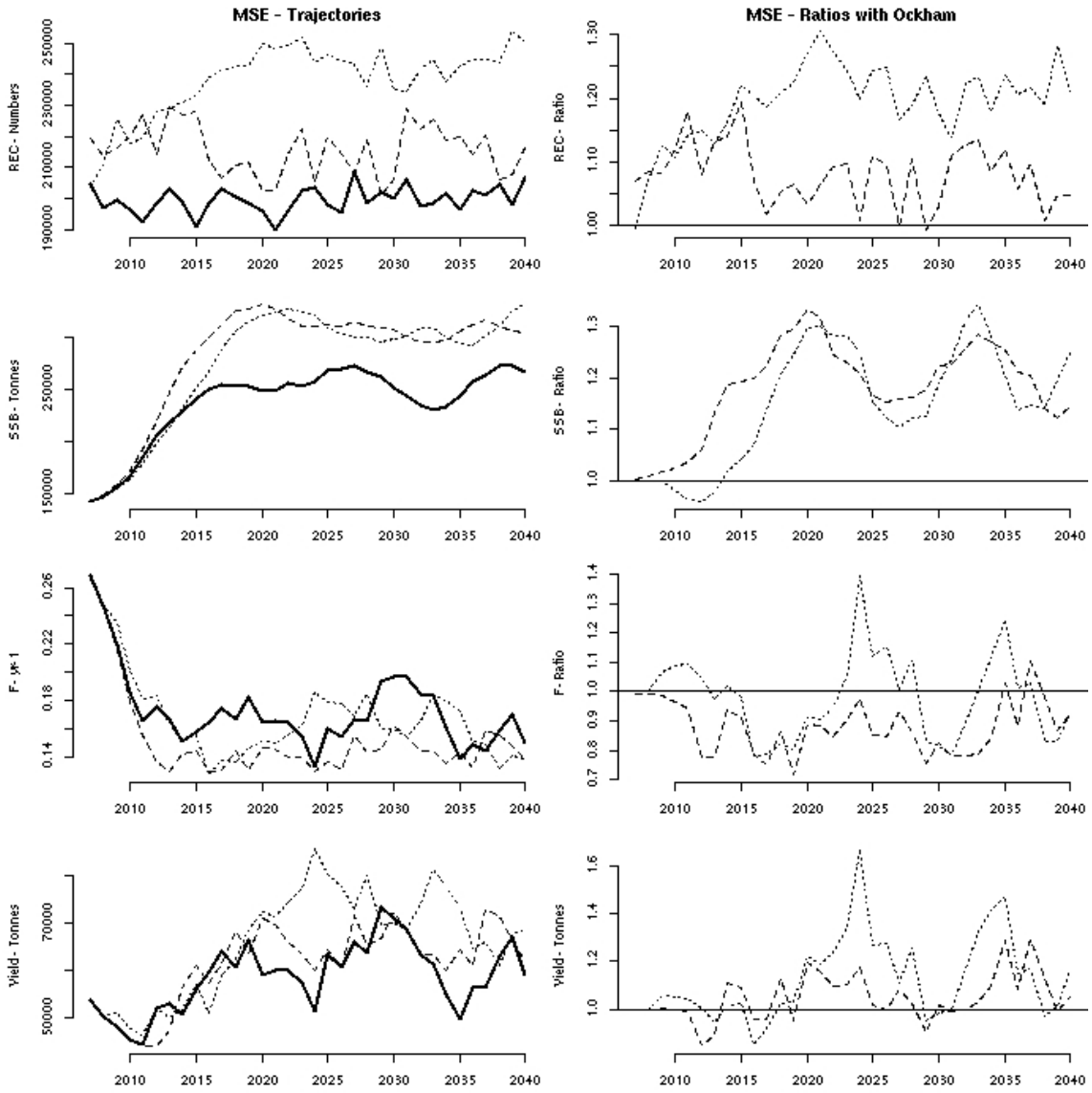


Fig 3.4.1. Robustness of models to SR relationships with MSE algorithm. Solid line = Ochkam, dashed line = Ricker, dotted line = Beverton & Holt.

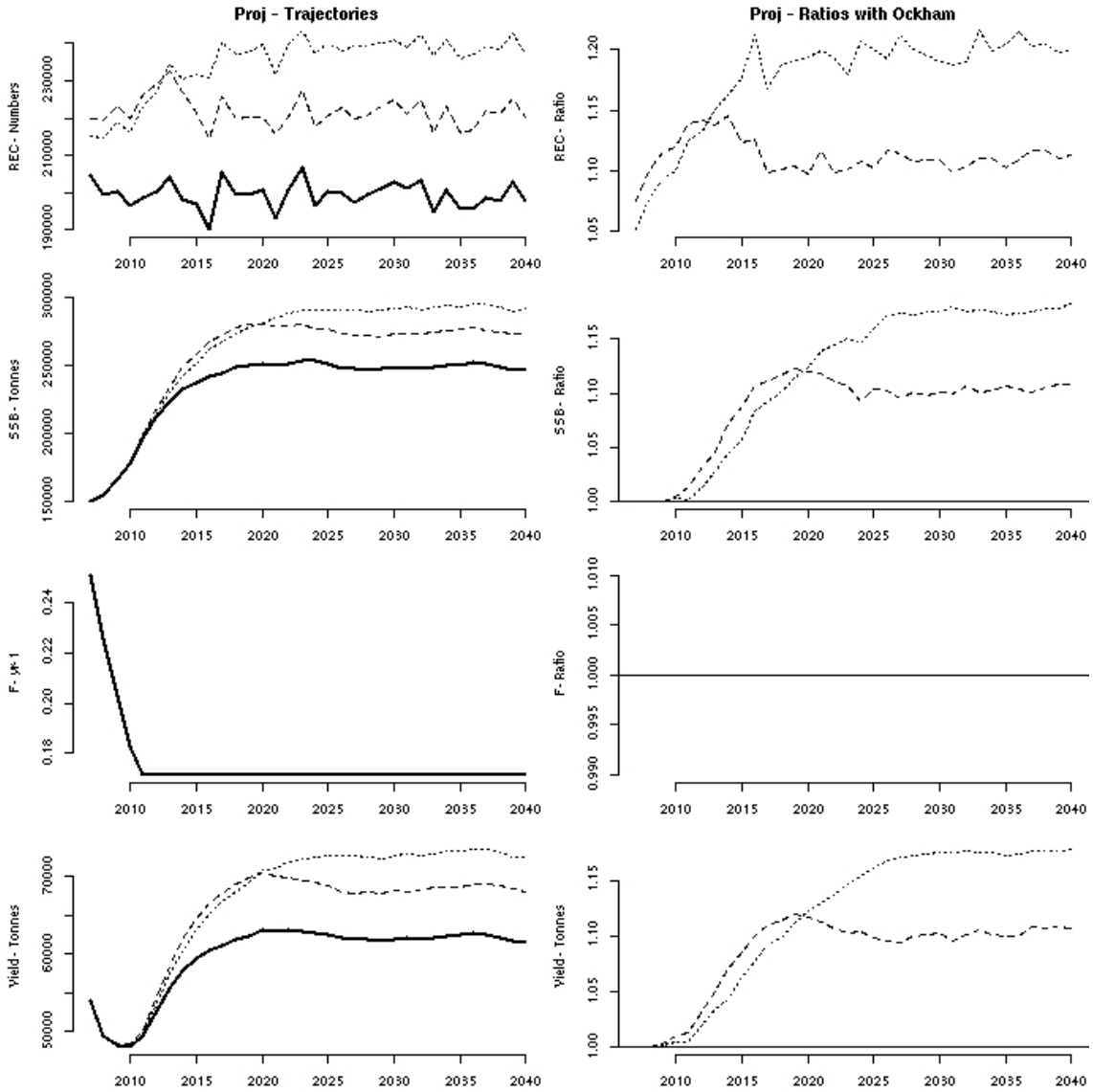


Fig 3.4.2. Robustness of models to SR relationships with projection algorithm. Solid line = Ochkam, dashed line = Ricker, dotted line = Beverton & Holt.

2.5. Impacts of different growth rates

When the simulations are carried out under a "faster" growth hypothesis, the absolute levels of abundance and F are quite different but trends are similar. It should be noted that this simulation has been conducted with a higher level of M than in the case of the "current" growth hypothesis (0.4 instead of 0.2). Under alternative hypothesis, results might be quite different and the group felt that some further sensitivity analysis should be conducted on M for both growth rate hypotheses.

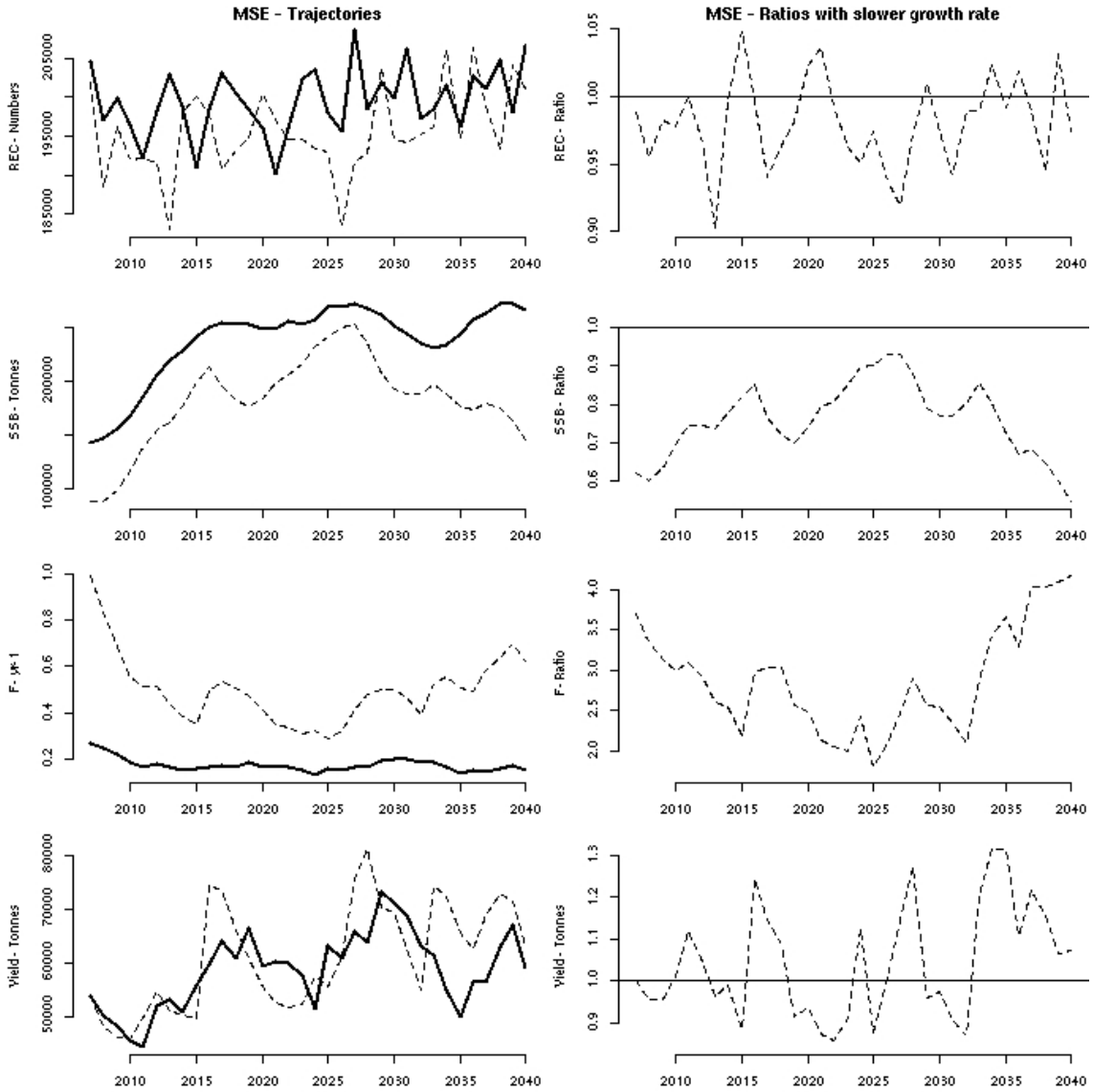


Fig. 3.5.1. Impacts of different growth rates with MSE algorithm. Solid line = slower growth rate, dashed line = faster growth rate.

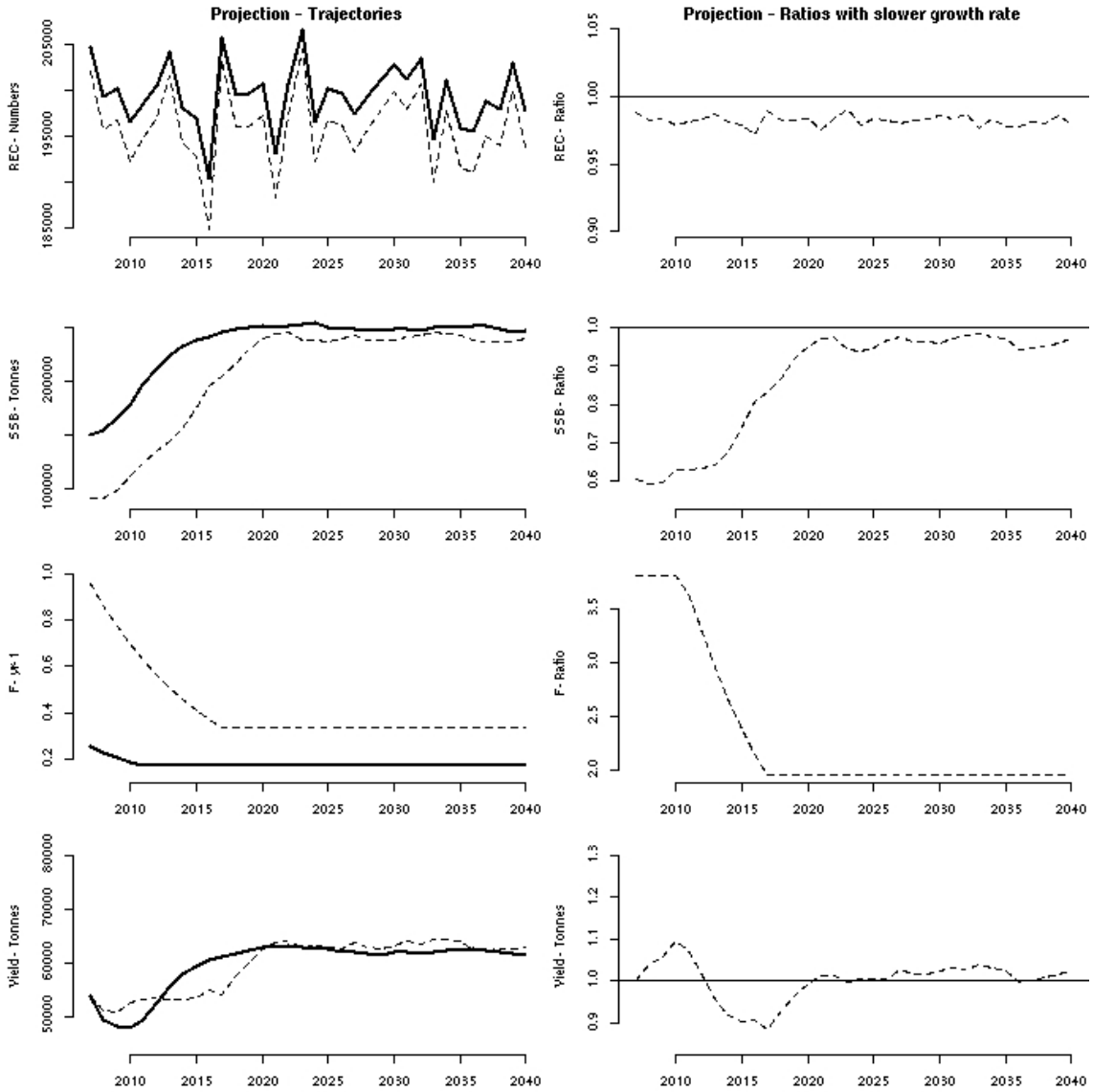


Fig. 3.5.2. Impacts of different growth rates with projection algorithm. Solid line = slower growth rate, dashed line = faster growth rate.

2.6. Measures for all scenarios

To synthesize the main results from the simulations carried out for a 36 years period, the group considered that 3 criteria could be used. Two of these are related with conservation issues: stability in the spawning biomass (SSB) and the probability of SSB falling below Bpa and one related with management issues: the probability of violating the 15% yearly change in TAC.

In the absence of information on the level of risk stakeholders consider acceptable the group decided to use 50% for the P(SSB< Bpa) and 0% for the P(violating the 15% yearly TAC change). However, the simulation results do allow further analysis under other risk levels.

The analysis is presented using a traffic light code and the text table below shows, by criteria.

Table 3.6.1. Traffic lights criteria and color scheme.

Criteria	GREEN	YELLOW	RED
Stable SSB (variation within 10%)	Always	Not every year	Declining trend
P(SSB<Bpa) > 50%	Never	In some years	Always
nº years P(Violation 15% TAC rule) > 0	< 5	5-10	> 10

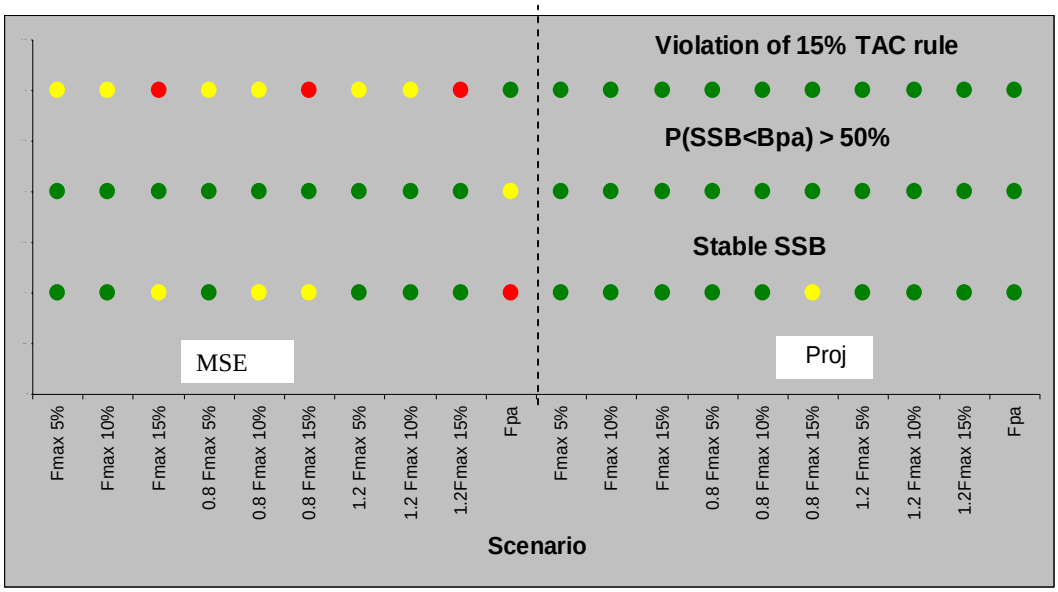


Figure 3.6.1 presents the traffic light analysis by scenario.

MSE algorithm

The risk of having year to year variations of more than 15% in landings is exceed in some years when Fmax is reduced by 5 or 10 percent however this violation occurs always when Fmax is reduced by 15%. When the Ftarget is set as Fpa, no risk of violating the 15% rule of TAC occurs

Whatever choice is made in terms of rate of reduction in F towards Fmax (5, 10 or 15 %), or even in terms of choosing other target (Fmax*0.8, 1.2), probability that SSB fall below Bpa is less than 50%. Thus, the probability of SSB being below Bpa becomes very low (close to 0) quite rapidly (after only 3 years, 2010) and remains at this low level over the rest of the simulation. However, when Fpa is set as the target, the probability that SSB fall below Bpa clearly increases.

SSB is less stable when the target F is at the lowest (0.8* Fmax) and using strategies of 10 and 15% reductions. When the target is defined as Fmax, SSB is stable but just in some years, especially when Fmax is reduced by 15%. When Fmax is the highest (Fmax *1.2), SSB appears always stable whatever strategy is used for reaching it.

Projection algorithm

What ever strategy is used to reach the Fmax (5, 10 or 15 %) or even a different target (0.8, 1.2 Fmax), resulting yield do not violate the 15% rule, the probability of SSB falling below Bpa is less than 50% in all years and SSB is very stable, except for 0.8Fmax*15% scenario, however instability only occurs in two years.

At the current recruitment levels, no reduction in yield occurs in both MSE and Proj simulations when Fmax is reduced by 5%.

For the Projection algorithm, year when target are reached for each of the strategies are presented in the following Table:

Table 3.6.2. Year to achieve Ftarget under different F reduction strategies.

	F strategies		
F targets	**5%**	**10%**	**15%**
0.8*Fmax	2019	2013	2011
Fmax	2015	2011	2010
1.2*Fmax	2011	2009	2009

It shows that under a 5% F strategy it will take 6, 4 and 2 more years to reach the target F in comparison to the 10% F strategy.

In general results, from the Projection algorithm compared to MSE algorithm appear to be better behave and more stable in relation to the criteria used.

The following figures present the results for all scenarios using an Ochkam SR model, for both simulation algorithms. Each plot shows the median, 25 and 75 percentile and the mean for spawning stock biomass (SSB), fishing mortality (F), recruitment (R), catches (TAC), SSB inter-year variability (SSB IYV), catches inter-year variability (TAC IYV), probability of SSB fall below Bpa (P[SSB<Bpa]) and probability of the TAC in year y+1 being above or below 15% of the previous year TAC (P[TACy+1<>TACy*15%]).

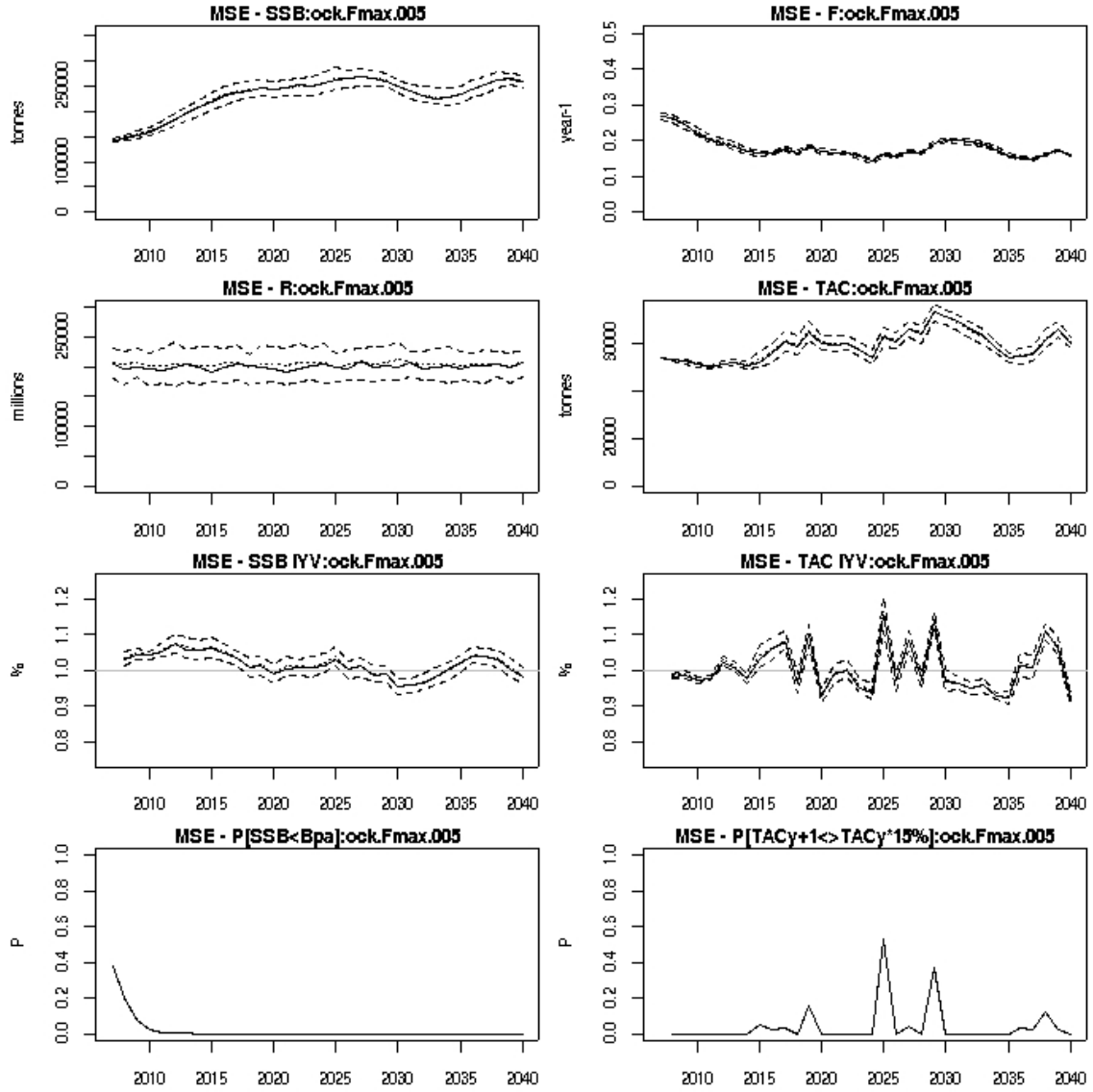


Fig. 3.6.2. Trajectories for scenario 5% decrease to Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

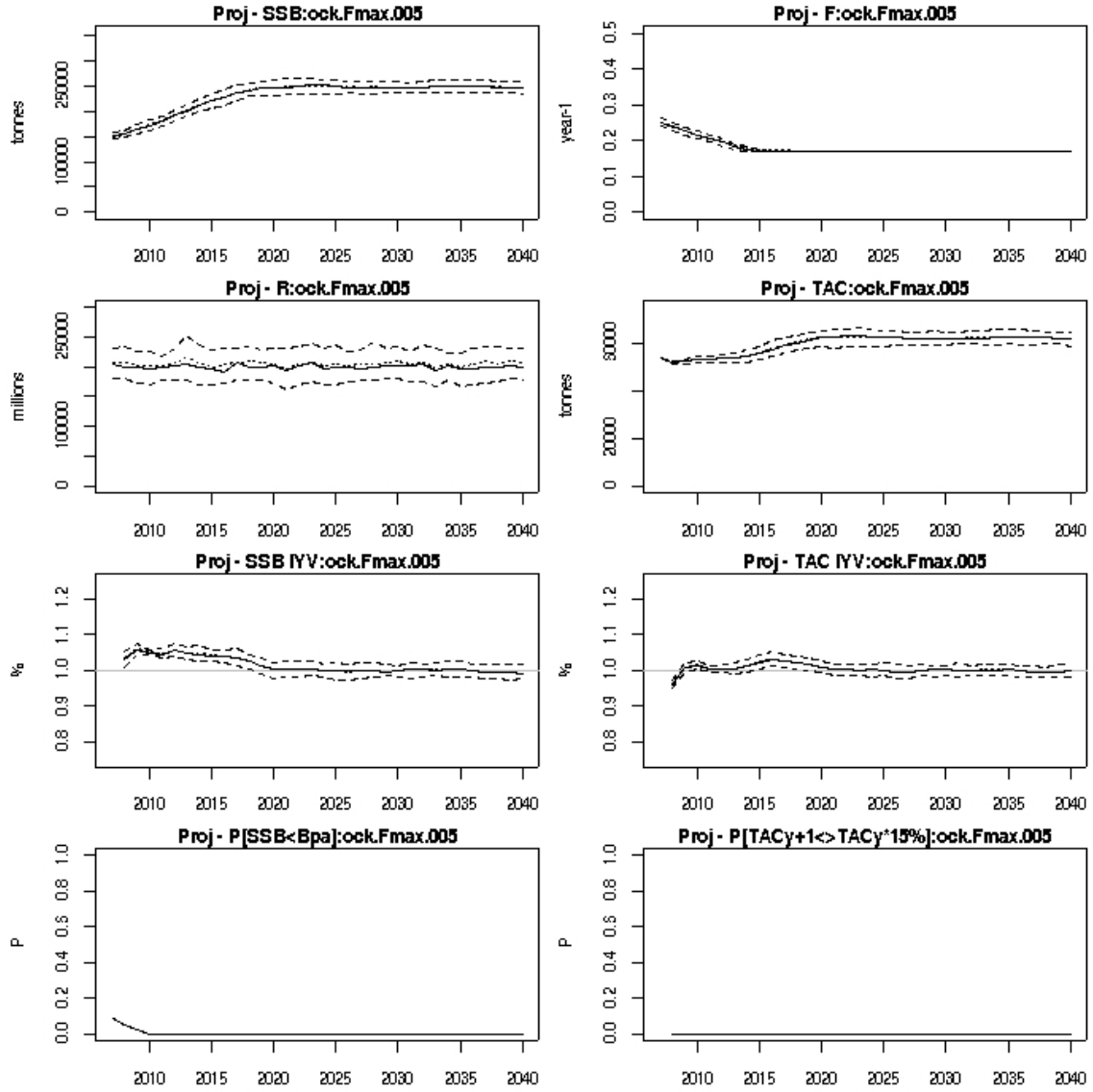


Fig. 3.6.3. Trajectories for scenario 5% decrease to Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

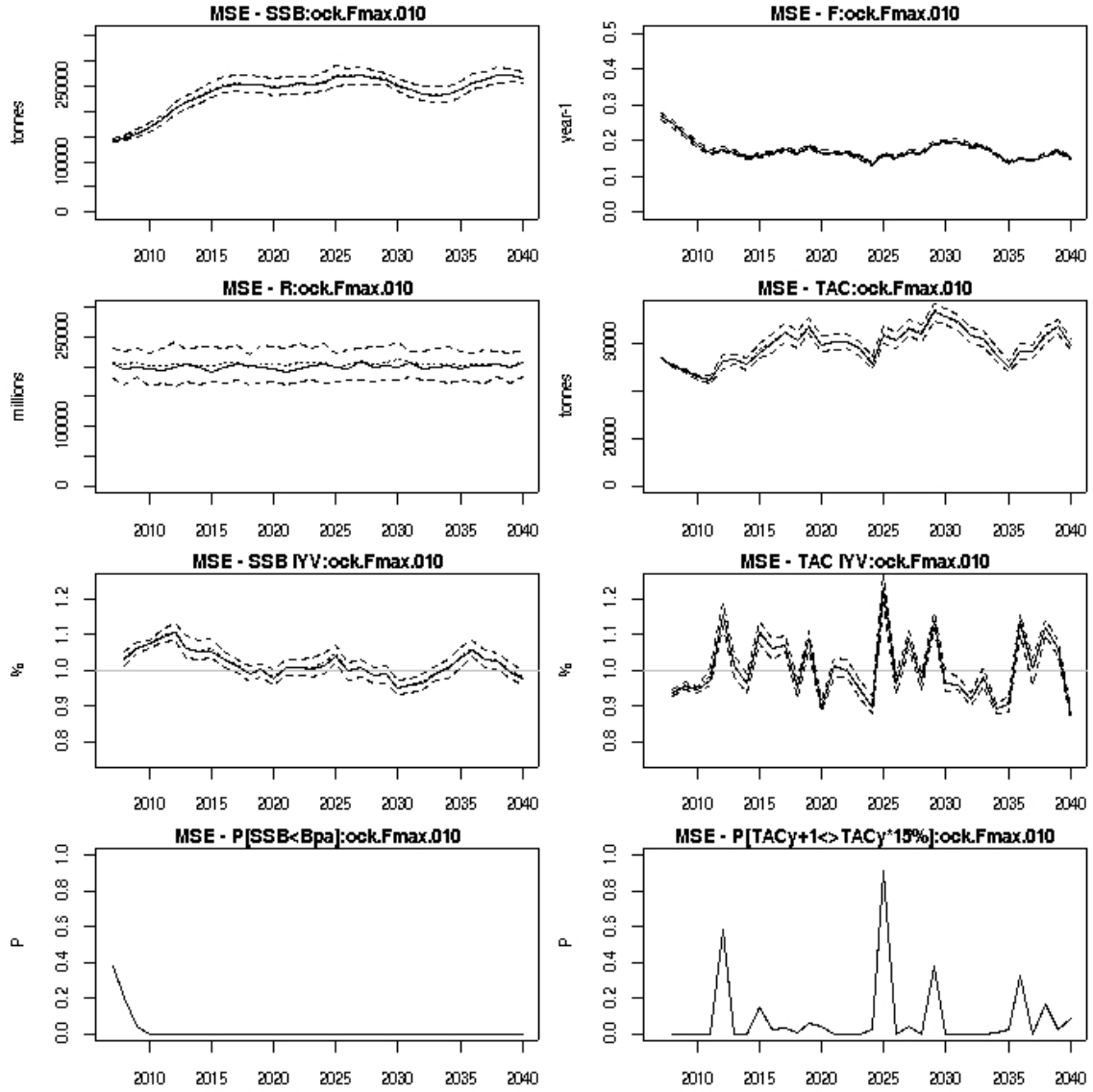


Fig. 3.6.4. Trajectories for scenario 10% decrease to Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

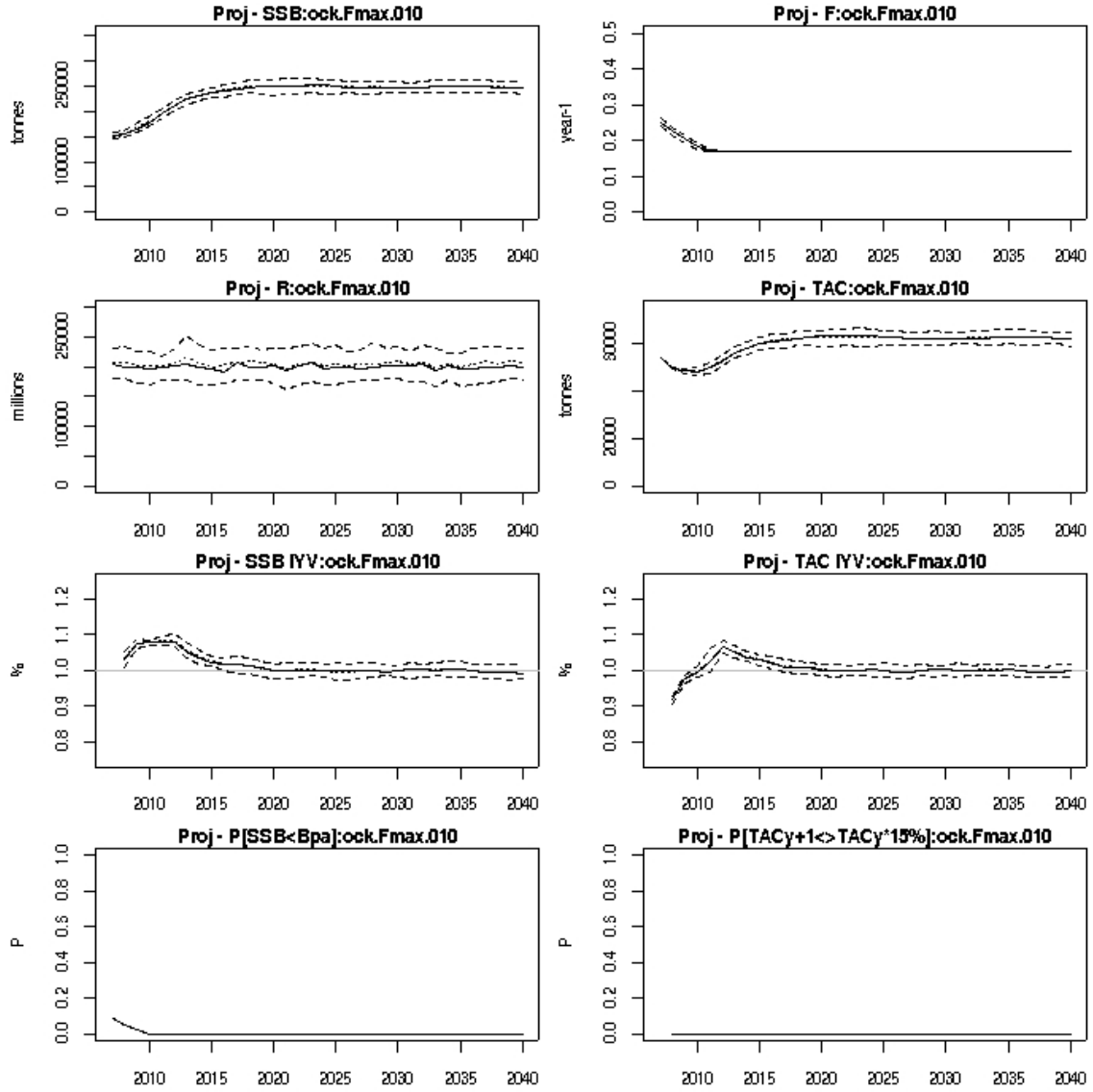


Fig. 3.6.5. Trajectories for scenario 10% decrease to Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

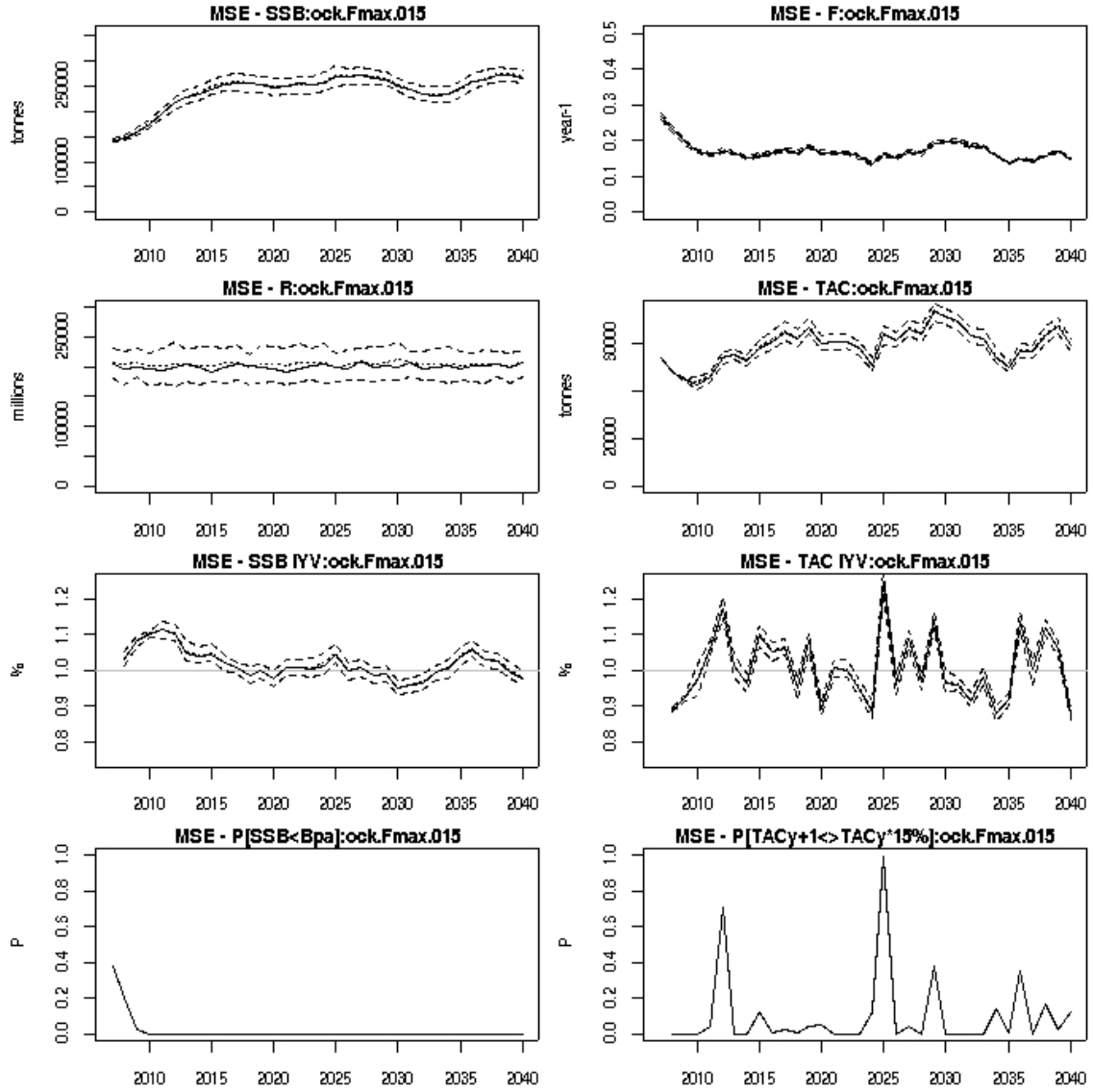


Fig. 3.6.6. Trajectories for scenario 15% decrease to Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

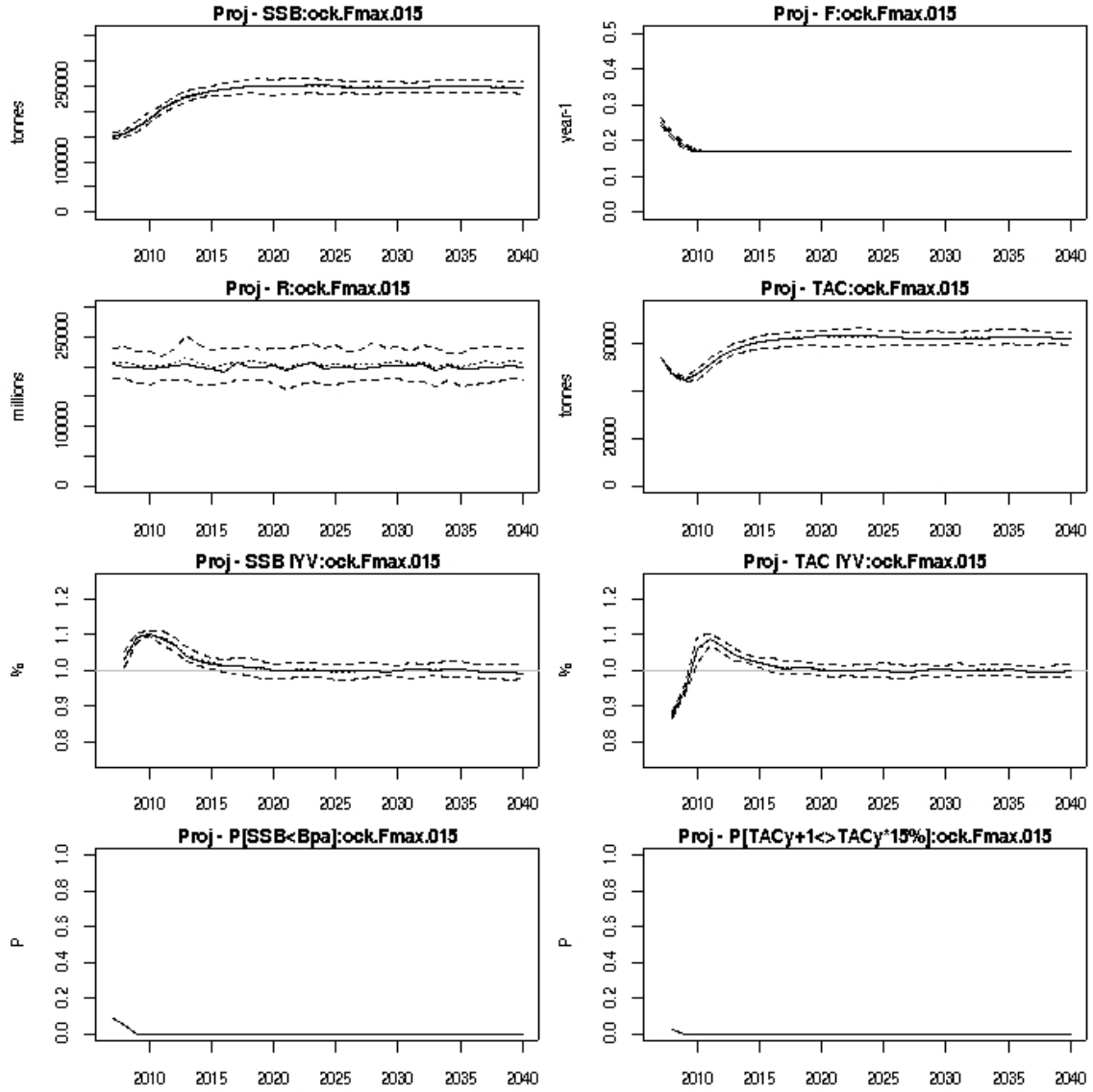


Fig. 3.6.7. Trajectories for scenario 15% decrease to Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

