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EU-Norway Ad Hoc Scientific Working Group

Multi-Annual management plans for stocks shared by EU and Norway

Brussels, 14 to 18 June 2004

CONTENTS

FIGURES

ACRONYMS AND ABBREVIATIONS

SSB	Spawning stock biomass
F	Annual Fishing Mortality
HCR	Harvest control regime
ICES	International Council for the Exploration of the Seas
MATES	EU project to evaluate long term multi-annual TACs for flat fish in the North Sea FISH/2001/02
MATACS	EU project to evaluate long term multi-annual TACs for demersal fish in the Baltic, North Sea and bay of Biscay. FISH-2000-02-01
TAC	Total allowable catch
B_{lim}	Lower Biomass limit to be avoided,
B_{pa}	Precautionary Biomass
B_{loss}	Biomass below which recruitment is reduced.
F_{lim}	higher limit for fishing mortality
F_{pa}	Precautionary Fishing mortality
F_{crash}	Fishing mortality exceeds replacement and causes a stock to collapse
F_{sq}	F status quo, (F=F in assessment year)
MSY	Maximum sustainable yield
B_{MSY}	Mean spawning stock biomass at maximum sustainable yield
F_{MSY}	Fishing mortality for maximum sustainable yield
TSA	Time series analysis based on Kalman filter – set of Fortran subroutines.
MTAC	Multispecies TAC allocation program
FEMS	Framework for the Evaluation of Management Strategies 3-year EU project Q5RS-CT-2002-01824 started 1 January, 2003
EFIMAS	EU project Operational evaluation tools for fisheries management options 1 April 2004-31 March 2008
COMMIT	EU project
WG	EU – Norway ad hoc scientific Working Group on multi-annual management plans for stocks shared by EU and Norway.

1. Summary

The Working Group has evaluated a range of harvest rules for the shared stocks in the North Sea, haddock, whiting, saithe, plaice sole and herring, with respect to yields, stability of yield ; and stock status with respect to risk of being below Blim. The WG did not explicitly choose a risk limit as safe biological limits but provided options with risks. As guidance the group considered that a risk of 5% would probably be regarded as precautionary. The evaluations were made on a single species basis, though the mixed fisheries exploitation of species was considered and preliminary concepts particularly for plaice and sole fisheries were developed.

METHODS

The types of harvest rules to be considered were harvest rules where TACs and/or fishing effort are derived according to a target fishing mortality, supplemented with a rule for reducing the mortality if the spawning stock biomass fell below a trigger level, to ensure avoiding a limit value for the spawning biomass. An additional constraint on the year to year variation of the TAC or F was included.

Some members of the group had received an annex to the agenda which contained comments by the Commission services. This annex also contained a list of candidate harvest rules for shared stocks. The group decided to consider only the original terms of reference and to regard the suggestions in the annex as illustrative examples of what could be done.

The rules were evaluated through simulations, taking as a starting point the state of the stocks on 1 January 2003 for all stocks except herring which was considered from 1 January 2004. Future recruitment was derived from stochastic stock recruit relationships fitted to the historic data. A limited exploration of sensitivity to the stock recruit model was carried out. Variability in weight at age weights and maturity at age were included by using historic variability. Where trends were observed only most recent years were included. Assessment error was derived from a simple examination of the performance of past assessments. Unaccounted mortality (e.g. unreported landings) was taken into account through inclusion of an implementation error in the model. The harvest rules were simulated with respect to the perceived state of the stock. The relation between this relatively simple approach and. the approach taken in the MATES/MATACS projects is discussed in the report.

The performance of the rules is presented with respect to the state of the stock expressed as a percentage chance of being above Blim in the underlying operating model population. Results are presented for differing levels of risk with a risk of 5% considered compatible with the precautionary approach. The development of the stock over the next 10 years resulting from an application of the rules is illustrated as percentiles of TACs, yield, spawning stock biomass and fishing mortality along with year to year variation in yield. Where stocks are outside safe biological limits at present, trajectories for recovery in five and ten years are presented.

Sensitivity or robustness of the analysis was evaluated by varying of simulation parameters. Implementation bias and assessment bias were seen to be the major technical control variables with the most severe effect on the performance of the harvest rules. Large uncertainties in the assessments (CV >25%) also had a substantial effect. The results for yield are very sensitive to the choice of stock recruit relationship and should not be taken as reliable in themselves, This is because the population dynamics (growth and recruitment) at higher biomass are not sufficiently understood and because the actual yield will be one specific set of realised recruitment coming from highly variable distributions not represented by the median.

The WG results should indicate whether qualitative changes in exploitation could be beneficial - delivering lower risk higher biomass and similar or higher yield. The precise parameters of harvest control rules cannot however be regarded as fully optimised. Due to time and planning constraints none of the harvest control rules have been fully evaluated for optimum performance, rather they have been tested against broad performance criteria. They should only be regarded as preliminary and need to be checked and monitored. This is particularly critical where it is intended to move the stock exploitation point to a

biomass for which no recent observations are available. With the exception of North Sea herring all the rules are untested in practice and should be carefully monitored and adapted over time as necessary.

RESULTS

The stock sections in the report provide details of a range of options for managers to choose from. The analysis indicated that saithe and herring are currently being managed at fishing mortalities that are near or below the optimal long term values. There is uncertainty in the current levels of exploitation for haddock but it is thought to be currently near the optimal long term value. The fishing mortalities of plaice and sole, however, are thought to be higher than optimal. A lower fishing mortality would give a more reliable yield for sole as well as a much lower risk and a moderate increase in long term yield for plaice. An analysis of whiting has been carried out but the uncertainties involved made it difficult to come up with useful recommendations. Only the main conclusions are provided here. The choice for managers is extensive and all the options cannot be included in a summary.

NORTH SEA PLAICE

If the risk of falling below B_{lim} in year 10 is to be below 5% and the historical biases observed in the assessment continue in the future, the analysis suggests that long term F should be set at 0.25. The reduction in fishing mortality could be achieved gradually over a time period of 5 or 10 years. However, the introduction of such a transition period is sensitive to the assessment bias. If the historically observed bias is maintained into the future, the aim of rebuilding the stock above B_{lim} with a high probability can be jeopardized.

The inclusion of discards into the assessment of North Sea plaice has a major effect on the long term equilibrium analysis. Comparisons between the STPR output and the long term equilibrium analysis suggest that an equilibrium situation may not have been reached after 10 years, which is the current limit on the STPR program. The modelling of the full feedback process (operating model – data collection – stock assessment – harvest rules) for North Sea plaice (and the interactions with sole) have not been finalized during the meeting. Preliminary results suggested that much larger and dynamic discrepancies may exist between operating model and perception than currently incorporated in the STPR approach.

NORTH SEA SOLE

Simulations indicate that a feasible long term F for sole in the North Sea might be in the region between 0.2 and 0.4. The expected long term yields for this stock are relatively stable for different fishing mortalities in this range. A fishing mortality of about 0.2 is more risk averse than an F of 0.4 without the loss of long term yield.

Substantial implementation error has been observed for this stock in the past. Sole is a high value species that is therefore prone to implementation error under restrictive management arrangements. Implementation error leading to a larger removal than the TAC was found to have a considerable impact by increasing the risk of biomass falling below the limit reference point at a given fishing mortality.

HADDOCK

Results for haddock are tentative as the available software did not allow an adequate representation of the recruitment dynamics as seen in the past, with occasional very large year classes. Because of this recruitment pattern, alternative kinds of harvest rules may need to be considered. A long-term F of < 0.3 should lead to a low risk of B falling below B_{lim} over the next 10 years. In general, lower F leads to reduced risk and higher yield. The starting point of simulations is uncertain, but the WG concluded that long-term considerations are not highly sensitive to this particular uncertainty.

SAITHE

Precautionary management of the saithe fishery can be achieved by several combinations of long term F and constraints on year-to-year variation in yield. The stricter the constraint, the lower F must be. There are no benefits in terms of increased long term yield to increase F above 0.3.

Several possible HCRs may increase SSB to levels not observed so far, where the effects on recruitment cannot be anticipated. The stock-recruitment issue will have to be revisited if the stock increases above previously observed levels. The perception of risk from this study is contingent on the assumed B_{lim} value. This value is currently set near some of the lowest observed SSBs, rather than based on population dynamics considerations.

Since the saithe stock is in a good condition, at the current F constraints in year to year variation in yield can be introduced in the fishery, without substantially increasing the risk.

WHITING

It was found difficult to envisage a fishing mortality that is precautionary as defined by a risk of $B < B_{lim}$ in 2013 of less than 5%. This is partly because of the high level of uncertainty with respect to the currents state of the stock, but may also indicate that the current B_{lim} for the whiting for this stock may be too high and it is recommended that this be considered further.

HERRING

The current harvest control rule and setting seems to be functioning well according to these simulations... However there are some matters for consideration.

Exceeding the levels of assessment and implementation error observed over the last 5-10 years are likely to result in an increased risk of $SSB < B_{lim}$.

The option of a linear F to biomass function between the depleted and long term regions of the HCR provides a 5% higher median yield than the constant F=0.2 setting at a slightly lower risk of $SSB<B_{lim}$,. However, this results in a slightly wider spread of yield but similar year on year change in yield. The impact of the abrupt change in yield at SSB=1300,000 is reduced but lower yields are obtained if SSB <1150,000 t.

There is a trade off between juvenile yield and adult yield. At comparable low levels of risk of SSB <Blim the total yield are higher when herring are taken as adult.

MIXED FISHERY ASPECTS

The harvest control rules investigated by the current WG imply substantial reductions in fishing mortality for most species. This may change the nature of the mixed species problem, particularly if it changes the abundance of the different species relative to each other. However, if the result is that all species are exploited at or below their long-term fishing mortalities, it would be much less critical to account for mixed-fishery effects in management. If the reduced Fs are achieved, another consequence would be that predator-prey interactions between and within species would have a more substantial influence on stock dynamics.

MODELLING APPROACHES

The performance of harvest control rules depend both upon the true dynamics stocks and our ability to perceive these trends. Discarding could act as a major cause for distorting our view of current stock status and could also distort our perception of the dynamics. An example was presented where discards were modelled and this showed a big difference between the true stock and our perception of it. This is also a cause for mismatch between quantities such as BMSY, FMSY, MSY and the fishing mortality that would cause the stock to collapse.

ORGANIZATIONAL ASPECTS

While considerable progress has been made, future meetings would benefit from a planning phase to identify the TOR and the participants; giving them more time to prepare. A planning meeting one month before the Working Group could allow time for the software refinements and user training needed to meet the needs of theWorking Group. In our case software modifications were required throughout the meeting.

2. Introduction

TERMS OF REFERENCE

1) The Working Group is requested to evaluate a range of harvest rules for the shared stocks in the North Sea, primarily haddock, whiting, saithe, plaice and herring, with respect to short, medium and long term yields, stability of yield and effort; stock status with respect to safe biological limits. Evaluations shall at a first instance be made on a single species basis, but the experts shall, to the extent possible, quantify mutual compatibility of the rules for stocks that are exploited in mixed fisheries.

- The types of harvest rules to be considered should include
- Harvest rules where TACs and/or fishing effort are derived according to a target fishing mortality, supplemented with a rule for reducing the mortality if the spawning stock biomass is below a trigger level, to ensure avoiding a limit value for the spawning biomass.
- Harvest rules as above, but with an additional constraint on the year to year variation of the TAC.
- Alternative rules if feasible.

2) The rules shall be evaluated through simulations, taking as a starting point the present state of the stocks concerned and taking into account *inter alia*:

- Alternative scenarios for future recruitments, weights and maturities at age, assessment error, discarding and other unaccounted mortality.
- Changes in fishing practise (i.e. selection at age).

3) The performance of the rules shall be evaluated both with respect to the perceived state of the stock and to the state of the underlying operating model population. The performance criteria shall include:

- Compatibility with the precautionary approach.
- Probability distributions of TACs, yield, spawning stock biomass and fishing mortality.
- Year to year variation in TACs, yield and fishing mortality.

4) Evaluations shall show:

- The robustness of the harvest rules in assuring stock recovery and maintaining stock within safe biological limits, considering a plausible range of scenarios as outlined in 3 and a range of alternative parameters as outlined in 2.

5) For stocks outside safe biological limits, the ability to ensure a safe and rapid rebuilding of the stock and a likely time frame for recovery.

- For stocks where different fleets exploit different segments of the stock (e.g. different ages), simulations shall give results for a range of alternative exploitation levels by these fleets.

The terms of reference for an earlier proposed meeting on this subject included an annex with candidate harvest rules for shared stocks. This annex was not included with the final agreed terms of reference. The Working Group therefore regarded the suggestions in the annex as illustrative examples of what could be done rather than a blueprint to be followed.

PARTICIPANTS

Are Salthaug
Institute of Marine Research
Nordnesgaten 50, P.O. Box 1870 N-5817 Bergen, Norway
telephone +47 55 23 85 00
ares@imr.no

Benoit Mesnil
Laboratoire MAERHA
IFREMER, B.P. 21105, F44311 Nantes Cedex 3, France
Telephone 02 40 37 40 09
Benoit.Mesnil@ifremer.fr

Carl O'Brien;
CEFAS (Centre for Environment, Fisheries and Aquaculture Science)
Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT
United Kingdom
telephone +44 1502 524256
c.m.obrien@cefas.co.uk

Coby Needle
FRS Marine Laboratory,
PO Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland
Tel: +44 (0) 1224 295 456
needlec@marlab.ac.uk

Dankert Skagen
Institute of Marine Research
P.O. Box 1870, Nordnes, 5024 Bergen, Norway
telephone +47 55 238 419
dankert@imr.no

Hans Joachim Rätz
Institute for Sea Fisheries
Palmaille 9, 22767 Hamburg, Germany
telephone +49 40 38905 169
hans-joachim.raetz@ish.bfa-fisch.de

Iain Shepherd
European Commission Joint Research Centre
I-21020 Ispra (Va), Italy
telephone +39 0332 789489
iain.shepherd@jrc.it

Laurence Kell
CEFAS (Centre for Environment, Fisheries and Aquaculture Science)
Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT
United Kingdom
telephone +44 1502 524257
l.t.kell@cefas.co.uk

Martin.Pastoors
RIVO,
P.O. Box 68, NL-1970 AB IJmuiden, Netherlands
+31 255 564 690
m.a.pastoors@rivo.wag-ur.nl

Sarah Kraak	Animal Sciences Group, Wageningen UR Netherlands Institute for Fisheries Research P.O.Box 68 1970 AB IJmuiden The Netherlands telephone +31 (0)255 564783 sarah.kraak@wur.nl
Tiit Raid	Estonian Marine Institute, University of Tartu Maealuse 10A, Tallinn EE-12618 Estonia telephone + 372 6718953 tiit.raid@ut.ee; raid@sea.ee
Stuart Reeves	Stuart A. Reeves Department of Marine Fisheries Danish Institute for Fisheries Research Charlottenlund Slot, DK2920 Charlottenlund, Denmark Telefone +45 3396 3467 sar@dfu.min.dk
John Simmonds (chairman)	FRS Marine Lab Aberdeen Aberdeen, Scotland, AB11 9DB, UK telephone +44 1224 295366 j.simmonds@marlab.ac.uk
Willy Vanhee	Ministerie van de Vlaamse Gemeenschap; Instituut voor Landbouw- en Visserijonderzoek; Departement voor Zeevisserij Ankerstraat 1, B-8400 Oostende Belgium telephone: +32 59-34 22 55 Willy.Vanhee@dvz.be

3. General Overview

HARVEST CONTROL RULES AND THE PRECAUTIONARY APPROACH

THE CURRENT APPROACH – SHORT-TERM CATCH FORECASTS AND THE PRECAUTIONARY APPROACH

Fisheries management advice is based on a set of implicit or explicit harvest control rules. Within Northern Europe the principal management tool is the total allowable catch (TAC) so the advice procedure typically leads to an advised catch. For stocks which are assessed annually, this catch target for each stock is calculated annually on the basis of a two year forecast based on the population one year prior to the fishing season, and a target fishing mortality, chosen to provide a precautionary management regime within defined reference points for biomass and fishing mortality (F). The SSB limit reference point $\mathbf{B_{lim}}$ is defined as the level below which recruitment is impaired, or the dynamics of the stock are unknown. A corresponding fishing mortality limit reference point $\mathbf{F_{lim}}$ is defined as the level of F that will drive the spawning stock to $\mathbf{B_{lim}}$. Recognition of uncertainty in estimating the current values of F and SSB has led to the use of two additional, more conservative, threshold reference points, $\mathbf{B_{pa}}$ and $\mathbf{F_{pa}}$, which act as triggers to initiate management action to conserve the stock before biomass or fishing mortalities reach the limits (ICES 2004a). Typically the precautionary reference level, F_{pa} is used as a target as the value provides the largest short term yield. If the assessment procedure indicates that the spawning stock biomass would fall below the precautionary biomass level, B_{pa}, in the subsequent two years, then a lower fishing mortality than the precautionary level is advised.

DIFFICULTIES WITH THE CURRENT APPROACH

There are indications for many stocks that managing fisheries at current fishing mortalities is not operating well. Annual variations in TAC can be substantial and recovery measures have had to be called upon too often. In order to address concerns expressed by the fisheries industry about these issues, simulations of this management strategy within the MATES project (Kell et al., 2001) were made for a thirty-year period for a range of important demersal stocks. These simulations indicated that because we are using imperfect models to make decisions based on an imperfect and out of date knowledge of current stock state, the outcome of decisions made can be quite different than that predicted during the assessment process. For many of the stocks considered, simulated applications of this rule led to biomasses at or below the B_{lim}, a level which is associated with a high risk of stock collapse.

In cases where Fpa is set to protect against recruitment failure, the results from the MATES project indicated that a strategy of aiming for a fishing mortality considerably less than $F_{pa,}$ can not only reduce the risk of stocks falling to these unsafe levels but also lead to higher yields (catches) in the medium to long term. Such lower F values lead to higher and more stable stocks as individual fish survive for longer and hence grow to a larger size. There is substantial benefit in this approach as it leads to the possibility of high and stable yields with little or no risk to the stock. Figure 0.2 shows some results from the MATES project for the Southern Hake stock which indicate a stock close to Bpa with a low yield, then a recovery trajectory to a higher stock and larger yield.

SIMULATIONS AND HARVEST CONTROL RULES

Computer simulations are used to evaluate the relative consequences of candidate harvest control rules (HCRs). The consequences are evaluated by summarising the results of a large number of simulated population trajectories, each of which has been subject to the same simulated HCR. A large number of simulations are run in order to reflect the range of variation which could occur due to natural variation (such as recruitment to the fish population) or variation in the precision of the population assessment or in the implementation of management measures. The results of all of these simulations are then summarised to give an estimate of one measure of risk to the stock. In the current context this is given as the probability of the stock being below Blim at the end of a ten year period. It should be noted that summaries across a wide range of simulations may not be particularly instructive for all purposes, as in reality only one sequence of populations, yields etc. will occur. This is illustrated Figure 0.3, which compares the results of simulations made to evaluate the proposed harvest control rule for North Sea herring from a starting point of 1996, with the population trajectory observed for the stock since then. Management of the stock has been based on that harvest control rule, and the assumptions made in running the original simulations are consistent with what has subsequently observed in the population so the comparison is valid. It can be seen that the population trajectory is consistent with the range of variation indicated by the simulations, but it does not follow any particular percentile.

While simulations provide a useful tool for the evaluation of potential harvest control rules, it is still necessary to treat the results with some caution. This is particularly true if the simulation results in stock sizes outside of the range which has been historically observed, where the dynamics, particularly of recruitment, are unknown.

SIMULATED HARVEST CONTROL RULE

The potential benefits of a lower mortality target indicated by the results of the MATES project suggest that further exploration of such regimes might be fruitful. In this report we summarise the results of a number of simulations of stocks for a ten year period using the kind of harvest control rules outlined in the terms of reference.. These rules aim provide stability for the fishery and in some cases to move the fishery from an unstable, high-risk regime to a stable, lower-risk one with the added benefit of a higher long-term yield.

The harvest control rules described in this report aim to achieve this through a long-term fishing mortality F_{LT}. For any stock biomass above $B_{trig,}$ a mortality of F_{LT} is aimed for. If in any year the biomass should fall below this level then the harvest control rules are set so as to achieve a lower fisheries mortality which is chosen depending on the assessed biomass. Between the trigger biomass B_{trig} and the biologically unsafe level, B_{lim}, the fisheries mortality is reduced linearly to a new fixed lower level. This rule is illustrated in Figure 0.1. Where current exploitation is not close to F_{LT} the working group also consider possible ways of moving from current F to the lower long term $F_{LT.}$

DETAILED IMPLEMENTATION

The simulations assumed that the stock is targeted by up to two separate fleets, each having a characteristic pattern of targeting age classes. The simulations include a decision rule for next year's fishery which is as follows.

The first step in the procedure is to calculate the yield, *Y,* for each fleet is the maximum that satisfies the following constraints.

Table 0.1 target fisheries mortality as a function of spawning stock biomass

Spawning stock biomass (SSB) in projection year	F
SSB < B_{lim}	$\leq F_{dep}$
B_{lim} < SSB < B_{trig}	$\leq F_{int}$
B_{trig} < SSB	$\leq$Flt

The change in catch for year n between the proposed catch C_n and last year's allocated catch resulting from this algorithm, Δ_c

$$\Delta_c = \frac{C_n - C_{n-1}}{C_{n-1}}$$

can be constrained by a maximum reduction factor and a maximum increase. If the catch would fall outside these values it is set to the limit value. This constraint can be applied to one fleet or the sum of both

The change in fisheries mortality Δ_F

$$\Delta_F = \frac{F_n - F_{n-1}}{F_{n-1}}$$

can be similarly constrained between a maximum reduction and a maximum increase.

However both the maximum catch and mortality reduction constraints may be over-ridden if the fishing mortality would move the target value stated in the basic harvest control rule. Moreover, constraining catch variation may lead to very high fishing mortalities if the stock is being reduced rapidly. To protect against this, a maximum permissible fishing mortality can be defined as one of the options for the simulations.

In a rebuilding situation, the harvest rule may include a requirement that the spawning stock biomass shall increase at least a certain percentage each year:

$$\frac{SSB_n}{SSB_{n-1}} \geq f_{ssb}$$

This constraint can apply to the fishery targeted by fleet 1 or fleet 2 or both.

The procedure followed is:

1. check catch variation
   a. If the catch increases too much, reduce F
   b. If the catch decreases too much, increase F,
   c. but not above the F set as the highest permissible F.
2. check fisheries mortality variation
   a. If the F increases too much, reduce F
   b. If the F decreases too much, increase F,
   c. but not above the F set as the highest permissible F.
3. check variation in spawning stock biomass
   a. If SSB ratio is too low, reduce F (levels 1 and 2 only)

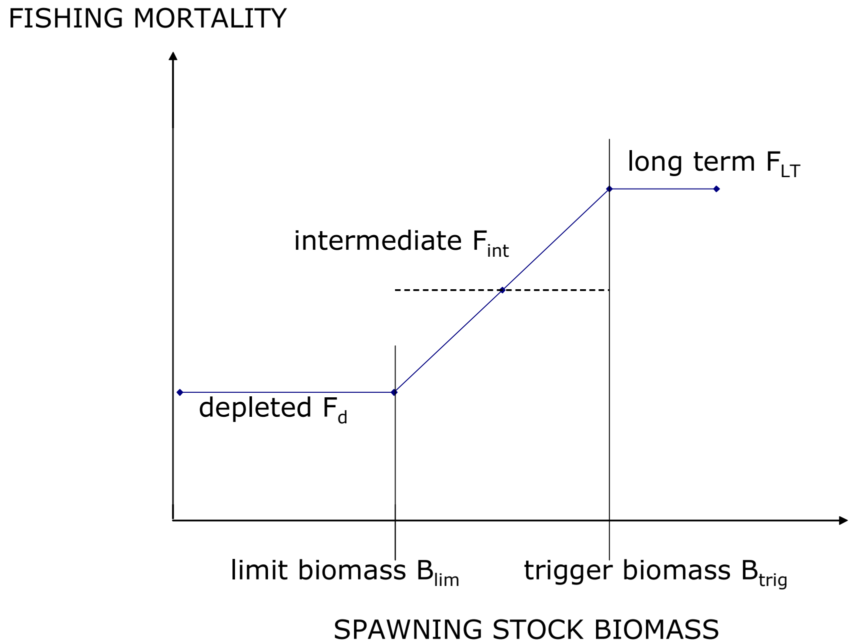


Figure 0.1 schematic diagram of harvest rule. There are three biomass regions; 1) Full exploitation, SSB is above Btrig -the long term fishing mortality is F_{LT}, 2) Intermediate region, SSB between B_{lim} and B_{trig} $F = F_{int}$ or F varies linearly with SSB from F_d to F_{LT}, 3) Depleted region, SSB is less than B_{lim}, $F=F_d$