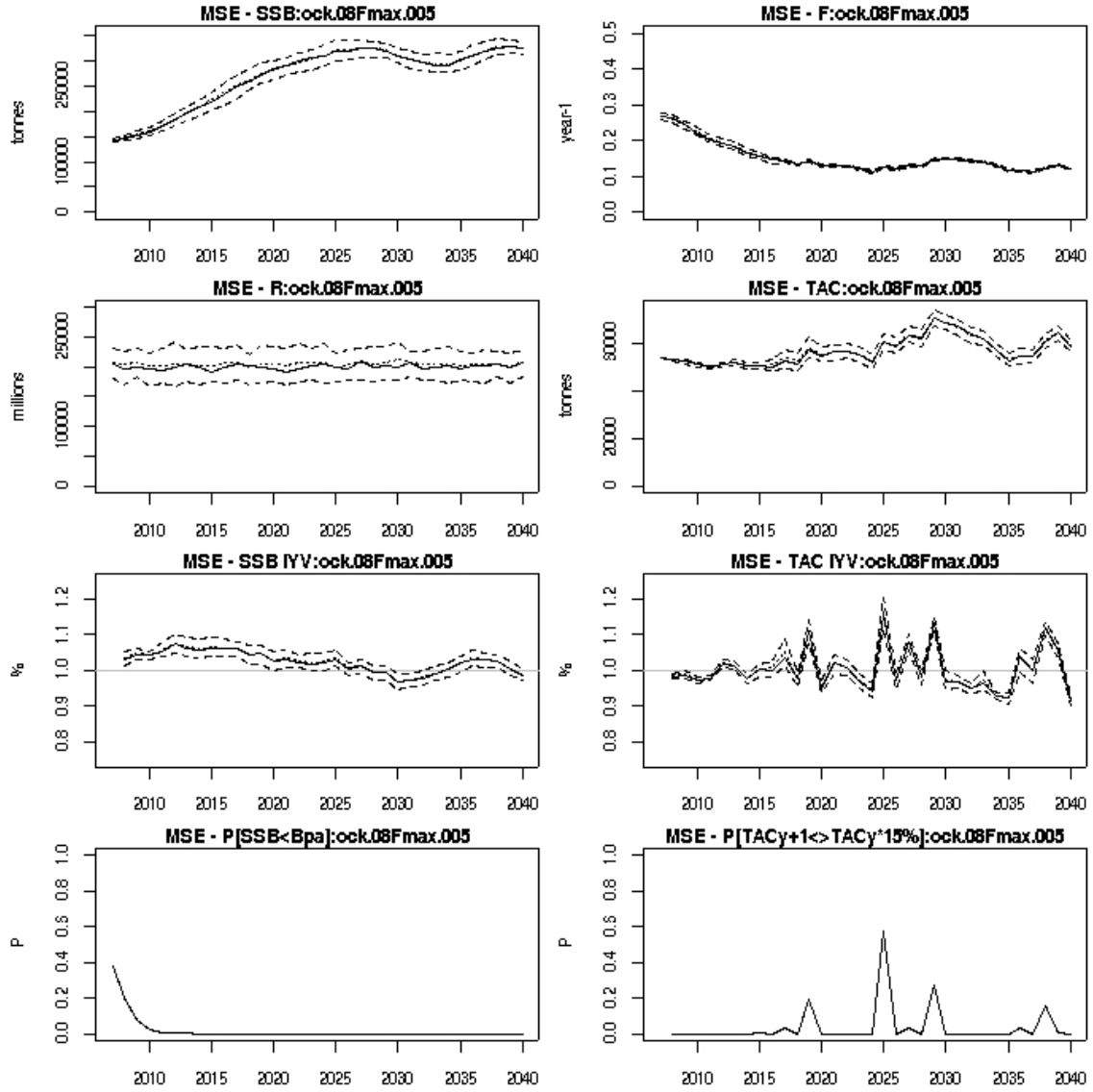


Fig. 3.6.8. Trajectories for scenario 5% decrease to 0.8Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

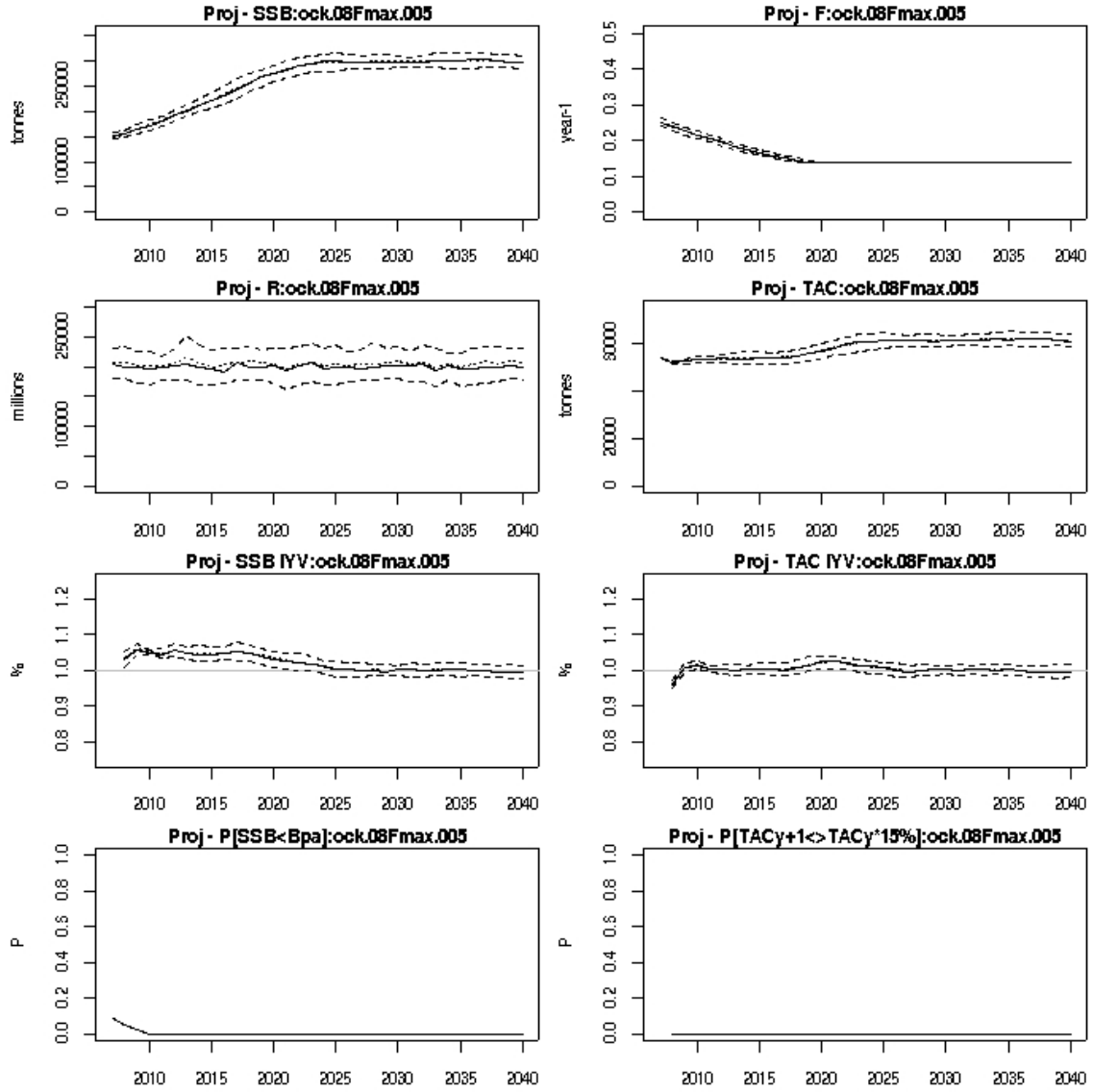


Fig. 3.6.9. Trajectories for scenario 5% decrease to 0.8Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

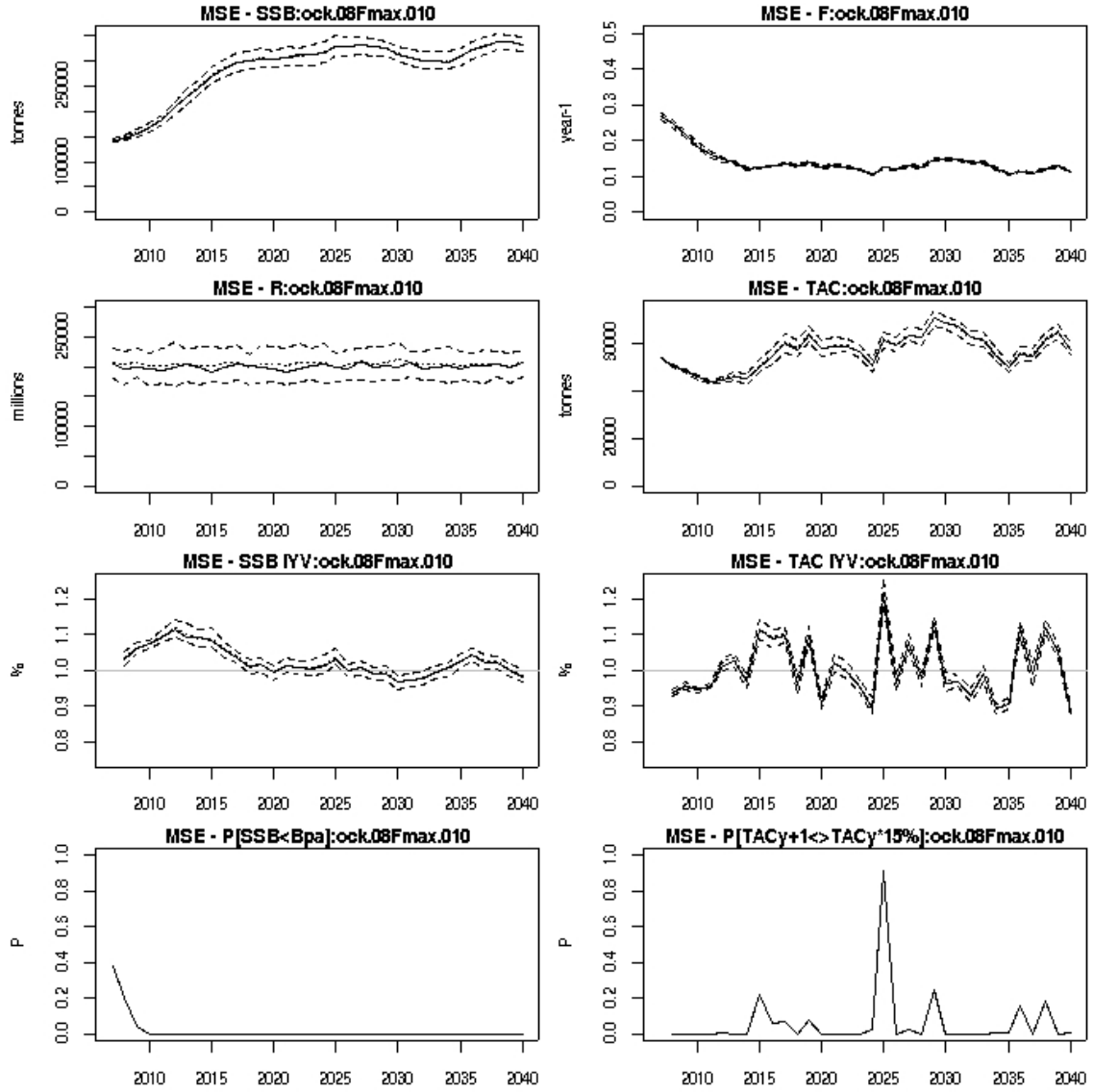


Fig. 3.6.10. Trajectories for scenario 10% decrease to 0.8Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

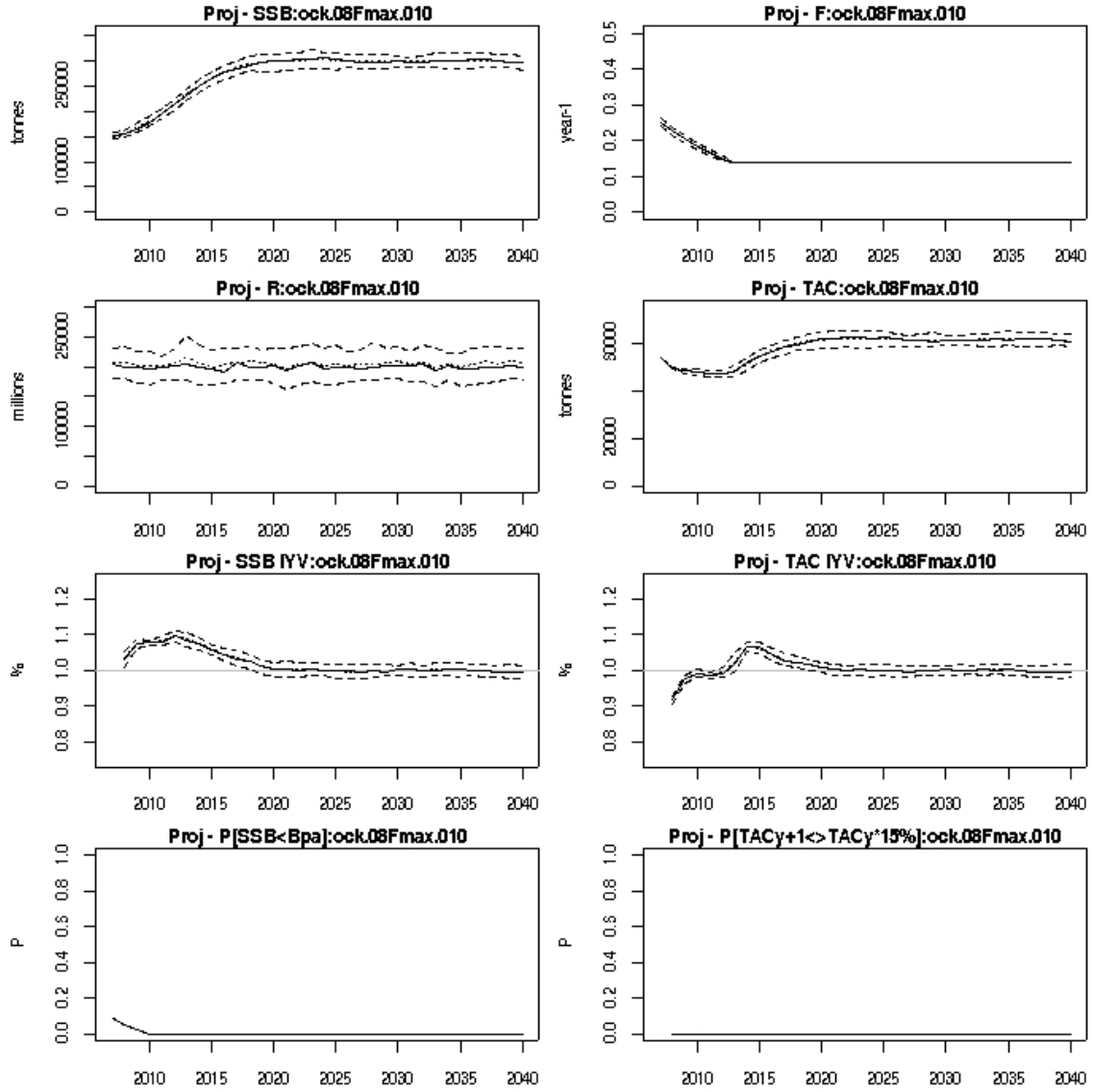


Fig. 3.6.11. Trajectories for scenario 10% decrease to 0.8Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

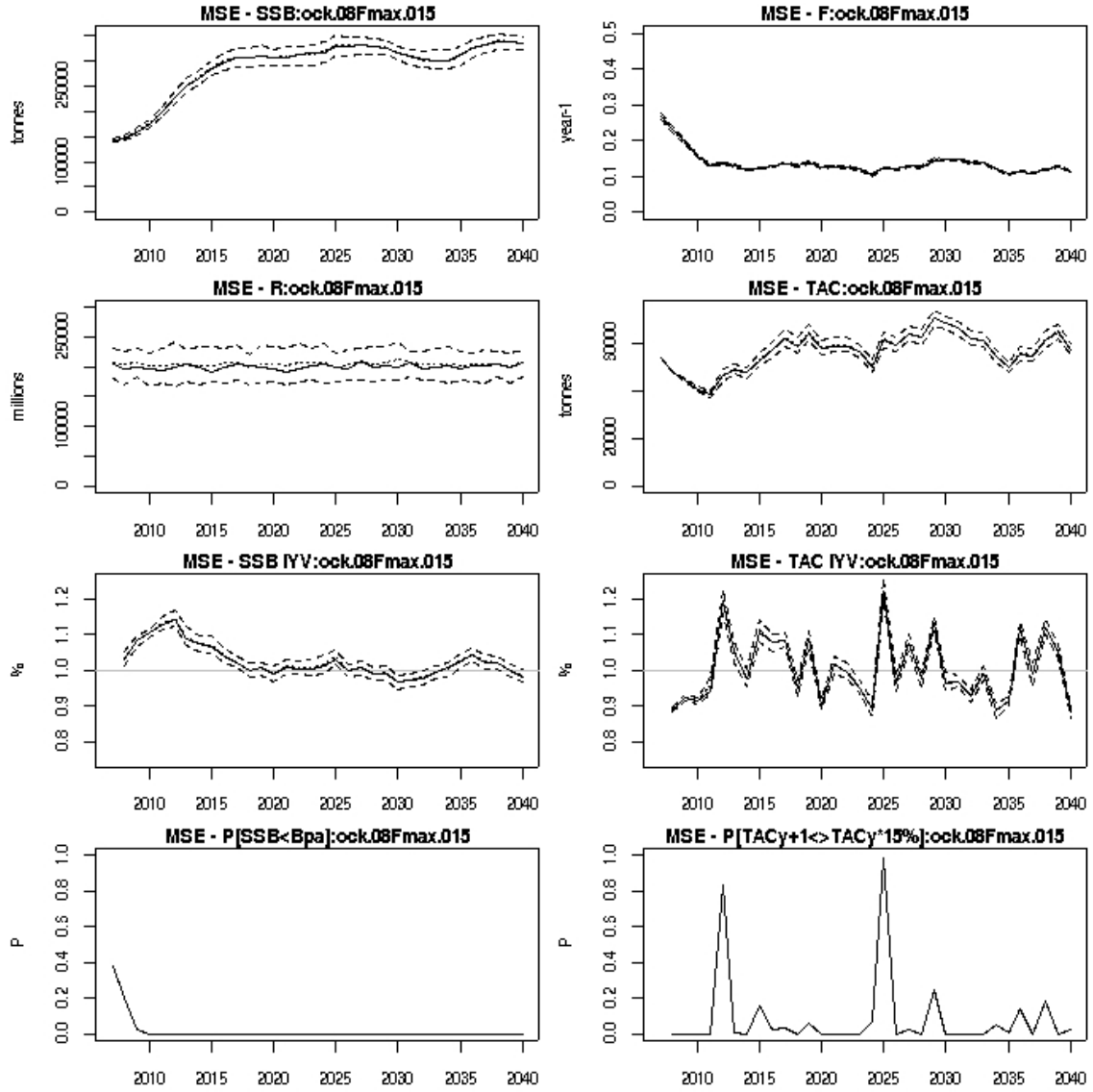


Fig. 3.6.12. Trajectories for scenario 15% decrease to 0.8Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

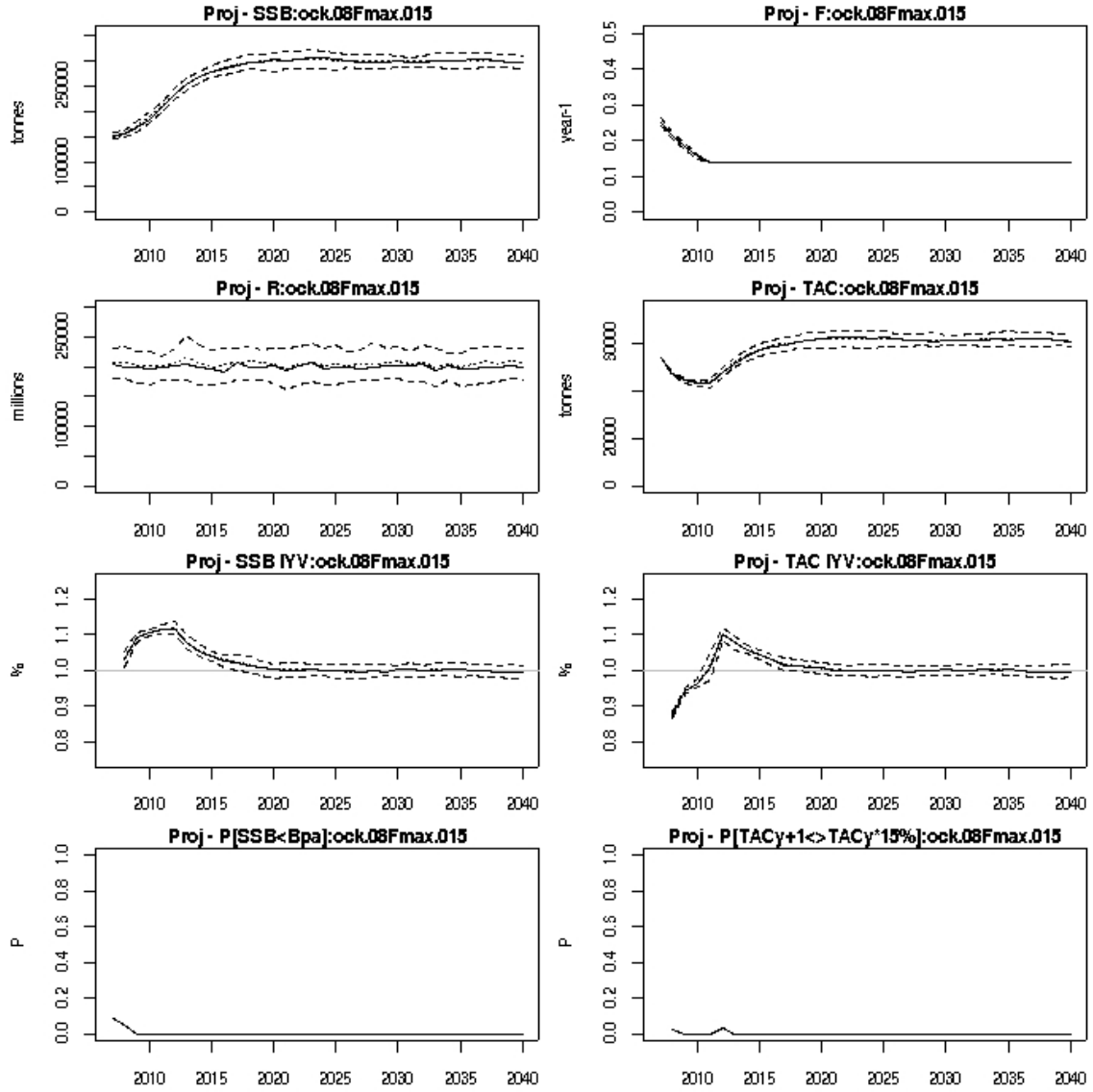


Fig. 3.6.13. Trajectories for scenario 15% decrease to 0.8Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

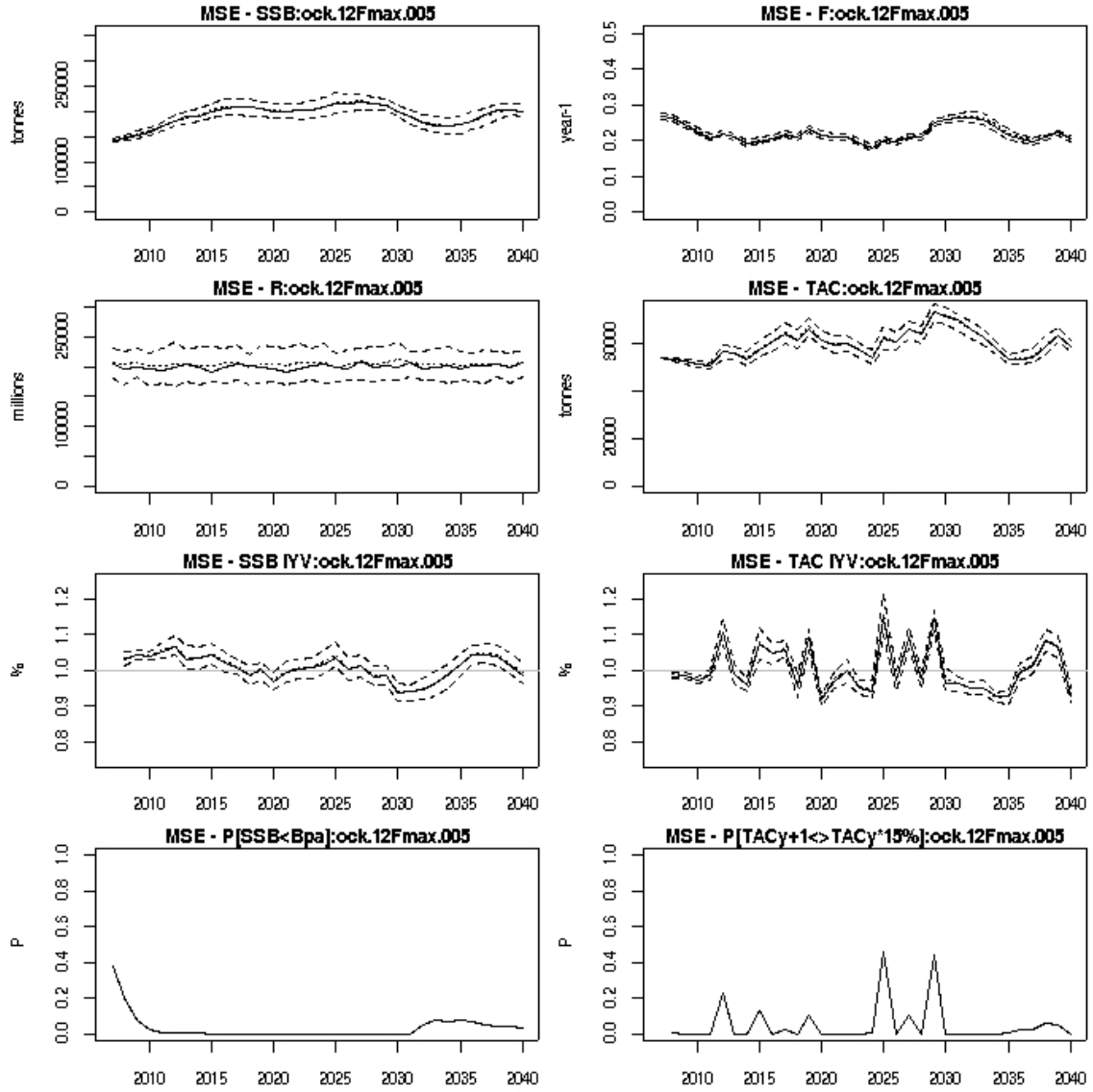


Fig. 3.6.14. Trajectories for scenario 5% decrease to 1.2Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

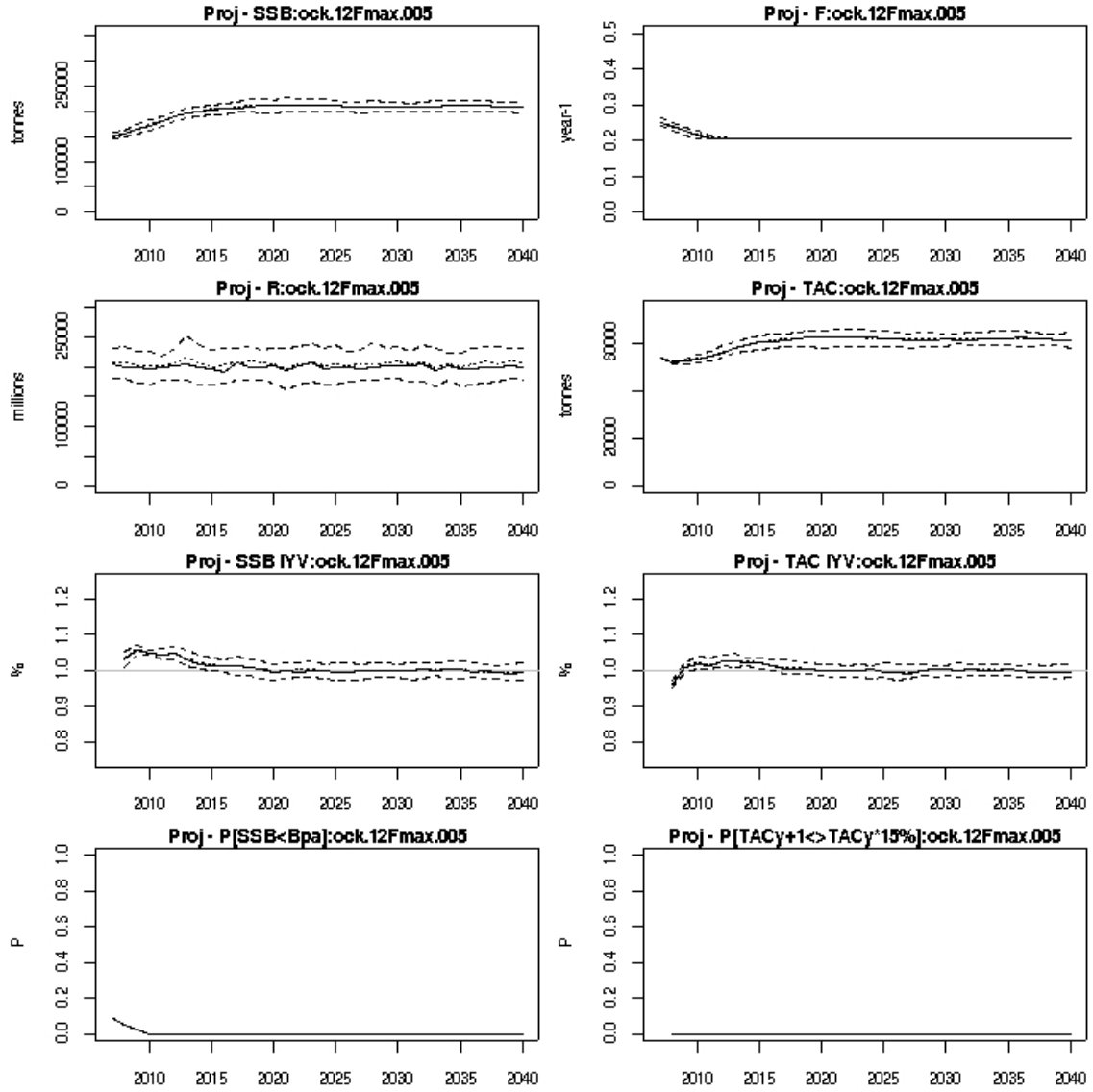


Fig. 3.6.15. Trajectories for scenario 5% decrease to 1.2Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

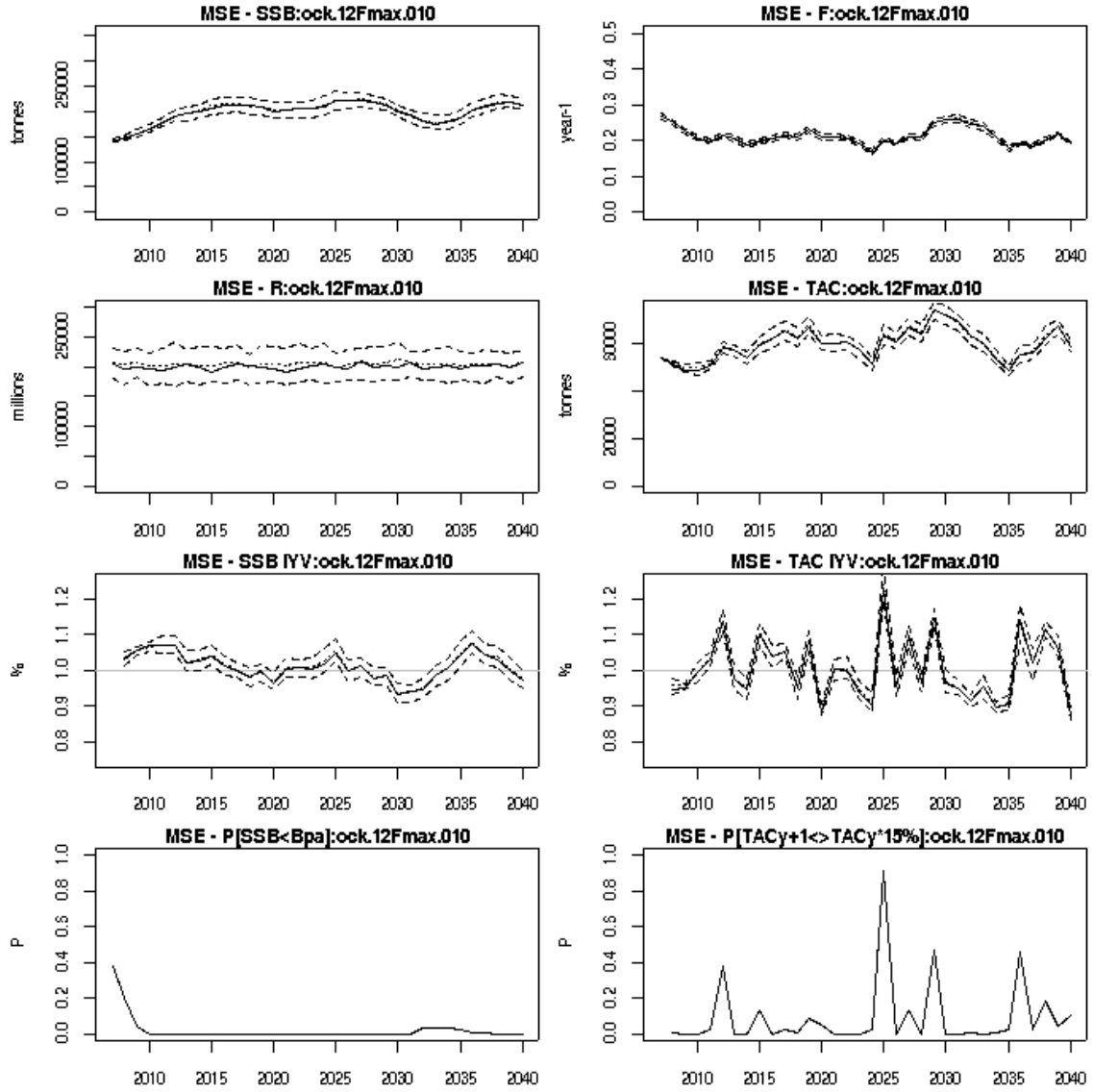


Fig. 3.6.16. Trajectories for scenario 10% decrease to 1.2Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

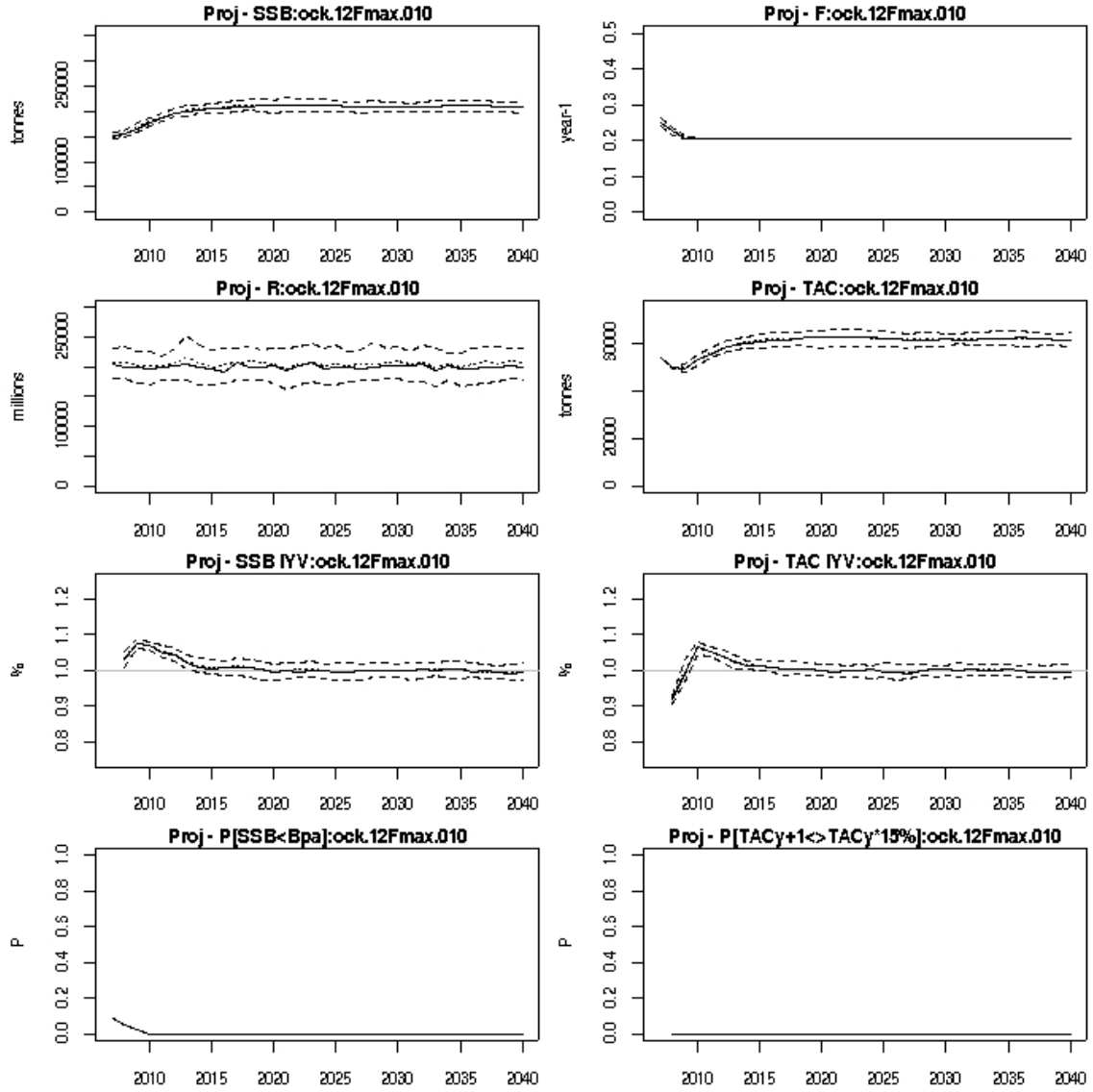


Fig. 3.6.17. Trajectories for scenario 10% decrease to 1.2Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

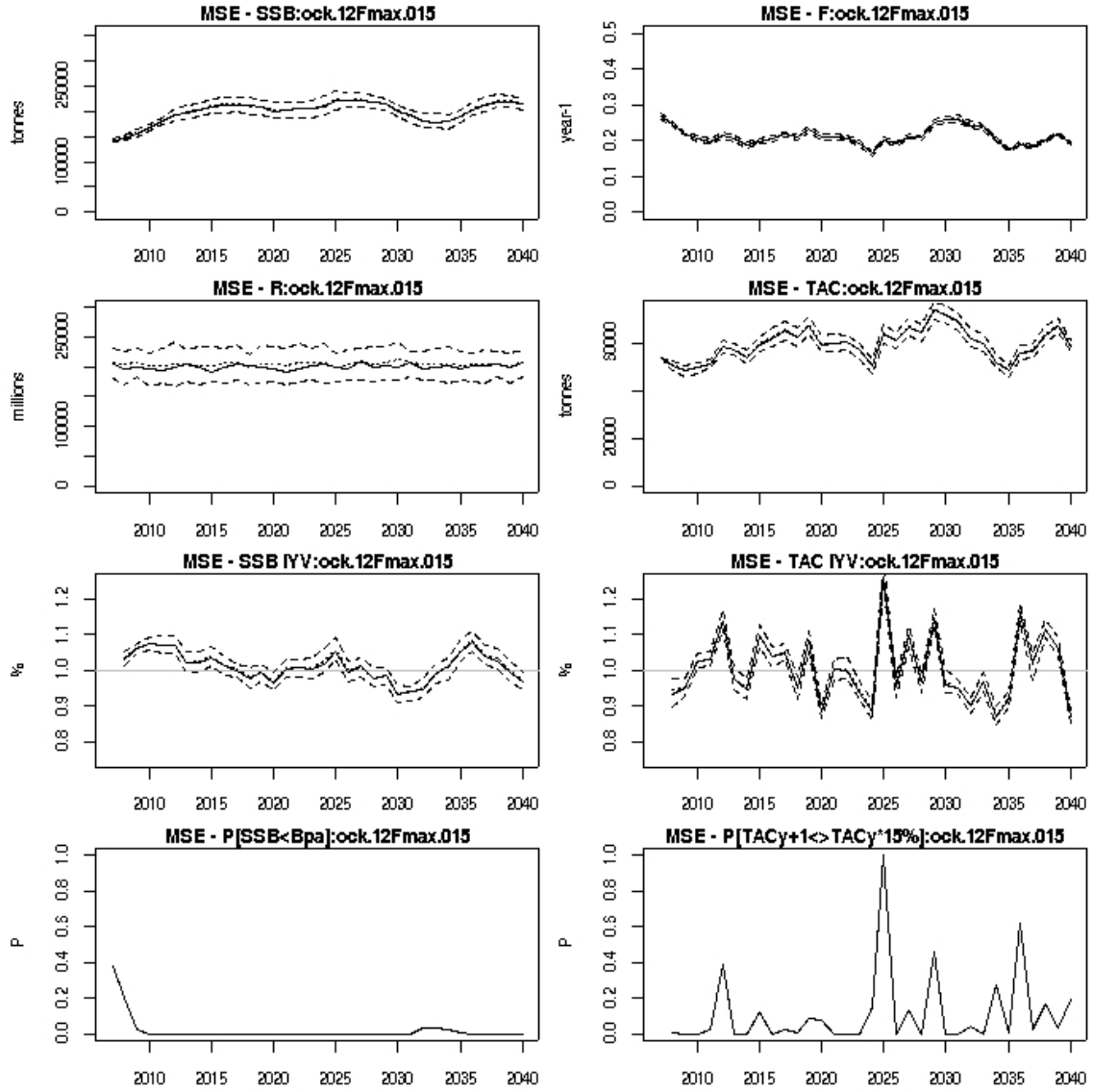


Fig. 3.6.18. Trajectories for scenario 15% decrease to 1.2Fmax with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