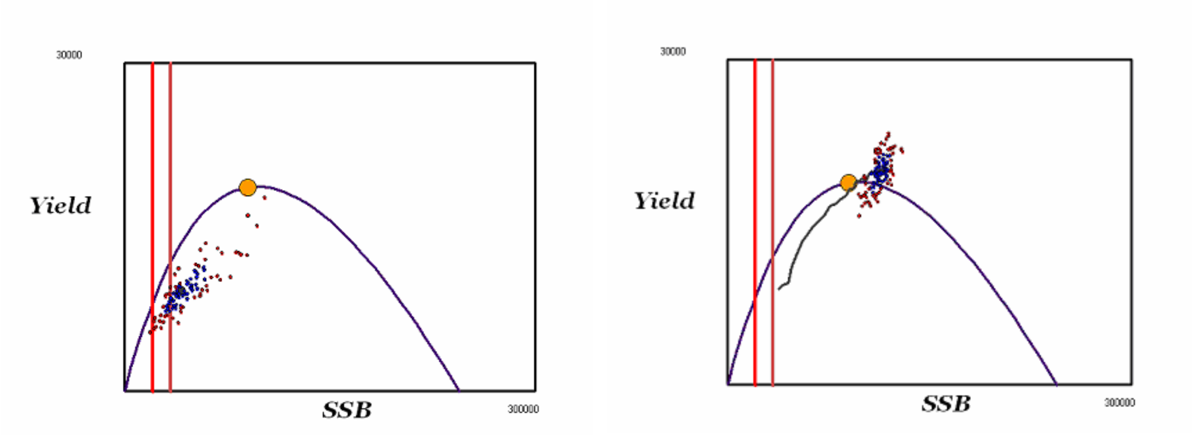


Figure 0.2 Results from MATAC simulations for hake, The equilibrium curve corresponds to the expected long-term consequence of fishing at a constant F. Also shown are the limit and precautionary biomass reference points as the two vertical lines. The yellow dot on the curve represents the expected yield and SSB for the fishing mortality that is trying to be achieved by the management strategy. The blue points represent the inter-quartile range of simulated results and the red the outer-quartile range. The grey line shows the previous expected realised yields and SSB. The left hand plot shows the situation at the start of the simulation period and the right hand one after 30 years..

a) *Yield and spawning biomass at the start of the simulation period, yield is currently less than would be expected at the current spawning stock biomass so the stock would be expected to recover in the medium-term. It can also be seen that there is a high probability of the stock falling below Blim.*

b) *Consequences for yield and spawning biomass of fishing at a fishing mortality of 0.27. It can be seen that yield and spawning stock biomass do increase in the long-term. Yield is high and F is less and there is a low risk of SSB falling below Bpa. Importantly the target point is not actually achieved due to bias in the management procedure*

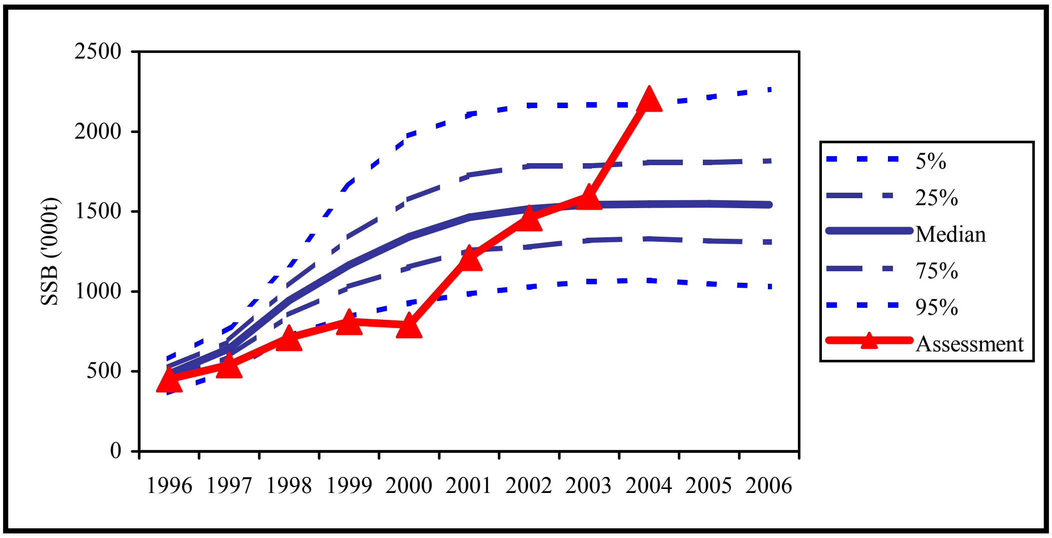


Figure 0.3 Summary of harvest control projections of spawning stock biomass for 1996 to 2006 for North Sea herring, compared with the observed population trajectory from 1996 to 2003 with 2004 projected. The projections assume the knowledge of the stock in 1996 and the assessment and implementation errors actually observed 1996 to 2003.

SOURCES OF INFORMATION

The data used as a basis for the simulations come from ICES assessment working group stock data. For plaice, sole, haddock, saithe and whiting the working group was WG North Sea Skaggerak and Kattegat (WKNSSK) and the data was taken from the most recent WG, the

2003 assessment data (ICES 2004b). For North Sea herring the most recent assessment WG was in March 2004 and ACFM accepted the assessment in May 2004. So for this stock the most recent ICES data comes from the 2004 Herring assessment working group report (ICES 2004c). In formation on agreed management objectives and reference points for these stocks come from ACFM reports in October 2003 (ICES 2004a) for demersal species and May 2004 (ICES 2004d) for herring.

METHODS AND SOFTWARE

The WG took advantage of the experience from previous studies for the stocks under consideration, among others, notably the MATES and MATAC projects. (Kell et al, 2004abc). A summary of these projects and a more detailed analysis of implementation error and the effect of differences between the actual and perceived dynamics are presented in section 7.

The main tool used by the present WG was medium term simulations of the development of the stock and the yield over a 10 year range, under a variety of harvest rule specifications. The state of the stock in year 10 was used to give some indication of the long term performance of the harvest rule, and to provide information on the choice of target fishing mortality. In addition, foe a small number of specific harvest rules trajectories over the 10 year period were made to show the possible transition from the present state towards the long term state. The projections were performed with the STPR3 software, supplemented with a version (S3S) made to ease screening over ranges of model parameter choices. The software documentation is included in Appendix 1, and the software is available.

The simulations covered alternative scenarios for future recruitment, weight and maturity at age, assessment error, discarding and other unaccounted mortality, as well as changes in fishing practice to the extent that was considered feasible and possible within the time the WG had available. Only selected scenarios are presented.

The harvest rules were examined with respect to error in future assessments by assuming that the stock numbers at age, and hence the SSB on which managers make their decisions deviates from the real state of the stock. This was done by a simple stochastic multiplier on the sock numbers as seen by decision makers. Likewise, discrepancy between the decided TAC and the catch actually taken was simulated by a common implementation multiplier. Uncertainty due to measurement (i.e. sampling of the catch derivation of CPUE) estimation within the assessment process, model mis-specification and implementation error were not explicitly modelled but assigned a combined assessment error... However, varying feedback between the assessment process and the management decision making process was not included. Feedback can cause bias in the assessment to affect the management and thus the stock which in turn affects bias in the assessment.

The simple approach in STPR allows for some evaluation of the robustness of a harvest rule to such errors, but does not pretend to foresee how these errors will appear in the future. However, to be feasible, one would assume that the harvest rule still should lead to a precautionary management if these errors have an order of magnitude that has been experienced in the past. It may be noted that previous implementation error that has not been accounted for, although it will have influenced the perception of the stock in the past. Hence, implementation error should only cover cases where it may be different from what it was in the past or already documented and explicitly included in past data. The procedure used for all the stocks presented here follows this usage of implementation error.

This simple implementation of future assessment and implementation errors does not take into account delay in realising and responding to changes in the state of the stock, which is known to amplify deviations from the intentions of a management regime. The assessment and management process includes important time lags between the monitoring, assessment and control processes. Actually determining the effectiveness of any management action may take longer then the nominal time lag since assessment methods in general perform poorly in detecting changes in the recent period. Including such lags in simulations may have substantial impact on the output in terms of performance criteria, in particular if the stock abundance fluctuates widely and the information about incoming year classes are sparse. Such effects are not explicitly modelled in the STPR software, which only allows for exploring the effect of a simple fixed bias with random error in the basis for management decisions.

Assumptions about future recruitment and its dependence on SSB are crucial in this kind of simulations. Critical factors are:

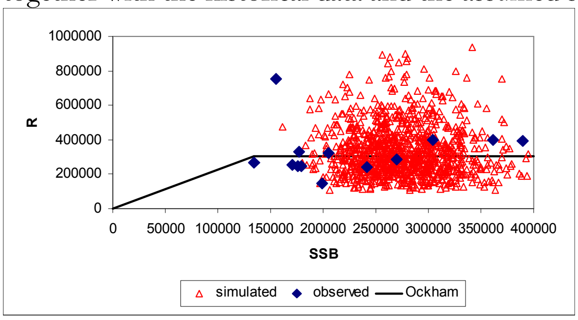
- the form of the relationship at low SSB, which pertains to the ability of the stock to rebuild from a low SSB.
- the form of the relationship at very high SSB, in particular whether the recruitment gets reduced when the stock is very large.
- the level of recruitment over the range of SSBs. This determines both level of catches and SSB, and the risk that SSB will fall below specified limits.

The shape of the stock-recruitment curve can be quite sensitive to bias in the historical stock-recruit data. Such bias can be caused when discarding is related to length-at-age and growth rates vary with time as in the example of North Sea plaice or due to misreporting in the past, and any other uncertainty in historical data, which is not accounted for in assessments of the history of the stock. Also, for most models, the shape of the curve at low SSB is heavily influenced by observations at high SSB and vice versa (Bravington et. al. 2000).

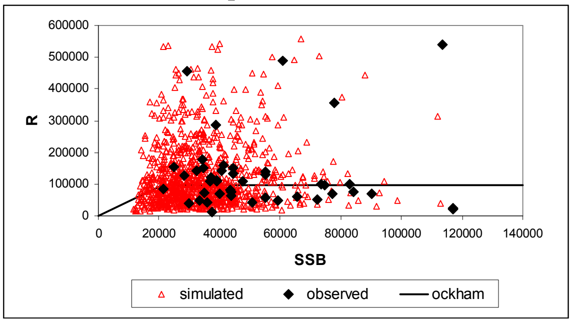
It is difficult to decide upon the "correct" Stock recruitment relationships the parameters of which may even vary in the presence of underlying (but unknown) time trends in productivity (Peterman et al. 2000). Therefore the approach taken in MATACS and MATES was to implement alternative stock recruitment relationship within the simulated stock (i.e. the operating model) and to evaluate outcomes on the basis of their robustness to uncertainty about the true relationship.

The approach taken by the Working Group has been to choose a single stock recruitment relationship based upon the historic data and when in doubt about the appropriate model, to make the very simplistic assumptions that recruitment is independent of SSB above a break-point SSB, and that it decreases linearly towards zero with SSB below this break-point (the so-called Okham model). This choice can be justified by the observation that various commonly used models, with quite different implications, are equally likely on statistical grounds. Moreover, this simplistic approach is compatible with the historical data, and any inference about recruitment outside the historical range of SSB depends on assumption on how the stock will behave in those regions..

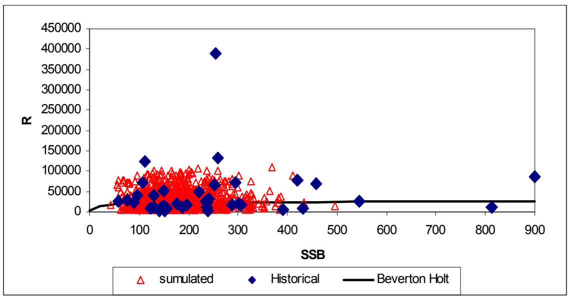
Figure 0.1 shows the assembly of SSB-recruit pairs generated by the simulation model in year 10, together with the historical data and the assumed stock-recruit relationship



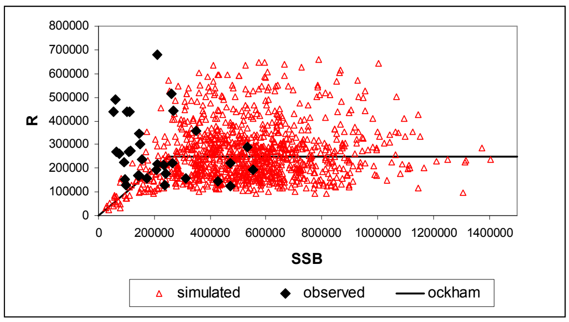
a) Observed modelled and simulated stock recruitment for North Sea Plaice



b) Observed modelled and simulated stock recruitment for North Sea Sole

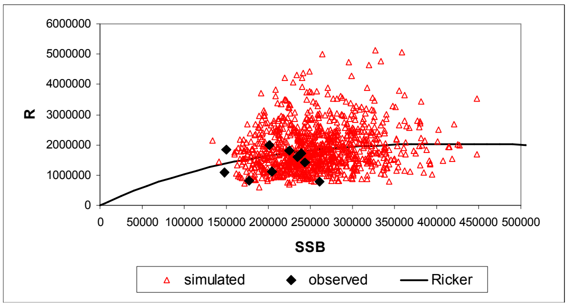


c) Observed modelled and simulated stock

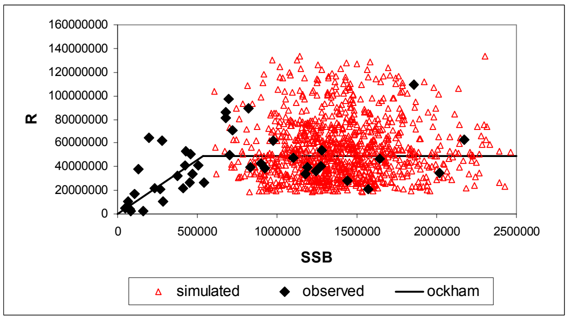


d) Observed modelled and simulated stock recruitment for North Sea haddock

recruitment for North Sea and West of Scotland Saithe



e) Observed modelled and simulated stock recruitment for North Sea whiting



f) Observed modelled and simulated stock recruitment for North Sea herring

Figure 0.1 assembly of SSB-recruit pairs generated by the simulation model in year 10, together with historical data and the assumed stock-recruit relation

4. Stock-based analyses

Analyses of individual stocks are given separately for plaice, sole, saithe, haddock, whiting and herring. Limited exploratory analyses were carried out to obtain plausible HCRs. The results are presented as a range of options comparing yield, fishing mortality and risk. If there are important changes in exploitation regime are included in the options, transition options are also presented. A sensitivity analysis showing the dependence on assessment and implementation errors is provided for each stock. Finally the conclusions are presented for each stock.