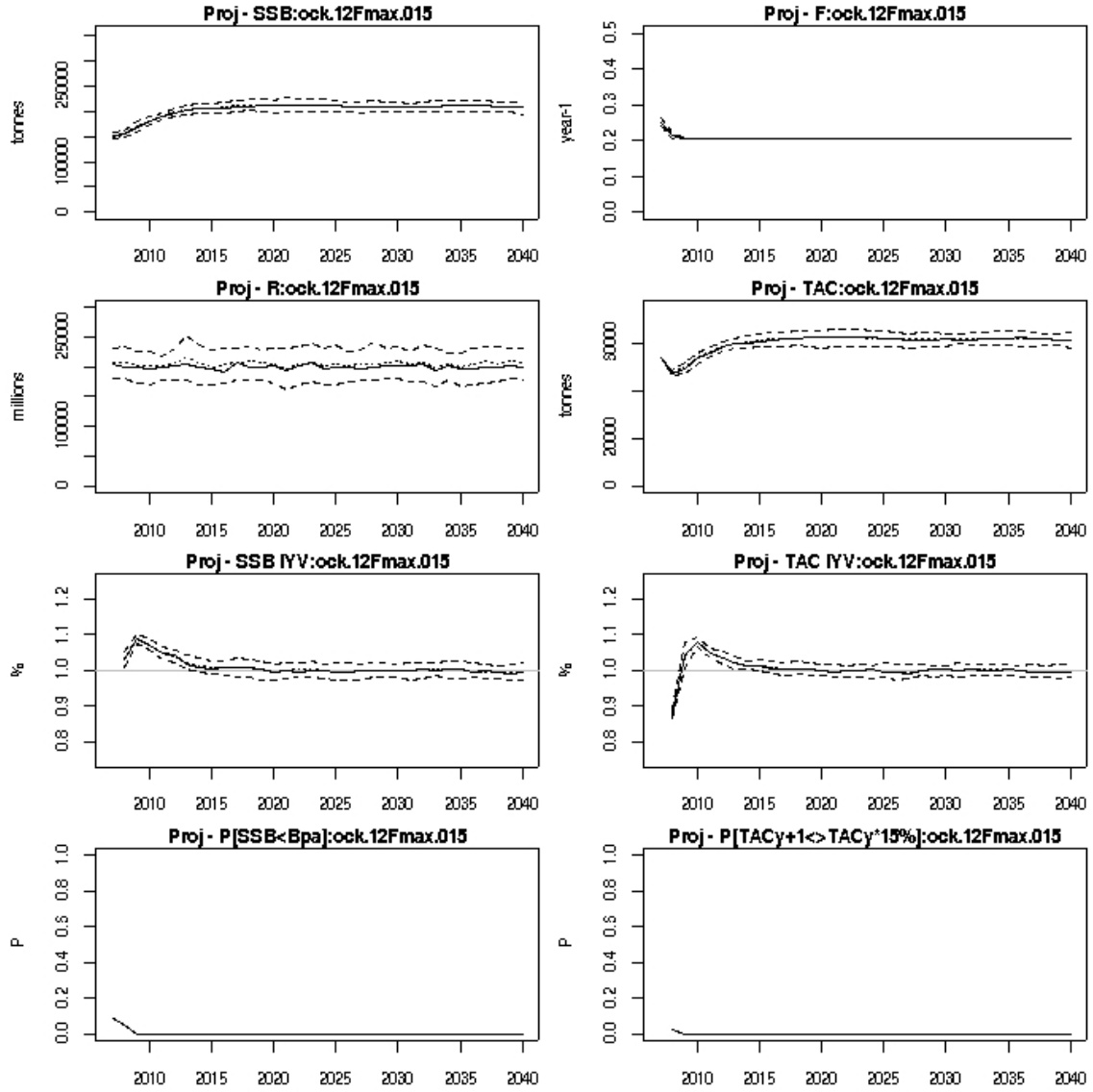


Fig. 3.6.19. Trajectories for scenario 15% decrease to 1.2Fmax with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

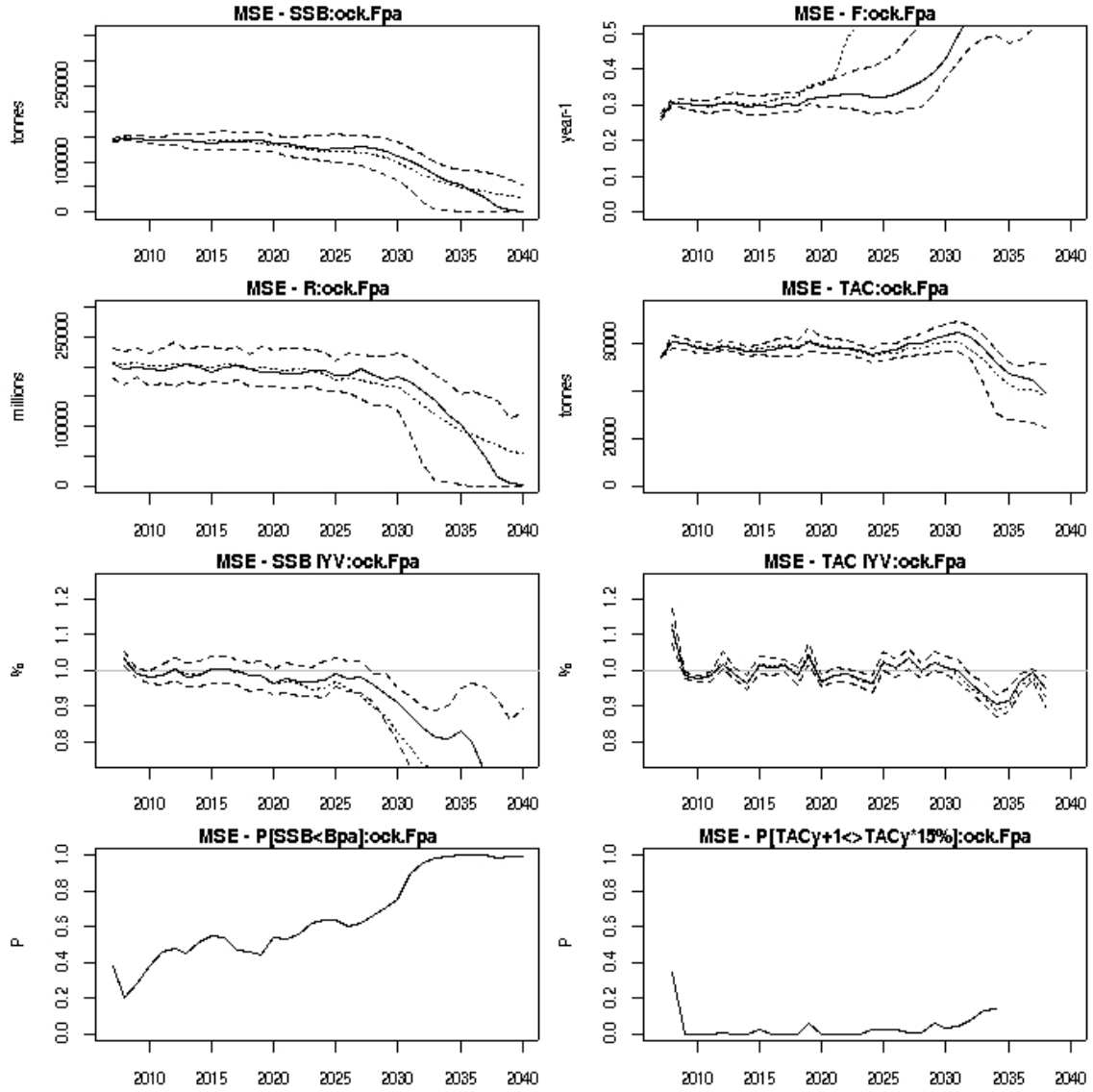


Fig. 3.6.20. Trajectories for scenario Fpa with MSE algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

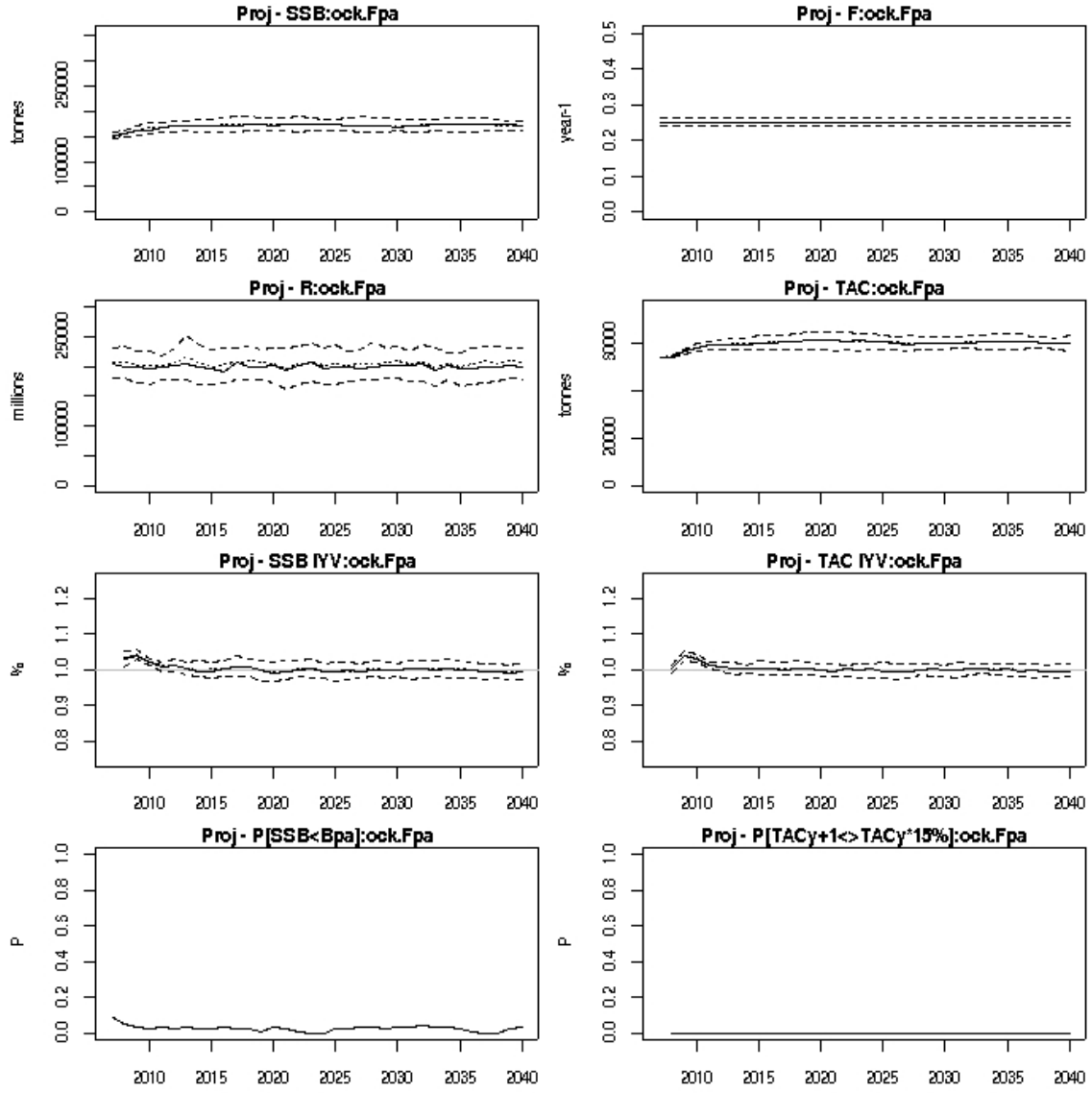


Fig. 3.6.21. Trajectories for scenario Fpa with projection algorithm. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

2.7. Distribution of F by Fishery Unit (FU)

In the ToR, the group was asked to estimate levels of fishing effort, disaggregated by gear and/or other appropriate categories, corresponding to the new fishing mortality levels. As data on effort were not readily available, the group felt that instead of computing effort, it would be useful to compute F at age by gear and/or fishery unit categories, as those F could be used in subsequent analysis, for instance to calculate landings by gear and thus investigate fishery interactions.

Landings are available by Fishery Units (see section 2.2) which is a combination of gear and area. Thus, in order to compute the F by gear, landings by FU were aggregated by gear categories: Trawl, Gillnet, Longline and Others (combination of various gears). This was carried out over the three last years available (2004 to 2006). Length distributions of landings by FU and gear were first converted into age composition using the ALK of the corresponding year. The resulting proportions of landings at age are presented in the Tables 3.7.1. and 3.7.2. below:

Table 3.7.1. Partition of landings at age by Fishery Unit.

FUs	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
FU1	0.0000	0.0000	0.0002	0.0074	0.0707	0.2131	0.2539	0.2630	0.2672
FU2	0.0000	0.0000	0.0000	0.0002	0.0015	0.0049	0.0058	0.0061	0.0062
FU3	0.0000	0.0000	0.0011	0.0069	0.0289	0.0750	0.1429	0.1969	0.2833
FU4	0.0000	0.0936	0.1548	0.2511	0.4192	0.3194	0.1963	0.1351	0.0731
FU5	0.0000	0.0023	0.0199	0.0283	0.0249	0.0148	0.0078	0.0059	0.0053
FU6	0.0000	0.0000	0.0002	0.0006	0.0007	0.0004	0.0003	0.0004	0.0005
FU8	0.0046	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072	0.0072
FU9	0.0000	0.1906	0.1274	0.0743	0.0228	0.0068	0.0048	0.0047	0.0048
FU10	0.2365	0.1168	0.0918	0.0601	0.0195	0.0146	0.0088	0.0062	0.0043
FU12	0.0000	0.0000	0.0001	0.0007	0.0040	0.0134	0.0215	0.0223	0.0151
FU13	0.0000	0.0108	0.0480	0.0658	0.0564	0.0917	0.1366	0.1521	0.1377
FU14	0.7579	0.5685	0.5219	0.4319	0.2086	0.0878	0.0604	0.0455	0.0264
FU15	0.0002	0.0018	0.0064	0.0143	0.0152	0.0178	0.0225	0.0257	0.0277
FU16	0.0000	0.0056	0.0182	0.0483	0.1175	0.1304	0.1284	0.1261	0.1385
FU00	0.0009	0.0029	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028

Table 3.7.2. Partition of landings at age by gear.

Gear	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
Trawl	0.9990	0.9790	0.9232	0.8535	0.7028	0.4510	0.2856	0.2050	0.1215
Gill.	0.0000	0.0108	0.0491	0.0727	0.0854	0.1666	0.2795	0.3490	0.4211
Long.	0.0000	0.0000	0.0003	0.0083	0.0763	0.2314	0.2812	0.2914	0.2884
Others	0.0010	0.0102	0.0274	0.0655	0.1356	0.1510	0.1537	0.1546	0.1690

It was not possible during this meeting to carry out this analysis further. If needed, these proportions could easily be used in subsequent analysis to compute from total F at age, the F at age for various FU and/or gear categories.

3. ToR 2. Multispecies management

3.1. Objectives

The Group was requested to investigate the effect that changing fishing mortality on Hake would have on the yields and stock sizes of main commercial species caught together with Northern hake. These accompanying species, for which there were enough data to undertake such analysis, were identified as Northern megrim (*Lepidorhombus whiffiagonis*) and Northern anglerfish (*Lophius piscatorius* and *L. budegassa*). For the analysis, the Group assumed that any reduction in fishing mortality for Northern Hake would also bring about a reduction in fishing mortality for the other identified accompanying species. In this sense, no displacement of fishing effort to other species was assumed.

It has to be taken into account that:
a) data used for the analysis lack the required quality in relation to sampling coverage, ageing validity, scarcity, specially in relation to discards and in general, reliability.

b) the model (XSA) do not appear appropriate for assessing the stocks status under consideration, providing unrealistic state of the population specially in 2007 which is the initial year for the projections.

3.2. Method

The first stage of the analysis estimated the percentage decrease in fishing mortality on Northern megrim and anglerfish that would be observed as a result of a 10% decrease in Northern Hake fishing mortality. It was assumed that any reduction in Hake fishing mortality would affect the fishing mortality of the other species equally. However, since the distribution of Hake, megrim and anglerfish catches differs by area and gear, it was postulated that a reduction in hake fishing effort would not similarly affect the fishing mortality on the additional species. As a result, the effective reduction in fishing mortality on the additional species would be less than 10%.

First, to determine which FU's would be affected by a decrease in Hake fishing mortality, FU's in which Hake and either megrim or anglerfish were caught were then identified based on an analysis carried out in WGHMM05. A complete list of Fishery Units (FU) is included in Section 2.2.

Table 4.2.1. Common Fishery Units between Northern Hake and other species.

Interaction between stocks	Northern Hake
Northern Megrim	FU4, FU5, FU8, FU9, FU14, FU15
Northern Black Anglerfish	FU3, FU4, FU5, FU9, FU14
Northern White Anglerfish	FU3, FU4, FU5, FU9, FU14

As shown above, FU's selected were different for each pair of Hake and accompanying species combination.

The main characteristic of each of these FUs are:

FU3: Gill nets in Subarea VII: usually compounded by directed fisheries for hake and anglerfish. In general, it has few interactions with other stocks.

FU4: Non-*Nephrops* trawling in medium to deep water in Subarea VII and FU5: Non-*Nephrops* trawling in shallow water in Subarea VIII A deep-water fishery targets roundnose grenadier, with by-catches of black scabbard and deep-water squalids. Orange roughy is also caught but technical interactions with the other commercial deep-water species are estimated to be at low levels. Fisheries for demersal gadoids target mainly hake, anglerfish, megrim, cod, whiting, haddock, and take by-catches of flatfish, rays and skates.

FU8: *Nephrops* trawling in medium to deep water in Subarea VII & FU9: *Nephrops* trawling in shallow to medium water in Subarea VIII: The *Nephrops* fishery was developed in the 1970s and 1980s. In the Celtic Sea, vessels targeting *Nephrops* catch a substantial amount of cod and whiting. In the Bay of Biscay *Nephrops* fishing results in by-catches of juvenile hake. Square-meshed panels have been introduced recently to improve the selectivity of the trawls.

FU14: Trawling in medium to deep water in Subarea VIII: Some fisheries are not targeting particular assemblages of species. For example, some bottom otter trawlers operating in Division VIIIabd target a variety of species including hake, anglerfish, megrim, but also flatfish, squids, elasmobranches.

FU15: Miscellaneous in Subareas VII & VIII: Everything not described above.

First, the proportion of the total catch of Northern megrim and anglerfish landed from each Fishery Unit (FU) was calculated, using data for the years 2003-2005. Next, the fishing mortality on Northern megrim and anglerfish in each FU was calculated by applying the same proportion of the total catch of each species landed in that FU to the total fishing mortality of that species. The total fishing mortalities used were those obtained during the WGHMM 2006 updated to 2007.

The fishing mortalities assigned to the chosen FU's for each accompanying species were then summed. The resulting fishing mortality for each of the accompanying species was, therefore, just a portion of the original total fishing mortality. The ratio between the new partial and the total fishing mortality is the multiplier to be applied every year in the projection starting in 2007 with the status quo fishing mortality on which the effect of hake fishing mortality reduction of 10 % will be applied.

In the second stage of the analysis, long-term stochastic predictions were run for Northern megrim and both anglerfish species to provide estimates of stock size (SSB) and yield when a reduction of 10% of Hake fishing mortality is applied to their corresponding partial fishing mortalities.

Fishing mortality was decreased firstly, by the ratio obtained from the FUs and then annually, by the estimated effective reduction in fishing mortality of Hake until Hake fishing mortality reached Fmax., after which, it was kept constant. Like the simulations for Northern hake, these accompanying species simulations were projected until 2040.
Stochastic projections for Northern megrim (*L. whiffiagonis*), anglerfish (*L. budegassa*) and monkfish (*L. piscatorius*) in Subarea VII & Div.VIIIabd were performed in an EXCEL ad hoc work sheet, since standard software available do not provide the possibility of consecutive annual reductions of Fs. Monte Carlo simulations were performed with @Risk add-in.

Inputs for stochastic predictions
For each stock, the input parameters for the projections were obtained from the final summary statistics of the 2006 updated assessment of the stocks conducted at WGHMM 2006. In this sense, it should be noted that data quality and uncertainties in the discards, catch matrix, age estimation and models used in this approach are only just indicative of trends and not indicative of absolute values.

Recruitment for predictions was estimated by a geometric mean (GM) for the updated time series established in WGHMM06. Recruitment estimates of the years not used for the GM were replaced by the GM. Their standard error was estimated. Recruitment distribution was simulated as Log Normal function.

Abundance at age for 2007 was obtained from updated XSA results. Standard errors were the maximum between internal and external XSA errors. Numbers at age distribution were simulated following Log normal function.

Fishing pattern, weight and maturity at age were calculated as the mean of the last 3 years. Errors for these means were estimated and their distribution was simulated following Log normal function. Maturity at age was kept constant since there is just one year of data.

Natural mortality was the same that used in the XSA model (0.2 for megrims and 0.15 for monkfish and anglerfish). A CV = 0.1 was used as a variability proxy and their distributions were simulated as normal function truncated for values lower than 0.

The fishing rate relating hake F and stock F was estimated as a mean of years 2003-05 with the corresponding error (see table 4.2.2. below) and their distribution was simulated as Beta function.

Table 4.2.2. Discard rates for Megrim and Anglerfish

stock	**Mean**	**S.E.**
Megrim	0.82	0.06
L. budegassa	0.92	0.03
L. piscatorius	0.85	0.03

Discards rate for megrim was estimated as the mean of the last 3 years with the corresponding error. Discards rate distribution was simulated as *Beta* function. This rate was applied to the yearly catches to estimate yield.

Stochastic Outputs
Resulting variables were SSB and yield from 2007 to 2040. After 2025 all the stocks get equilibrium among recruitment and F for SSB and yield median and percentile values. Monte Carlo simulations were performed for 2000 iterations; % in change for mean and standard error was lower than 1% for all outputs among consecutive iterations well before iteration 2000.

3.3. Results

The relative projected biomasses and yields are presented in the following figures.. Relative values are presented as, as commented above, data and model used are still uncertain and so these results should be used just as indicative of trends and never as absolute values. Period represented is just until 2025, as it was considered that at that time, both population indicators were already stabilised.
Fishing mortalities trajectories for the accompanying Northern Hake species are presented in Figure 4.5.1 (deterministic) and 4.5.2 (stochastic). These trajectories are almost parallel to the Hake ones as reduction rate was about 0.9 for all the stocks. As for Hake, stability in Fs is reached in 2012. In that year, the final reductions of the Fishing mortalities for each stock reached were 33, 35 and 32 % for Northern Megrim, *L. budegassa* and *L. piscatorius*, respectively.

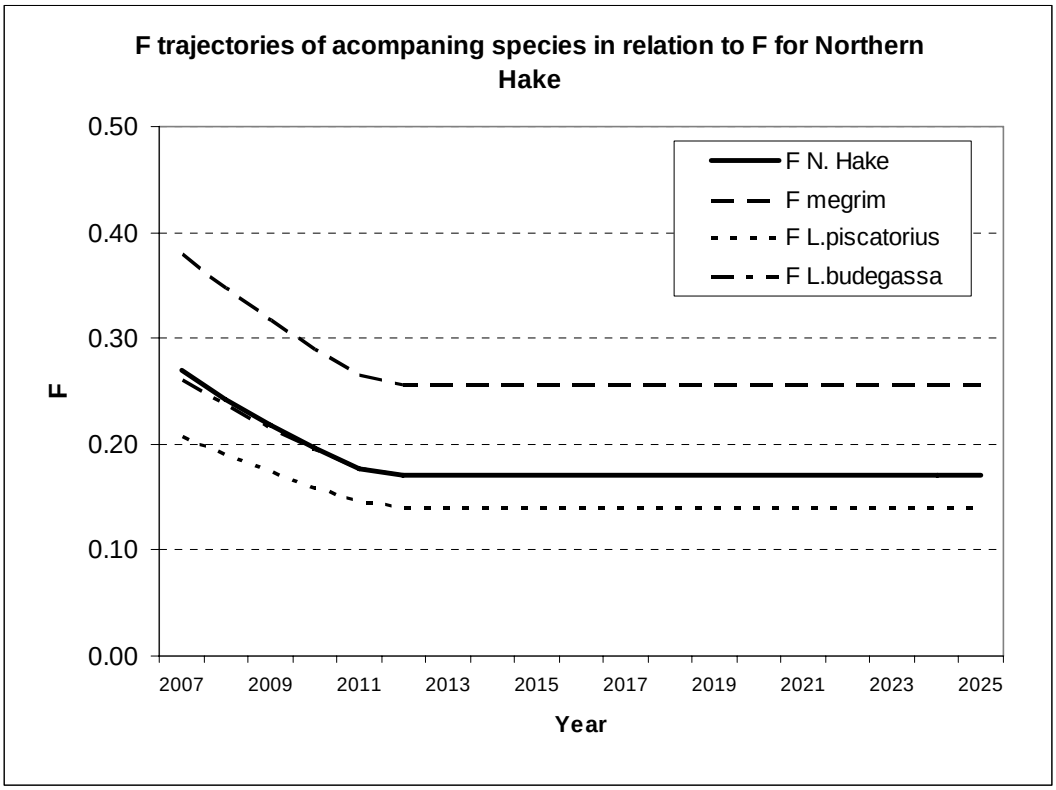


Figure 4.5.1. F trajectories of the main accompanying species in relation to the Northern Hake F.

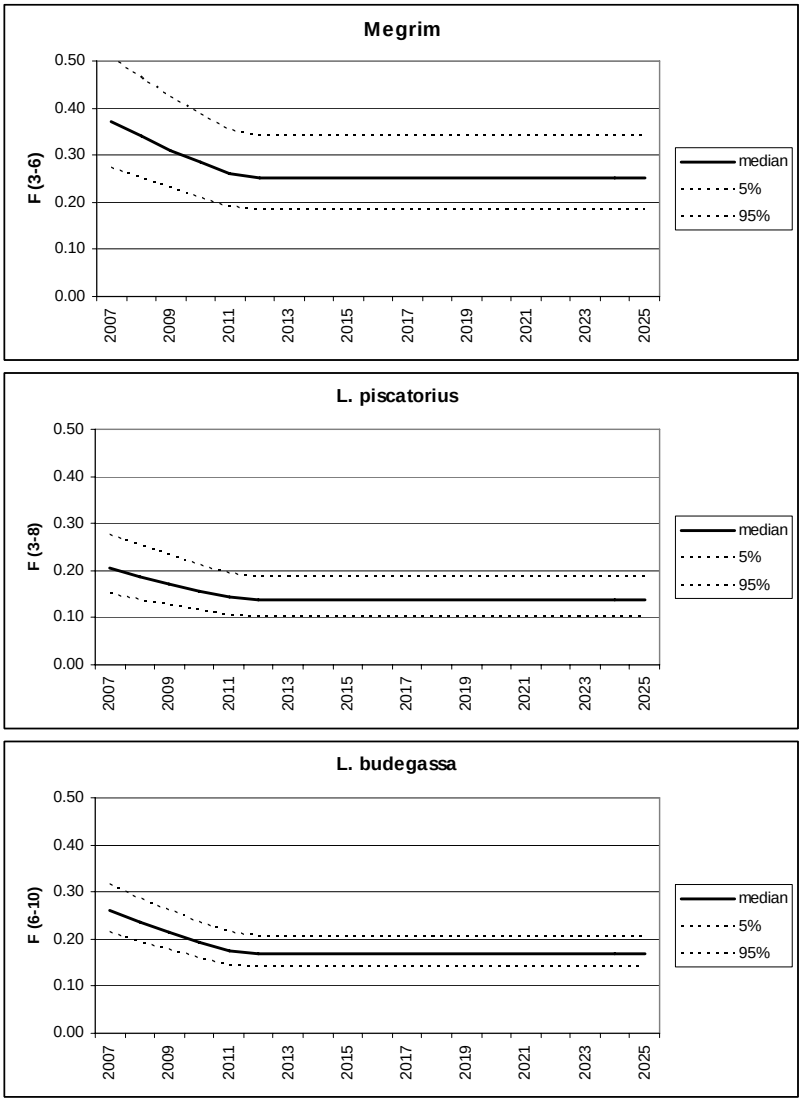


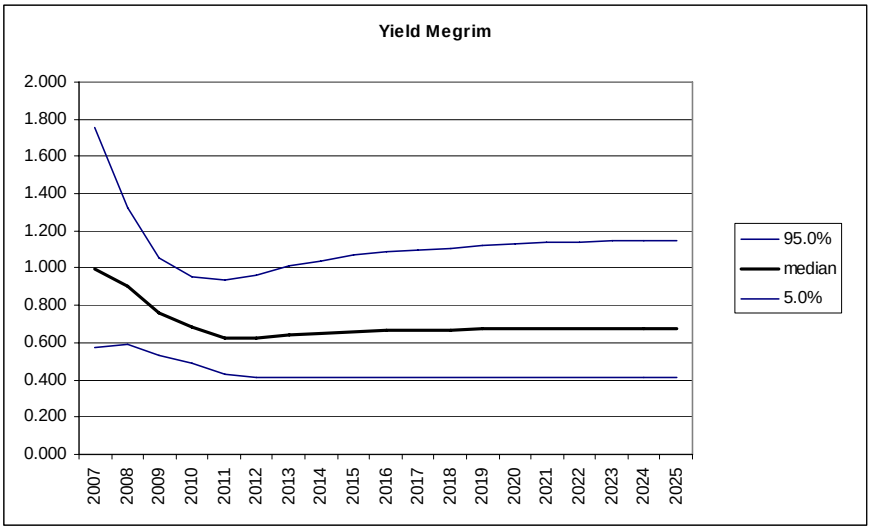
Figure 4.5.2. Stochastic trends in F bar for megrim, *L. piscatorius* and *L. budegassa*.

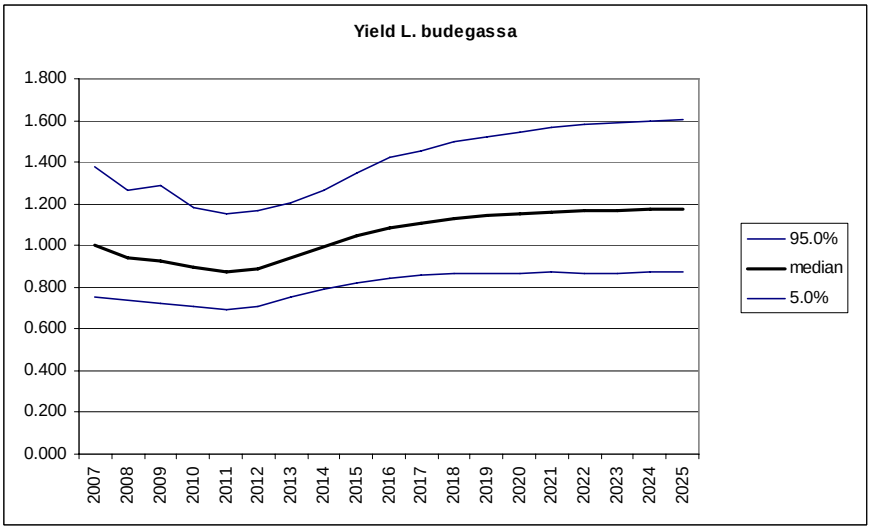
Figure 4.5.2 shows median F and confidence intervals for megrim, *L. piscatorius* and *L. budegassa*. Implemented sources of variability for F in every stock are: Fsq, estimated as a mean at age of the last three years, and the F rate relating F hake with F in corresponding stock. Variability for F in hake was not taking into account.

F decreases for the three stocks until 2012 following the F decreasing for hake, after that, median and percentiles stabilize. Variance coefficients for all the stocks are: 0.19 for megrim, 0.12 for *L. budegassa* and 0.18 for *L. piscatorius*. There is not any kind of dynamic variability in the F estimation so this CV remains nearly constant in time for the three stocks.

Relative yields and confidence limits obtained for the projected populations of Northern Megrim, and both anglerfishes are presented in Figure 4.5.3. In all stocks a reduction in the yield is presented in the first years of the projection (around 2010) when also F is stabilised. From that year onwards, an increase in the yield will be expected whilst stock is recovering. However, yields for Northern Megrim and *L .piscatorius* increased very little stabilising along all series. *L. budegassa* yield increase the most, reaching higher levels at the end of the series than in 2007. Uncertainty of the initial population of Northern Megrim and *L. pìscatorius* appear to be bigger than in the rest of the years of the projection. This is probably driven by some inconsistent scenarios resulting from the simulations

developed, in which variability was introduced in all initial parameters. Some inconsistencies in, for instance high fishing mortality and high numbers could result which may be unrealistic since they are negatively correlated. This explains why megrim and *L. piscatorius* show higher yield uncertainty in 2007 than in the following years.





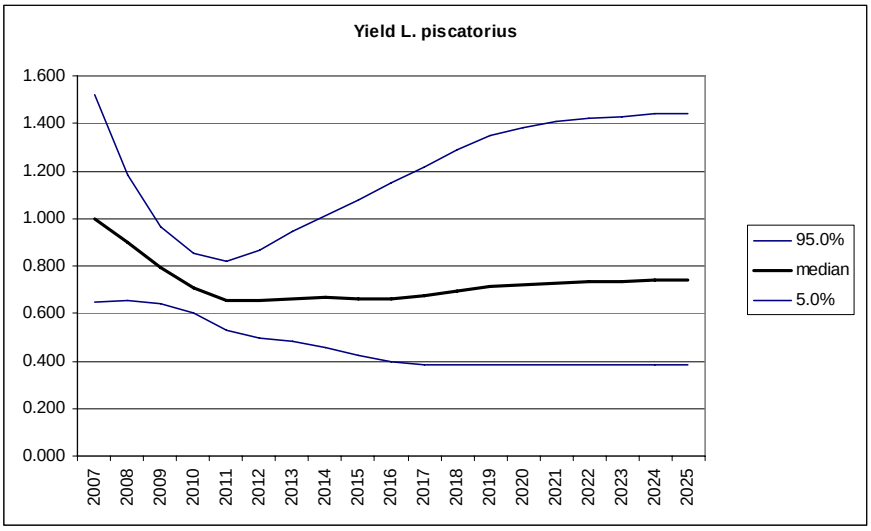
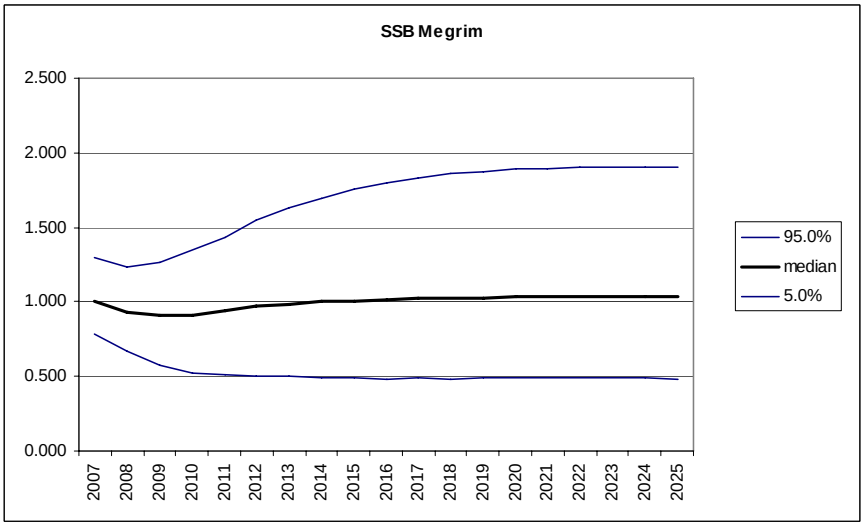


Figure 4.5.3. Relative projected yield of the main accompanying species and confidence intervals.

Relative trends in SSB (median and percentiles) for the three stocks are presented in Figure 4.5.4 Median values show different answers for the three stocks. Megrim SSB started with a small decrease and after that recovered until values slightly higher than those at the beginning. *L. budegassa* SSB increased from 2007 until it stabilized at a 70% higher value in 2025. *L. piscatorius* SSB falls 20% from 2007 to 2011 and after that it recovered slightly reaching equilibrium after 2021 slightly under the initial figure. Confidence margins increase since the beginning; just *L. budegassa* shows a high probability of SSB increase.



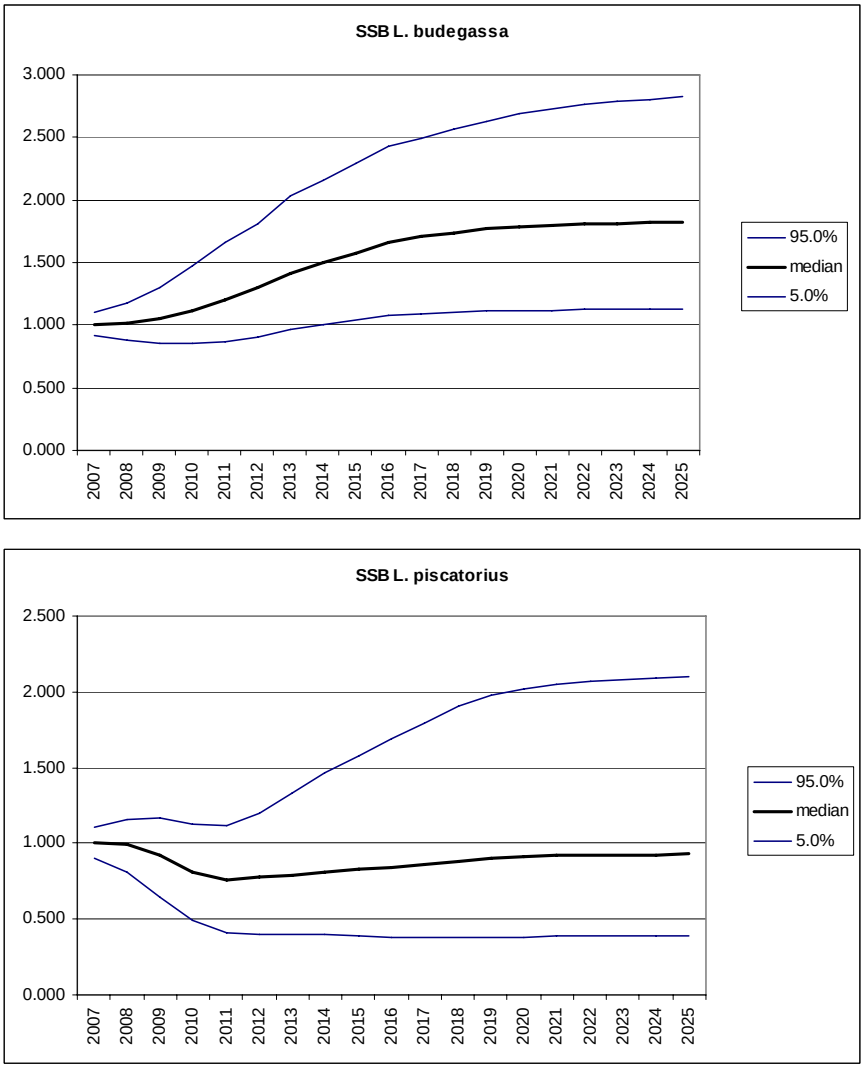


Figure 4.5.4. Relative projected biomass of the main accompanying species and confidence intervals.

3.4. Conclusions

a) A linear decrease in Northern Hake affect decreasing fishing mortalities in the accompanying species caught in the same FUs although the rate of change and their precision should be further investigated.
b) This exercise, despites data quality problems, is a possible way of dealing with the problem of how a decrease in fishing mortality of a main species can affect fishing mortality of the accompanying ones. If further conclusions would be desirable to be reached the stochasticity of the parameters could be investigated.

4. ToR 3. Other scenarios

4.1. Discards

The ICES WGHMM did not take discards into account in the assessment process since sampling for discards does not cover all fleets contributing to hake catches. Consequently, discards rates of several

fleets are simply not known and when data are available, it is not possible to incorporate them in a consistent way.

Furthermore, this Group did not have confidence in the estimate of age 0 in the landings because of inconsistencies in the data for this age group in recent years. Therefore, age 0 was removed from the catch at age matrix (replaced with 0 landings) and from the commercial fleet data.

However, because all information available suggest that discards rate could be high (up to 95%) in some years, area and for some fleets, and landings at age 0 were substantial in the past, the WGHMM commented on the underestimation of F given by the assessment for younger ages.

Therefore, the Group considered that aiming to an optimum long-term management of this stock must not avoid to address this issue.

An ad-hoc rebuilding of historical discards data was performed. Since recent information from sampling on board the *Nephrops* vessels in the Bay of Biscay have shown that the past series of discards estimated for this fishery (based on a scientific survey) was largely underestimated, the whole series was corrected using the ratio of the mean estimates of discards in the past and in the recent years. Historical data (prior to 1990) were kept unchanged. Since 2003, discards for other fisheries were calculated using the mean ratio *Nephrops* / Others over the period 1990-2002.

A new assessment was carried out (using the same settings as the current one) and results were used as input data for predictions and simulations.
As shown in figure 5.1.1., estimates of F and SSB are very similar when using landings (without age 0) only or all catches. Obviously absolute values of R are different, but the overall trend remains similar.

Northern Hake stock (IIIa, IV, VI, VII, VIIIab)
Assessements results using catches (Including discards and age 0 landings) or landings (without age 0) only

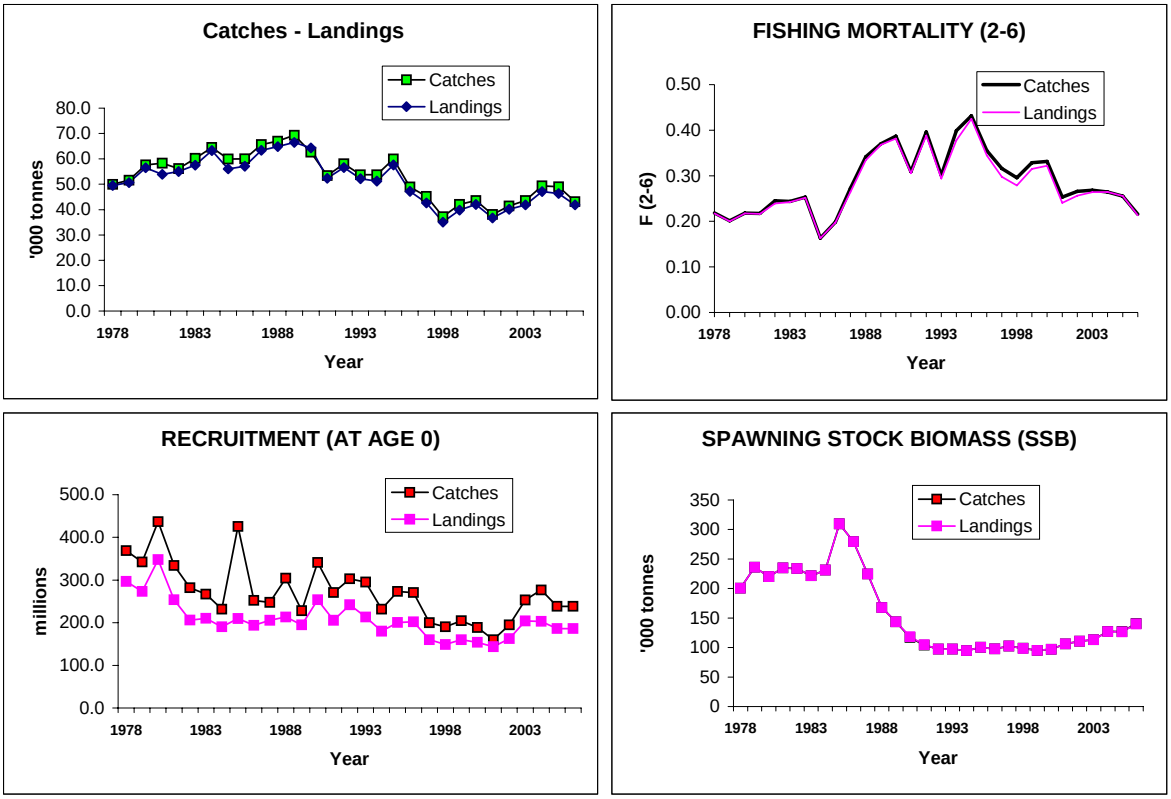


Fig. 5.1.1.

The main result is that F is now estimated for younger ages (Fig. 5.1.2.)

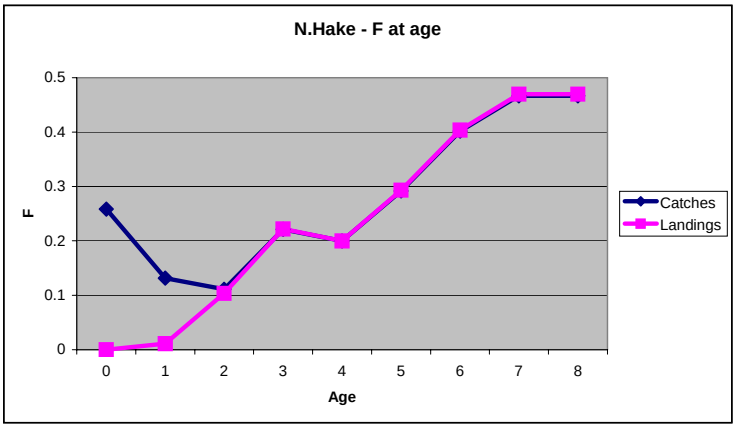


Fig. 5.1.2. The pink line is the F given by the 'current' assessment based on landings only. The blue line gives F at age from XSA with Catches. F are Fsq mean 2004-2006.

4.2. Starting conditions

CS5 software (Patterson, 2002) was used to perform simulations over the 2007-2027 period. The principal biological and statistical assumptions used by the Group are listed below:
a. Underlying population dynamics are fixed with a determined population abundance at age in the first year of the simulations. The starting point for the simulations is a random draw of abundance at age in the first year of the simulation.
b. Population abundance at age a in year y (Na,y) is assumed to be observed with lognormal error with age-specific standard deviation. For present purposes no bias has been assumed.
c. Recruitment N1,y is modelled as a stochastic variable dependent on spawning biomass SSB according to an Ockham-razor relationship with the break point at (Blim, long-term GM) with a lognormal error based on the standard deviation of recruitments.
d. All other population dynamic parameters (weights at age, maturity, natural mortality) are assumed known precisely and time-invariant.
e. Fishing mortalities for 2007 – 2027 are computed using inputs of F multipliers for each simulated years (i.e. effort limitation system)
f. When changes in the exploitation pattern are simulated, the changes are assumed to be implemented in the first year of the simulation (ie. 2007).