NORTH SEA PLAICE

INTRODUCTION

Description of the fishery

North Sea plaice is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea. Directed fisheries are also carried out with seine and gill net, and by beam trawlers in the central North Sea. Due to the minimum mesh size (80 mm in the mixed beam trawl fishery), large numbers of undersized plaice are discarded. It is estimated that the mixed fishery takes around 50% of the plaice landings.

The number of vessels in the fleets exploiting North Sea plaice have generally decreased in the last 10 years, partly due to the MAGP policy. The Working Group Members believe that fishing effort has decreased in the major fleets. The reductions in effort have not been mirrored in a reduction of fishing mortality in the most recent stock assessments of plaice and sole.

Management applicable

The advice for North Sea plaice is formalised in an agreement between the EU and Norway which implements a long-term management plan based upon biological reference points for both spawning stock biomass (SSB) and fishing mortality (F). Currently, $\mathbf{B_{lim}}$ is 210,000 t and $\mathbf{B_{pa}}$ is 300,000 t. $\mathbf{F_{lim}}$ is set at 0.6 and $\mathbf{F_{pa}}$ at 0.3.

The management of plaice is not formally connected to the management of sole in the North Sea although the fisheries are linked to a considerable extent. The sole stock is not a shared stock with Norway, whereas plaice is a shared stock. The issue of mixed fisheries issues is further addressed in section 0 and section 5

STRATEGIC CHOICES

The current estimate of F *status quo* in 2003 is 0.51, and the current estimate of SSB in 2003 is 152000 tonnes, which is substantially below Blim (210000).

The harvest control rule investigated makes use of Blim = 210000 tonnes and a Trigger SSB set at Bpa = 300000 tonnes. F depleted is set at 0.05, and F intermediate increases linearly from F depleted to long term F with SSB. One fleet was assumed. Table 0.1 shows the main parameters used in the calculations.

Table 0.1 North Sea Plaice parameters used for simulation

Run settings for STPR/S3S		Parameter
Youngest/oldest age		1-10
Ref F age interval		2-6
Fsq		0.51
Blim		21 000
Trigger Biomass (B_{trig})		30 000
F-level 1 (depleted) (F_d)		0.05
F-level 2 (intermediate) (F_I)		Linear
Max TAC change		not constrained
Max F change		not constrained
Maximum F		1.5
SRR Model		Ockhams razor
	GM	30 500 thousands
	Bloss	134 000 tonnes
	std-residuals on rec.	0.426
	max-value rec.	1.2
Assessment-bias		1.0
Assessment-std		0.1
Implementation-bias		1.0
Implementation-std		0.05

The exploration consists of two parts. The first part (this section) describes efforts aimed at finding the long term F with the highest long term yield (here yield in year 10) with a risk <5% of SSB falling below Blim (in year 10). Note that the simulation by STPR3/S3S is limited to 10 years, while there is no guarantee that the equilibrium has been reached by year 10. The second part (section 0) is aimed at finding the optimal trajectory for reaching the long term F from current F.

In these explorations an Ockham's razor recruitment function was assumed, with the break point at Bloss (134000 tonnes), and the geometric mean of recruitment in 1990-2002. In Figure 0.1 the SRR observed in 1990-2002, and the one simulated in the base scan (see below) are shown.

In the exercise of searching the optimal long term F, the STPR3/S3S simulations were run without constraints on year to year change. A scan was performed as follows:

- Long term F ranging from 0.2 to 0.5 in steps of 0.01,
- Assessment bias set at 1.0 (error 0.1), i.e. no assessment bias and 10% CV.
- Implementation bias set at 1.0 (error 0.05), i.e. no implementation bias and 5% CV..

The input parameters are shown in Table 0.1. F-yield plots with indications of risk level, risk-F plots, and risk-yield plots are shown in Figure 0.2

A second scan was performed as follows:

- Long term F ranging from 0.2 to 0.5 in steps of 0.01,
- Assessment bias ranging from 0.8 to 1.4 (error 0.1),
- Implementation bias set at 1.1 (error 0.05),

The rationale for the choice of the range of assessment bias, is that it is not clear whether to expect a positive or a negative assessment bias. Historical assessment bias has been of the order of 1.2 (and recently even higher). However, applying shrinkage when F is declining will result in an overestimate of F and therefore an underestimate of SSB. Implementation bias is to be expected when management restricts the catches.

F-yield plots with indications of risk level, risk-F plots, and risk-yield plots are shown for two levels of assessment bias, in Figure 0.3 for assessment bias of 1.2 (error 0.1), and Figure 0.4 for assessment bias of 0.9 (error 0.1).

Assuming that SSB is overestimated by a magnitude of around 1.2, 0.25 is the long term F with the highest yield with a risk <5% of SSB falling below Blim (Figure 0.3). In case SSB is underestimated, a long term F of 0.25 will pose low risk, as well as any other long term F between 0.2 and 0.4 (Figure 0.4).

In conclusion, if risk of falling below Blim in year 10 is to be below 5%, this limited scan suggests that long term F should be set at 0.25. This number is sensitive to the assessment bias assumed. The higher is the assessment bias, the lower is the long-term F required to achieve a low risk.

SENSITIVITIES

The search for the optimal trajectory to get from current F to the long term F of 0.25 was carried out with the base settings as in section 4.1.1:

- assessment bias 1.0 (error 0.1)
- Implementation bias 1.0 (error 0.05).

Two options for year to year decline in F were investigated:

- a decline from current F to F = 0.25 over 5 years, corresponding to a yearly decrease in F of 13%,
- a decline from current F to F = 0.25 over 10 years, corresponding to a yearly decrease in F of 7%.

Within these two options two further options were investigated:

- the year to year change in TAC is not constrained,
- the year to year change in TAC is constrained to a maximum of 15%.

Some results of these four explorations are shown in Table 0.2 and in Figure 0.5, Figure 0.6 and Figure 0.7.

Table 0.2 results of exploratory calculations

Long term F	Period taken for decline (years)	Max.15% year to year change in TAC	Risk % in year 10	Median yield in year 10 (tonnes)	Median cumulative yield in 11 years (tonnes)	Median lowest yield of 10 years (tonnes)	Median year of recovery above Bpa
0.25	5	No	0.0	85014	822548	61730	2011
0.25	10	No	9.1	70109	845272	70109	No recovery
0.25	5	Yes	5.3	77203	653317	66191	2010
0.25	10	Yes	22.2	72746	838008	71148	2012

With a decline in 5 years, without constraints on year to year change in TAC, recovery above Bpa is reached in year 2011. This is the only scenario with a risk of 0% in year 10, and the highest yield in year 10. However, yield goes through a dip in the course of the trajectory (around year 6). The lowest yield found is, however, not below the TAC for plaice in 2004 (61000 tonnes). In the scenario where the decline takes place over 10 years without constraint on year to year change in TAC, the risk is >5%, no equilibrium is reached in year 10 (the lowest yield in the period is the yield in year 10) and no recovery above Bpa is reached within the simulation period. However, cumulative yield over the 11 year period is higher than with a decline over 5 years. It appears that implementing a constraint on year to year change in TAC, leads to a higher risk of falling below Blim in year 10. In the case of a decline over 5 years, the risk is still quite low (5.3%), the dip in yield is less deep than without constraint on year to year change in the TAC, but the yield in year 10 and the cumulative yield are lower than without constraint.

Sensitivity to assessment bias and implementation bias

Subsequently, the trajectory that was found to have low risk (from current F to long term F in 5 years without constraint on change in TAC) was simulated under the following assumptions:

- assessment bias of 1.2 (error 0.1)
- Implementation bias of 1.1 (error 0.5).

Historical assessment bias has been of the order of 1.2 (and recently even higher). Implementation bias is to be expected when management restricts the catches. The results are in Table 0.3.

Table 0.3 sensitivity calculation for North Sea Plaice

Long term F	Period taken for decline (years)	Max.15% year to year change in TAC	Risk % in year 10	Median yield in year 10 (tonnes)	Median cumulative yield in 11 years (tonnes)	Median lowest yield of 10 years (tonnes)	Median year of recovery above Bpa
0.25	5	No	14.1	84538	776508	57835	No recovery

With such assessment bias, the risk of falling below Blim is above 5% and there is no recovery above Bpa within the simulated period. The yield in year 10 is still good, but the dip in yield around year 7 is deeper, and the cumulative yield is lower (see also Figure 0.7.).

In case assessment bias is in the order of 1.2 and the implementation bias is in the order of 1.1, this HCR will have high risk of SSB falling below Blim. The risk will be increased if implementation bias is higher.

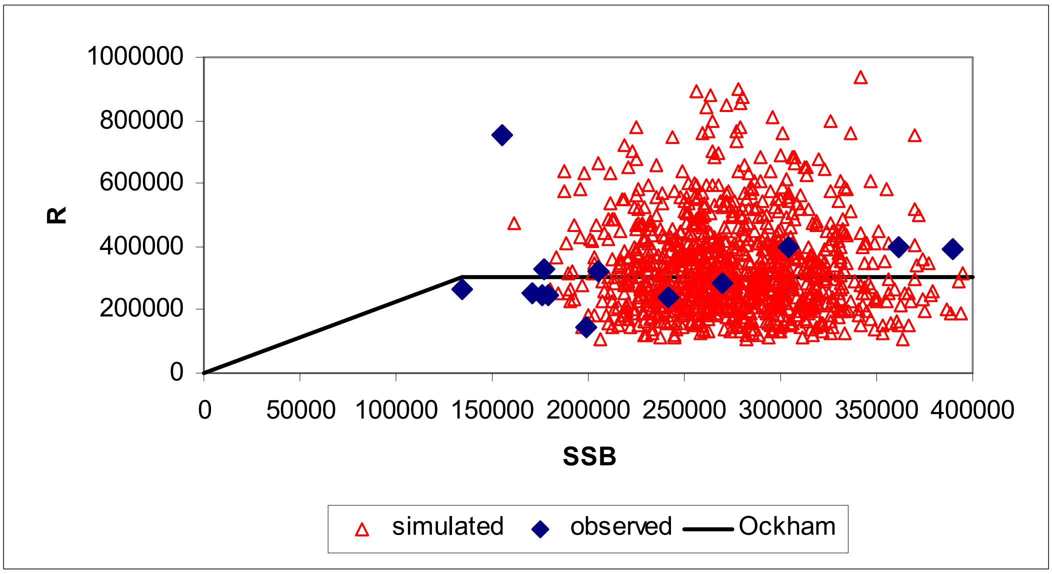


Figure 0.1 Plaice. Observed recruitment (1990-2002) and simulated recruitment in year 10 of the base simulation.

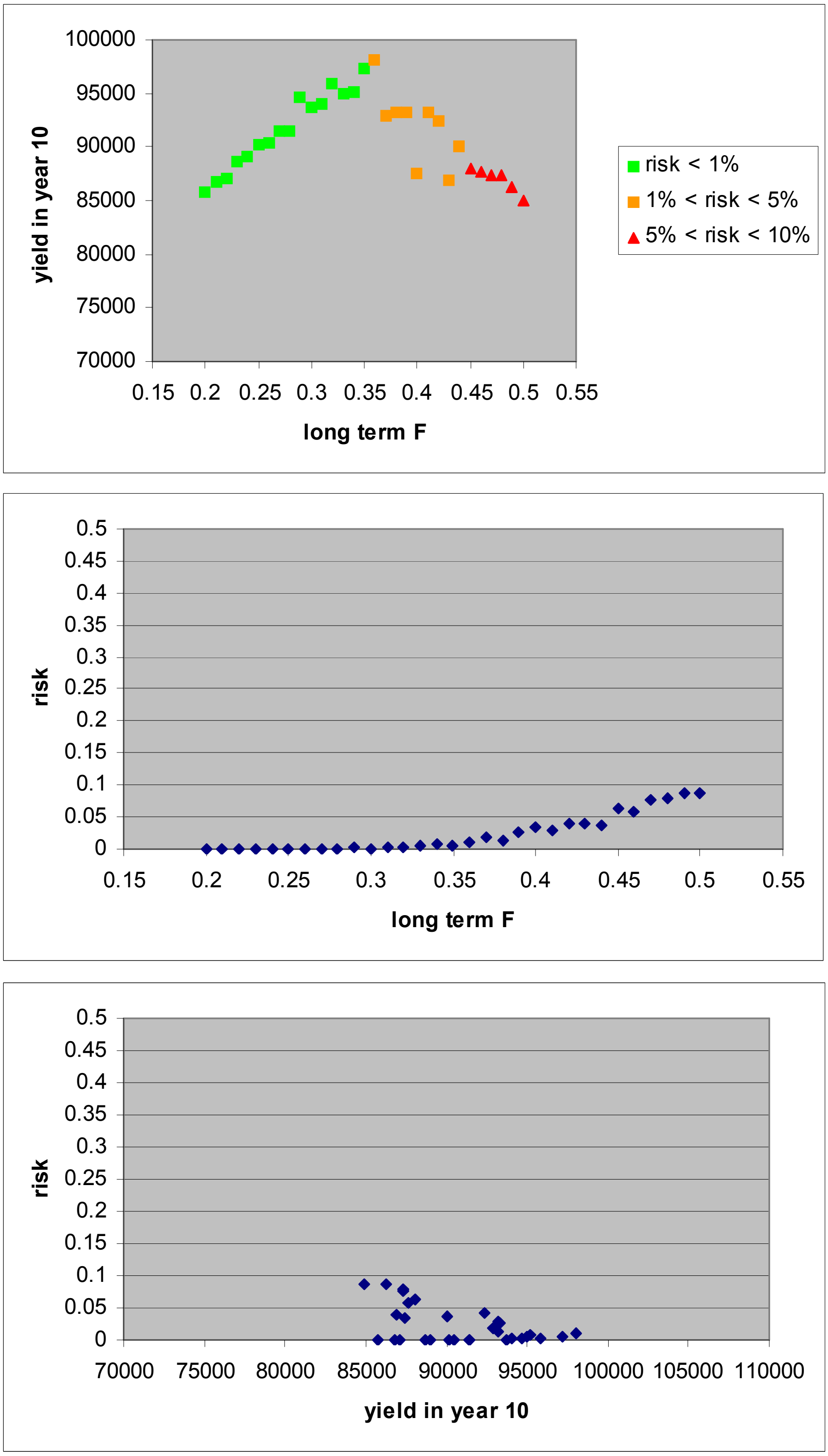
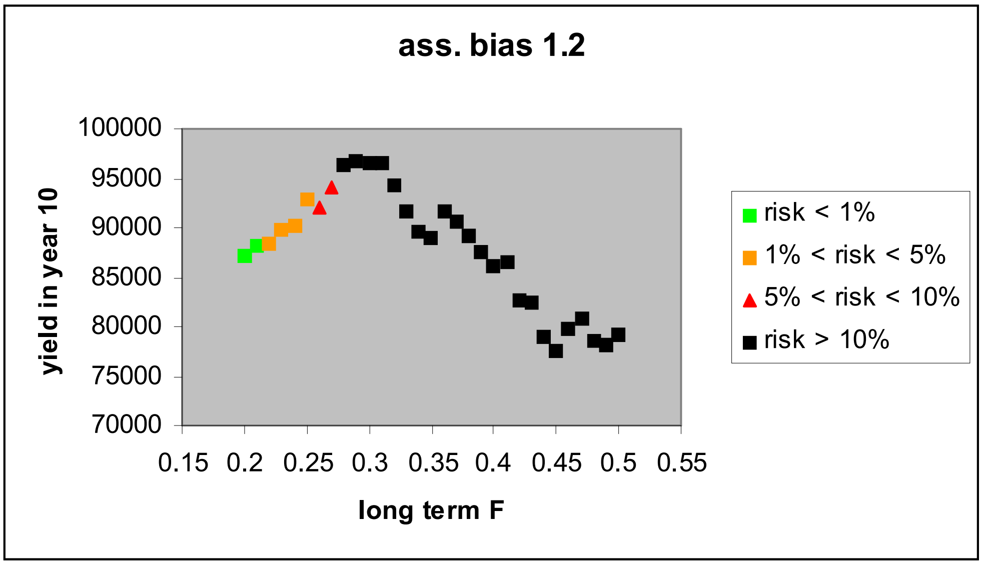
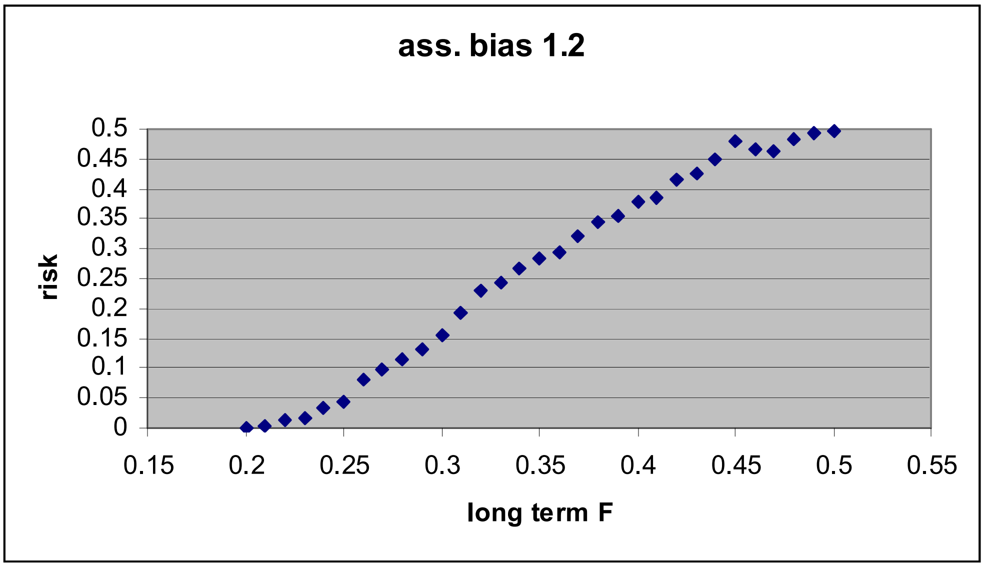


Figure 0.2 Plaice. Base scan of long term F





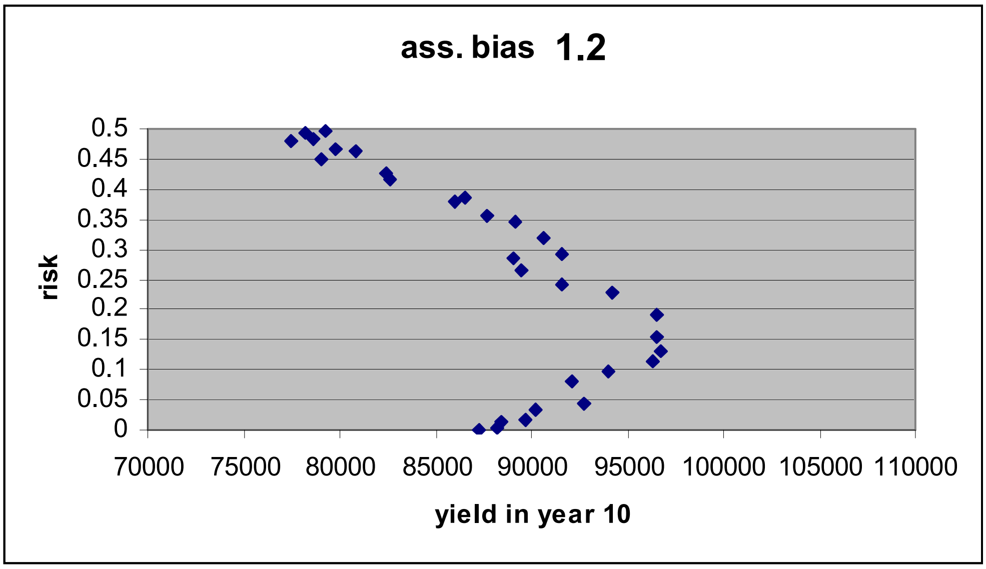


Figure 0.3 Plaice Scan of long term F with assessment bias at 1.2 (+ 0.1).

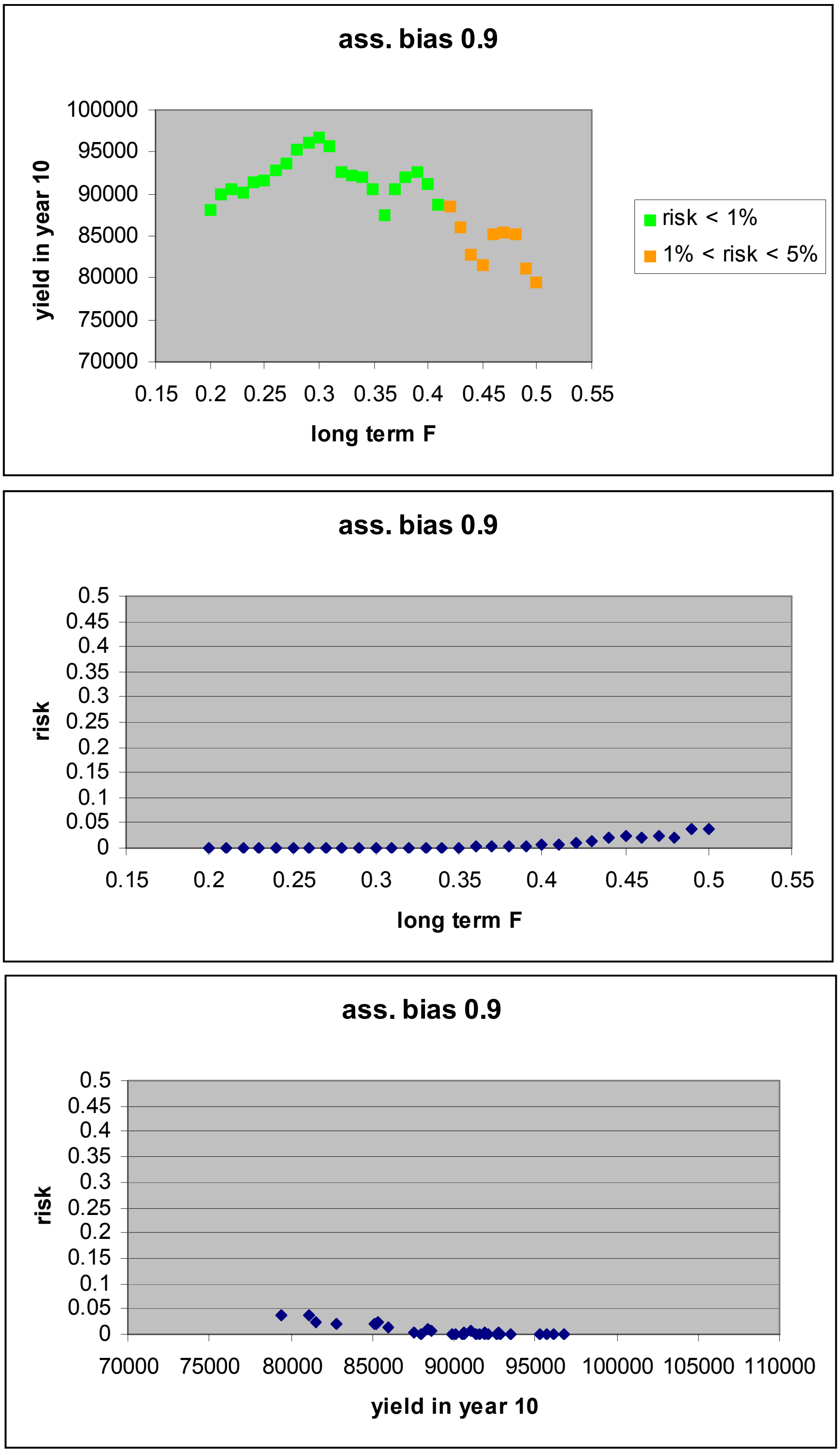


Figure 0.4 Plaice Scan of long term F with assessment bias at 0.9 (+ 0.1).