An example of input data is presented below.
The outputs of the model are plotted in eight different graphs:
- Four give the trends in simulated Recruitment and Fishing mortality, and the expected yield and SSB showing the median and the 25 and 75 percentiles.
- Two give the relative variations of SSB and yield. Note that the first point of these graphs show the variation of the simulated SSB and yield compared to the last observed one (2006).
- One give the risk of yield (landings) to vary more than 15% from one year to another with one figure if landings would be greater than the upper 15% limit and another if landings are below than the lower 15% limit.
- One give the risk for the spawning stock biomass to be below Bpa (140 000 t).

4.3. Current exploitation pattern (including discards)

Using these new estimates as input for predictions, a new Fmax was computed, corresponding to a maximisation of landings in the long term. The corresponding F multiplier is 0.48, much lower than the one computed in the current assessment (based on landings only) (i.e. 0.70).

Simulations were therefore carried out using different F strategies:

1. Fsq all over the period:

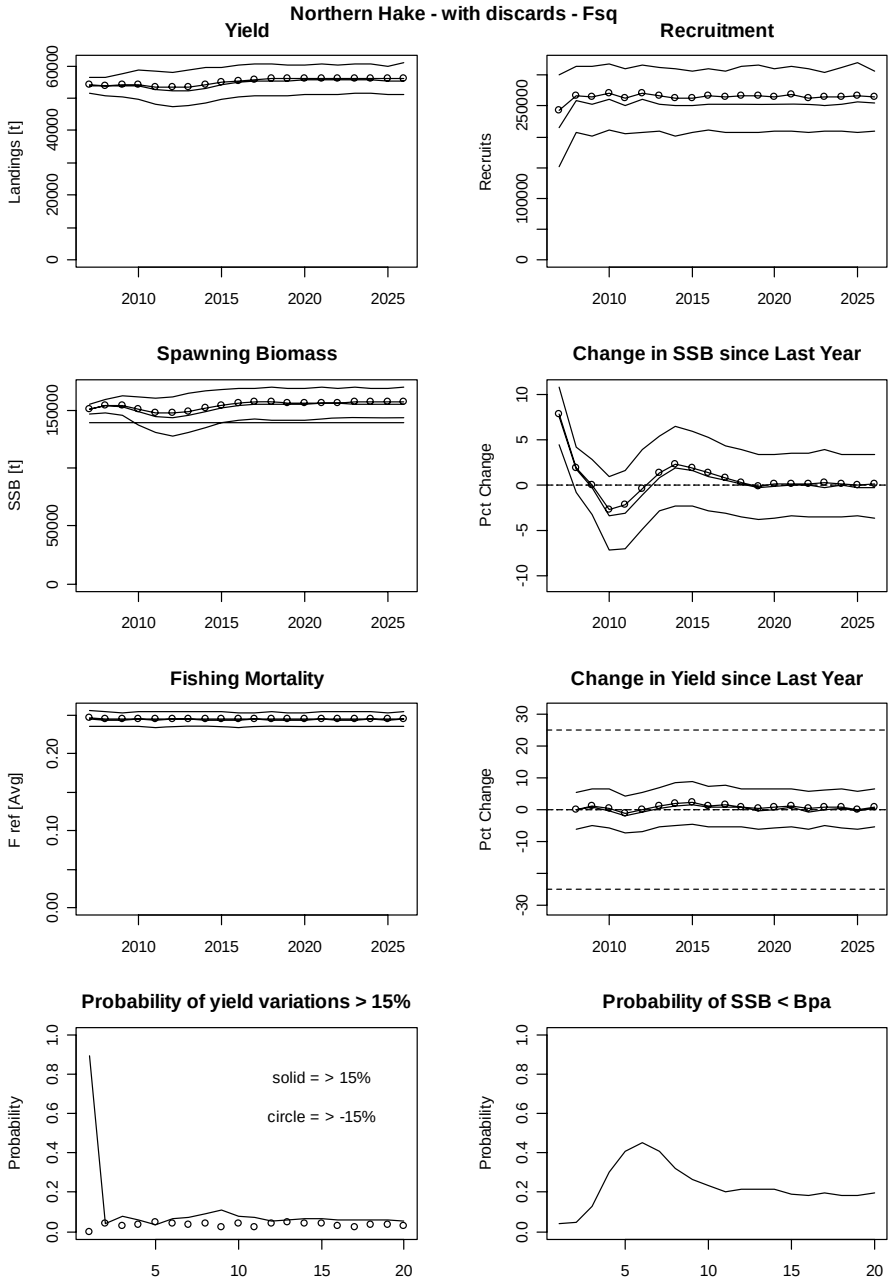


Fig. 5.2.1. Simulations using Fsq all over the period

2. a 10% reduction in F until this new Fmax is reached:

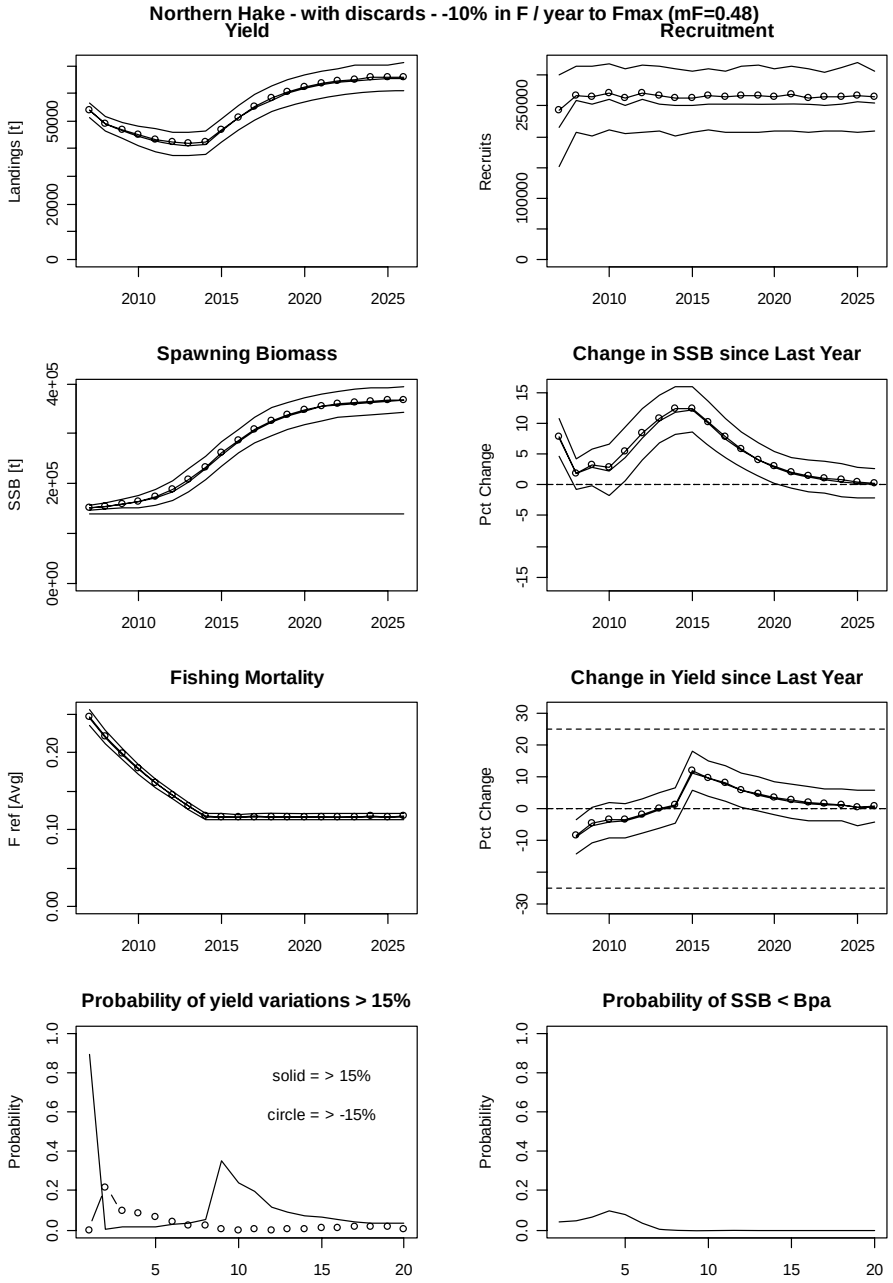


Fig. 5.2.2. Simulations using a 10% reduction in F until this new Fmax is reached

4.4. Change in the exploitation pattern

Various assumptions could be made on possible improvements of the current fishing pattern. The main purpose of the present exercise is to show the impact of some real and drastic improvement of the overall fishing pattern, on both the needed reduction in F and in the expected long-term yield. The simulated improvement of the selection pattern cannot easily be linked to existing devices or practices. However it is thought that this should show the way the fishery should aim to, given in mind that an improvement of the exploitation pattern can be achieved by an increase in the mesh-size, but also by implementing selecting devices in existing gear (like square mesh panels in trawls), or by using

different kind of gears or by changing of fishing areas or period to avoid those for which there is a high proportion of small fish in the catch.

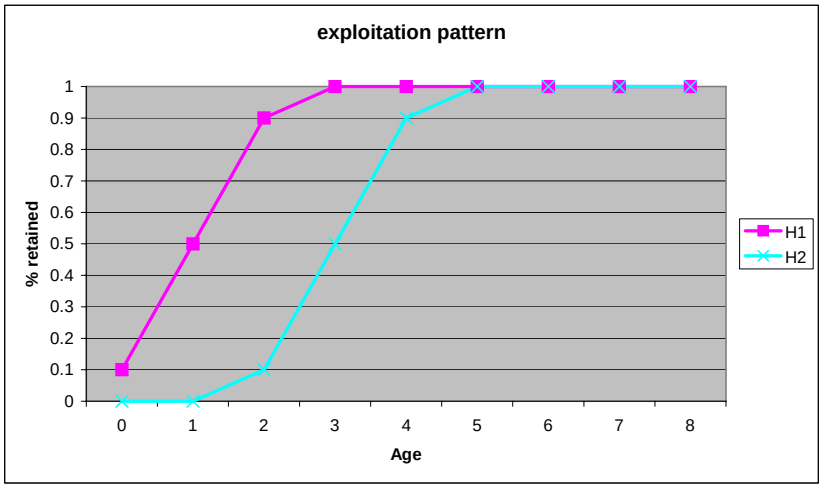


Fig. 5.3.1. or illustration purposes, two different exploitation patterns have been assumed:
• H1: assumed than 90% of hake at age 0 are spared, 50% at age 1 and 10% at age 2.
• H2: assumed no catch at age 0 and 1, 10% at age 2, 50% at age 3 and 90% at age 4, compared to the current one.

For each of these assumptions, long-term equilibrium yield is computed, and Fmax estimated. This calculation assumed that weights at age remain unchanged despite the change in the fishing pattern.
F multipliers required to reach Fmax are 0.64 and 0.88, for H1 and H2 respectively.

In addition to a smaller required reduction in F, fishing at Fmax with improved exploitation pattern leads to much higher long term yield.

The relative gains on landings compared to the long term yield with current exploitation pattern and status quo F (mF) are given below:

Table 5.3.1.

Scenario	mF to Fmax	% gain
Current Fmax	0.48	18%
H1Fsq		31%
H1 Fmax	0.64	37%
H2 Fsq		58%
H2 Fmax	0.88	58%

Long term simulations are carried out assuming a 10% reduction in F each year until corresponding Fmax is reached.

- For assumption H1: maintaining current overall effort (Fsq)

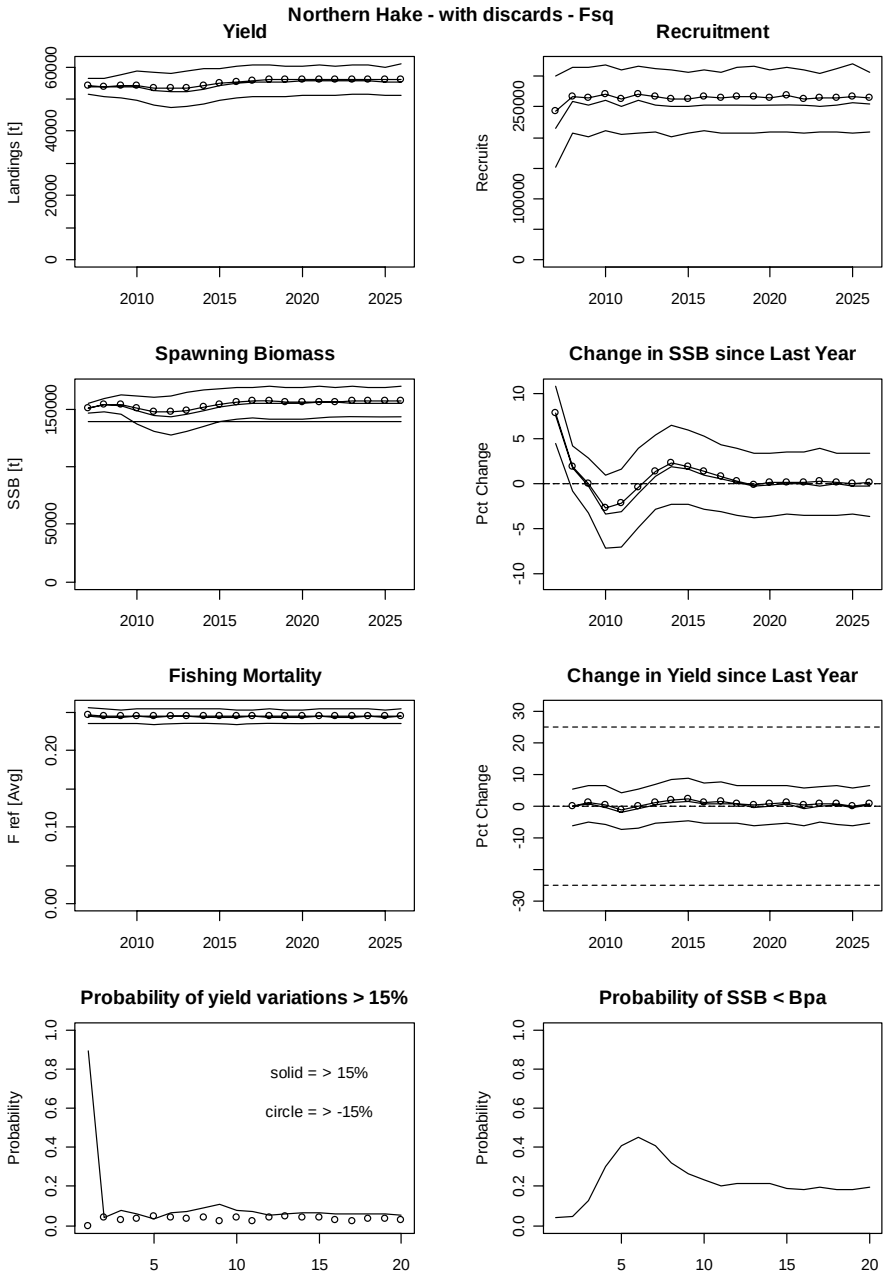


Fig. 5.3.2.

- For assumption H1: -10% reduction in F to Fmax

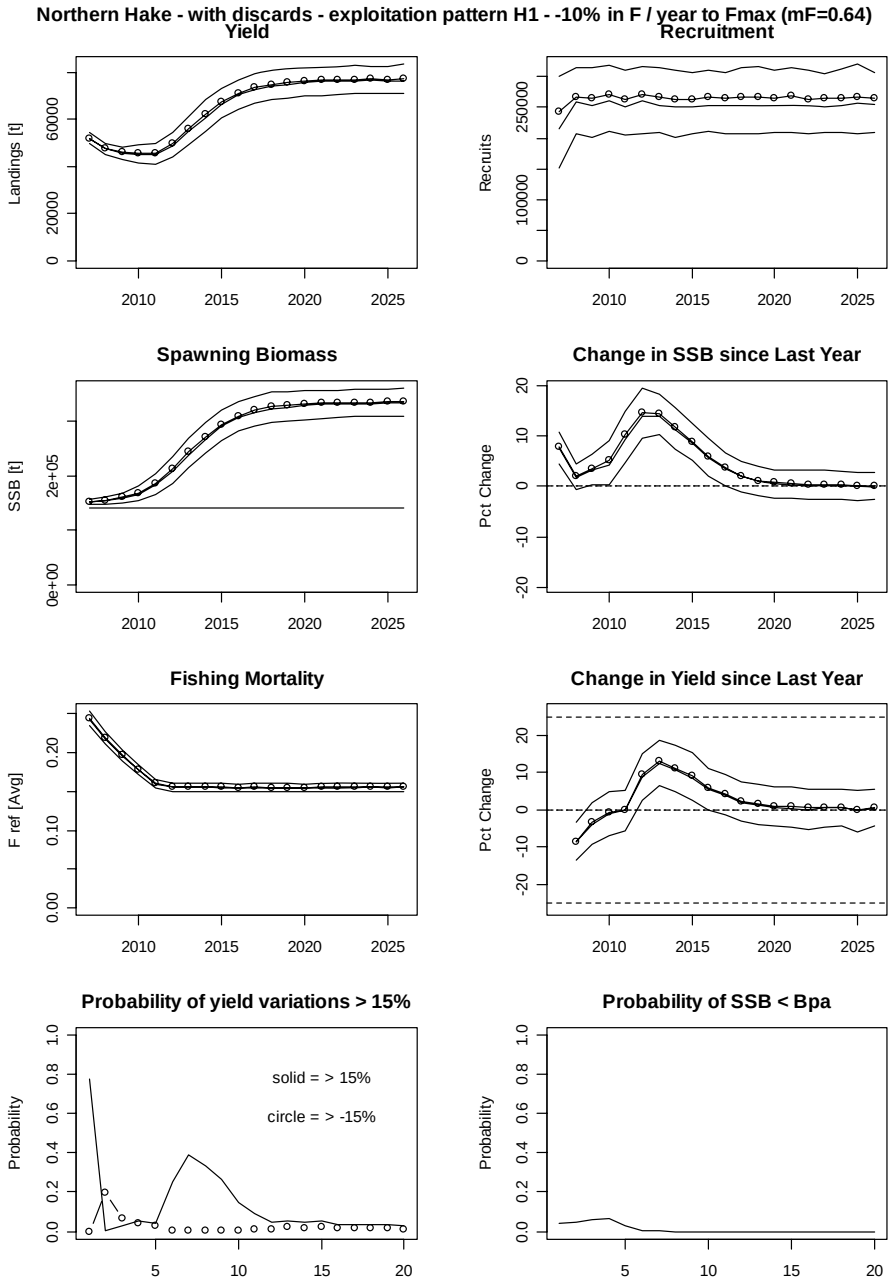


Fig. 5.3.3

- For assumption H2: maintaining current overall effort (Fsq)

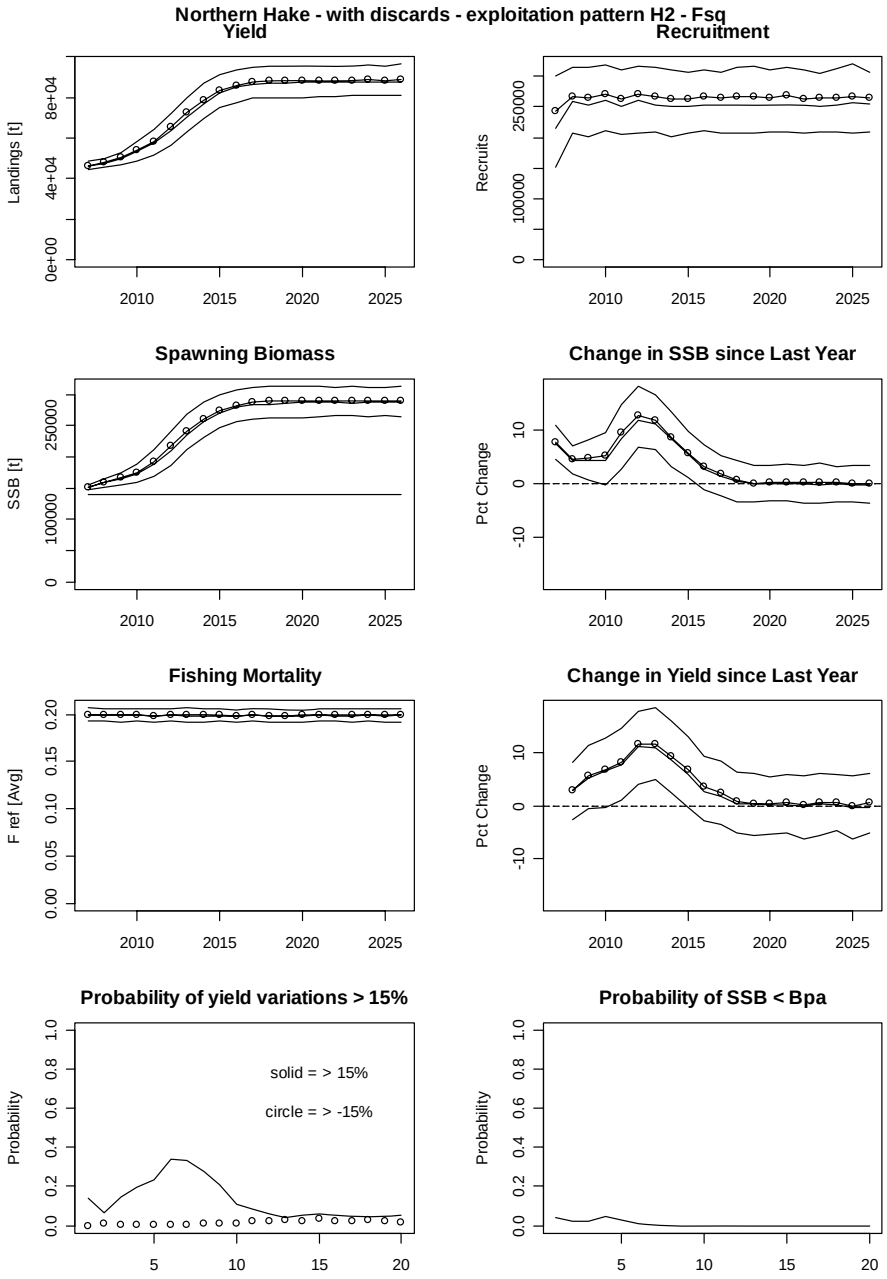


Fig. 5.3.4.

- For assumption H2: 10% reduction in F each year to Fmax

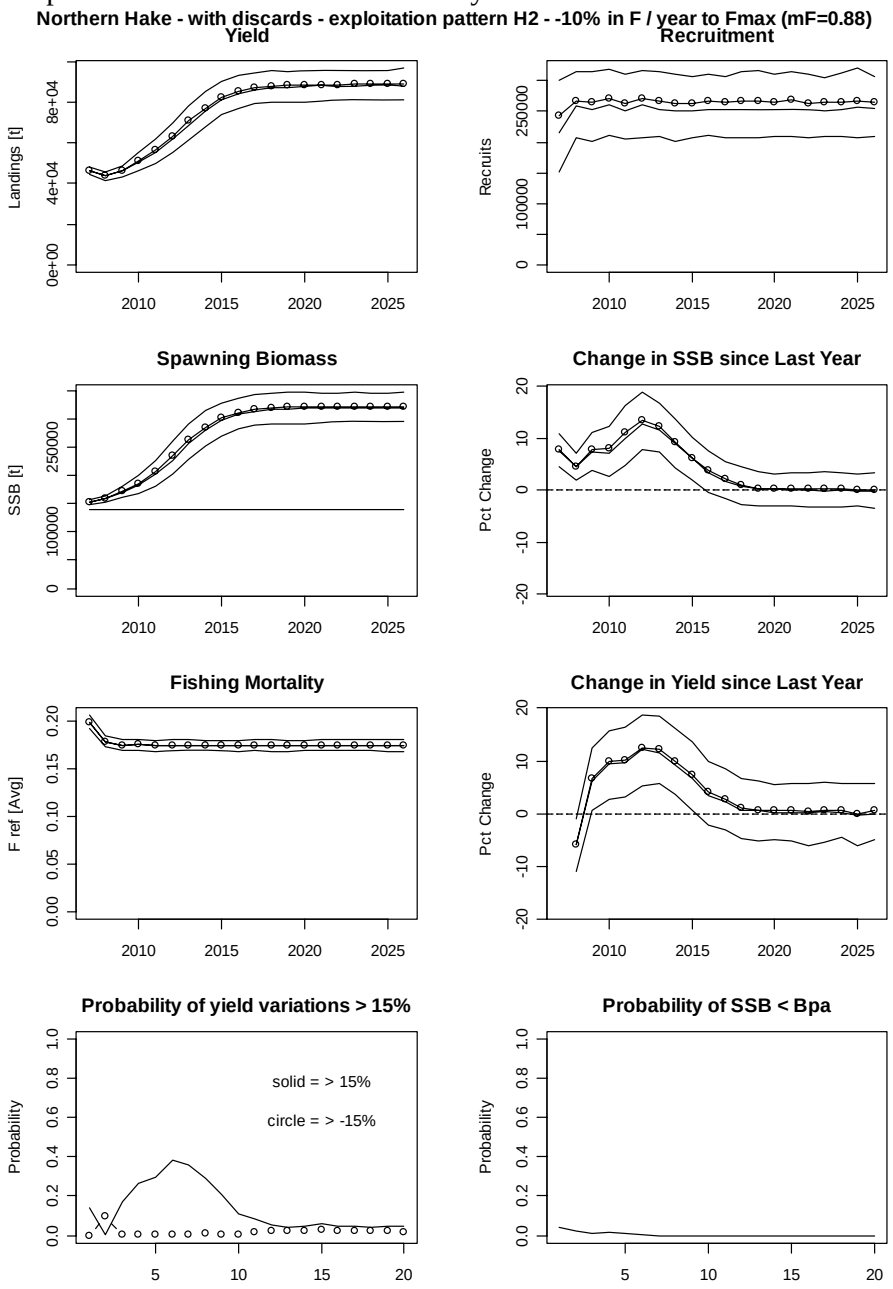


Fig. 5.3.5.

4.5. Conclusions

If the H1 exploitation pattern is applied, and if the overall fishing effort is maintained (Fsq), the probability of SSB being below Bpa would be around 40% at year 5 then decreasing close to 20%. The 'risk' of landings variation exceeding 15% (above) is around 20% in the first 10 years of the simulation, while the risk of variation exceeding 15% (below) is negligible.

When simulating a 10% reduction in F each year until Fmax is reached, the probability of SSB falling below Bpa is very low, and the risk of exceeding the 15% variation in yield is around 40% (above)

when the fishing mortality will stabilise and close to 0% (below), with the exception of the first year (20%).

Applying the H2 exploitation pattern would lead to exploitation and biomass levels which lead to a very low probability for SSB to be below Bpa. [note that the reference F (ages range 3-6) is affected by the new exploitation pattern]. The risk of landings variations greater than 15% (below) is negligible, while it could reach around 20-40% in the early period of simulation.

When reducing F by 10% each year [for 1 year, since the F multiplier leading to Fmax in that case is 0.88], the results would be very similar to the Fsq case.

As a matter of conclusion, these simulations showed that improving the exploitation pattern could lead to better results in term of long-term yields while the reduction in overall effort would be smaller. Furthermore, it should be noted that given the current state of the stock, the tested assumptions of changes in the exploitation pattern would not lead to absolute loss in the short term.

The Group is well aware that such results remain very theoretical since these tested selection patterns were/are not linked to any practical management measure (in terms of selective devices or changes in fishing strategies). Nevertheless, it is considered that this is an important issue to be considered in any future long term management plan: the more the exploitation pattern is improved, the biggest would be the yield and the lowest would be the needed reduction in overall effort, as shown by the figure 5.4.1. below:

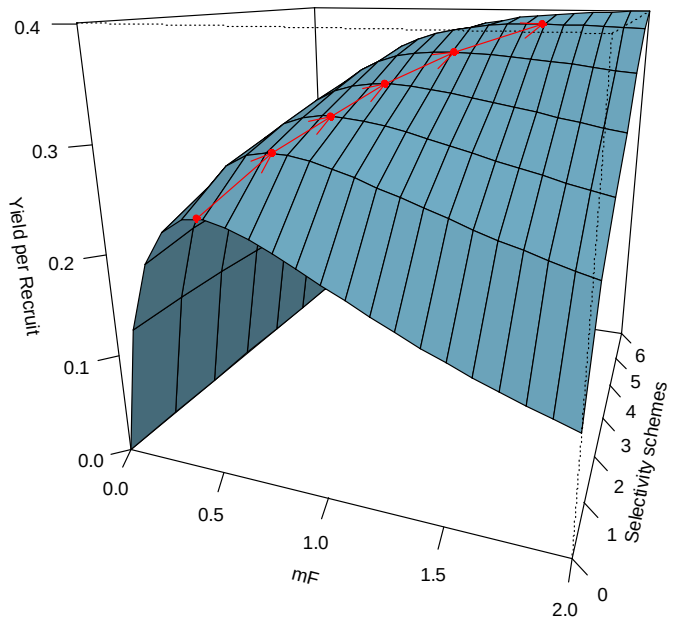


Fig. 5.4.1. Yield per recruit values for various combinations of overall F multiplier and selection patterns. The red points show what would be Fmax for given selection pattern.

5. ToR 4. Economic analysis

5.1. Data required

At an overall level, three basic types of data are essential for the economic analysis:

1) Stock information,
2) Economic information for relevant fishing fleets,
3) Catch compositions on fishing fleets.

The amount of effort used by the fishermen and the size of their catches are influenced by the stock size. It is therefore necessary to have this biological information about stock size. The number of stock sizes needed are dependent on the analysed fishery, is it a single or a multiple species fishery?

With respect to the economic information, the EU member states collect economic data within lines specified in the Data Collection Regulation (DCR)[1]. Collection of data is on a yearly basis for the specified fleets within the regulation. It covers information on 1) income, 2) variable costs related to crew, fuel, repair and maintenance and other operational costs, 3) fixed costs, 4) investments, 5) prices per species, 6) employment and 7) fleet characteristics in form of tonnage, engine power, age and gear used.

Nevertheless the segmentation that DCR proposes does not distribute costs parameters among seas. It has implication in the economical assessment of the northern hake. For example in the segment covering trawlers 24-40 m in Spain, vessels from the Atlantic and the Mediterranean are mixed, which makes that the data collected from the DCR should be used carefully, given that the Mediterranean and the Atlantic are two different fishing realities, in terms of costs supported.

For each fleet segment, it is necessary to have information about their catch composition in order to combine the stock and economic information. The catch composition is important in order determine the dependency of the analysed species for each fleet segment, and thus how much the individual fleets are economically influenced by changes in stock size.

To conclude, the success of the economic analysis is dependent on the availability of the three data groups. However, it is of cause dependent by the level of detail in the questions asked, but it is important to stress that a general standardised collection of economic information disaggregated to time-periods of less than a year is not available.

Going into more detail about the more specific data requirements, a distinction can be made between two types of analysis.

1) Simple projections of stock biomass and landings based on simulated stock dynamics using parameters estimated by the current stock assessment procedure. The results on landings and F would then be used to calculate revenue and costs.

2) An integrated approach where the determination of catches takes place in the economic part of the bioeconomic model, which describes the behaviour of fishermen. The determined catches then feeds into the biological part of the bioeconomic model, which then calculate the stocks for the forthcoming period.

[1] See for instance Council Regulation (EC) No 1543/2000.

The type of analysis performed in 1) cannot in strict terms be described as an economic analysis. There is no inclusion of fishermen's behaviour, and thus therefore not a realistic description of the fishery. The analysis is a more statistical calculation, where prices and costs are determined afterwards using the results from the biological estimations. Given that management plans must be expected to change fishermen behaviour, this type of (economic) analysis is considered insufficient for doing economic impact assessment.

The data requirements for this type of analysis are however limited. Information about prices for the relevant species and information about costs are basically only needed. The parameters collected under the DCR should be enough for doing these simple calculations

A more realistic description of the fishery, and thus an improved economic impact assessment, is accomplished by using the type of analysis described in 2). By using the feedback loop system between biological and economical components fishermen behaviour - and changes in this - is accounted for, and this will allow assessing the economic impacts of different management options. As discussed in Sections 6.3 and 6.4, different models exist for this type of analysis, which can be utilised.

5.2. Compatibility between fleet definitions

The current DCR (Council Regulation (EC) Nº 1639/2001) in its Appendix III provides that economic data should be collected following the double dimension of length segments and fishing technique (Table 6.2.1)

Table 6.2.1. Segmentation (1639/2001 appendix III)

Vessel length		<12 m	12-24 m	24-40 m	>40 m
Type of fishing technique					
Mobile gears	Beam trawl				
	Demersal trawl and demersal seiner				
	Pelagic trawl and seiners				
	Dredges				
	Polyvalent				
Passive gears	Gears using hooks				
	Drift and fixed nets		Fr	Sp, Dk	
	Pots and traps				
	Polyvalent				
Polyvalent gears	Combining mobile and passive gears				

A vessel can only be in one fleet per year, but can participate in several metiers during that year. A metier is a group of fishing operations (trips) targeting the same species, using similar gear, during the same period of the year and/or within the same area. For a same vessel or fleet, the species composition of the catches and their amount may differ substantially. Furthermore, the exploitation pattern may also vary from a métier to another. Biological data are collected and used on a métier basis (called Fishery Units in the current Northern Hake assessment), see section 2.2.

This segmentation of the fishery activities allows computing partial fishing mortalities (and/or catchabilities) on a metier basis. Subsequently, partial F (or catchabilities) would be the basis to carry out simulations of management measures.

Revenues can be computed on the metier basis (using catches by metier and age-groups and corresponding prices). However, cost data are only available on a yearly vessel/fleet basis according to the DCR. If cost data are to be distributed on metiers, this will require assumptions about effort distributions among metiers for variable costs and calendar distribution for fixed costs (for example), or alternatively collection of costs in more detail, if sufficient funds and effort are allocated into this. If any of these approaches are possible and justifiable must be considered in more detail. If not, the yearly cost data compiled through the DCR, must be used in the economic analysis.

For better understanding the compatibility of the economic and the biological data, the group discussed the creation of an allocation table using the length overall distribution of each fishing unit as used in the assessment, based on the cost and revenue parameters allocation of the different economic segments (Table 6.2.1). This needs to be further considered in future analysis.

5.3. Application of FLR

FLR is a framework designed for implementing bio-economic models. At present (May 2007), the biological side of the FLR is developed to a larger degree than the economic part, but currently a working group under the EFIMAS (Operational evaluation tools for fisheries management options) and COMMIT (Creation of multi-annual management plans for commitment) projects are enhancing and developing the economic R-package FLEcon containing a variety of economic modules, e.g. dynamic investment/disinvestment, price dynamics, compliance etc. It should however be clear, that if a certain economic (or biological) function is not yet present in FLR, it requires both experience in general design of bioeconomic models and in using the R language to include this in the FLR. Moreover, access to appropriate (preferable compatible) biological and economic data is necessary.

A first approach to check the bio-economic possibilities of the FLR is the AHF model (Hoff and Frost, 2006). It combines two different approaches into one by a “switch” mechanism depending on the choice of harvest control rule being TAC/quotas or kW-days.

Northern hake is one of the case studies used for testing the FLR under EFIMAS and COMMIT projects. FLR has been developed for simulating the current management of the northern hake and also for simulating several alternative management alternatives, including northern hake recovery plan and multi-annual management scenarios.

The economic part is still under development both as generic tool and in its application to this case study. For northern hake, the approach taken has been the use of the FLEcon as it was established in the EFIMAS project, creating a FLEconazti. This last class is similar to the FLEcon (with some more indicators) and the list of variable and fixed costs are the same in order to ensure comparability between case studies. The only difference has been in the approach taken for capturing the multi fleet characteristics. In the FLEconazti there is a list with several (three, ie, Bakas, Pairs and “others”) fleets named as FLfleets, while in the FLEcon for each fleet a FLfleet has to be defined. The approach is different but, in any case, comparability is guaranteed.

Entry exit behaviour is planned to be incorporated following a similar approach to the one taken in the AHF model (Hoff and Frost, 2006). Tactical responses are also planned, using a Random Utility Model (RUM) approach which probably will be developed in the AFRAME (A Framework for Fleet and Area Based Fisheries Management) project.

Finally, even still under discussion, a compliance and enforcement method is to be developed under the COBECOS (Costs and Benefits of Control Strategies) for northern hake.

In terms of management procedures, recovery plan is to be analyzed in economical terms (EFIMAS). It implies that a long term management procedure can also be tested, and compared with the recovery plan.

Besides the bioeconomic model being developed in the EFIMAS project, other models can be utilised in order to make a bioeconomic impact assessment of the northern hake fishery. One of these models is the EIAA-model, which has been approved and used by STECF to make an economic interpretation of the ACFM advice. It is designed to fit to fish stock assessments (estimated by use of VPA and XSA by ICES/STECF) and economic data (collected according to the Data Collection Regulation). Further the EIAA-model is flexible and has been used in the assessment of the flatfish recovery proposal, see SEC (2006) and SEC (2007). In fact the EIAA model includes the economic analysis of a fleet (the Spanish "300 fleet") that conducts hake fishery.

5.4. Problems and solutions

In September 2006 and March 2007, an impact assessment was performed with respect to the proposed management plan for flatfish (sole and plaice) in the North Sea. This impact assessment exercise illustrated that there are several key issues, which must be addressed before doing the actual analysis. Two economic models were used, the EIAA-model and the IMARES/LEI-model. STECF uses the first model to make economic interpretation of the ACFM advice, and fits the stock assessments made by ICES. The IMARES/LEI-model is under development as a part of the EFIMAS-project, but use currently only a very simple economic approach.

Determination of catches
In the flatfish impact assessment, a key issue was the determination of catches. The main question was thus, are the catch levels determined in the biological model or in the economic model? This issue became important, because the flatfish management plan used output regulation (TACs) and input regulation (days at sea). Therefore, the catches calculated in the biological model (IMARES) did not match with the catches calculated in the economic model (EIAA-model). The issue will also be of importance, if the distribution of catches changes between fleet segments that uses gear with different biological effects (discards, damage on fishing grounds etc.).

The cause of this discrepancy was related to the assumptions regarding the relationship between catch per unit effort and biomass. The IMARES-model assumes a linear relationship, while a non-linear relationship is assumed in the EIAA-model. With increasing biomass, the economic model will thus predict lower catches than the biological model. See SEC (2006) and SEC (2007) for further details into this very important issue.

The conclusion is however that it is essential to discuss openly this linearity issue, because it is of outmost importance in the analysis.

Management schemes
Most models are not able to work with output (TAC/quota) and input (sea days) restrictions at the same time because of causality problems. However, for a management plan combining input and output restrictions, the modelling framework must be able to account for this. Only by coincidence, both restrictions, for instance TACs and days at sea restrictions, will be binding at the same time. If

one becomes binding before the other, this must be a possible scenario within the modelling framework.

The EIAA-model (Economic Interpretation of ACFM Advice) is in its basic version output-driven and uses fish stock assessment results in terms of biomass and corresponding TAC's directly as basis for the economic calculations. It was however changed to account for both input and output management in order to facilitate the analysis in the flatfish impact assessment.

Other models, for instance the TEMAS-model, uses effort in terms of kW-days as basis for the calculation of catches, economic performance and the corresponding fish stock biomasses, see SEC (2006). The AHF-model (Hoff and Frost, 2006) using FLR combines two different approaches into one by a "switch" mechanism depending on the choice of harvest control rule being TAC/quotas or kW-days. Most models are not able to work with output (TAC/quota) and input (sea days) restrictions at the same time because of causality problems (what determines what).

It is therefore essential to consider the proposed management plan in detail before doing any analysis. Biologists and economists should do this jointly in order to have a common understanding of how to approach the proposed plan in the actual analysis, and on this basis choose the actual model framework to be used.

Model choice

Besides the general issues that need attention, when applying bioeconomic modelling in the impact assessment, the specific model choice must also be considered.

Besides the model should be able to account for the specific characteristics of the analysed fishery, it is necessary also to consider the time perspective. Is there time to develop new models? Is it at all necessary? Can already existing models be used with simple modifications?

In relation to the hake impact assessment, the FLR-framework used in EFIMAS is considered possible to apply. However, it must be stressed that a less time consuming way to evaluate the recovery plans is to use the EIAA-model model. This model has been approved by the STECF, and is designed to fit to fish stock assessments (estimated by use of VPA and XSA by ICES/STECF) and economic data (collected according to the Data Collection Regulation). Further the EIAA-model is flexible and has been used in the assessment of the flatfish recovery proposal, see SEC (2006) and SEC (2007). It should also be noted that the flatfish recovery proposal was assessed by used of the IMARES/LEI-model, which scales costs and sea days proportionately with the fishing mortality rate F.

In terms of northern hake, currently it has the limitation that it only has a proper OM for one species. Northern hake is being targeted by many fleets of many countries but normally (even if there are some exceptions) as multi-species fishery. Obviously it creates the problem of making the current economical evaluation of these fleets partial, or even negligible given that hake is only part (and sometimes small) of the total turnover obtained from the fishery.
For the EFIMAS case study, it is being solved including other species as something "fixed" in the sense that they do not have a proper OM. It allows to asses economically the performance of the fleets but we are not able to capture the dynamics of these fleets due to management, abundance, changes of the other stocks, which in fact can be the target species for some of the fleets. It is also remarkable that for some fleets the target species can be pelagic instead of demersal which created further difficulties to the economic assessment. Nevertheless it should be noted that for economical assessment purposes some other key species should be incorporated in the OM.

6. Further research

The discussions convene during the meeting raised several issues the group would like to describe with regards to further research requested to move onwards about long term management plans for Northern Hake.

- MSE extensions
  - Include discards on the Operating Model;
  - Include implementation error;
  - Run more interactions;
  - Simulate more years;
- Simulation analysis
  - Develop performance statistics;
  - Evaluate the assessment model effect (bias);
  - Develop robustness tests to growth rates, recruitment failure, S/R models, etc;
  - Investigate fishery interactions using F disaggregated by FU or/and gear as estimated during the meeting;
- Presentation of results
  - Further develop the "traffic lights" example and agree on thresholds;
- Economics
  - Investigate the link between the assessment fleet segmentation (Fishery Units) and economic fleet segmentation (DCR fleets), including the distribution of length-over-all in each Fishery Unit;
  - Develop an effort allocation model based on economic decisions to be included in the generic operating model and thus facilitate an improved link between the biological and economic models;
- Multispecies management
  - Develop the algorithm to include correlation between the different parameters;
  - To develop a stochastic link among F in hake and F in other stocks;

7. Acknowledgements

The Group would like to thank AZTI (Spain), Cefas (UK), IPIMAR (Portugal) and LEG/UFPR (Lab of Statistics and Geo-information, Federal University of Paraná, Brazil) for providing computer support to the Group by running some of the simulations.