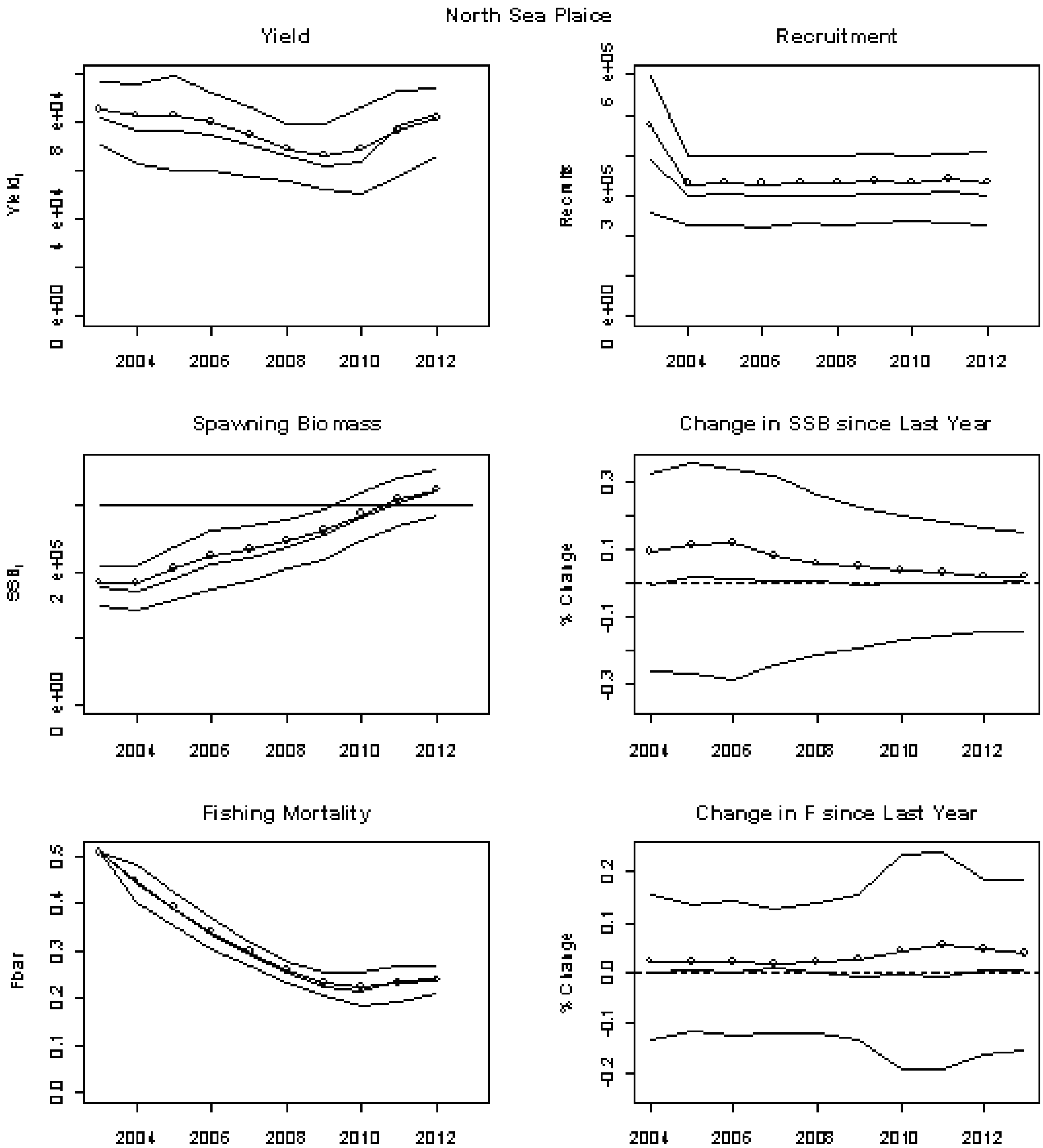


Figure 0.5 Plaice. Trajectory from Fsq to long term F =0.25 in 5 years without constraint on change in TAC, without assessment bias and implementation bias Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. . For a full set of input and output parameters see appendix 8.

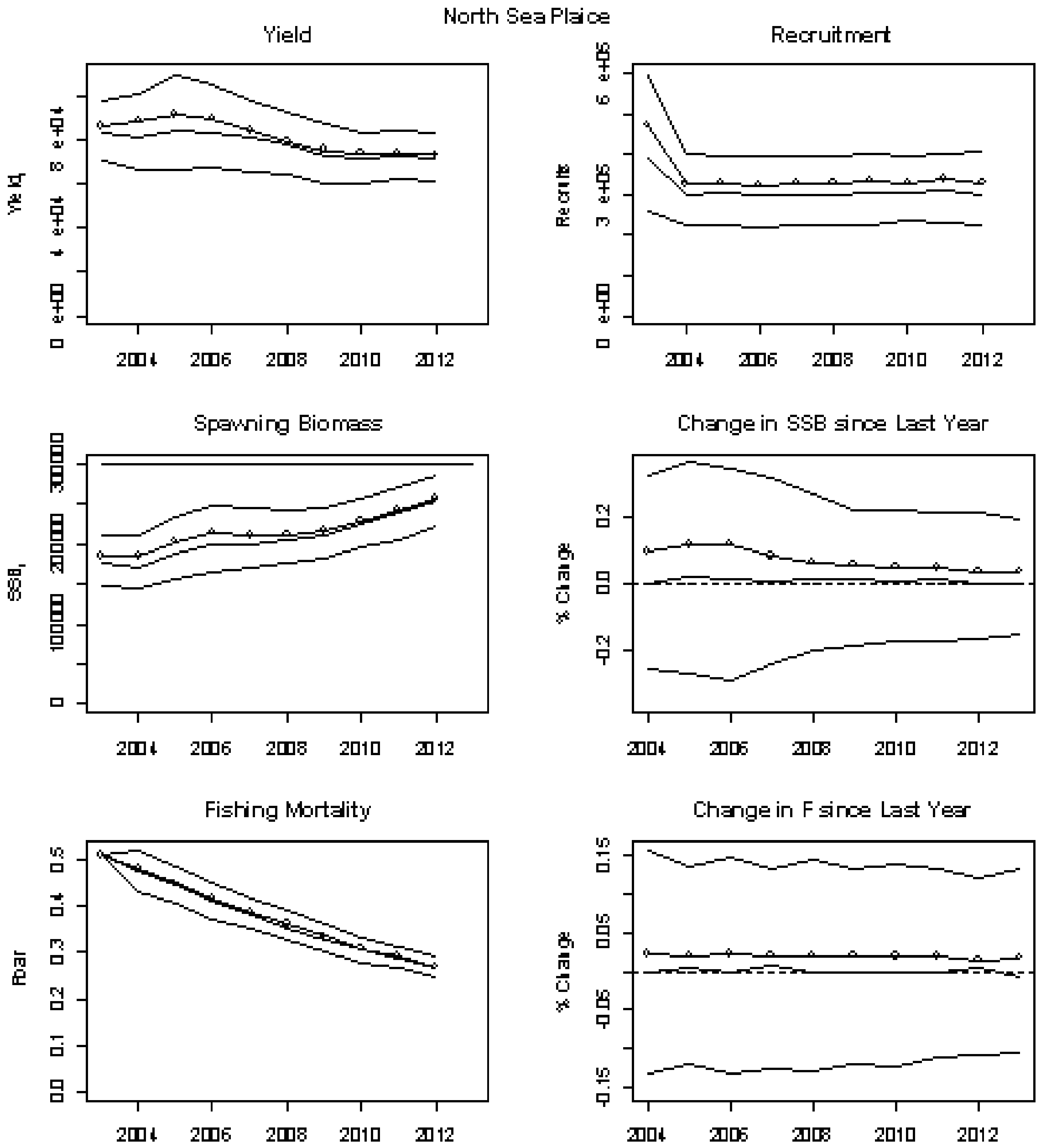


Figure 0.6 Plaice. Trajectory from Fsq to long term F =0.25 in 10 years without constraint on change in TAC, without assessment bias or implementation bias. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. . For a full set of input and output parameters see appendix 8.

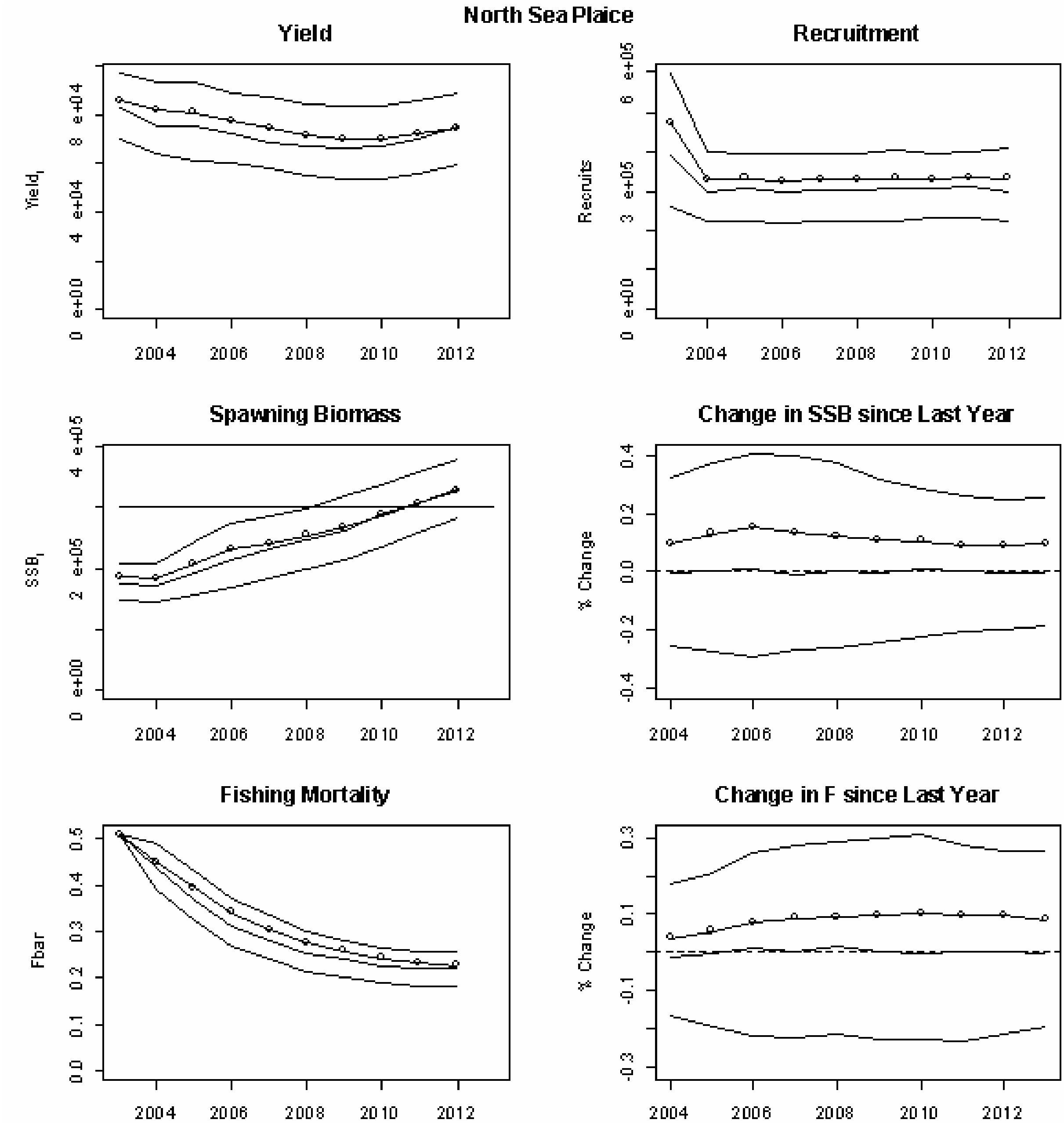


Figure 0.7. Plaice. Trajectory from Fsq to long term F =0.25 in 5 years with constraint on change in TAC, without assessment bias and implementation bias. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period.

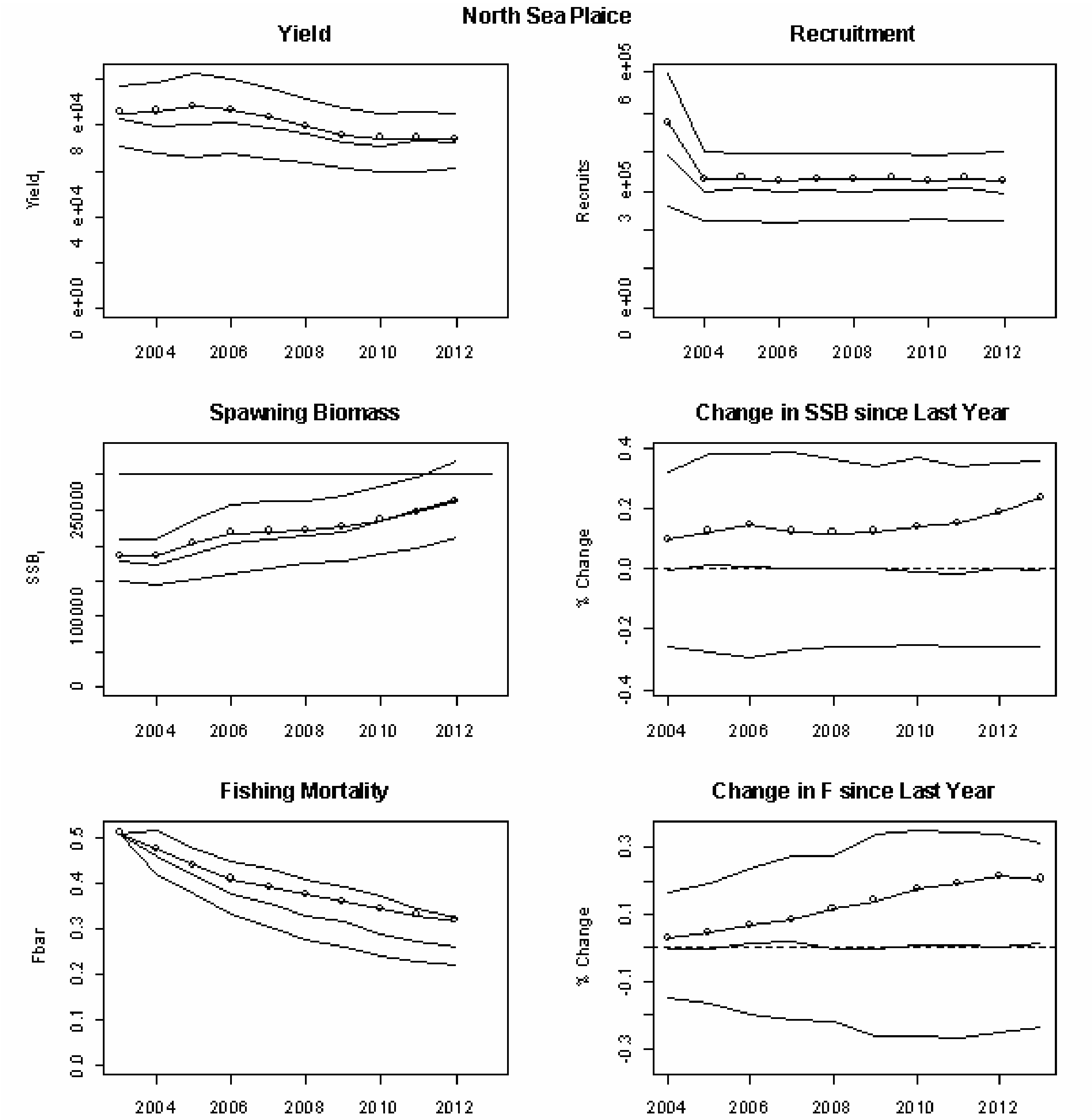


Figure 0.8 Plaice. Trajectory from Fsq to long term F =0.25 in 5 years with no constraint on change in TAC, with assessment bias and implementation bias. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. SSB> Blim) changes with time. For a full set of input and output parameters see appendix 8.

Modelling Discards

The stock assessment of North Sea plaice do not incorporate discards estimates (ICES 2004b). ACFM has commented that the absence of discards seriously compromised the reliability of this assessment as an indicator of stock development (ICES 2004a).

During the meeting the discarding of plaice was simulated. Estimates of historic discards can be made based on the growth signal, which is incorporated in the weight at age data (Kell and Bromley 2004). If it is assumed that the distribution of weight-at-age is normal and that all fish below the minimum size are discarded, then the proportion discarded (*P(Discard)*) will vary according to the mean weight as shown:

$$P(Discard) = \frac{\int_0^{w_m} \frac{1}{\sqrt{2\pi\sigma^2}} e^{\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right]} dx}{\int_0^{\infty} \frac{1}{\sqrt{2\pi\sigma^2}} e^{\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right]} dx} \qquad (1)$$

where

- w is weight-at-age
- w_m is the minimum landing size in weight
- x observed weight-at-age
- μ mean weight-at-age
- σ standard error of the weight-at-age distribution

Mean weight at age in the stock was derived from 1st quarter weights in the commercial landings. Surveys broadly confirm the trends in mean weight at age. Minimum landing weight (MLW) was set at 0.25 (kg) and the CV was set at 0.2 since this gave the best fit to observed discards rates (ICES, 2002)... The maximum proportion discarded was limited to 0.97 to avoid the effects of dividing a small number (catch at age 1) by a very small number. Discarding to stay within the quota was not modelled. The calculated proportion discarded for the weight at age in the final year is presented in Figure 0.9. The reconstruction of % discards over the years is shown in Figure 0.10. The reconstructed series of discards did not include processes other than discarding fish below minimum size and the overall percentage discards appears to be lower than available from the (scanty) discards trips (Van Beek 1998; ICES 2002; Van Keeken et al. 2004)

Sensitivity of long term considerations to stock recruitment assumptions and inclusion of discards

The expected productivity of the stock, is explored through the use of an equilibrium age structured production models that combine SSB-per-recruit, yield-per-recruit and stock-recruitment analysis. This requires selection, natural mortality and weight-at-age data and a stock-recruitment relationship.

The Ockham model is reliant upon the VPA results, which are biased due to discarding etc. (Kell and Bromley, 2004). A knowledge of flatfish biological dynamics suggests the Beverton and Holt model instead. This is also consistent with the MATACS work for which a meta-analysis was performed for 7 flatfish stocks. This stock-recruitment model was fitted for SSB and recruits

$$R = \frac{\alpha B}{1+\beta B} e^{\varepsilon}$$

where

- R are number of recruits
- B Biomass of mature individuals

The parameters can be constrained within more meaningful limits if α and β are re-parameterised as steepness (τ) and virgin biomass (γ) (Francis 1992). Steepness is the fraction of the virgin recruitment (R_γ) that is expected when SSB has been reduced to 20% of its maximum (i.e., $R = \tau R_\gamma$ when SSB = $\gamma/5$).

Figure 0.12 compares the productivity of the stocks as currently perceived and when discarded fish are included in the VPA and for different parameterisations of the Beverton stock recruitment relationship. There is not enough information within the stock recruitment data to decide upon the parameterisation of the stock recruitment relationship therefore the sensitivity of the analysis to different assumptions about steepness (how quickly recruitment declines as SSB declines) was investigated.

Results are presented in the form of yield-SSB curves, where productivity (the expected yield) is given as a function of SSB. The maximum of these curves represents the maximum sustainable yield (**MSY**) and the corresponding value of SSB is equivalent to $\mathbf{B_{MSY}}$. Fishing mortality goes from zero at the origin to a maximum value where SSB declines to zero on the right of the curve. This maximum value corresponds to **Fcrash** , the level of fishing mortality which - if maintained indefinitely – is expected to drive the stock to extinction. The second panel shows yield as a function of F and the third SSB as a function of F.

Table 0.4 A comparison of reference points from the equilibrium analysis contrasting the effect of including discards and different stock recruitment assumptions

	Steepness = 0.7		Steepness = 0.8		Steepness = 0.9		Steepness = 1.0	
	WG	Discards	WG	Discards	WG	Discards	WG	Discards
F_{Crash}	0.58	0.41	1.20	0.68	>2.00	1.43	>2.00	>2.00
F_{MSY}	0.11	0.10	0.13	0.13	0.17	0.16	0.21	0.22
$B_{20\%}$ Virgin	380927	1496152	301349	771171	260398	564975	235179	466273
B_{MSY}	583904	2254789	429473	1064808	341109	698458	274986	475864

The results presented in Figure 0.12 and Table 0.4 indicate that the perception of the dynamics of the stock is very sensitive to the inclusion of discards in the model and the assumed stock recruitment relationship. When discards are modelled, lowering the fishing mortality from the status quo value will cause the yield to be higher than the case where they are not modelled. This is because younger fish will have more chance to grow and the total biomass will increase. .

A second observation is that the estimate of fishing mortality at which the optimal yield is taken, is not affected by excluding or including the discards in the analysis but is affected by the assumed stock and recruitment relationship. If discards are excluded from the analysis then there appears to be a wide range of fishing mortalities that would provide high yield and that in practice will be difficult to distinguish between, however when discards are included the fishing mortality associated with high yield is better defined.

The situation is further complicated since it is difficult to decide upon the "correct" stock recruitment relationships the parameters of which may vary in the presence of underlying (but unknown) time trends in productivity (Peterman et al. 2000, Fromentin et al 2001, Kell and Bromley 2004).However, it will be difficult to assess the stock using VPA at such low fishing mortalities, to achieve a low F regime will depend upon long-term management rather than an annual management procedure based upon an assessment and harvest control rule.

The fishing mortality that would drive the stock to extinction F_{Crash} is affected both by what is assumed about discardings and the stock recruitment relationship. For example when discards are included in the assessment then a fishing mortality of 0.68 is not sustainable compared to the estimate of 1.2 based upon the ICES assessment.

Bigger differences are seen with respect to biomass and large differences are seen both in the level that would be expected to provide the largest sustainable yields and the level at which recruitment starts to be impaired. The later is represented by the biomass at 20% of virgin biomass, the ratio of recruitment at these two levels is the steepness.

The picture is further complicated since what is currently occurring is that the stock is being managed under the "WG" assumptions but the actual stock dynamics are closer to that of the assessment that includes discards. This makes it difficult to predict the performance of any management procedure and setting up an appropriate simulation model will be very important.

However, overall these results indicate that a substantially lower fishing mortality than presently observed in the fishing is expected to benefit both stock biomass and yield.

The results of the equilibrium production model described above (Kell and Bromley 2004) were compared to the outcome from a run with the LTEQ program (Appendix 1). LTEQ is a long term stochastic equilibrium program to calculate long term distributions of SSB for a range of fishing mortalities, taking into account the variation of the recruitment around a stock-recruitment relationship, as well as variations in weights and maturity. The LTEQ model was parameterized similar to the STPR analysis presented in section 4.1.2 and 4.1.3. The results of the comparison between the LTEQ and the equilibrium production model (excluding discards and with a steepness of 1.0) are shown in Figure 0.13 and indicate that both models give estimates of optimal fishing mortality in the region of 0.2 although the surface of the curve is relatively flat. This means that the optimum F cannot be approximated very precisely.

A final comparison was carried out between the equilibrium production model and the results of the STPR analysis presented in section 0. Yield against F in year 10 of the STPR analysis (without assessment bias) is not yet in an equilibrium situation because the optimal fishing mortality is still higher than in the long term equilibrium (Figure 0.13). This indicates that a 10 year window may not be sufficient to judge the performance of these harvest control rules in the management of this fishery.

Modelling the feedback within fishery systems

A model was developed during the meeting to address the feedback between operating model and management procedure. The performance of the management procedure that is implicit within ICES framework of advice for North Sea plaice was incorporated into an integrated modelling approach that modelled both the 'real' and observed systems and the interactions between all system components. Specifically the model incorporated two fleets: one carrying out a mixed flatfish fishery (on sole and plaice) and the other which was characterized as a directed plaice fishery. The discarding process was included into the simulation model.

Simulations with full feedback between operating model and management procedure were not conclusive due to the large differences in the simulated and assessed stocks when discarding were modelled in the operating model but not included in the assessment. This demonstrates the difficulties in trying to model the dynamics of the stock and fishery in a realistic way.

Simulations with an fixed F scenario (i.e. without feedback) showed that when the perception in the management procedure is based on an XSA assessment using shrinkage, the management procedure may perceive the stock to behave very different from the true stock development. This could be one of the problems leading to the imperfections described above. This work is preliminary and needs further development, the implications may affect the perception of the magnitude and nature of errors in heavily discarded stocks but are unlikely to effect the general conclusions about a suitable long term F for this stock. The results point to the need to examine the effects of errors more fully and to examine alternative assessment methods that are not so prone to the problems of using commercial CPUE tuned XSA assessments.

Mixed fisheries considerations

The linkage between plaice and sole in the catching process is important but could not be addressed within the time-frame of the meeting. Recent (preliminary) work which incorporated biological and economic considerations into the simulation of the management of North Sea flatfish has shown that these interactions are very important to take into account when evaluating the performance of management (S.B.M. Kraak et al. (2004) A simulation study of the effect of management choices on the sustainability and economic performance of a mixed fishery. Draft RIVO report).. However Kell et al 2004 showed that in a mixed fishery it is important to implement any management regulations consistently for all the stocks in the mixed fishery both in the short- and long-terms.

Within the EU funded research projects FEMS (acronym), EFIMAS and COMMIT, management strategies for mixed fisheries explicitly being considered using a simulation framework. It is expected that results from these projects will start to become available from 2005 onwards.

CONCLUSIONS/SUMMARY

If risk of falling below Blim in year 10 is to be below 5% and the historical biases in this assessment are maintained in the future, this analysis suggests that long term F should be set at 0.25. The reduction in fishing mortality could be achieved gradually over a time period of 5 or 10 years. However, the introduction of such a transition period is sensitive to the assessment bias. If the historically observed bias is maintained into the future, the aim of rebuilding the stock above Blim with a high probability can be jeopardized.

The inclusion of discards into the assessment of North Sea plaice was shown to have a major effect on the long term equilibrium analysis. The gains of reducing fishing mortality when discards are included are much larger than when discards are ignored. This is because the discards are expected to contribute much more to the yield when fishing mortality is low (i.e. lower discard rates and catching fish when they have grown to bigger sizes).