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9. Annex I

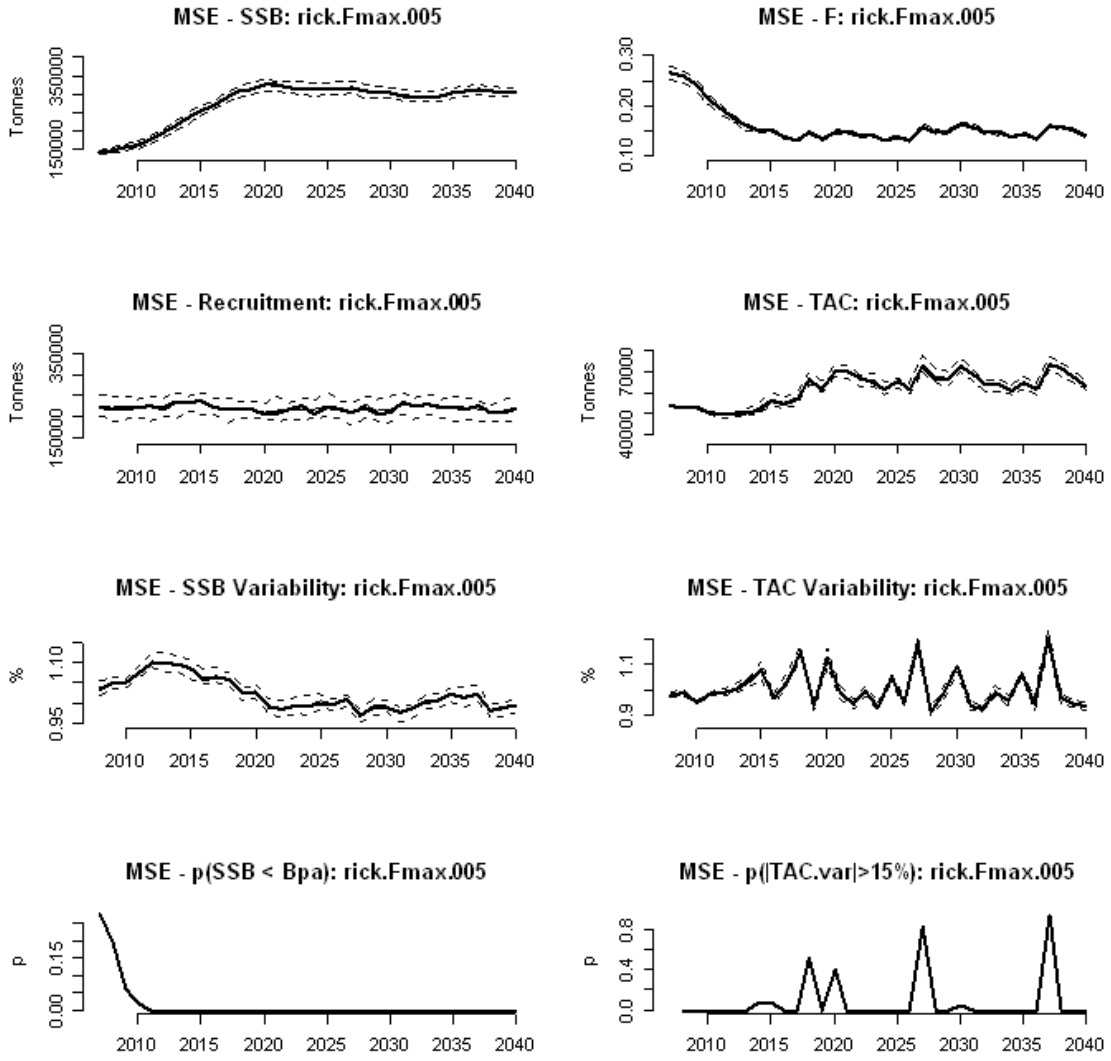

Fig. A.1. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

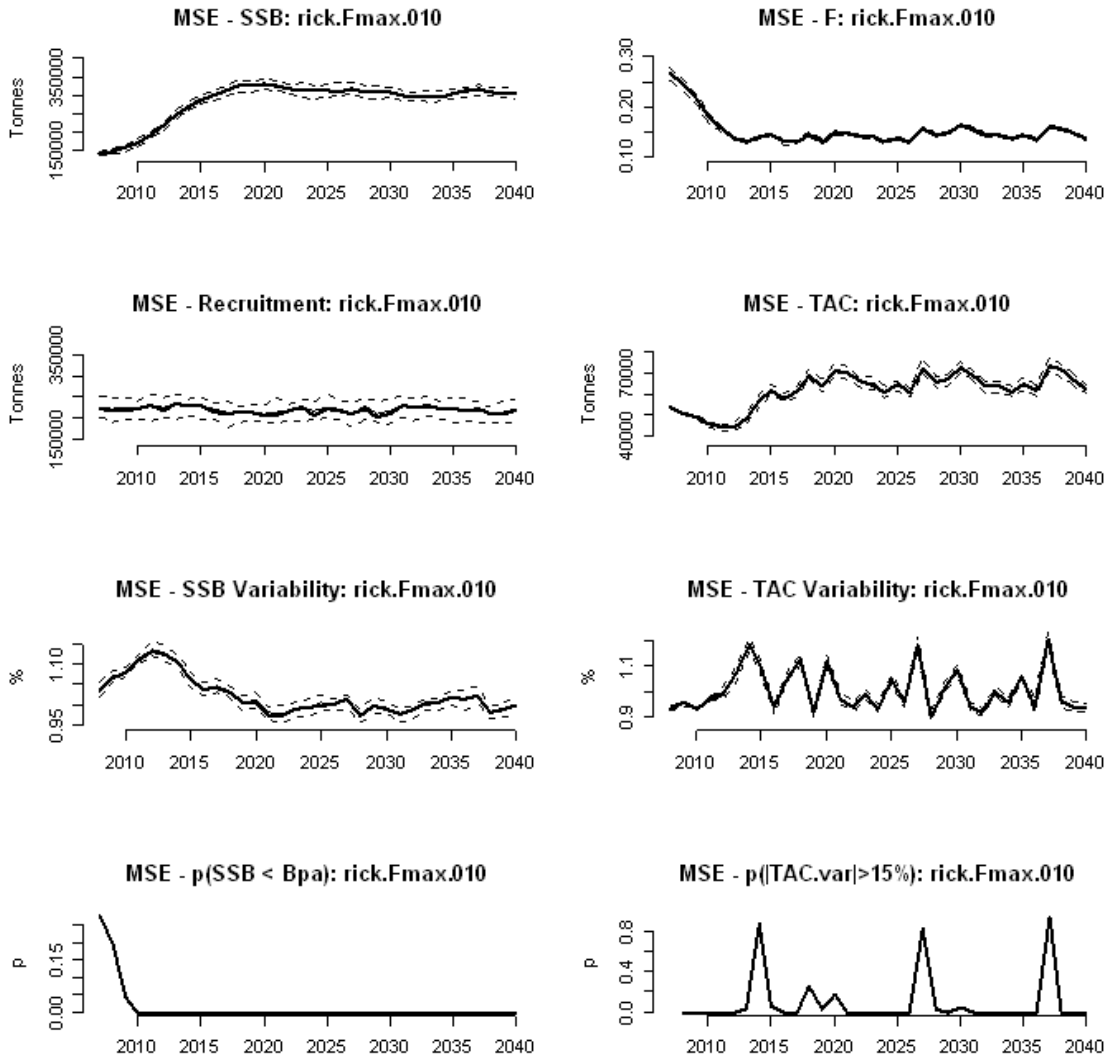

Fig. A.2. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

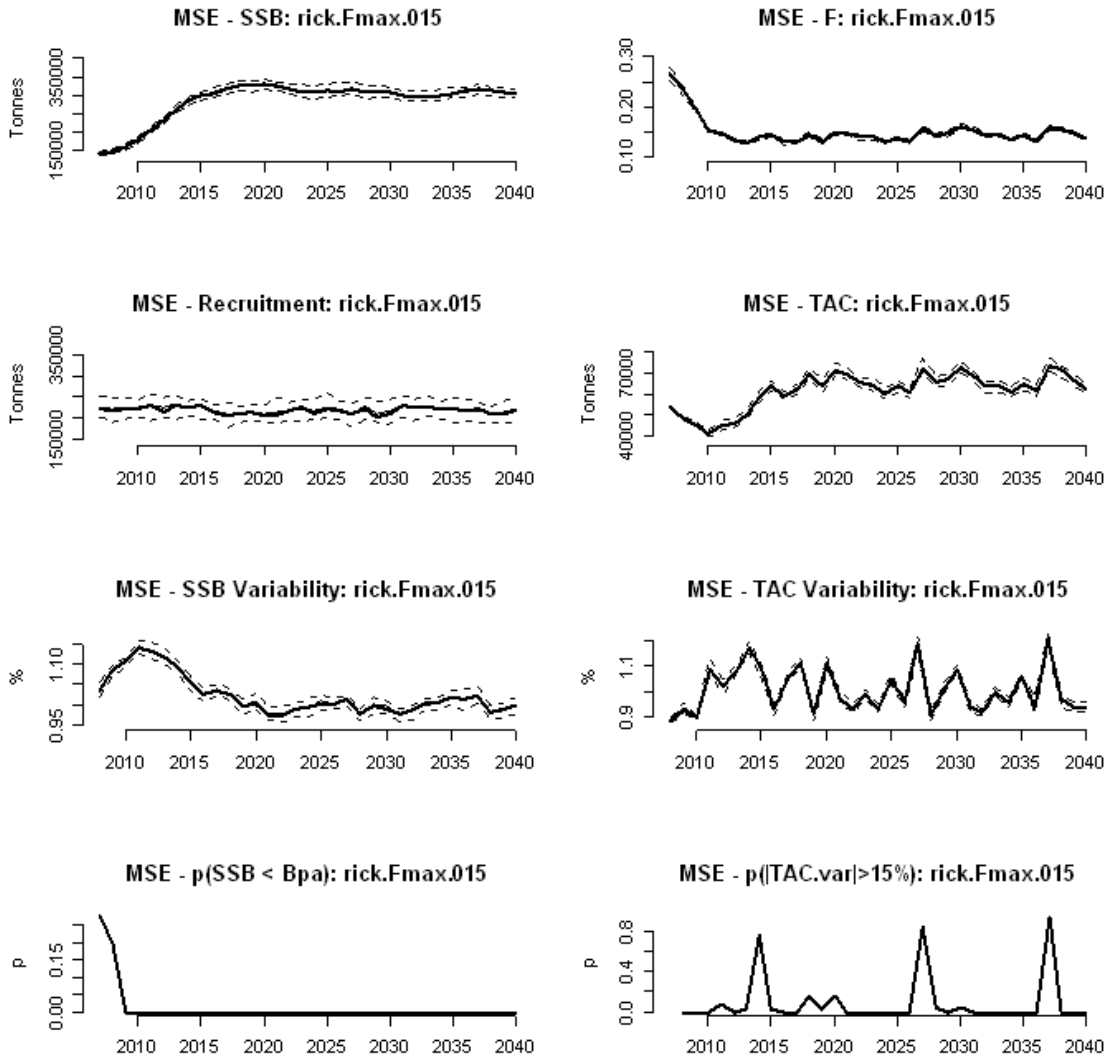

Fig. A.3. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

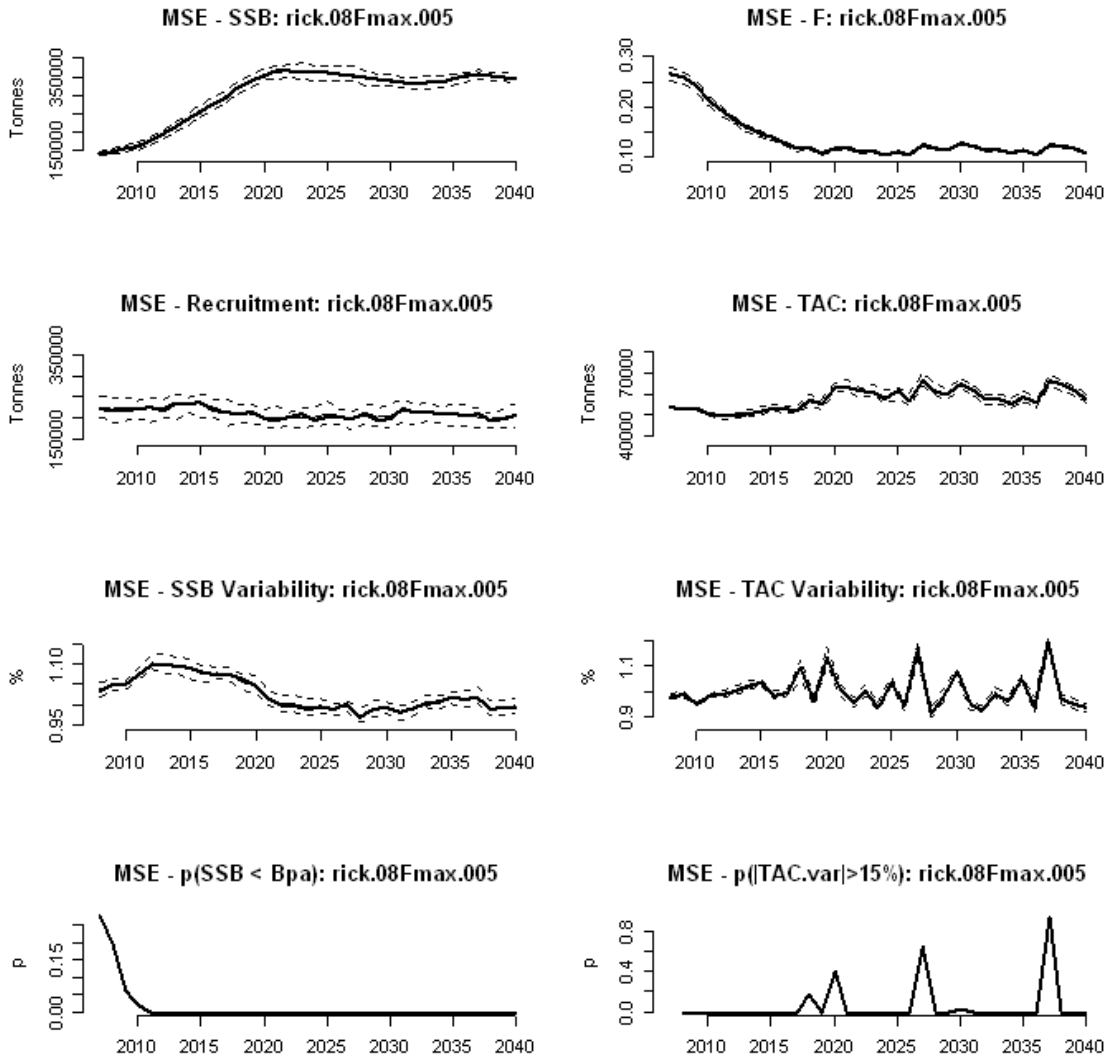

Fig. A.4. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

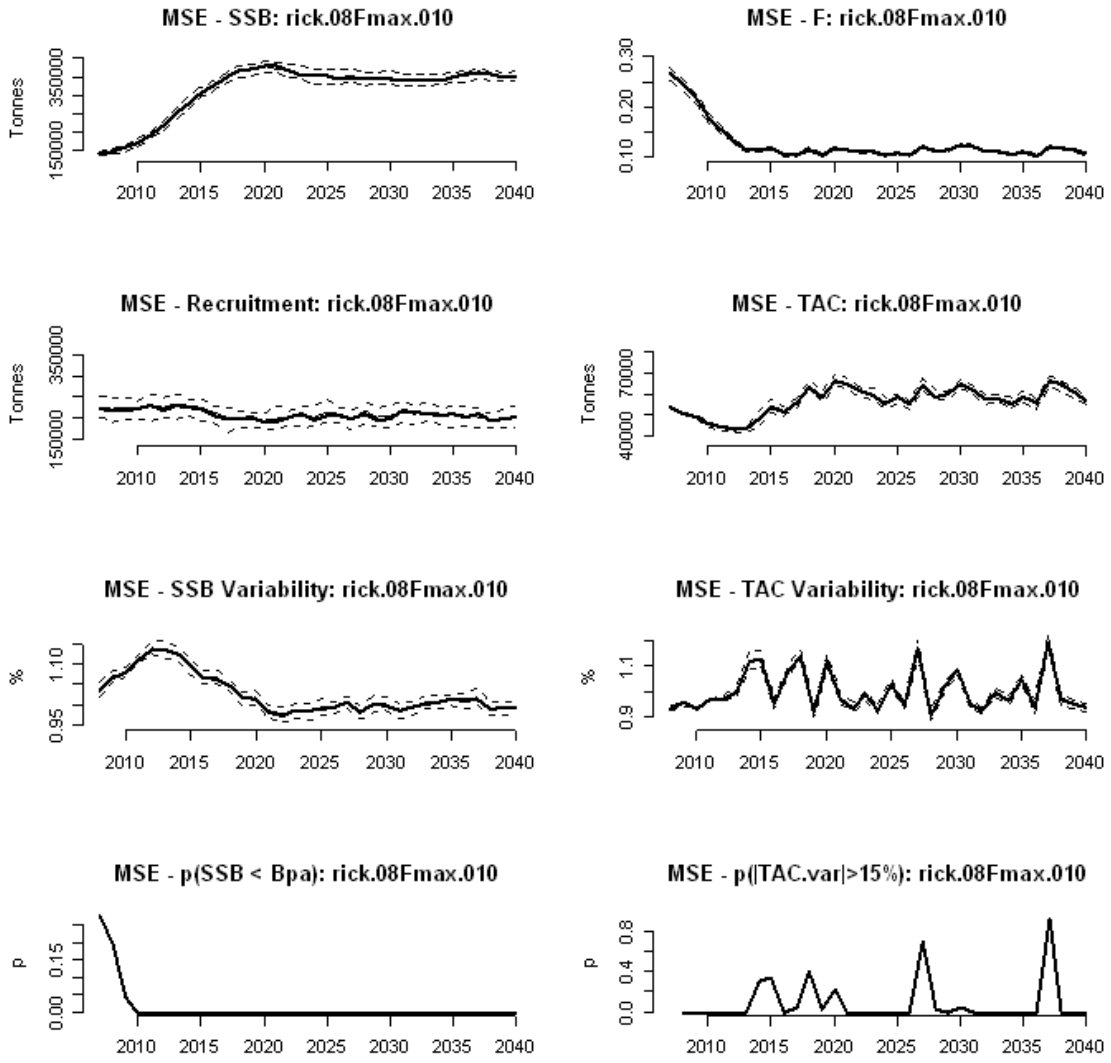

Fig. A.5. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

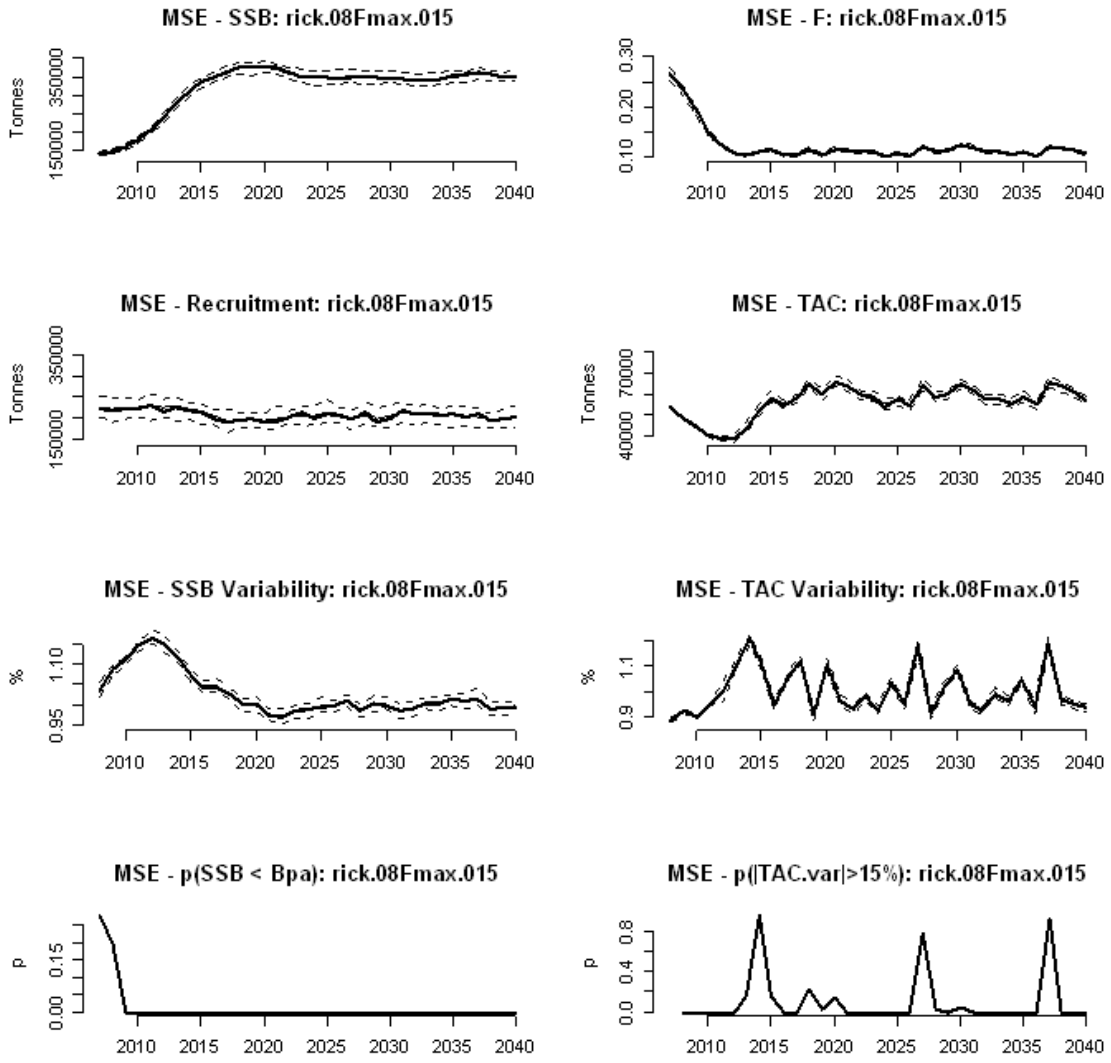

Fig. A.6. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

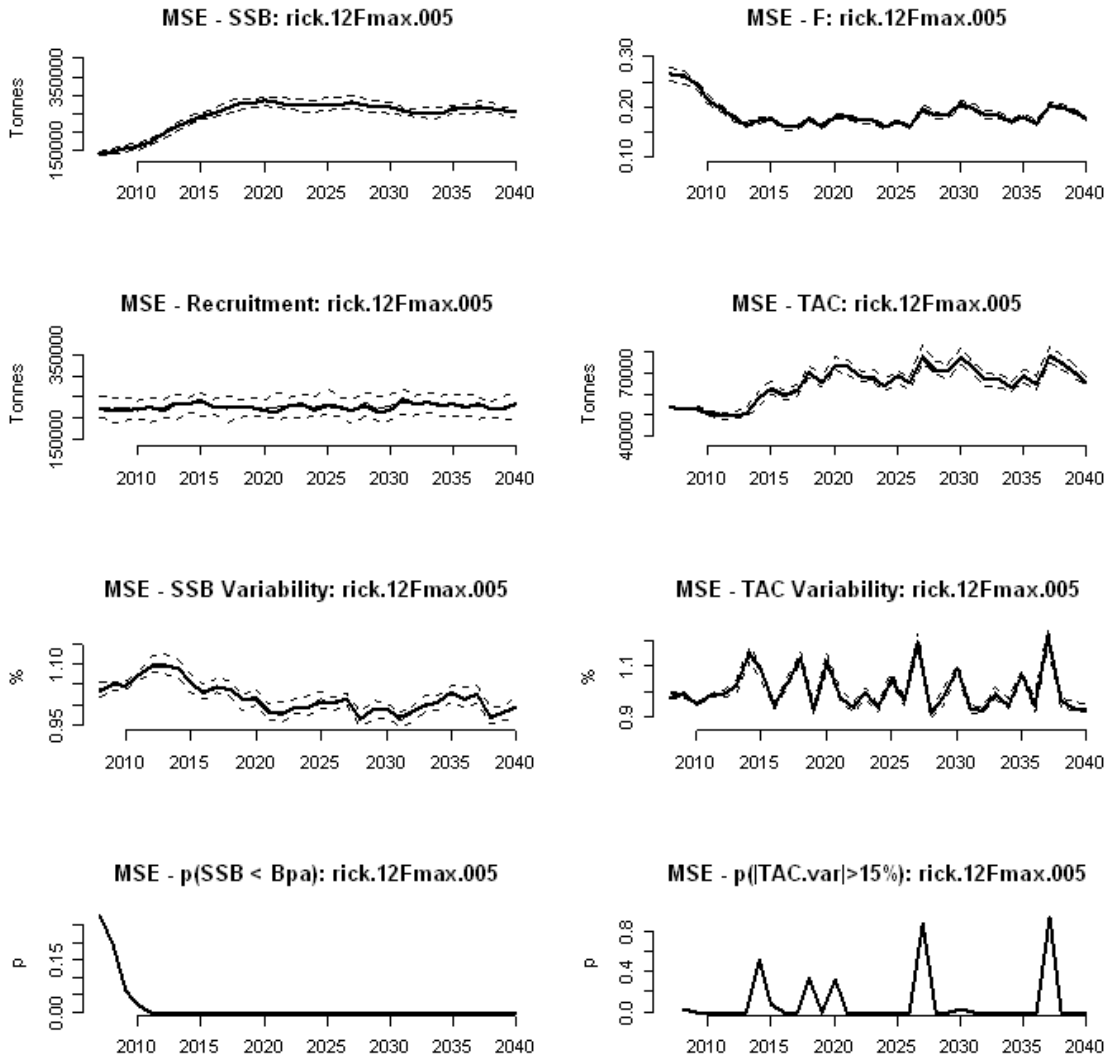

Fig. A.7. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

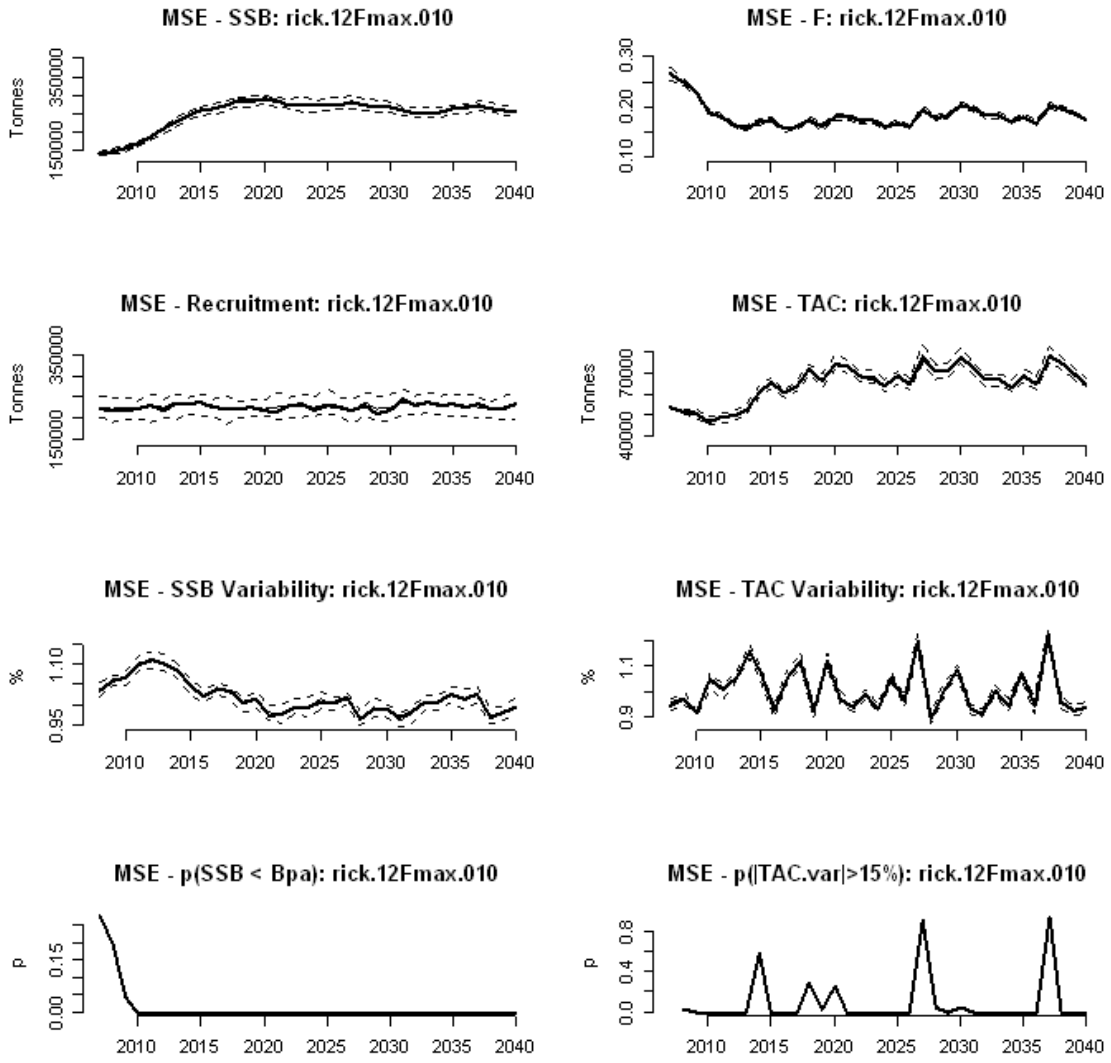

Fig. A.8. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

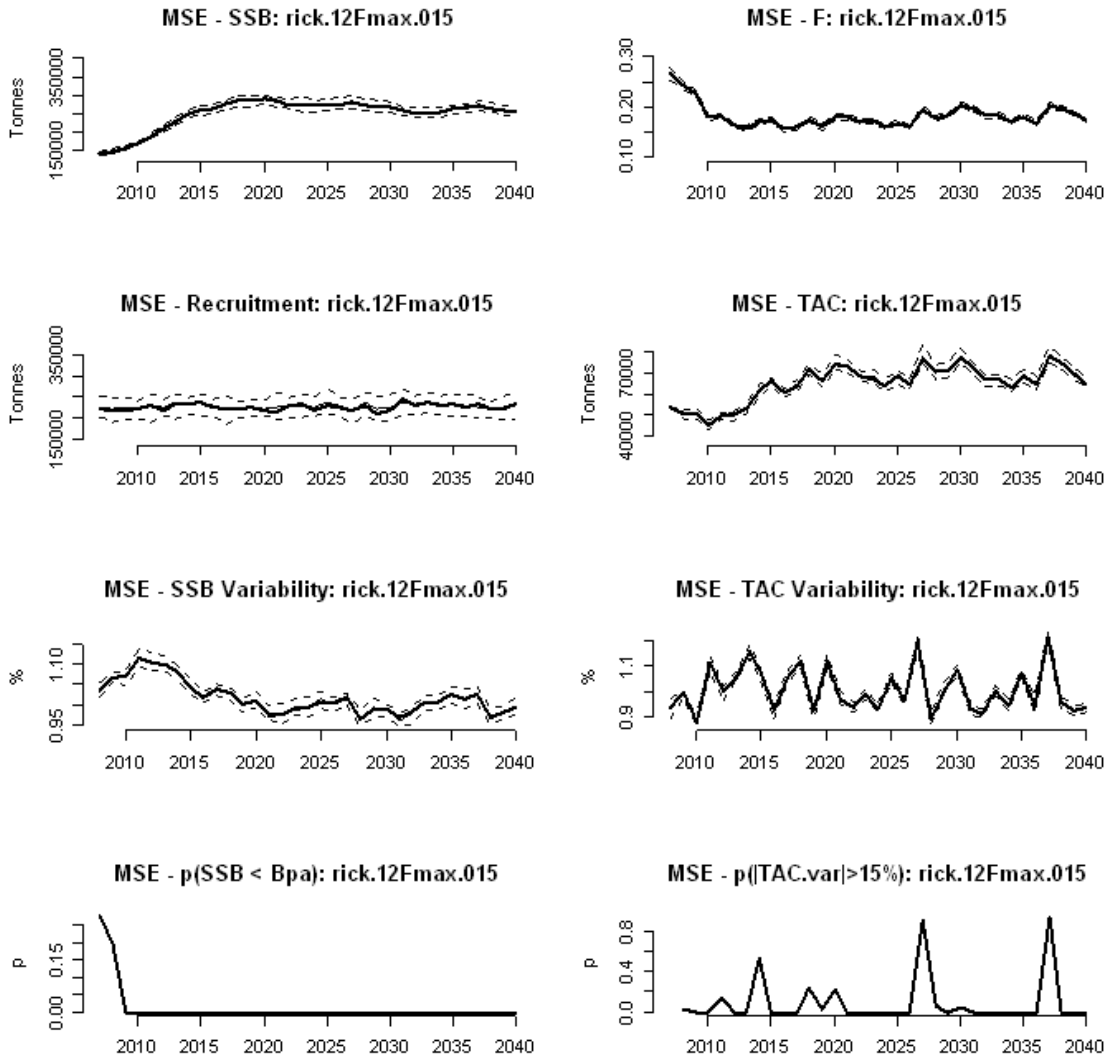

Fig. A.9. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

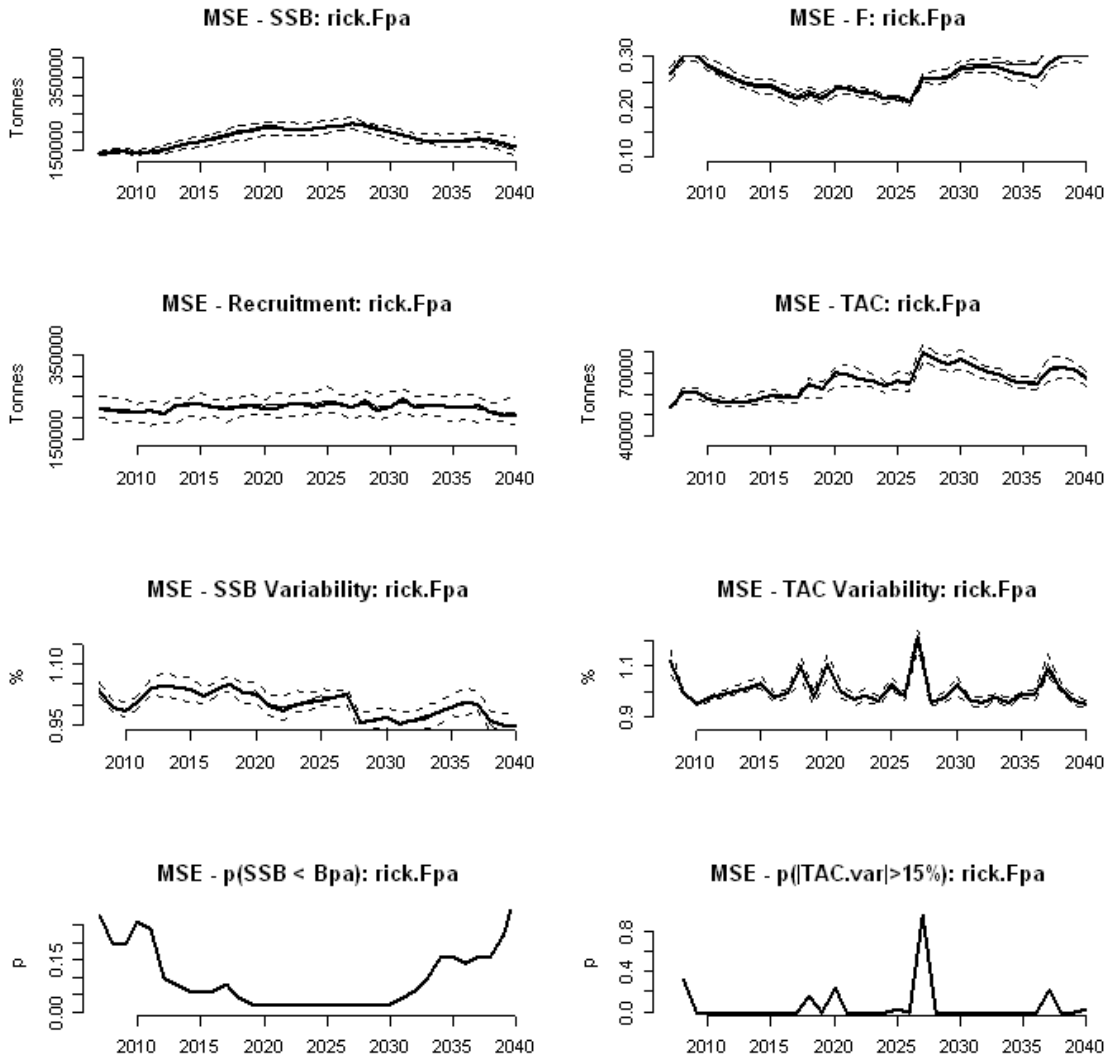

Fig. A.10 Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

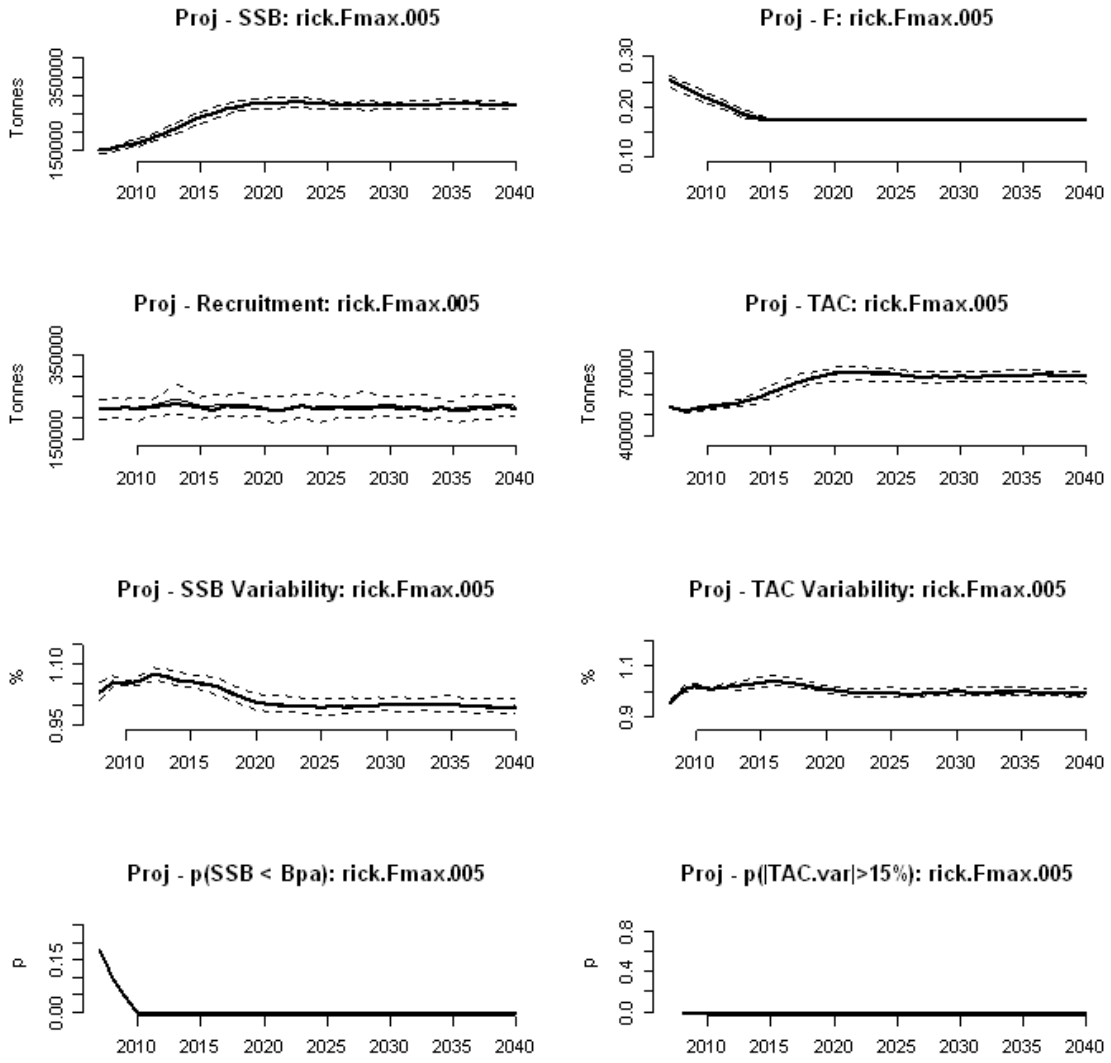

Fig. A.11. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

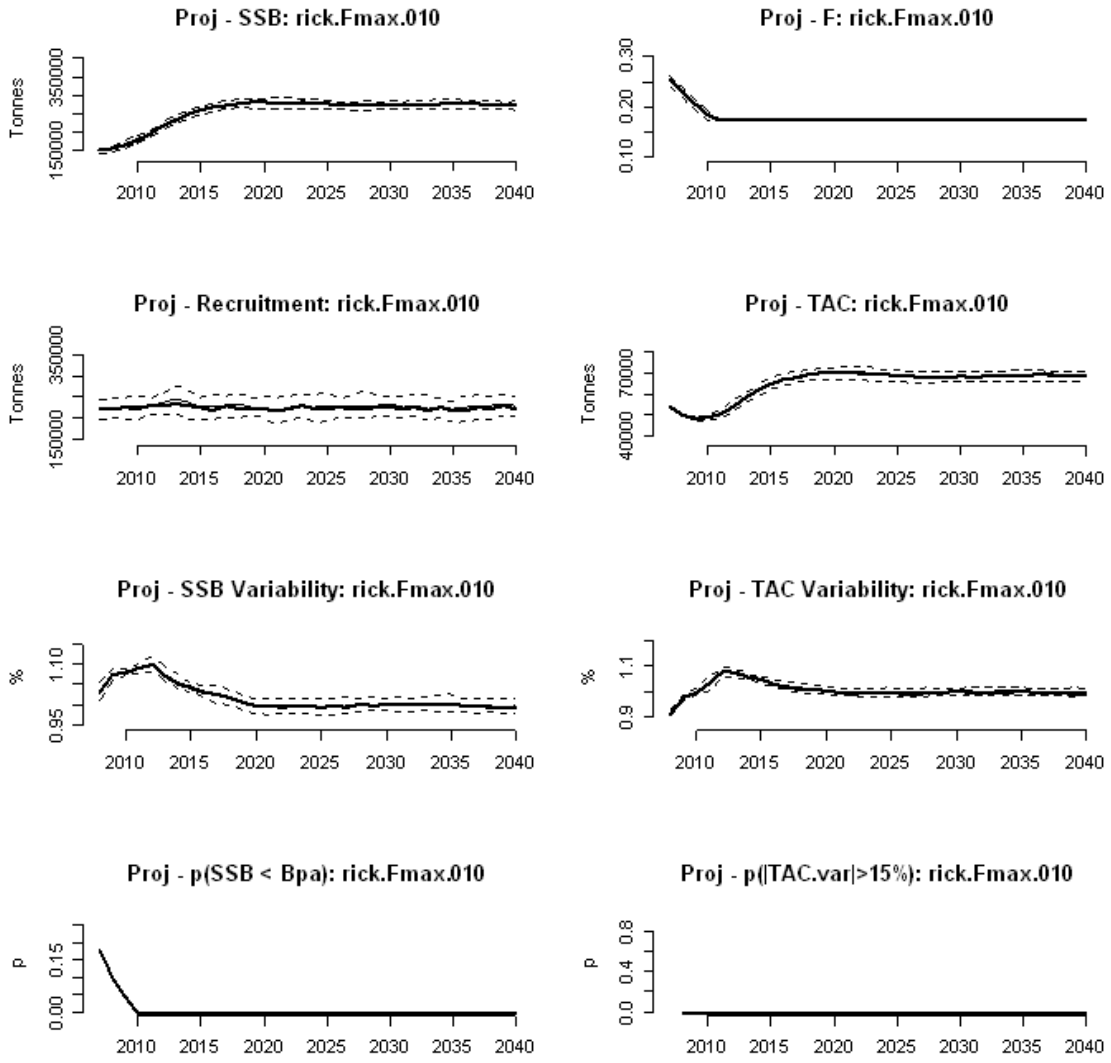

Fig. A.12. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

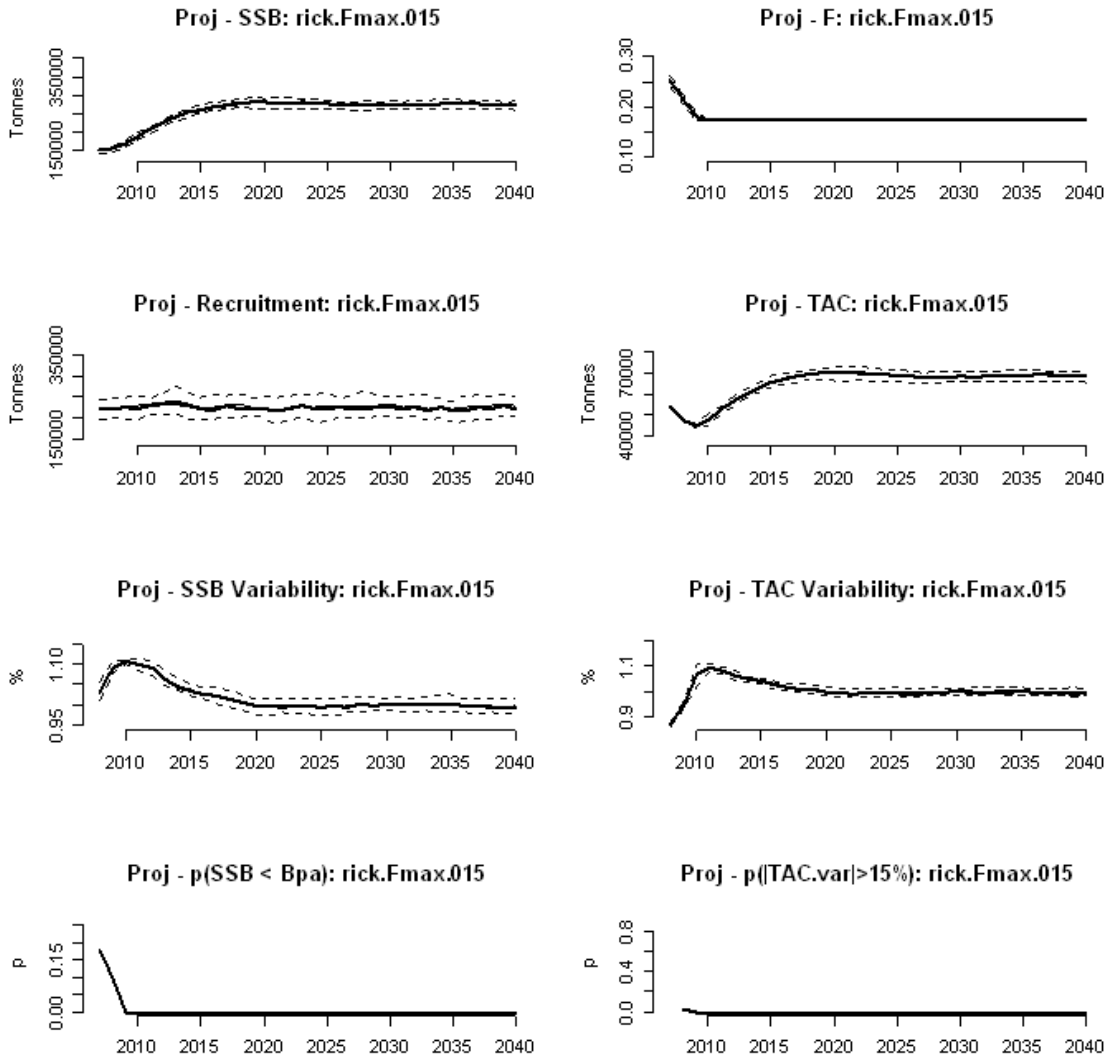

Fig. A.13. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

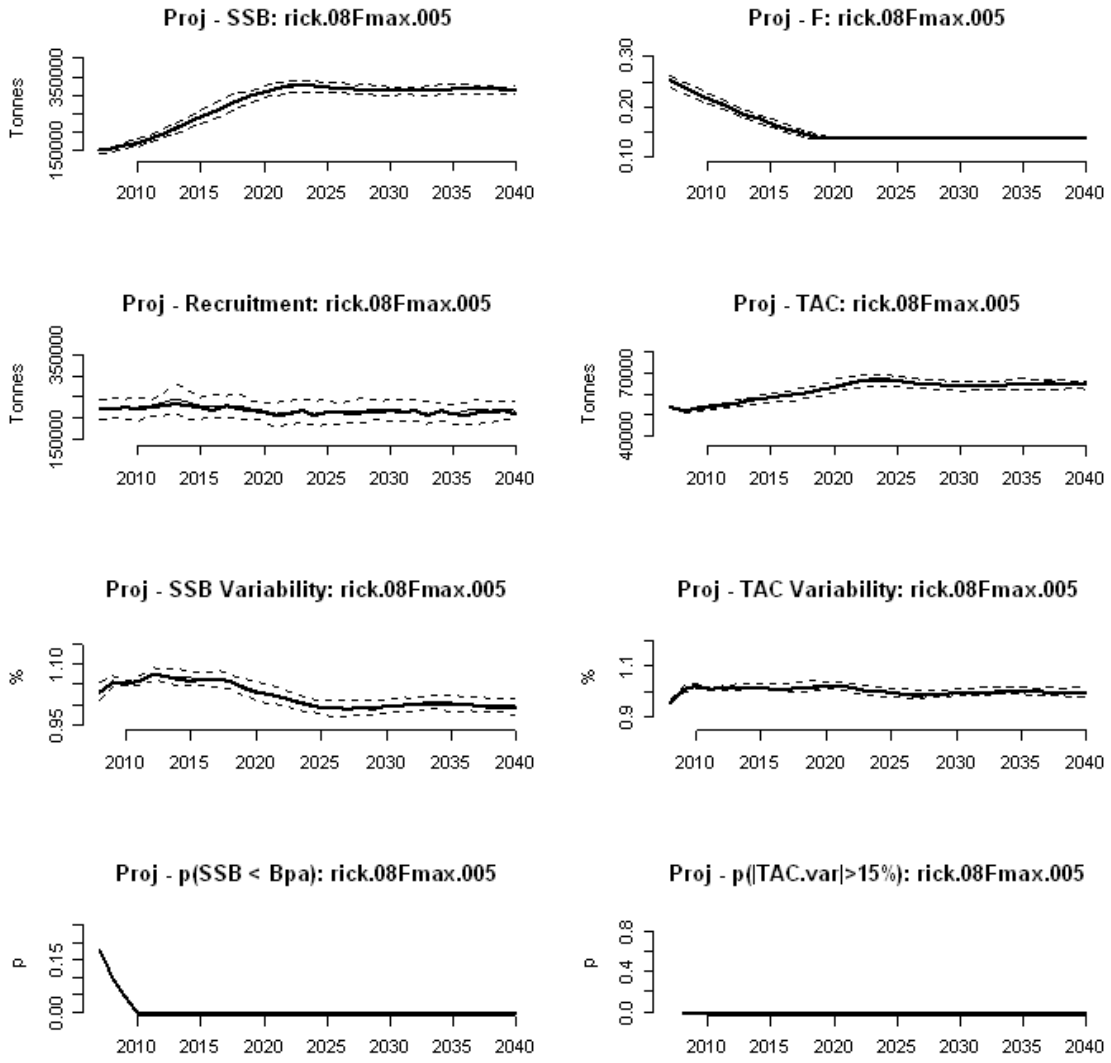

Fig. A.14. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

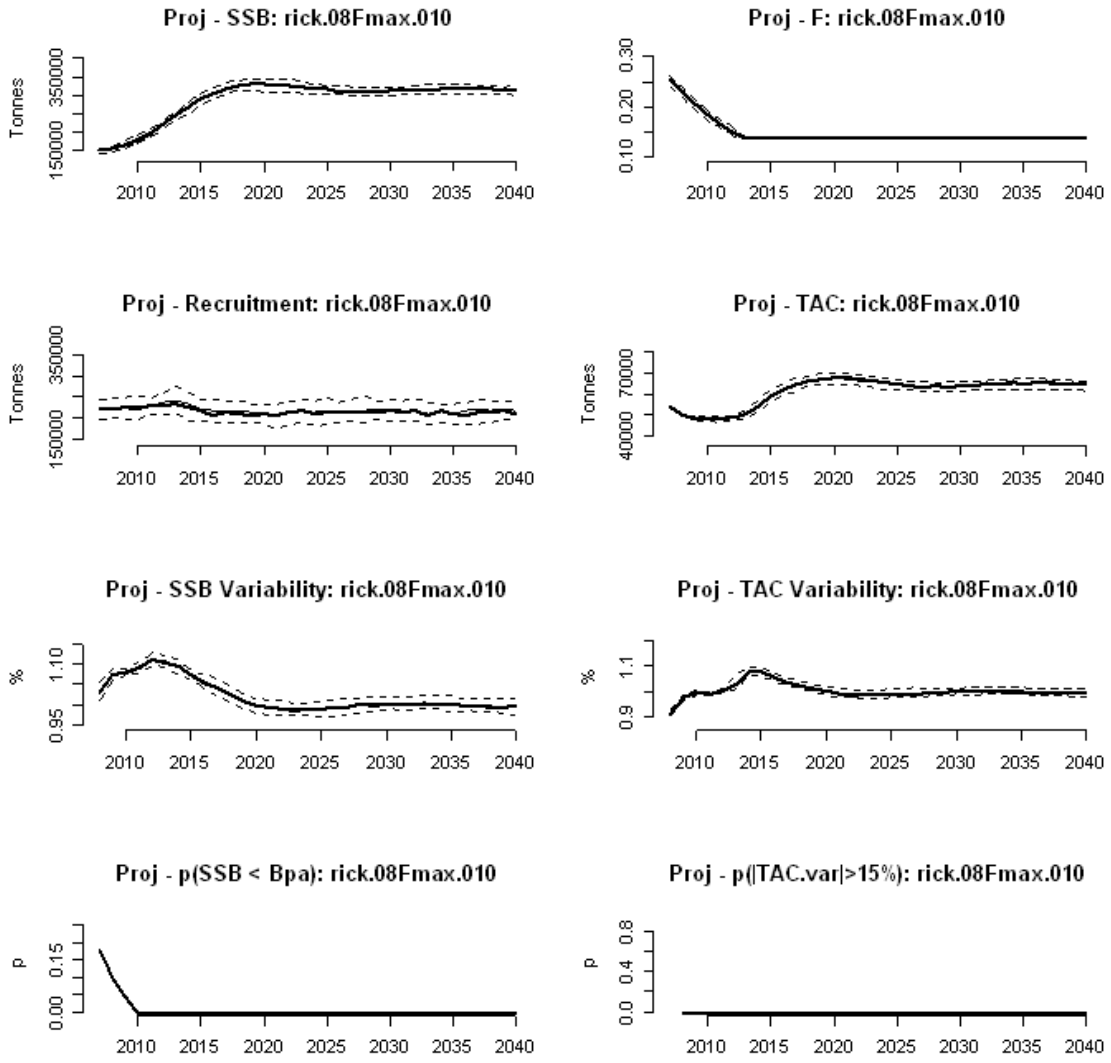

Fig. A.15. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

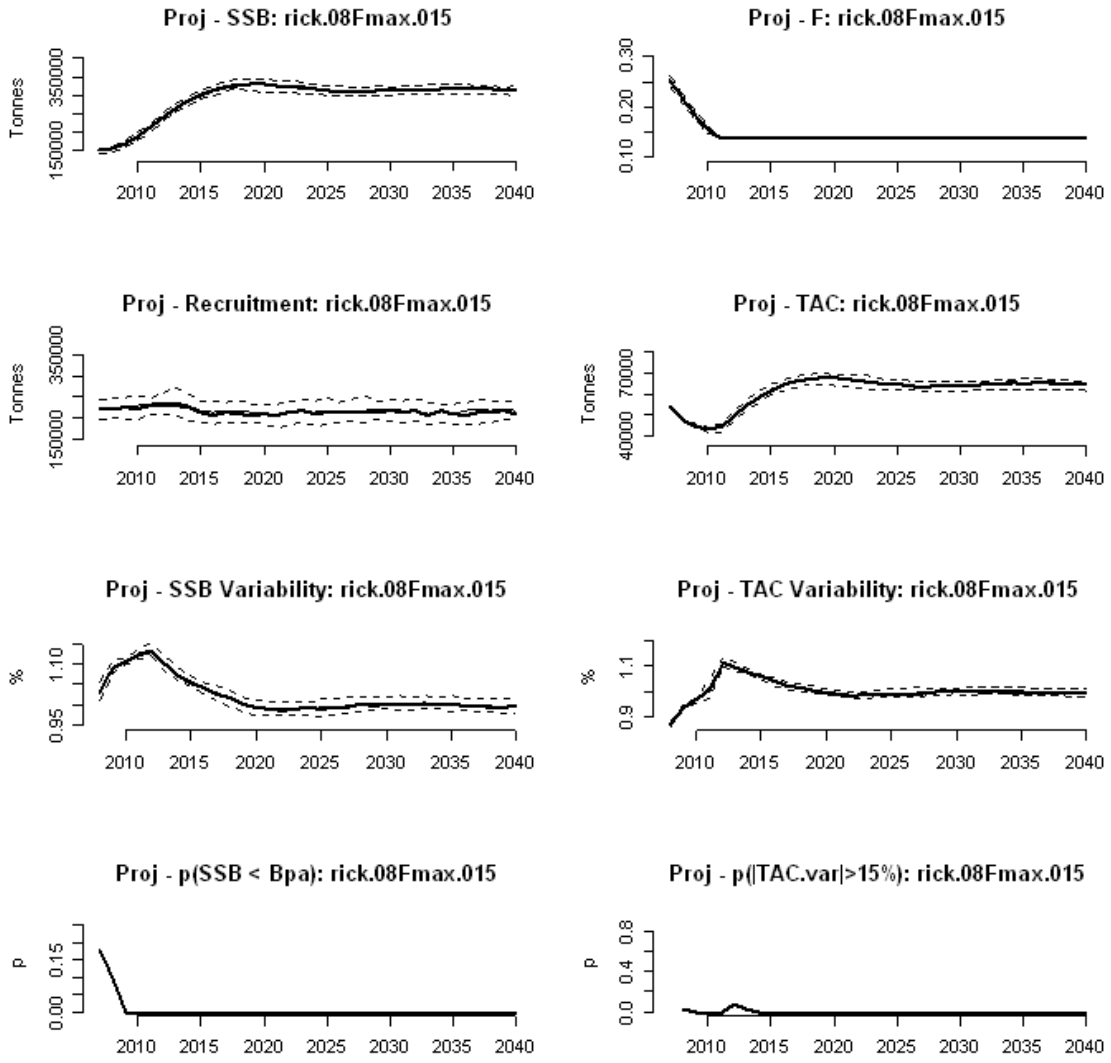

Fig. A.16. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

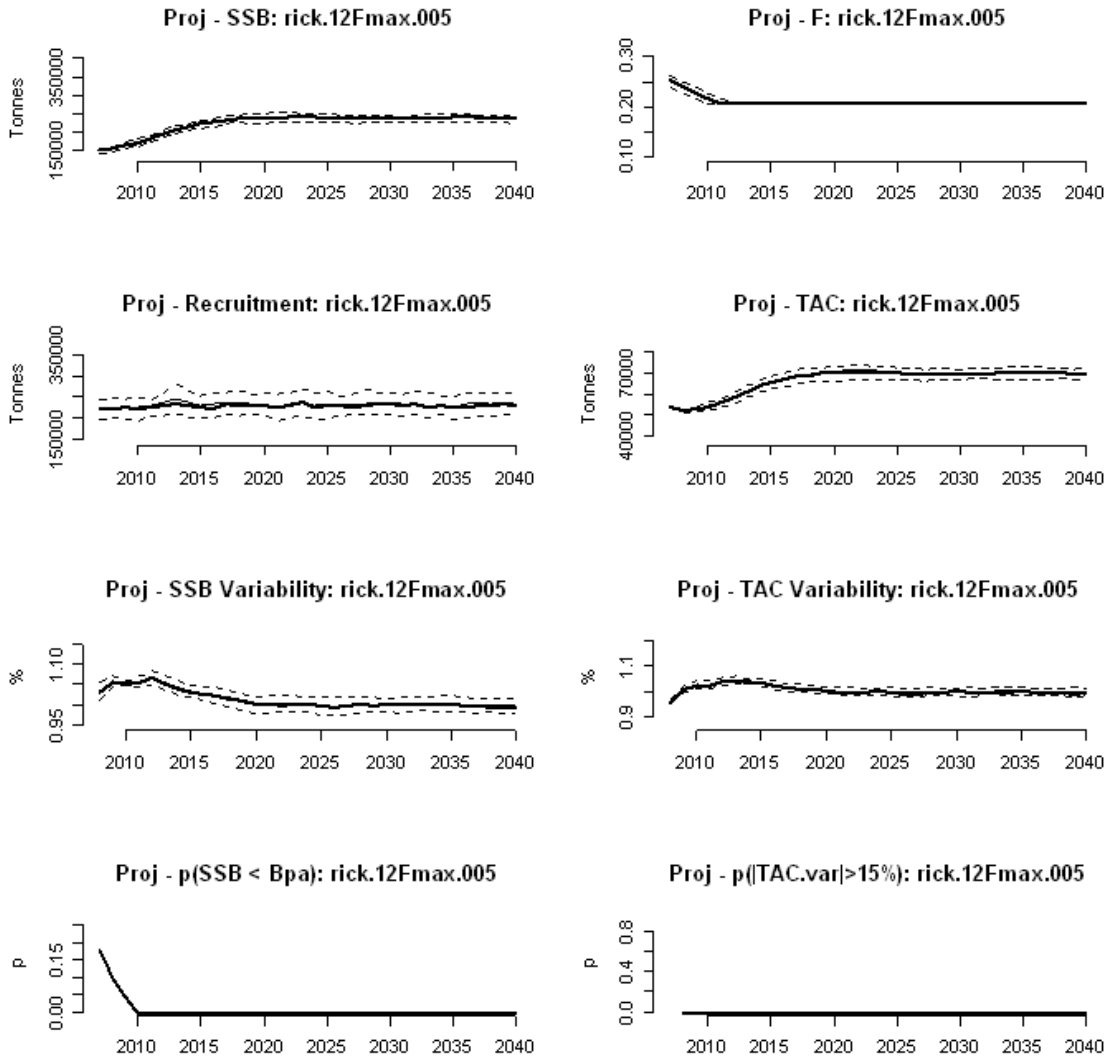

Fig. A.17. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

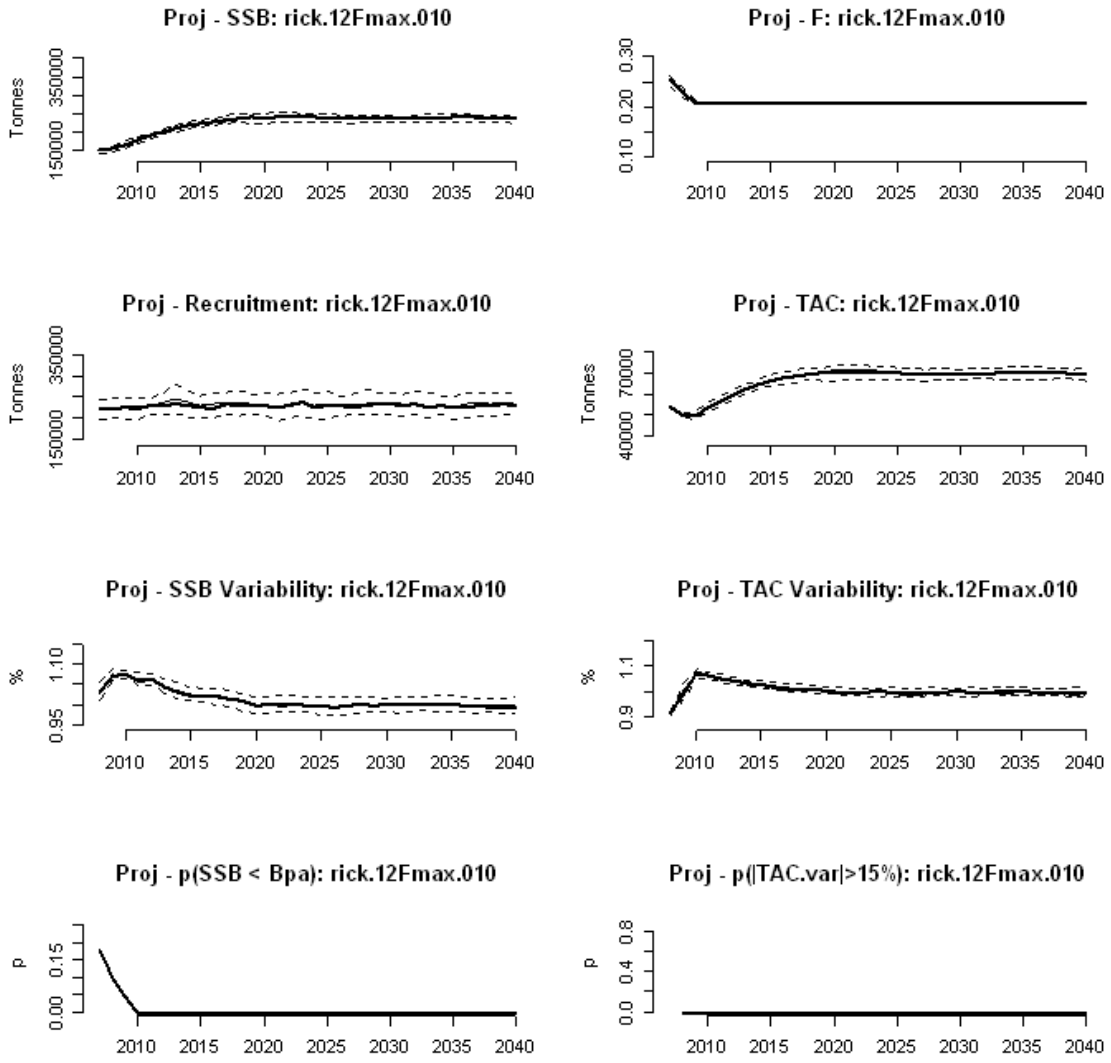

Fig. A.18. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

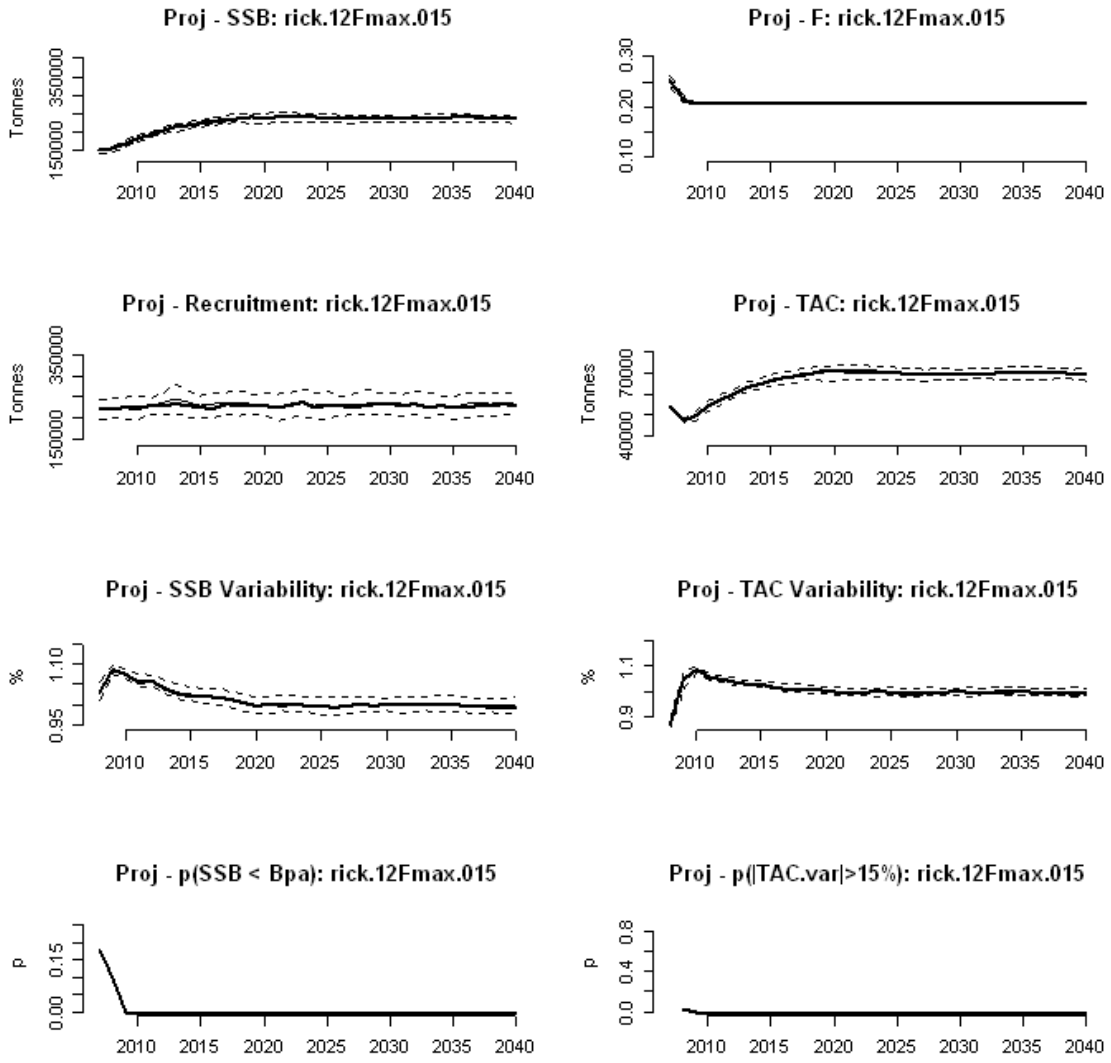

Fig. A.19. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

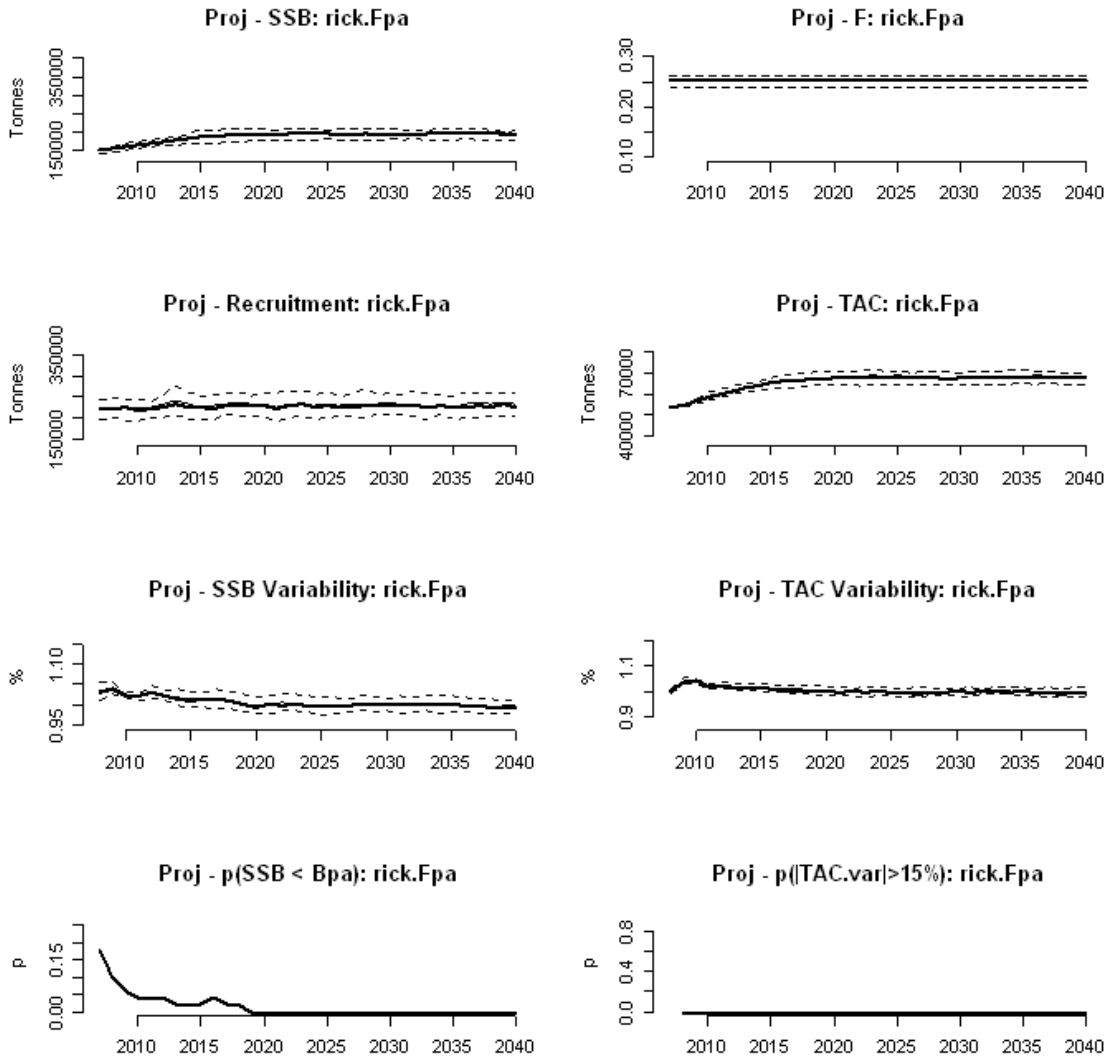

Fig. A.20. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

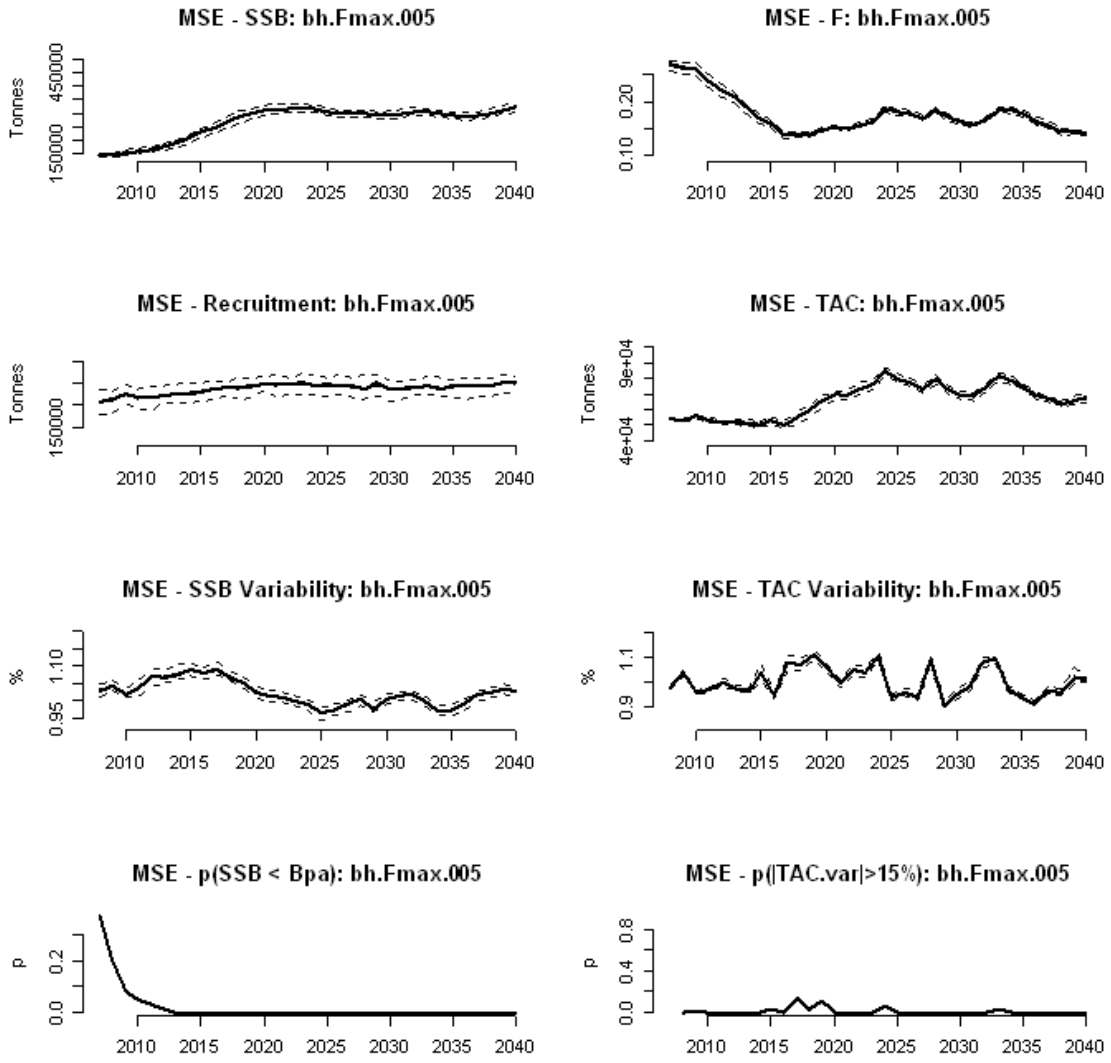

Fig. A.21. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

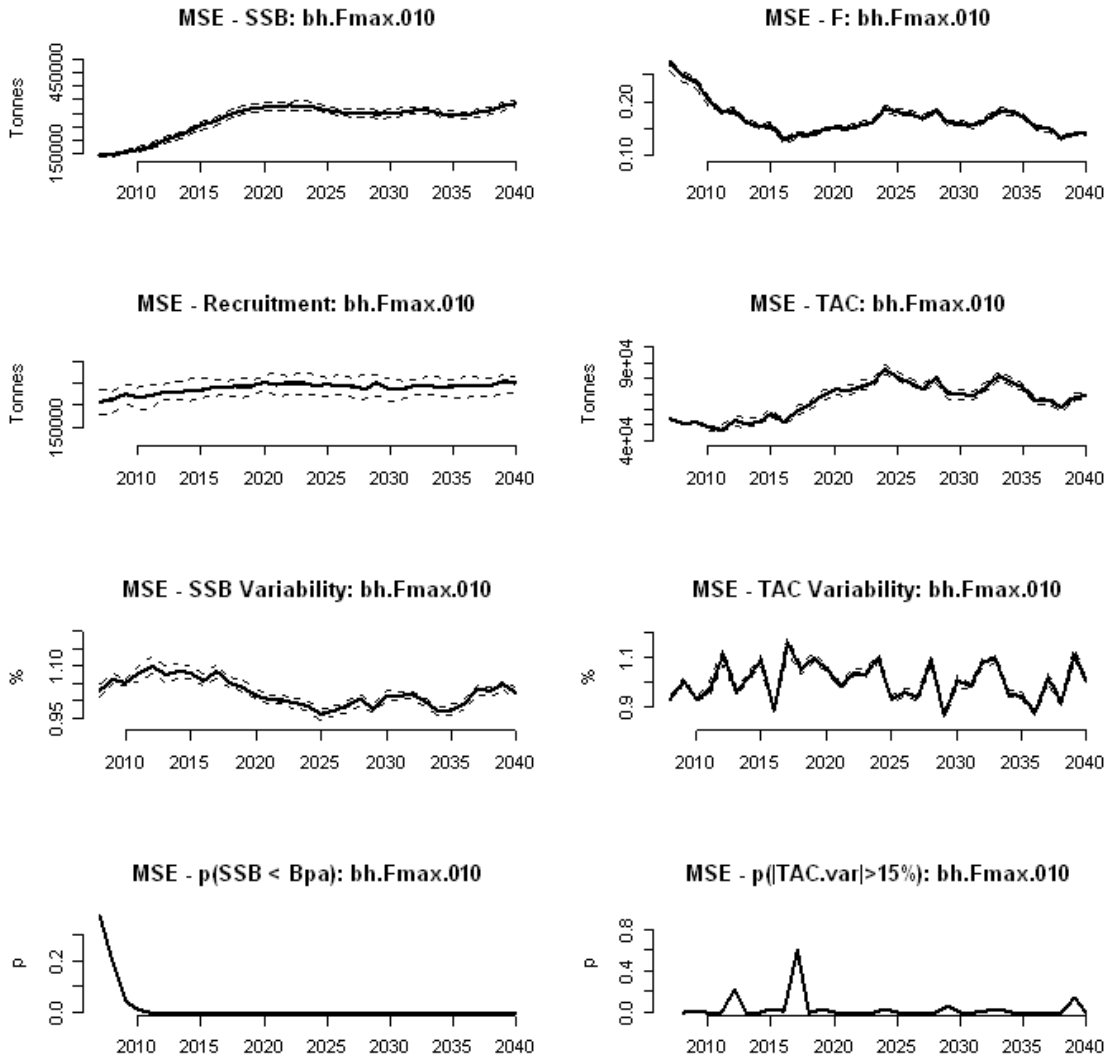

Fig. A.22. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

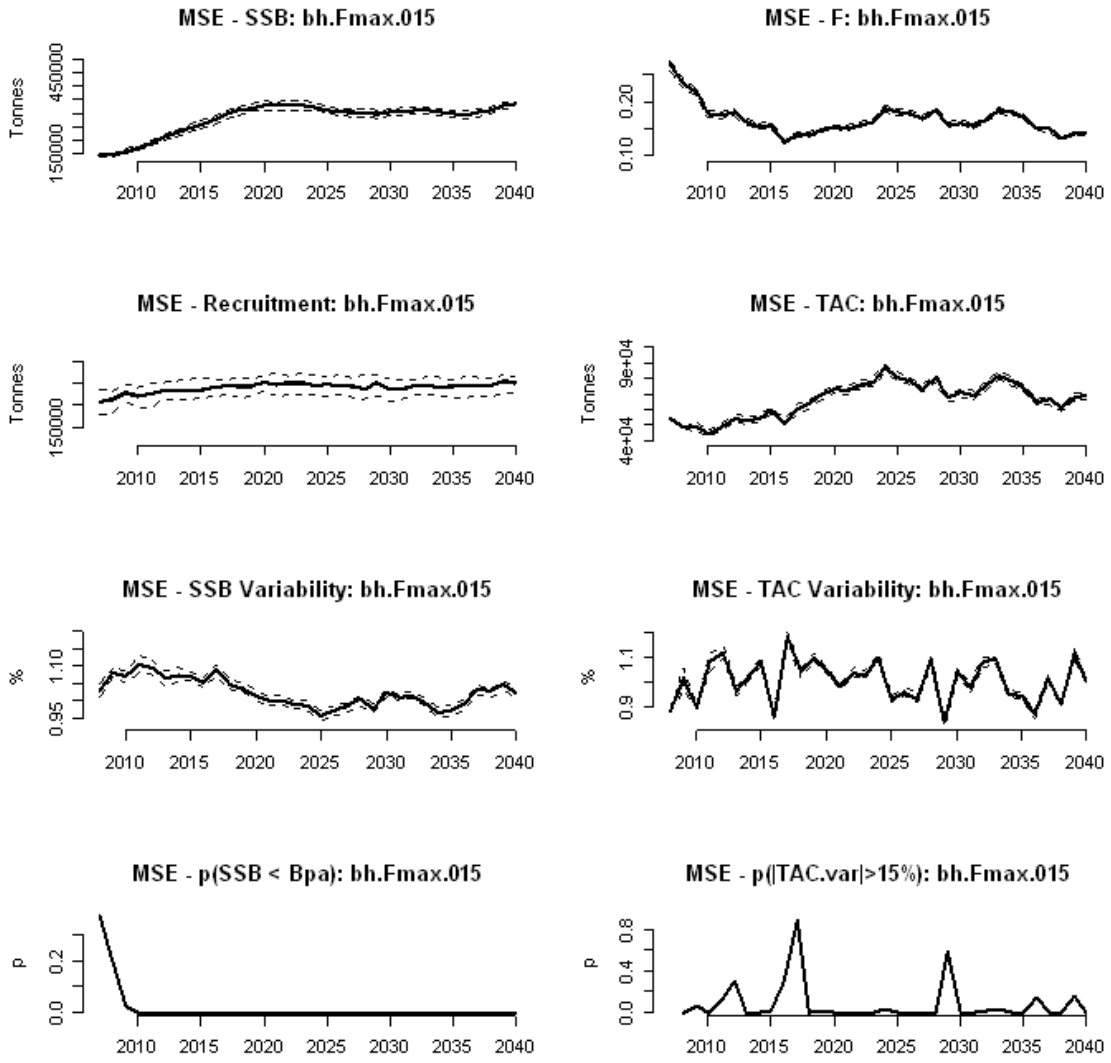

Fig. A.23. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

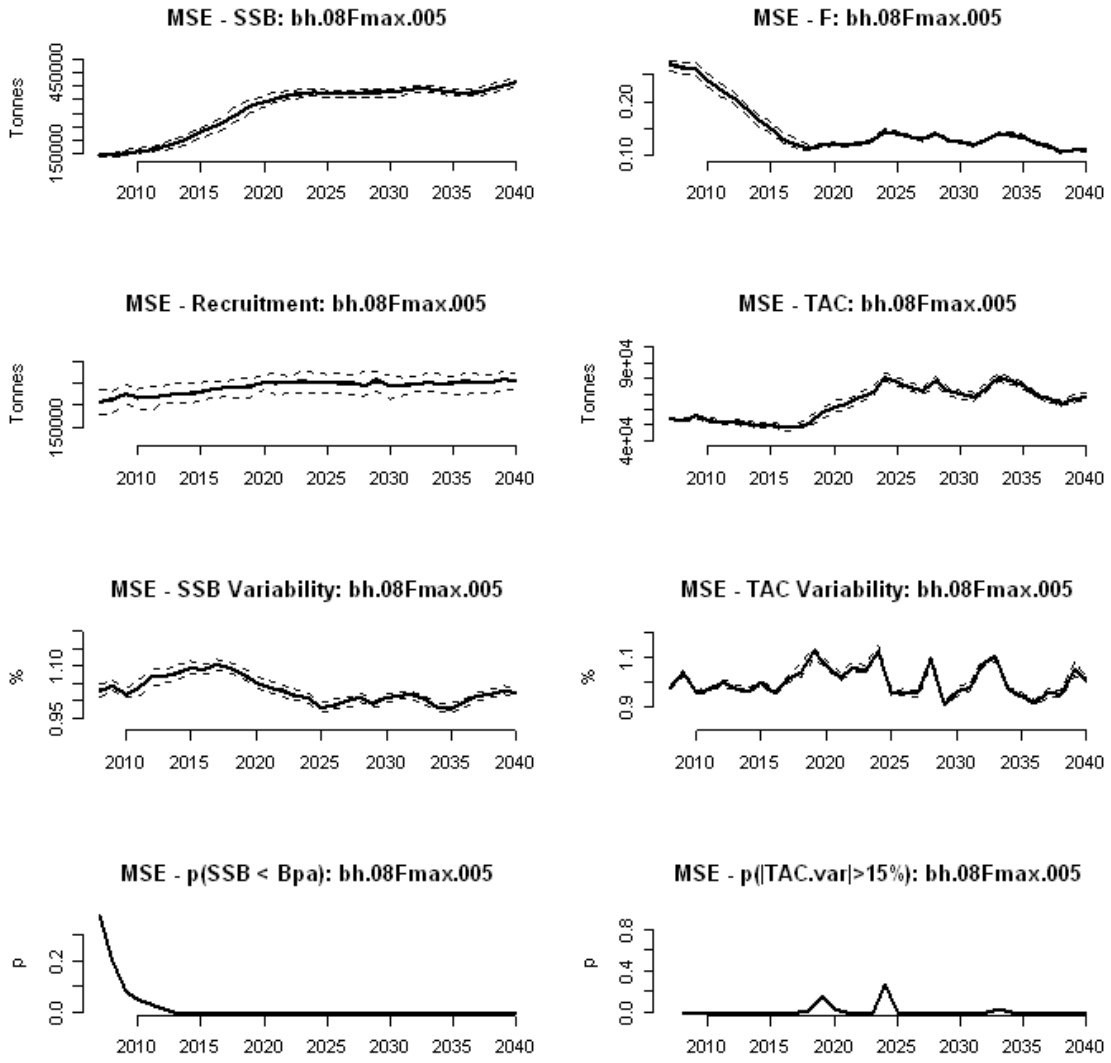

Fig. A.24. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

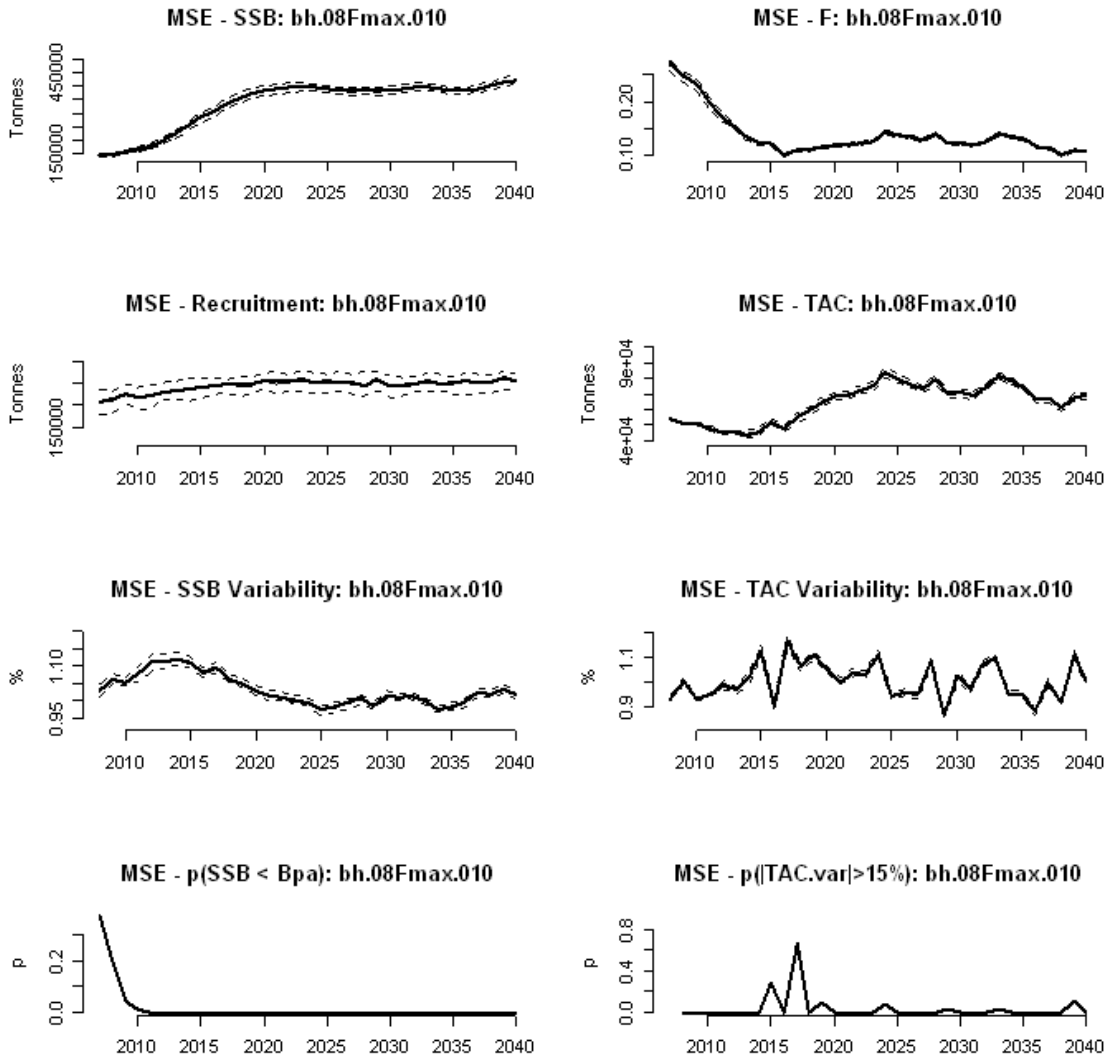

Fig. A.25. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

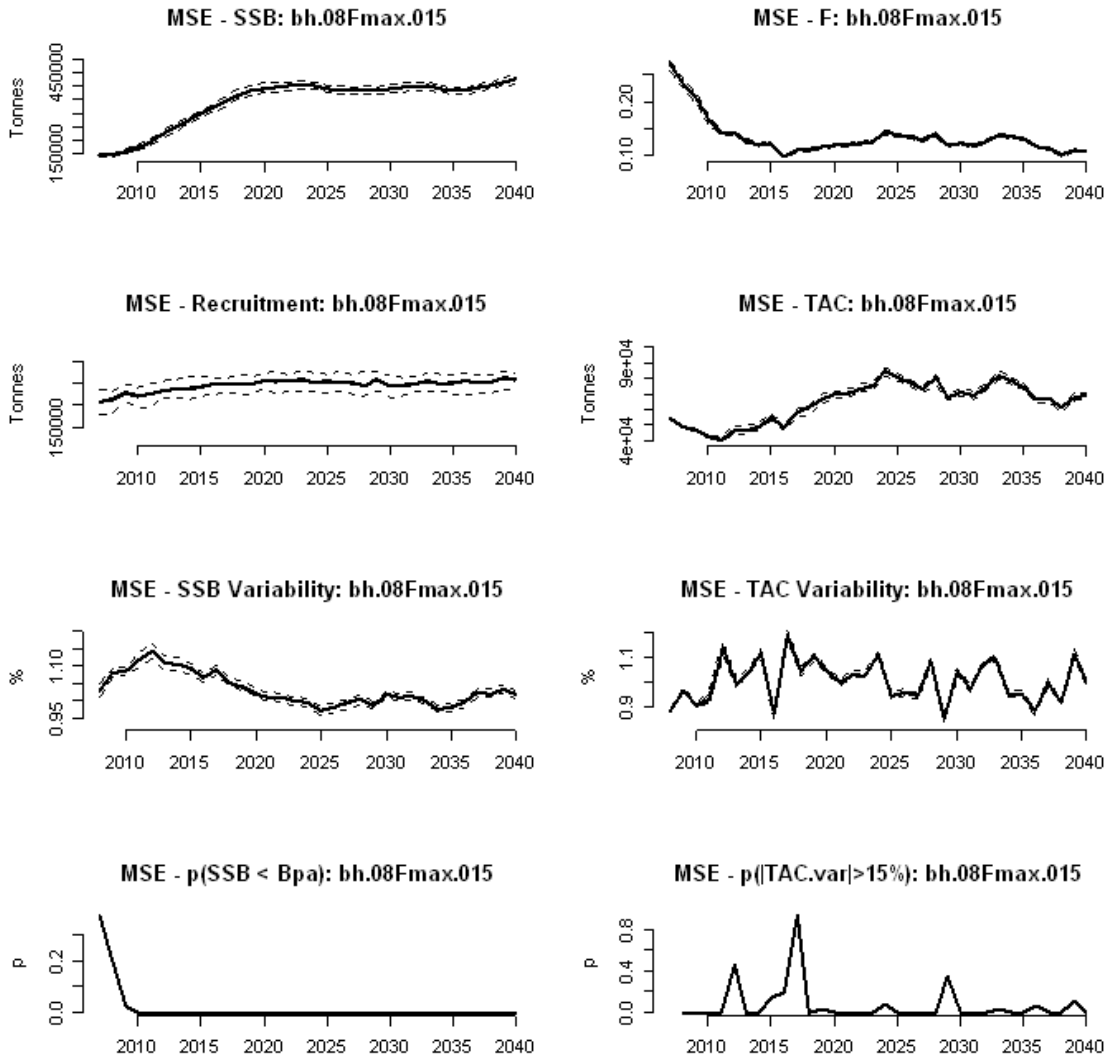

Fig. A.26. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

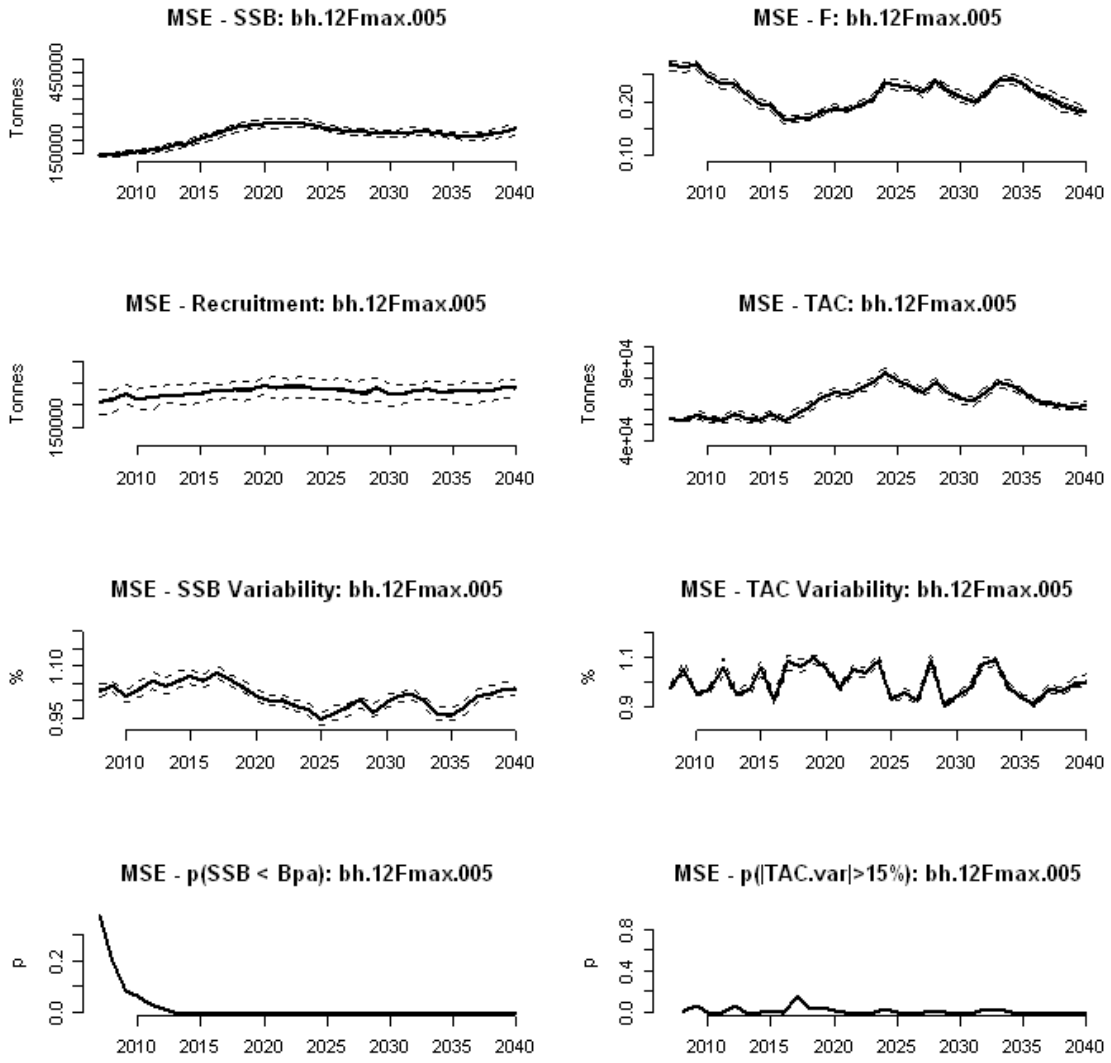

Fig. A.27. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

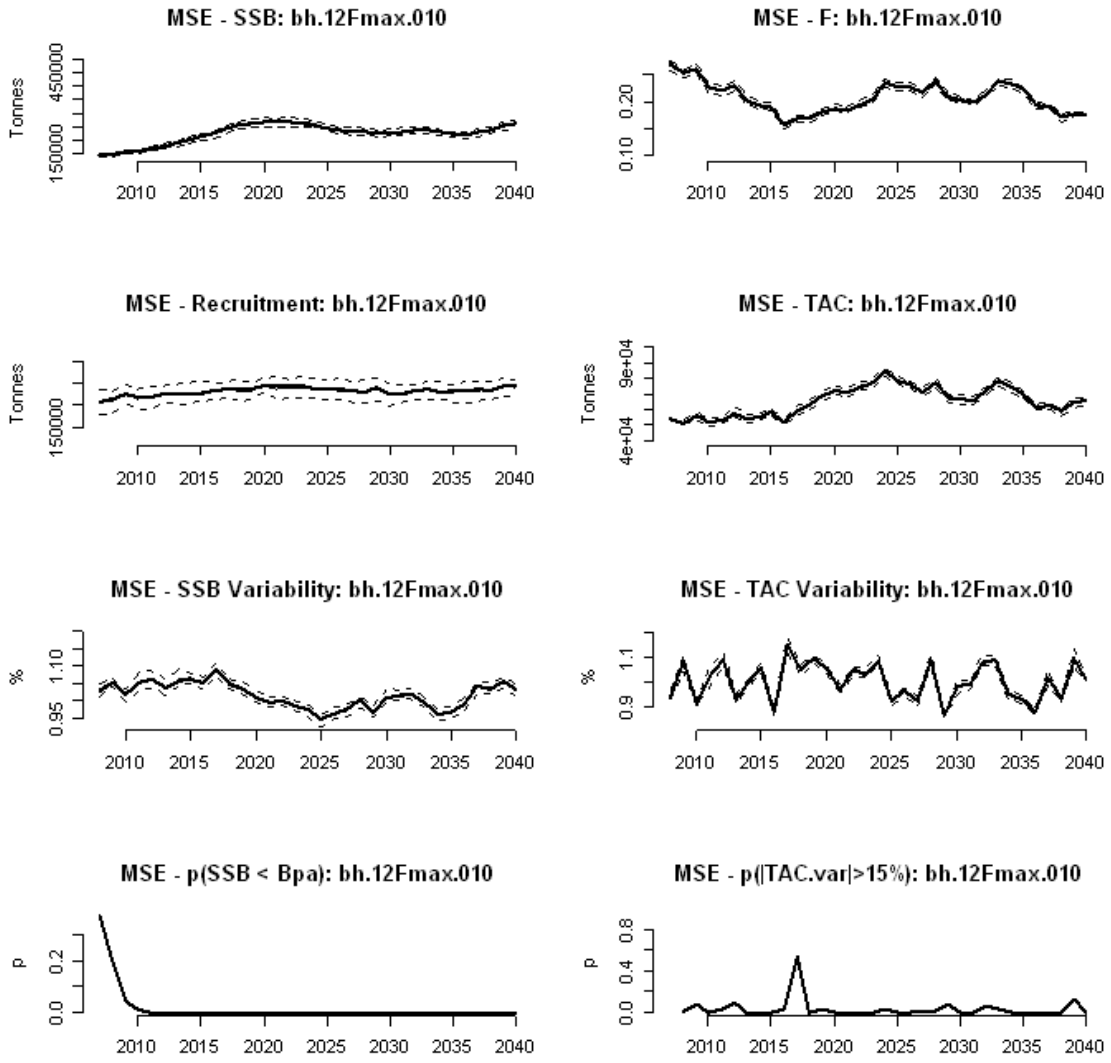

Fig. A.28. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

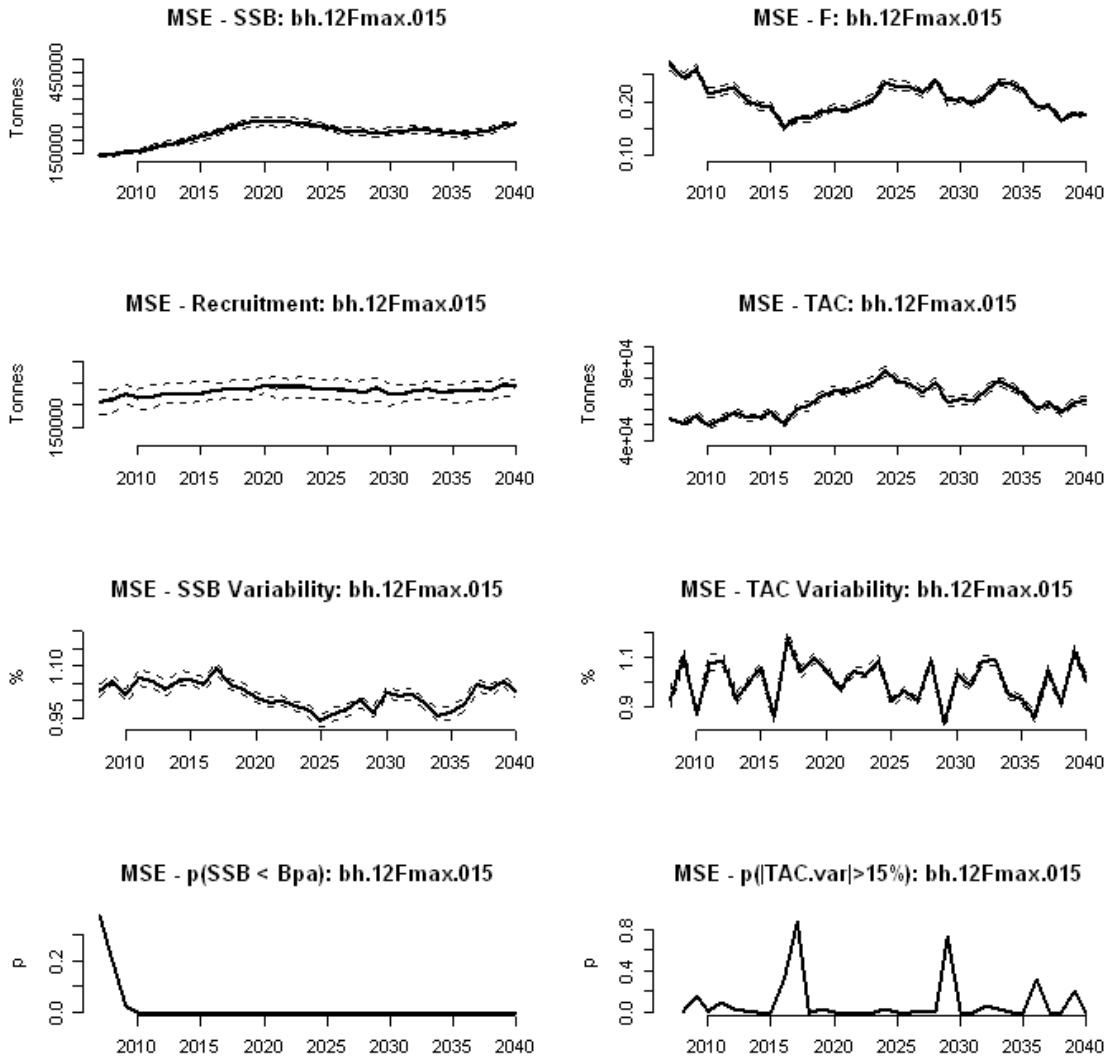

Fig. A.29. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

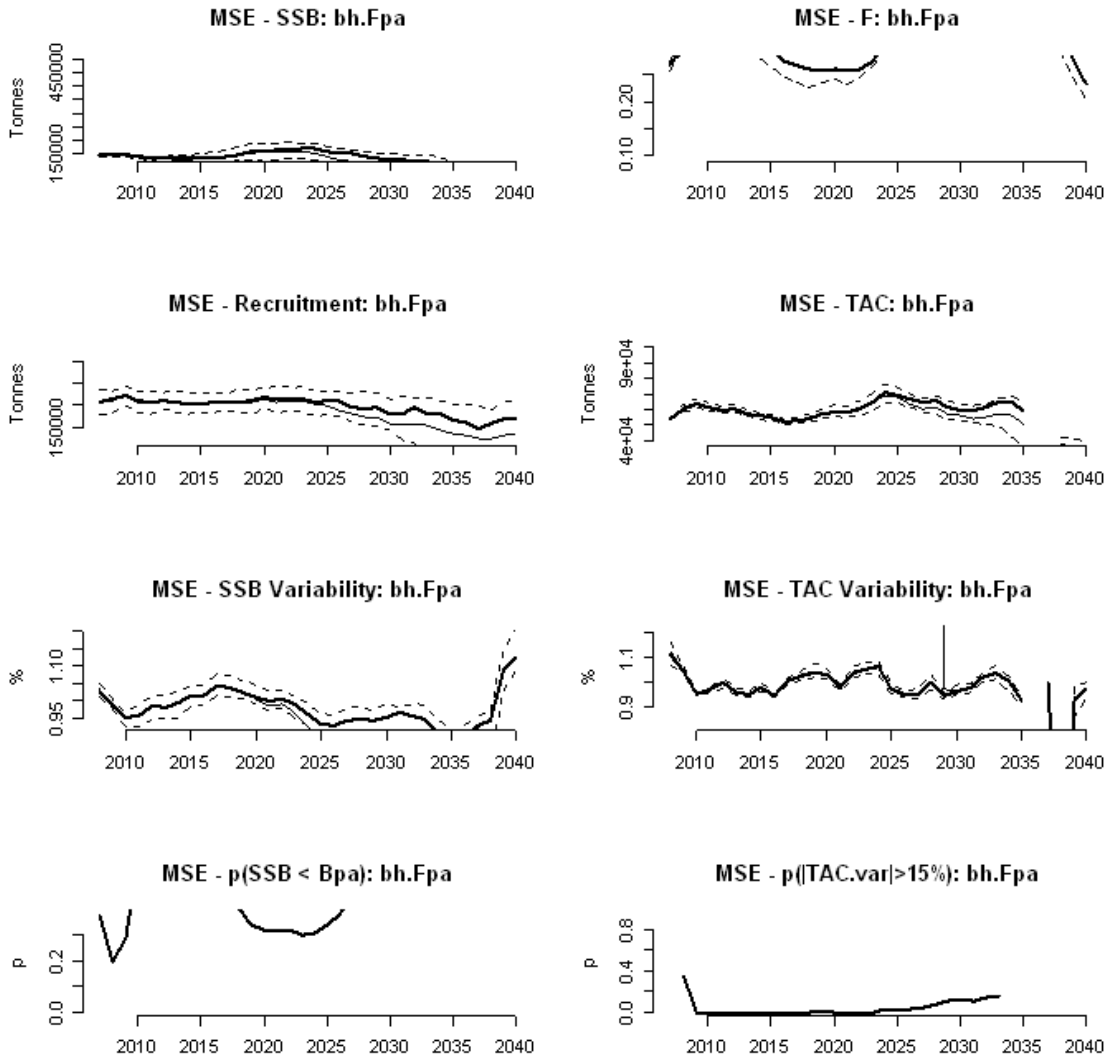

Fig. A.30. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

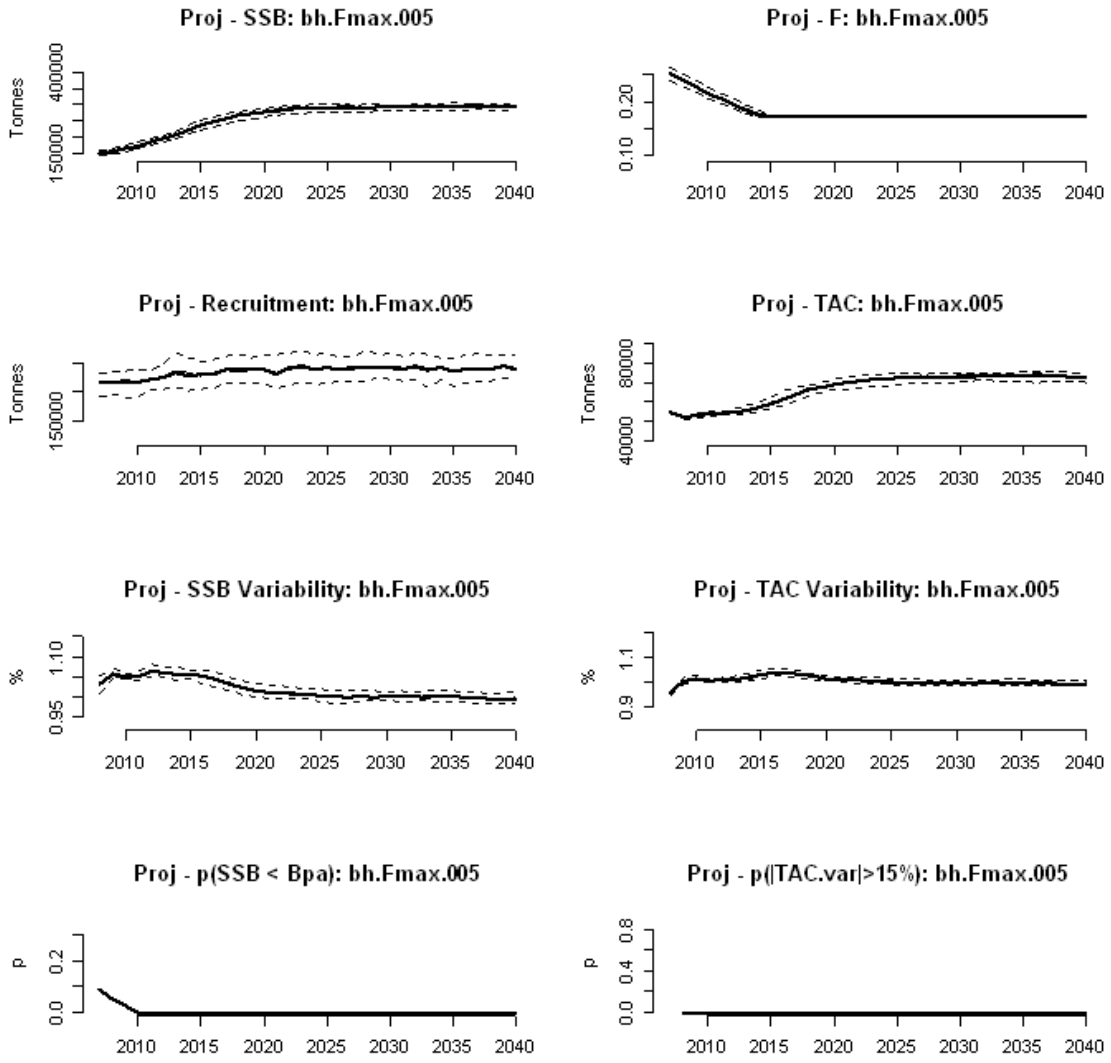

Fig. A.31. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

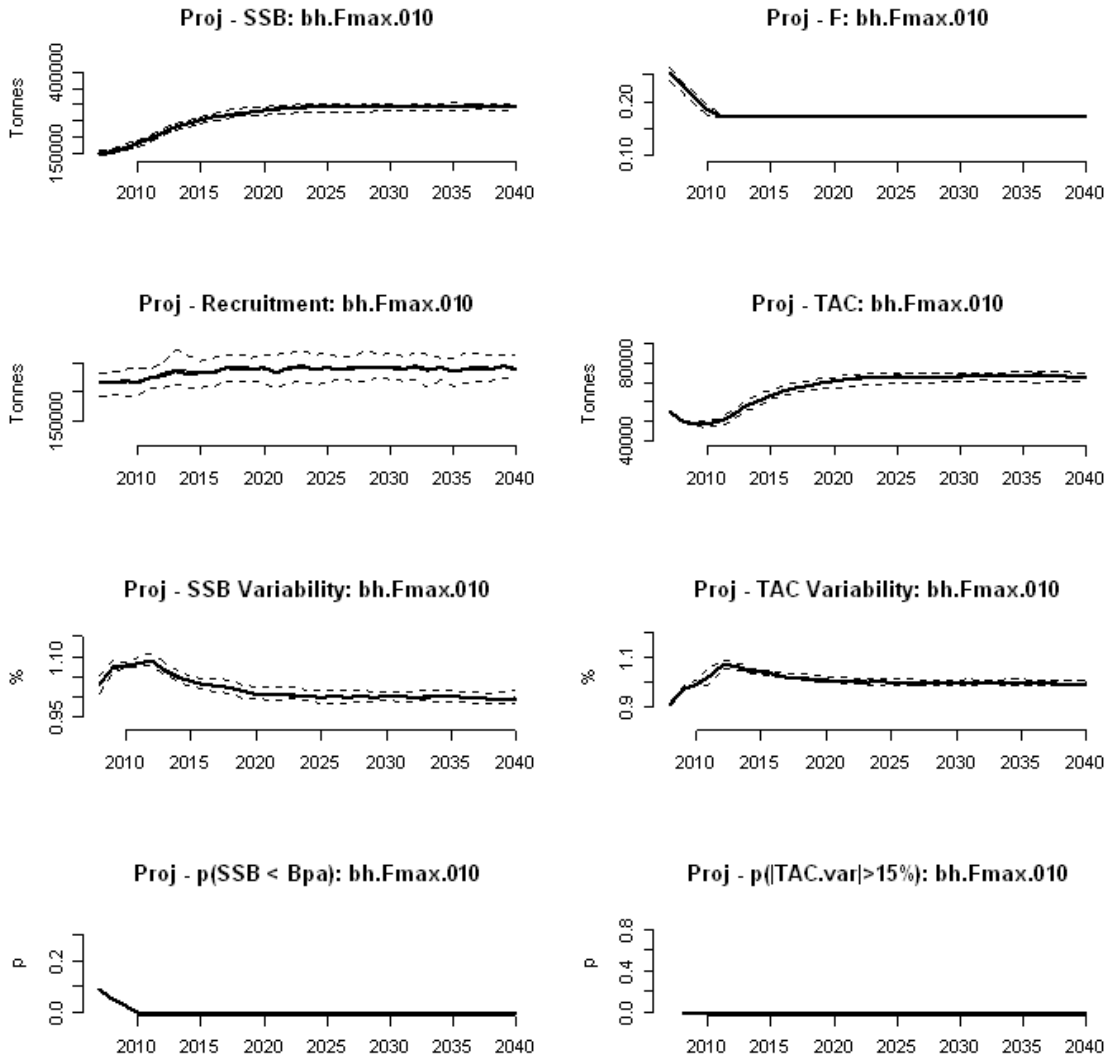

Fig. A.32. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

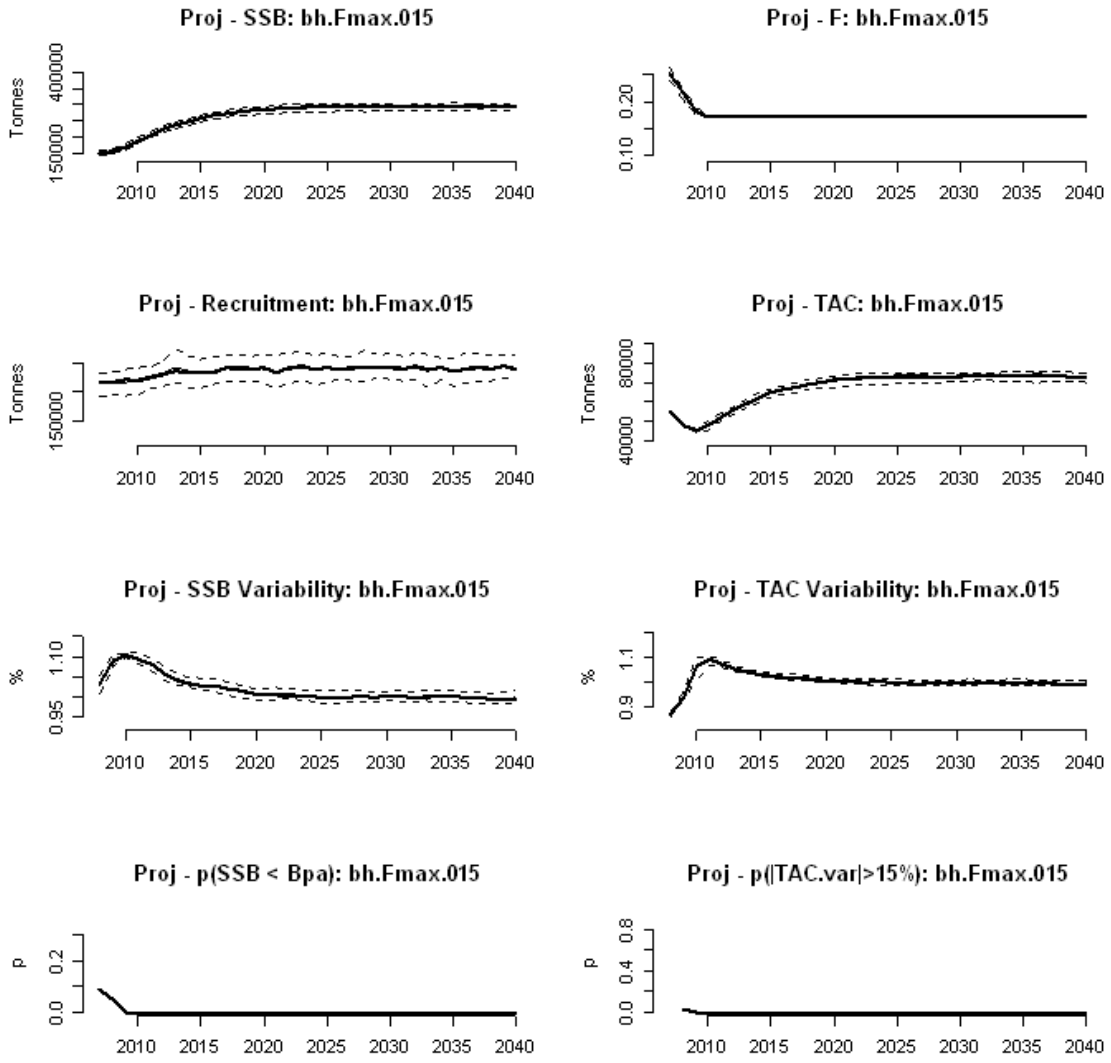

Fig. A.33. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

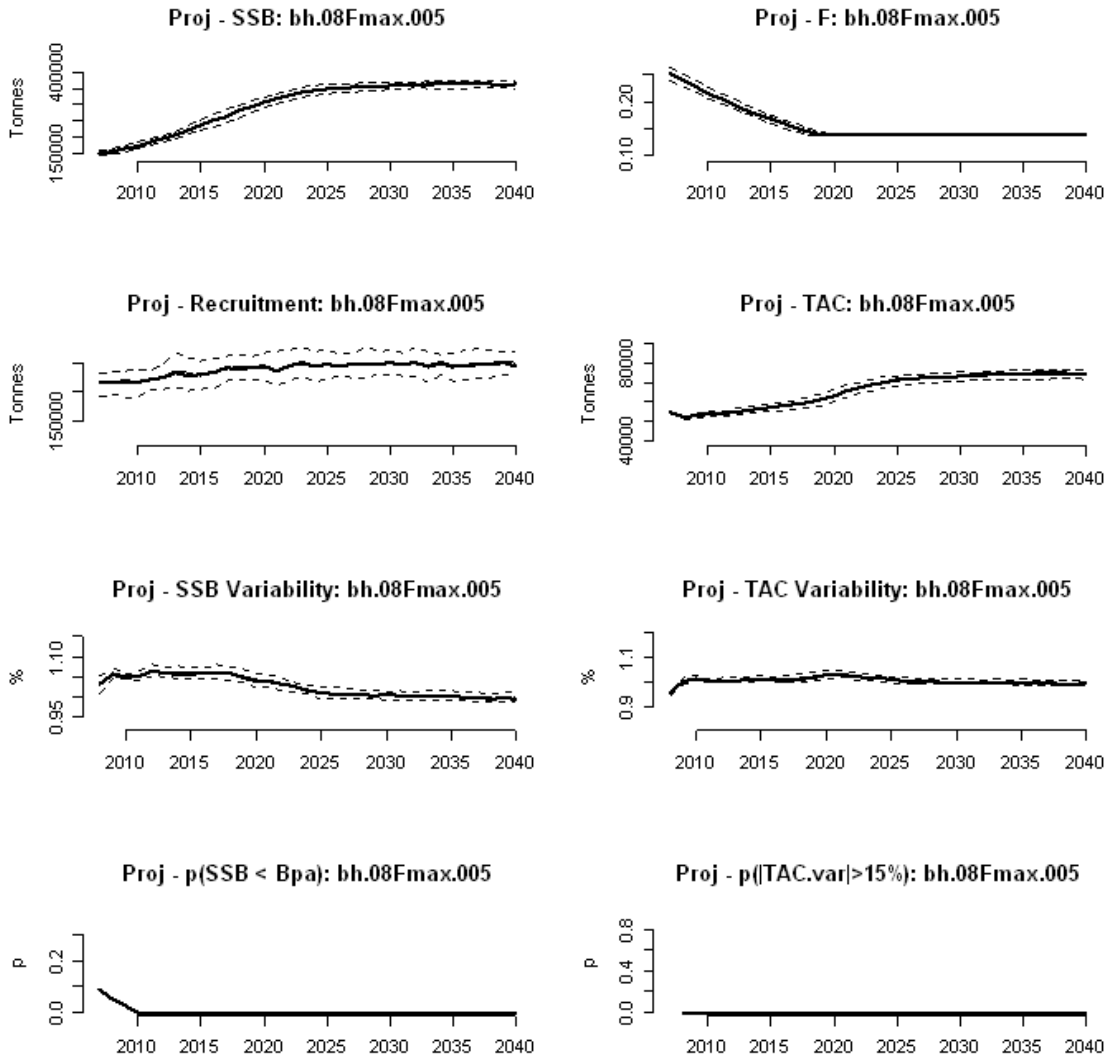

Fig. A.34. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

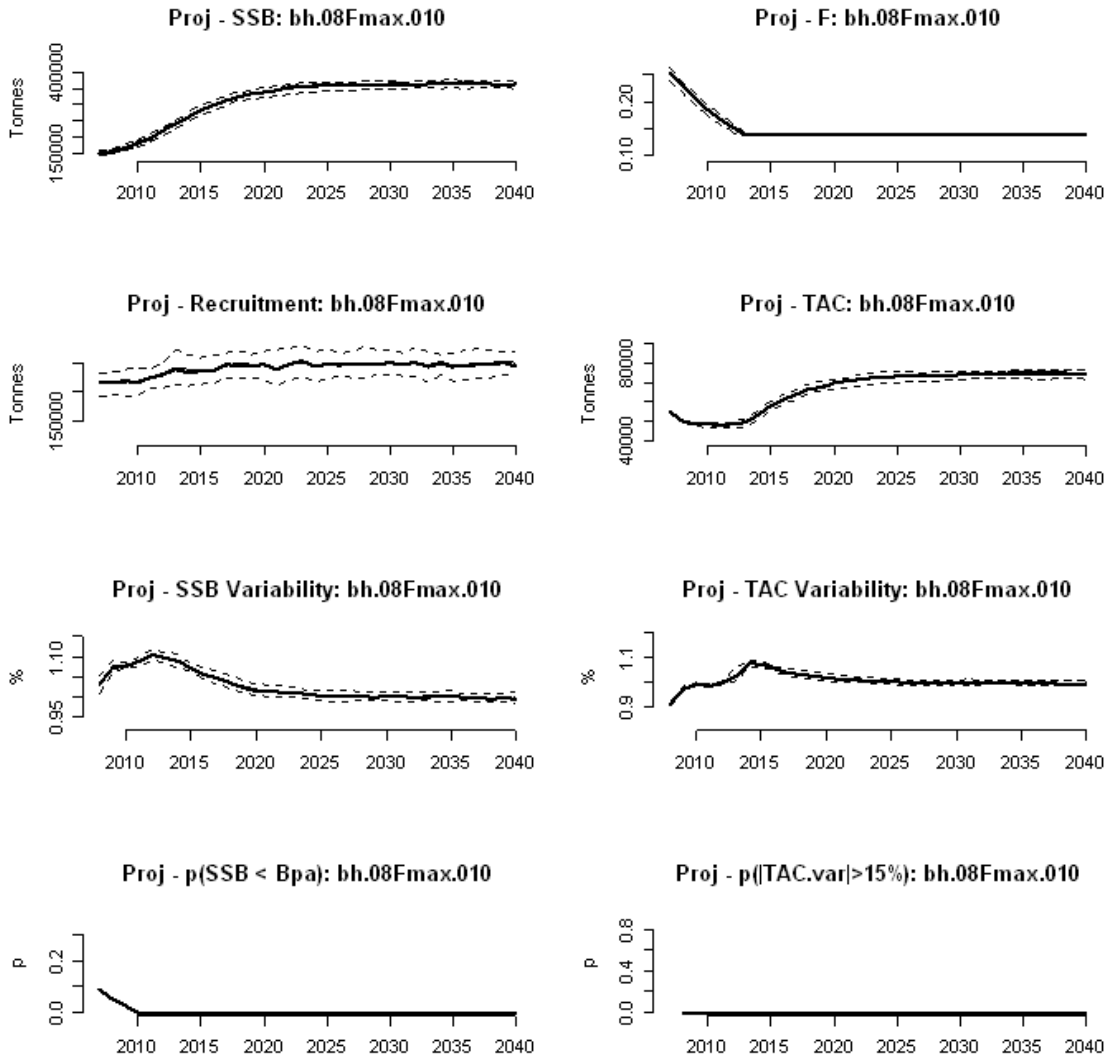

Fig. A.35. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

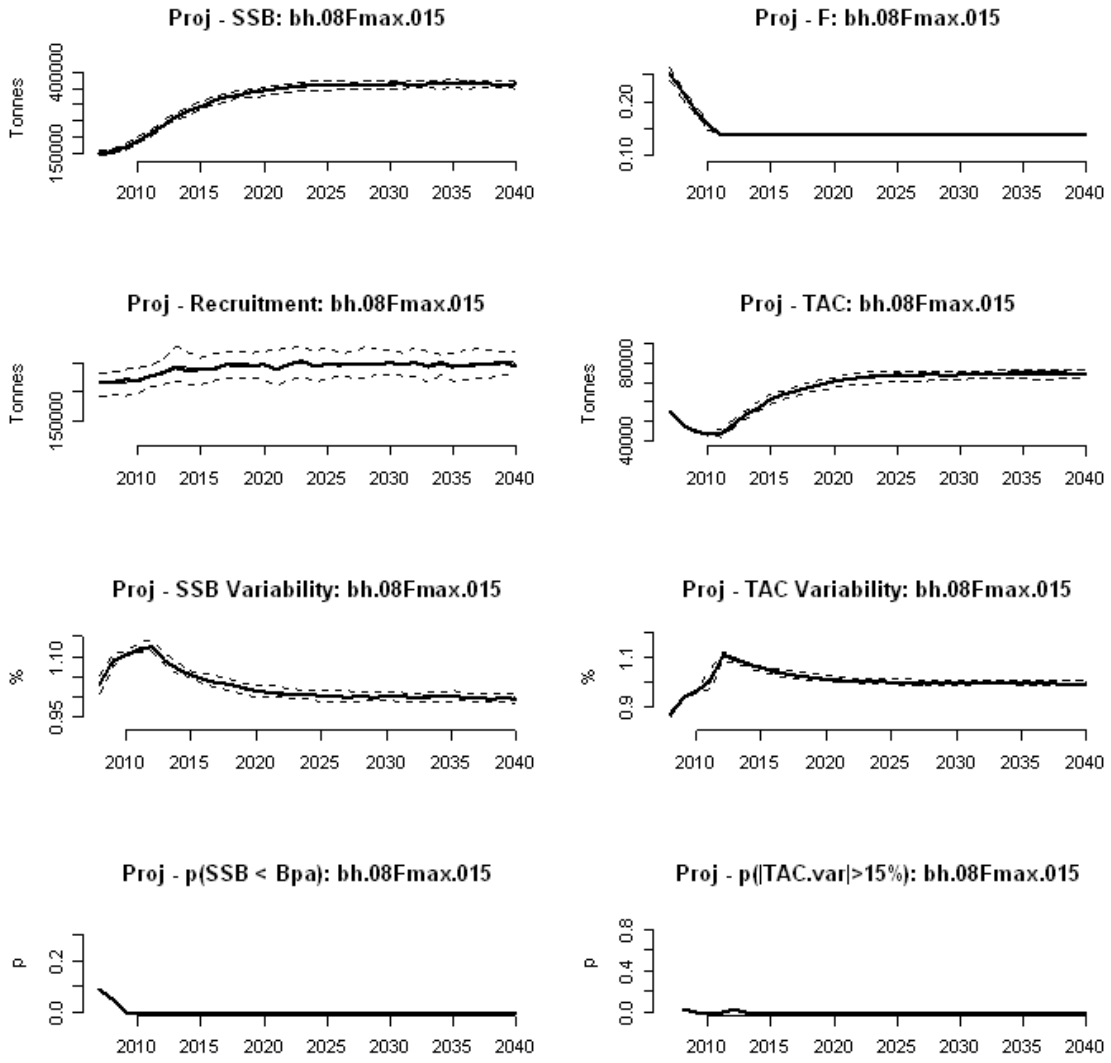

Fig. A.36. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

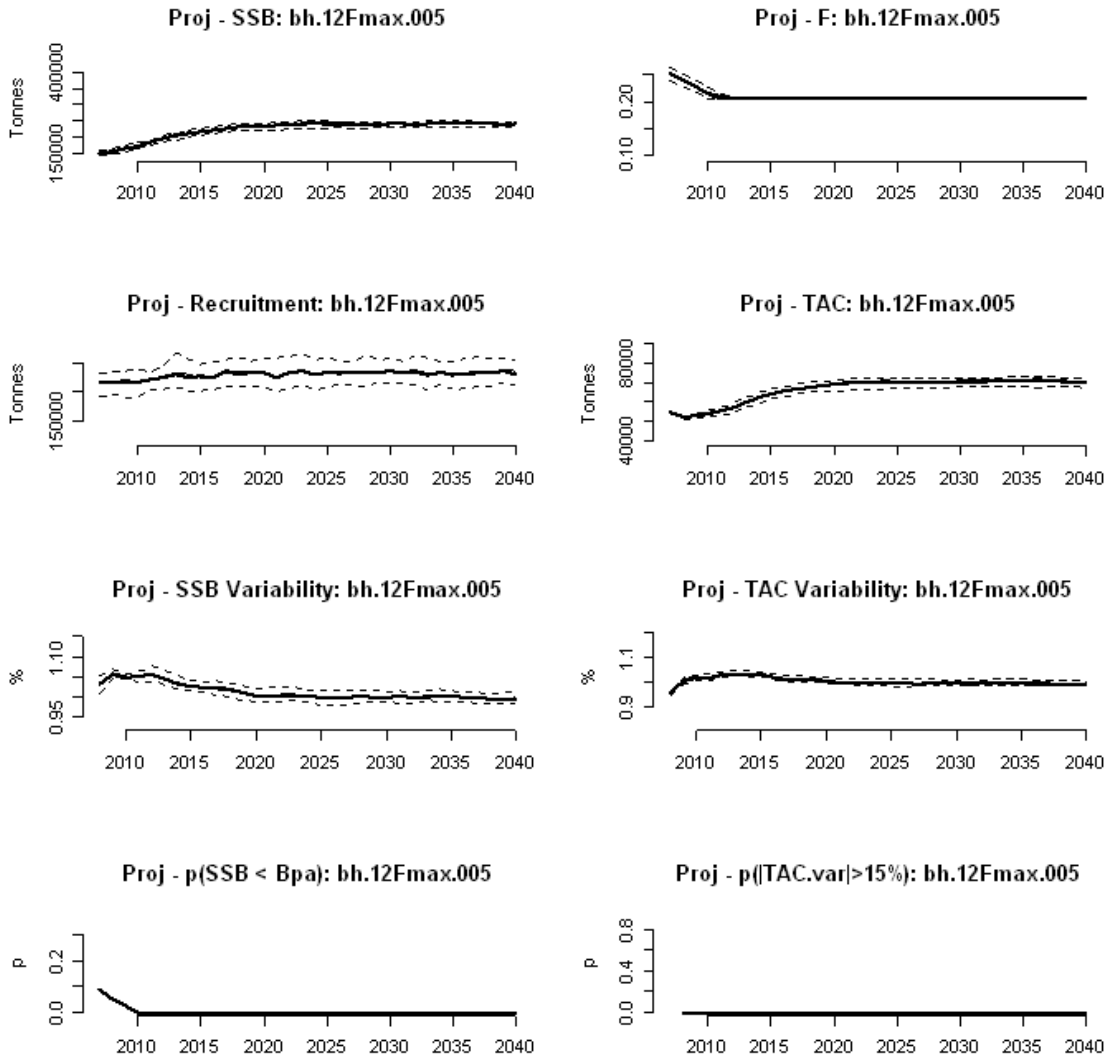

Fig. A.37. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

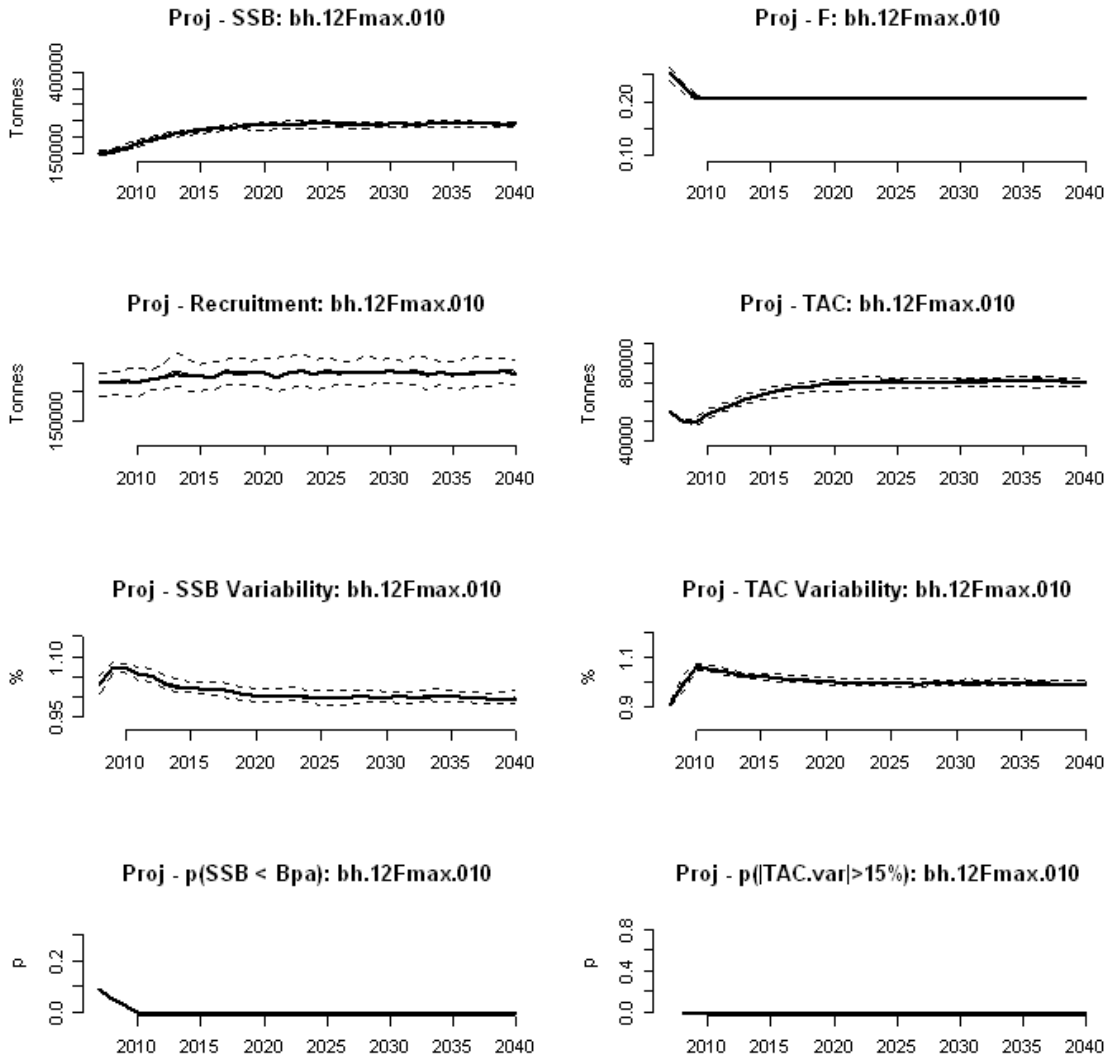

Fig. A.38. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

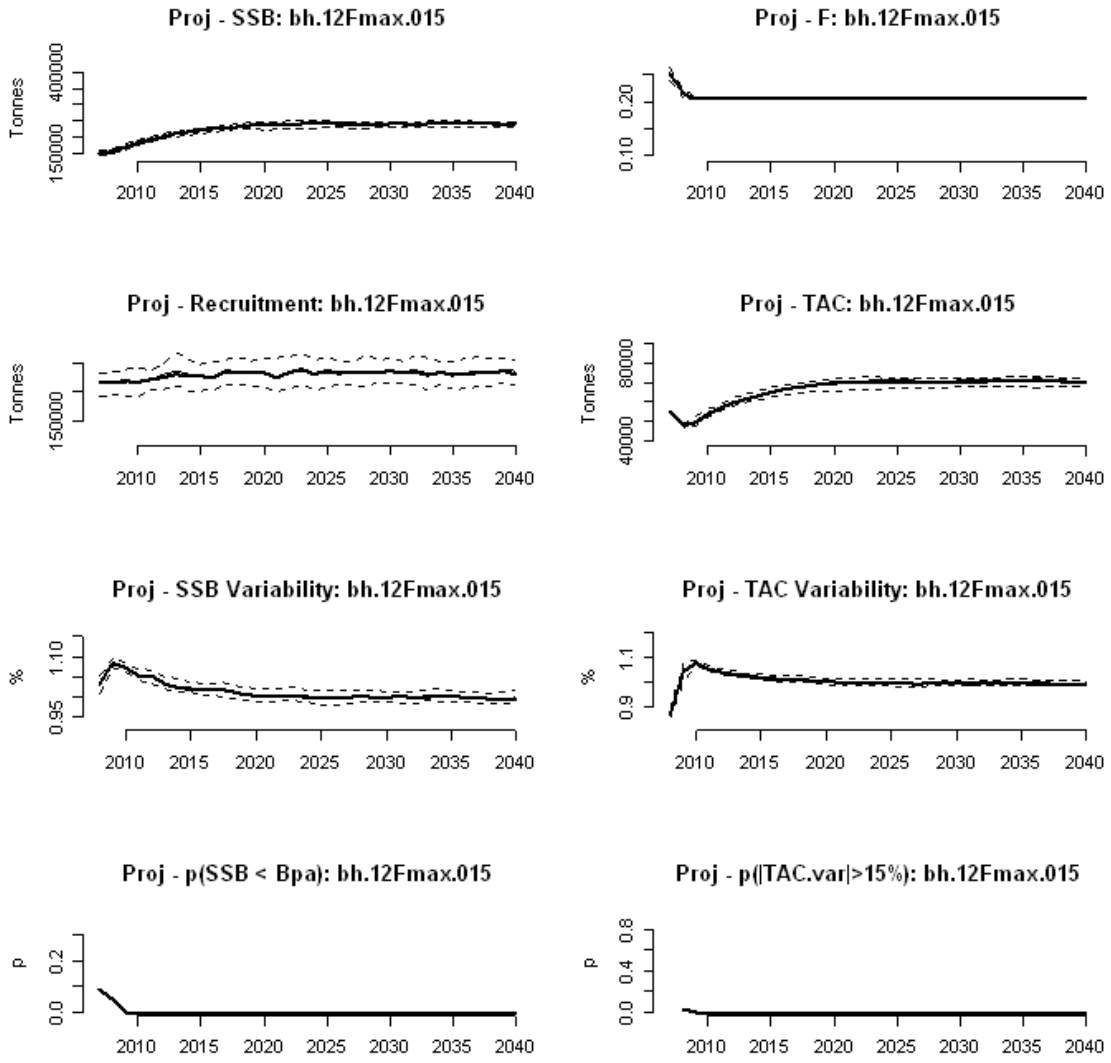

Fig. A.39. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

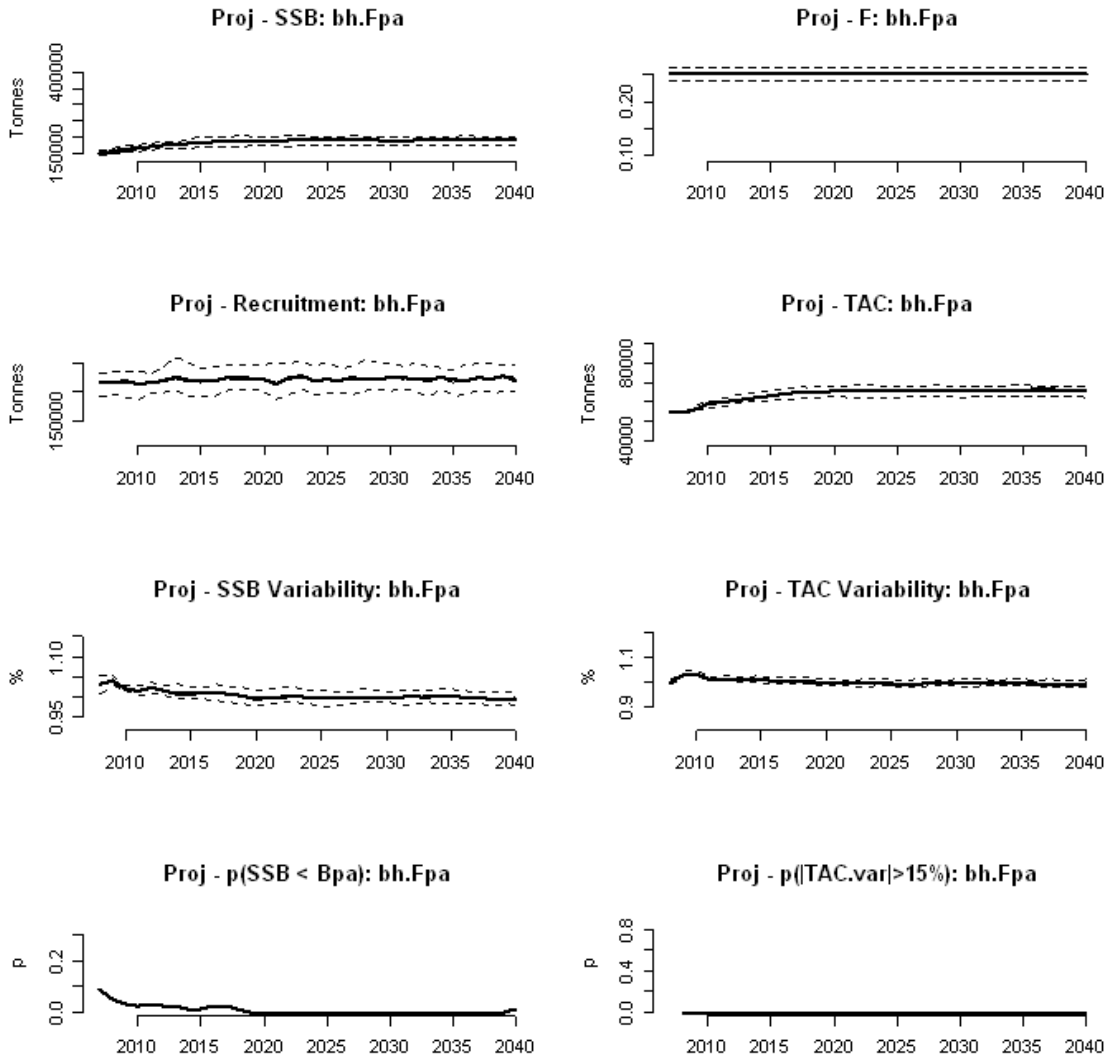

Fig. A.40. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

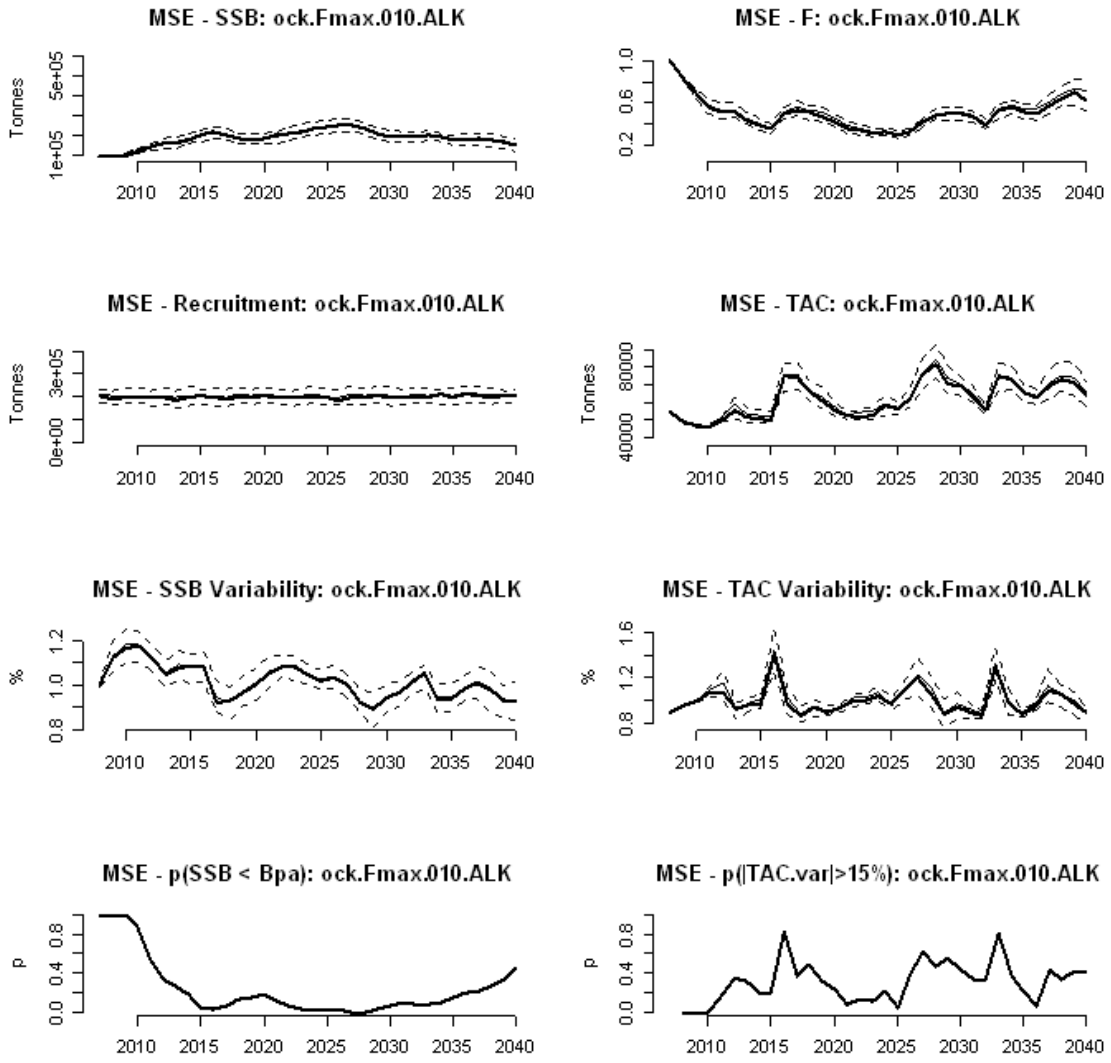

Fig. A.41. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

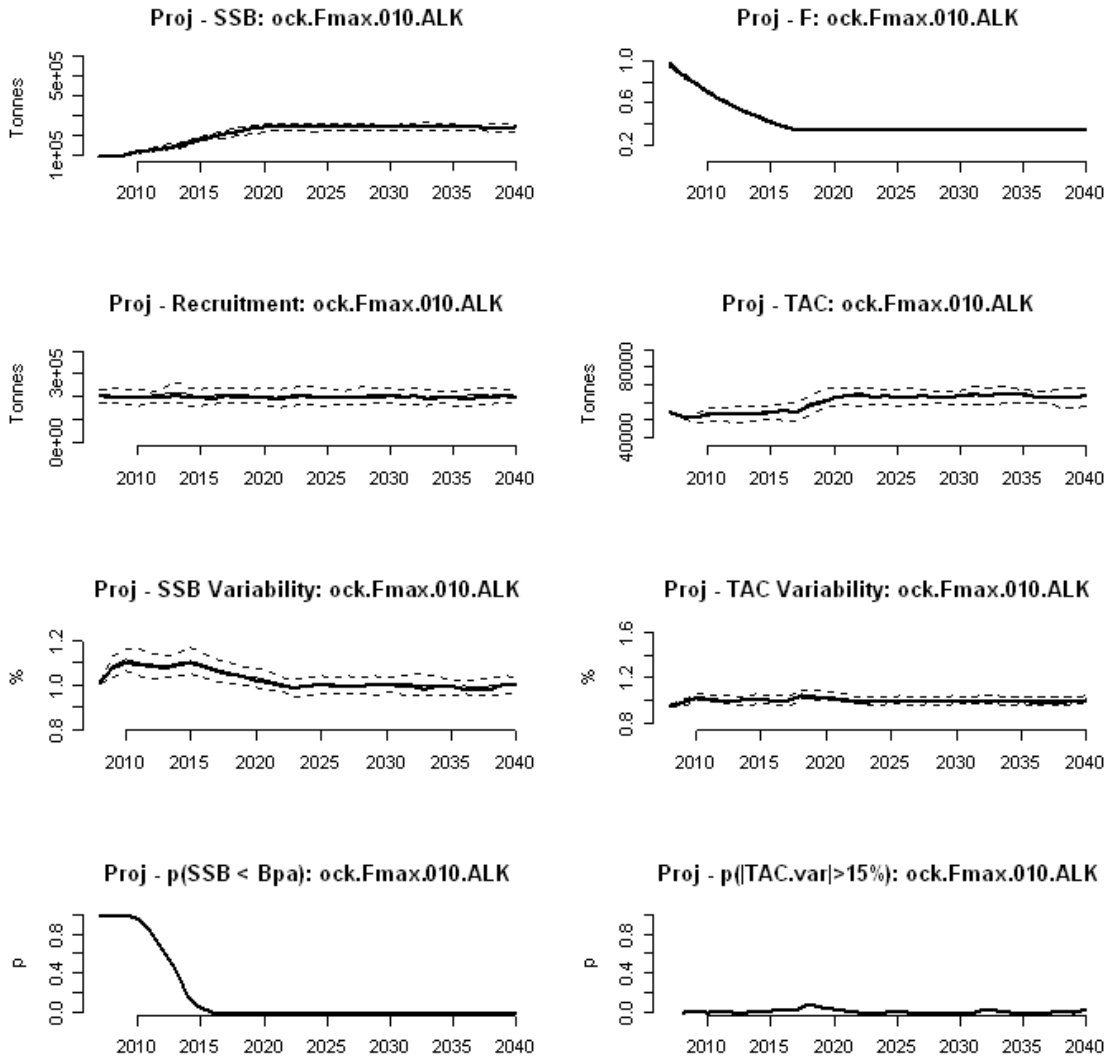

Fig. A.42. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

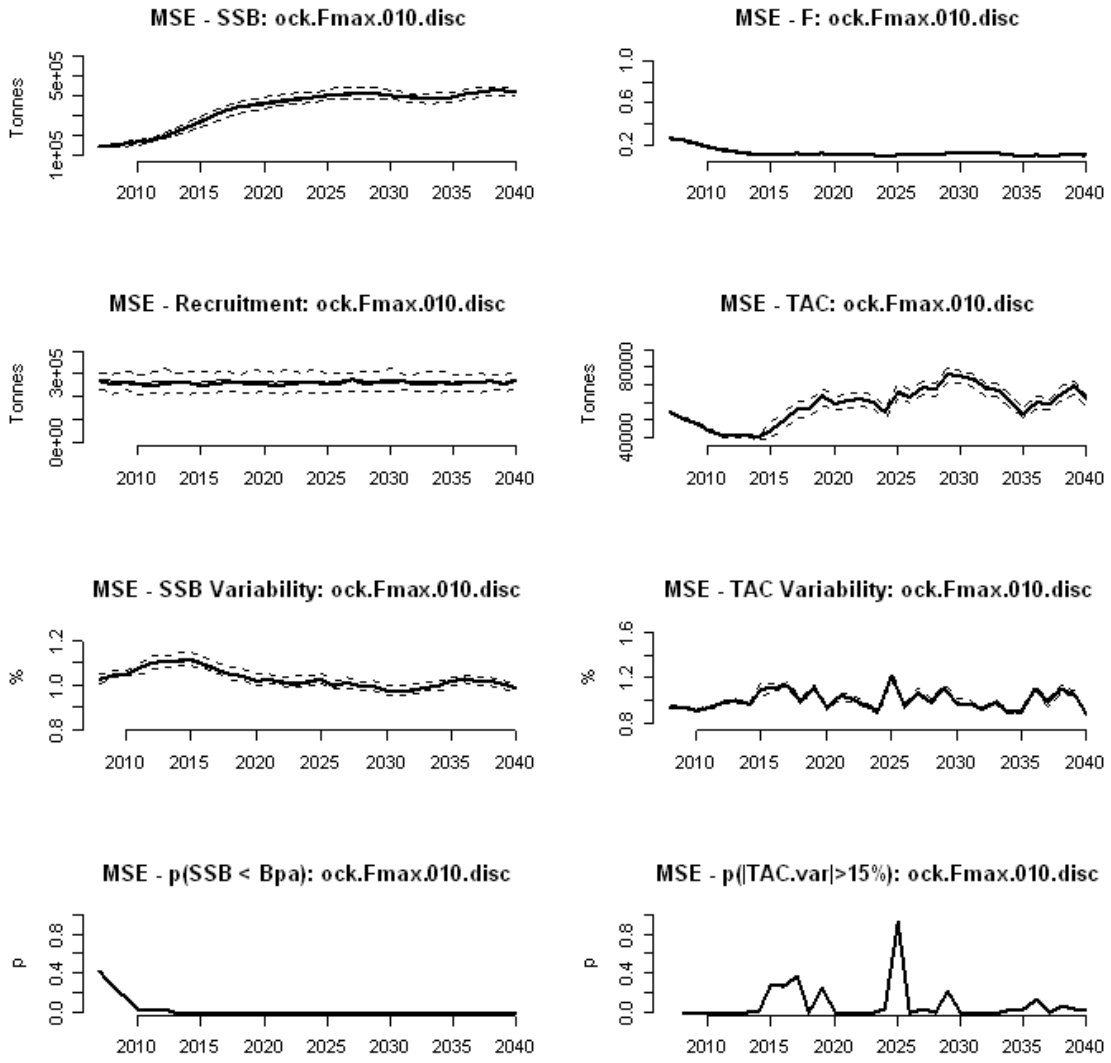

Fig. A.43. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

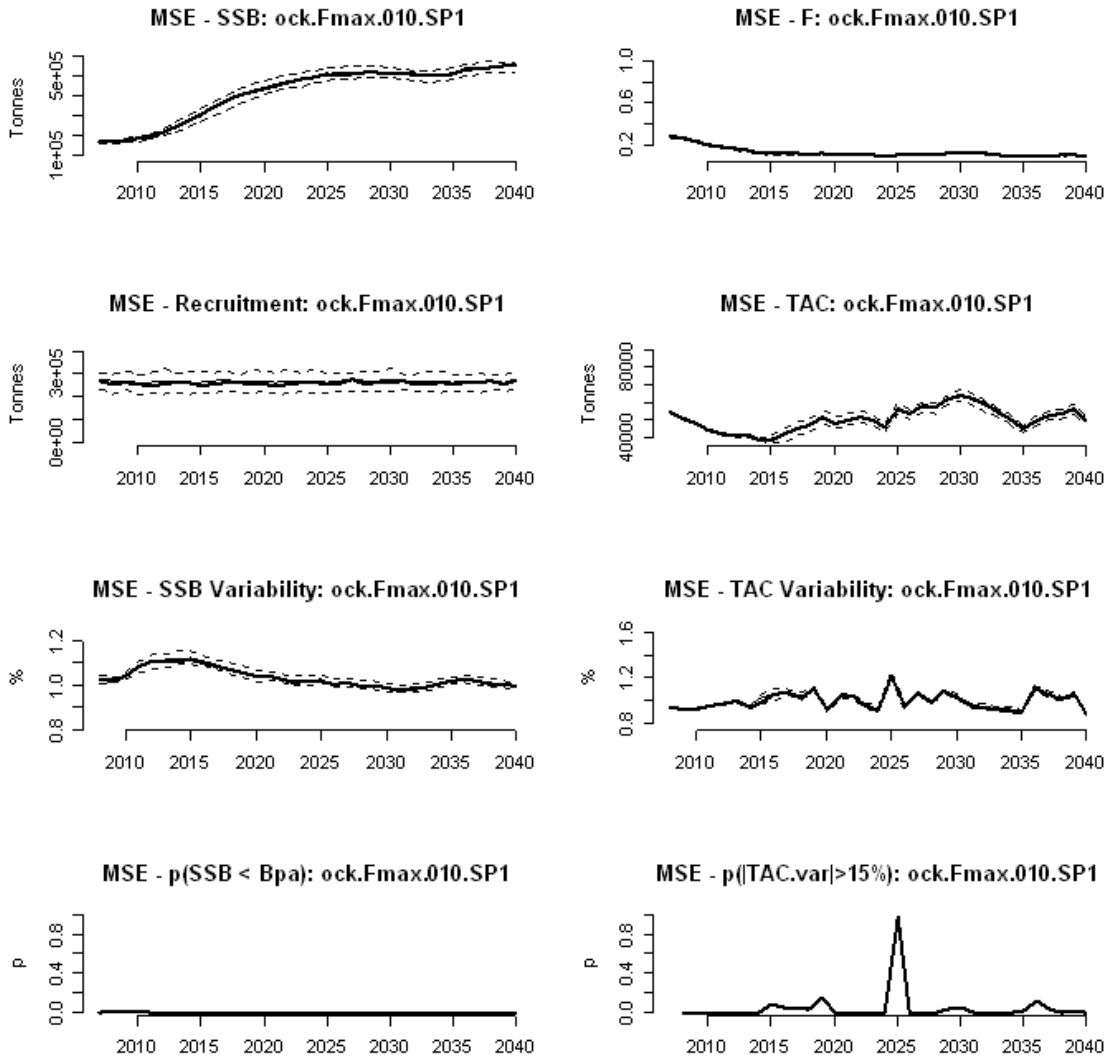

Fig. A.44. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

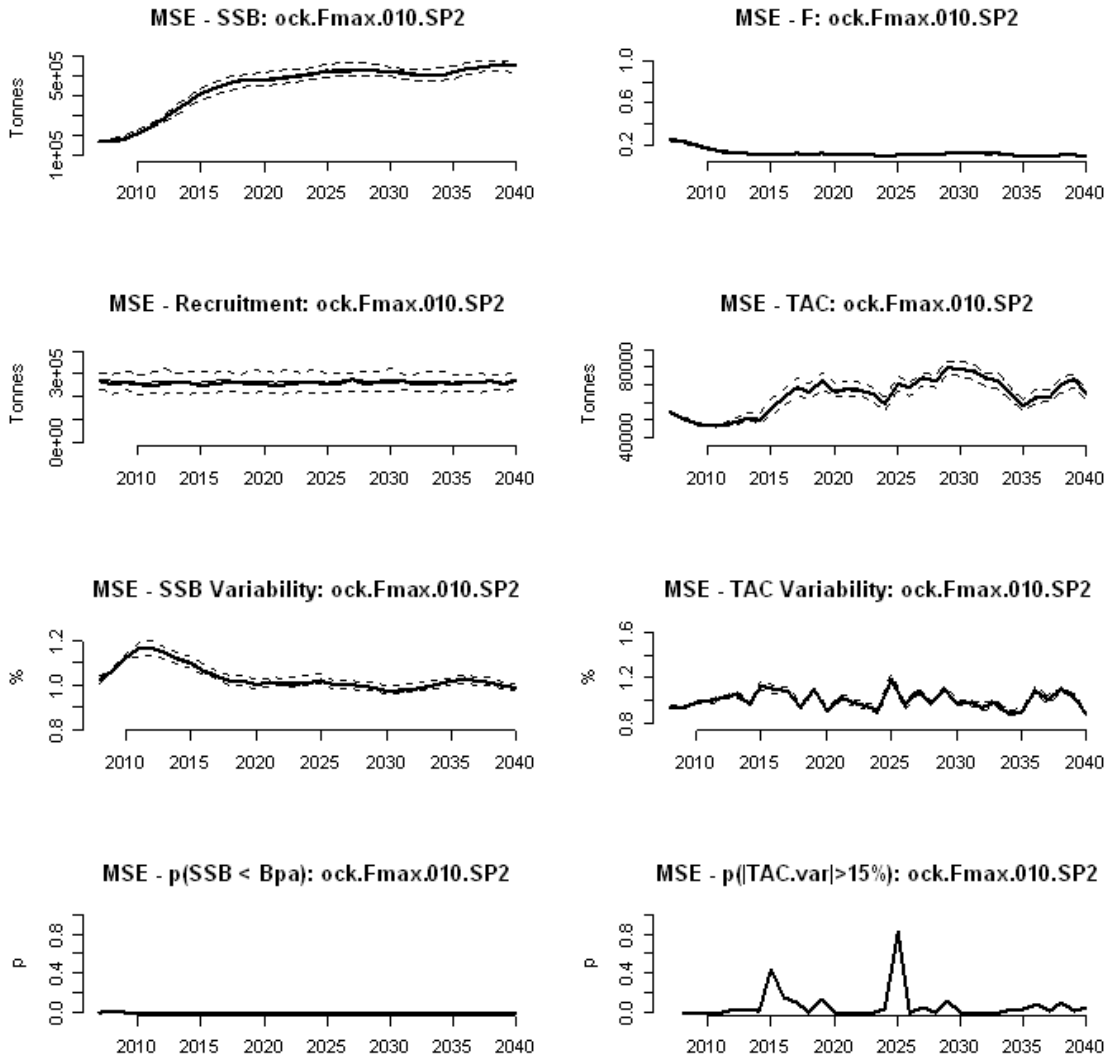

Fig. A.45. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

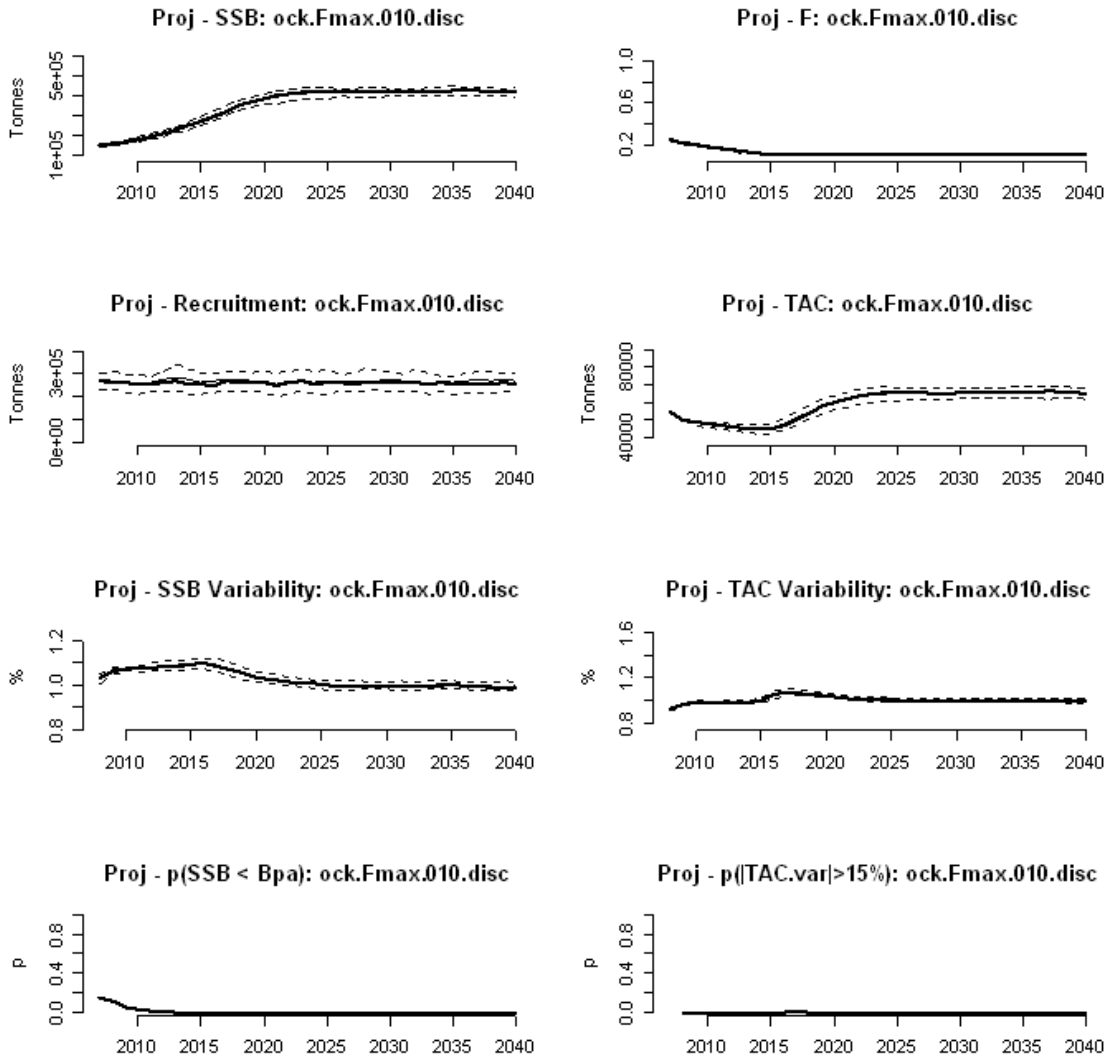

Fig. A.46. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

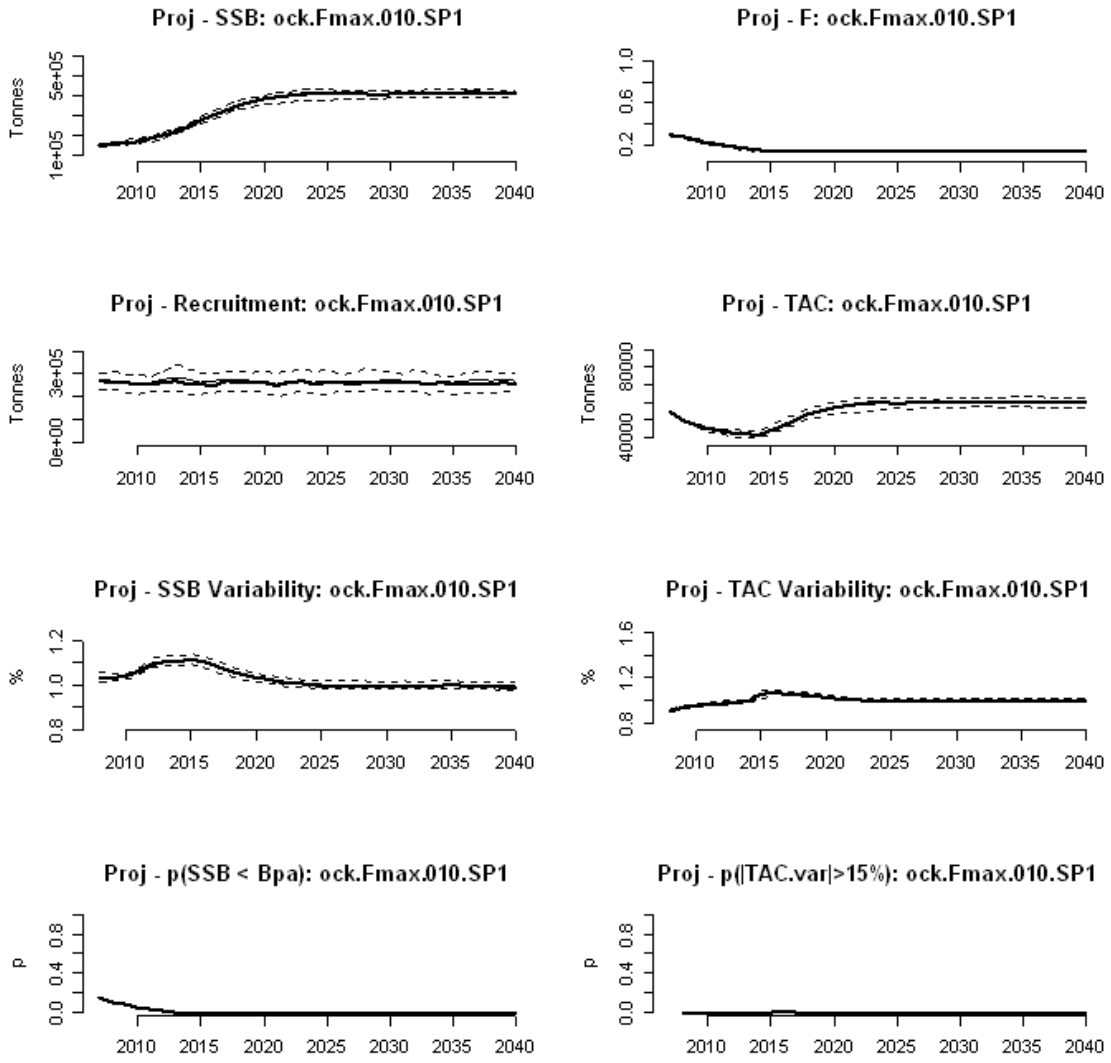

Fig. A.47. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

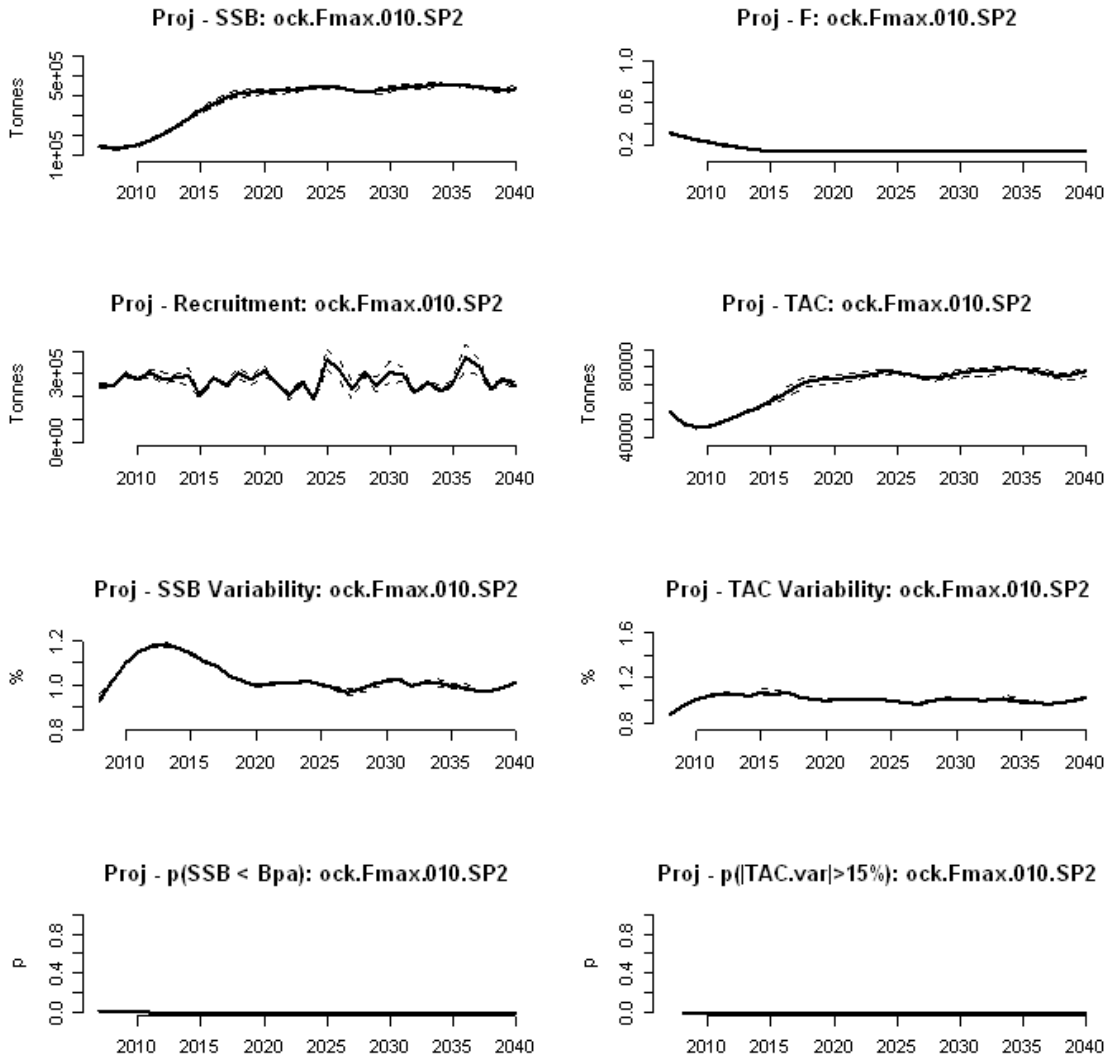

Fig. A.48. Median (solid line), 25 and 75 percentile (dashed line), mean (dotted line).

10. Annex II Expert declarations

Declarations of invited experts are published on the STECF web site on https://stecf.jrc.ec.europa.eu/home together with the final report.

European Commission

EUR 23644 EN **– Joint Research Centre – Institute for the Protection and Security of the Citizen**
Title: Scientific, Technical and Economic Committee for Fisheries. Report of Working Group on balance between resources and their exploitation (SGBRE). Northern hake long-term management plans (SGBRE-07-03).
Author(s): Jardim E., Santurtun M., García D., Biseau A., Cerviño S., Azevedo M., Andersen J.L., Prellezo R., Da Rocha J. M., Walmsley S., & Bertignac M.

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Abstract
SGBRE-08-03 was held on 4-8 June 2007 in Lisbon (Portugal). The meeting was focusing on the assessment of the impact of long-term management plans on northern hake stocks. STECF reviewed the report during its plenary meeting 18-22 June 2007.

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