Comparisons between the STPR output and the long term equilibrium analysis has suggested that an equilibrium situation may not have been reached after 10 years, which is the current limit on the STPR program. The optimal fishing mortalities in the long term equilibrium analysis tend to be slightly lower than the results of STPR.

The modelling of the full feedback process (operating model – data collection – stock assessment – harvest rules) for North Sea plaice (and the interactions with sole) have not been finalized during the meeting. Preliminary results suggested that much larger and dynamic discrepancies may exist between operating model and perception than currently incorporated in the STPR approach. However, these effects to not change the general conclusions regarding suitable long term F_{LT} given for North Sea Plaice but suggest that the influence of assessment error needs further investigation.

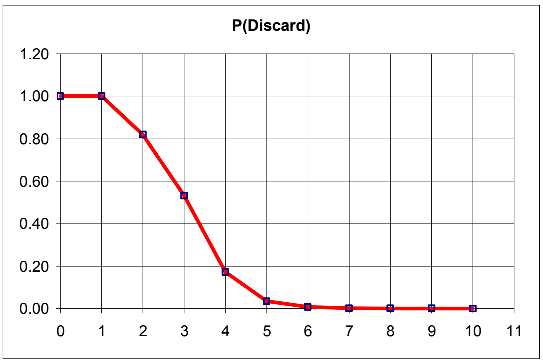


Figure 0.9 Plaice Proportion discards at age simulated based on the mean weight at age in the most recent five years

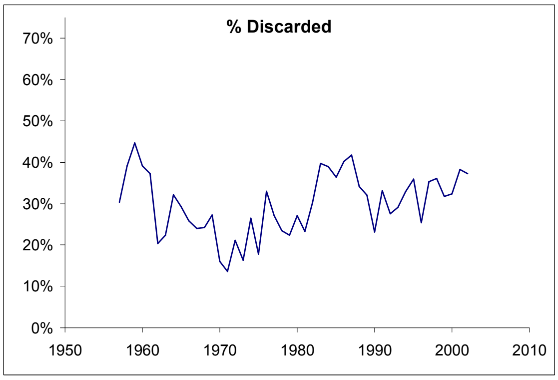
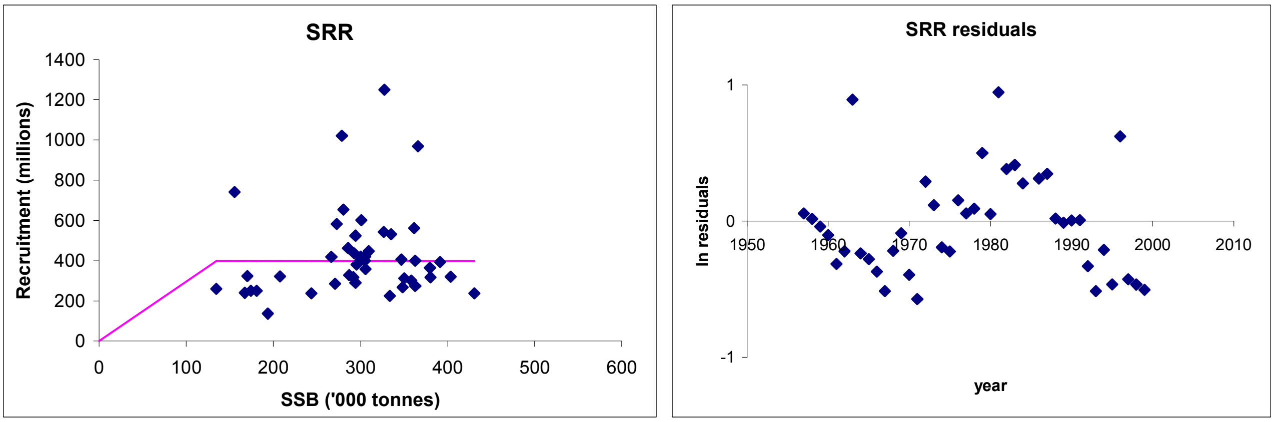


Figure 0.10 Proportion plaice discarded (in number) calculated from discard values based on the mean weight at age

Without discards



Discards included

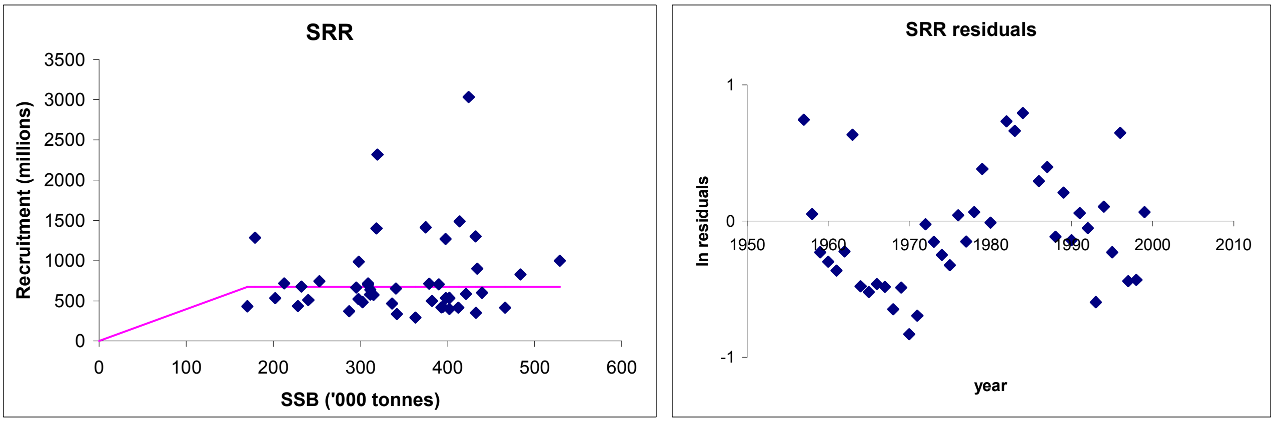
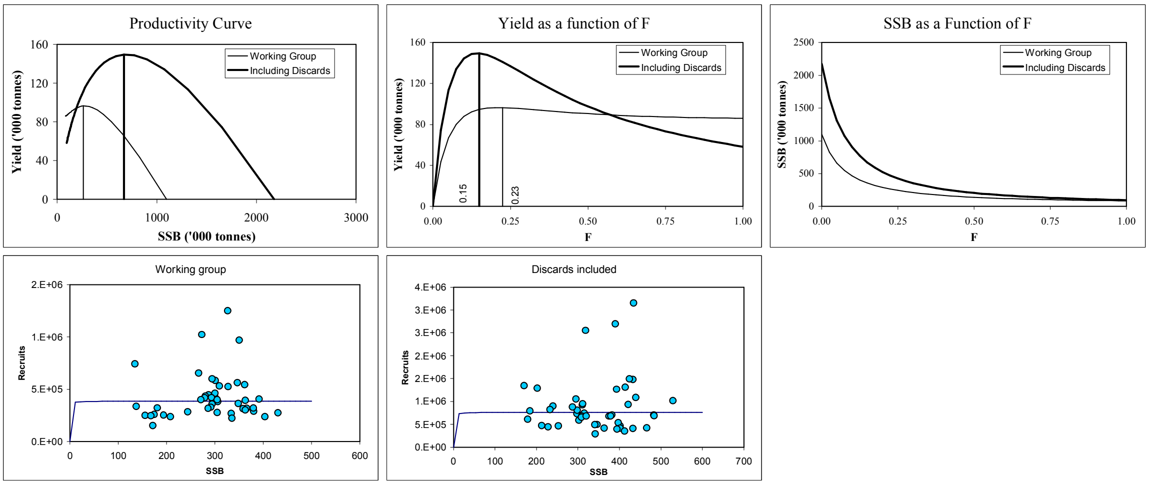
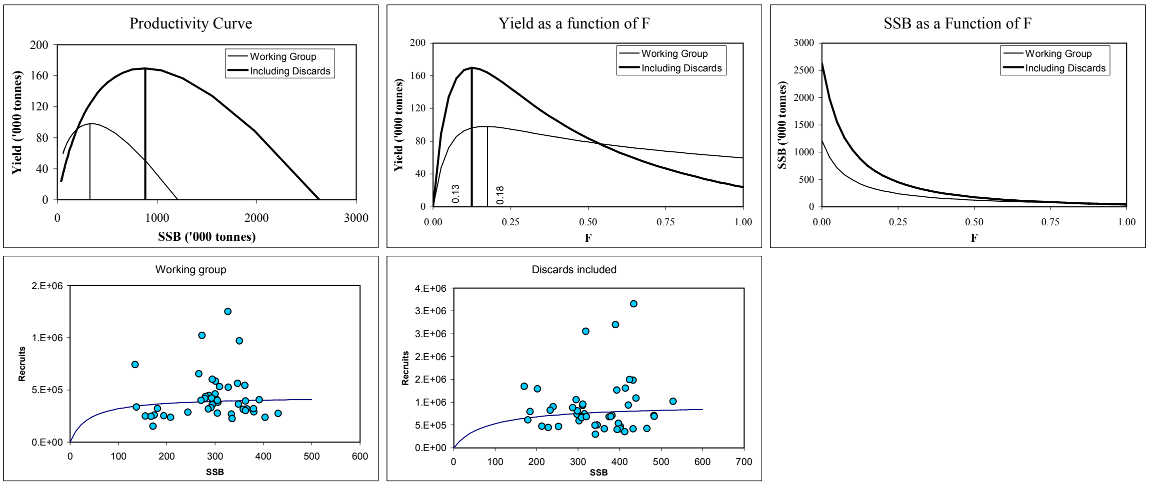


Figure 0.11 Stock recruitment relationship of North Sea plaice from the working group estimates without discards (top)) and from the assessment including discards (bottom(). Log residuals are shown in the graphs on the right.

Steepness = 1.0



Steepness = 0.9



Steepness = 0.8

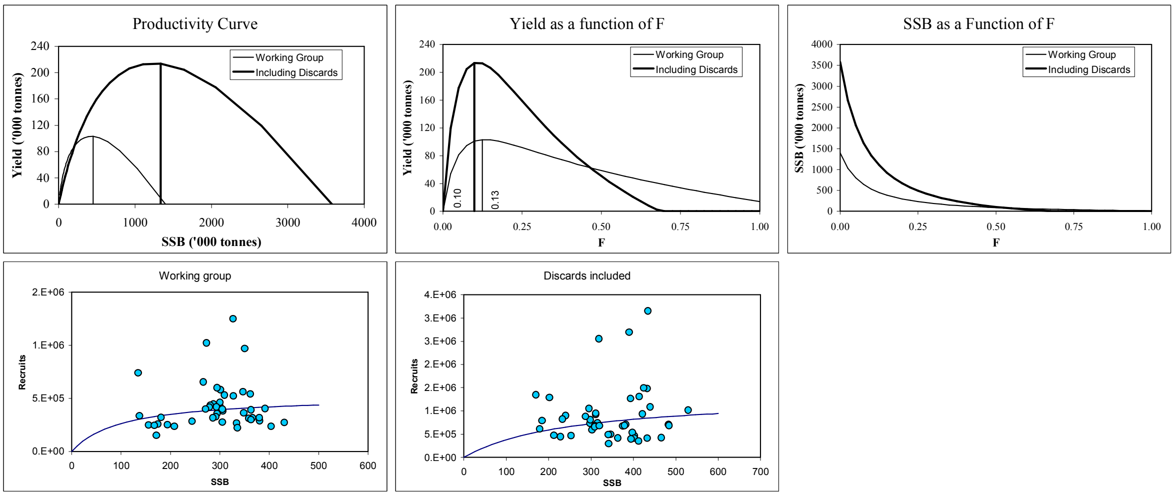


Figure 0.12 Plaice. the productivity of the stocks as currently perceived and when discarded fish are included in the VPA and for different parameterisations of the Beverton stock recruitment relationship

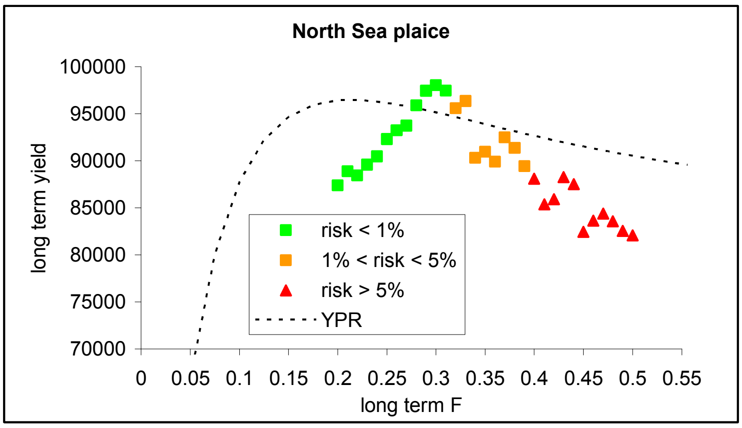


Figure 0.13 North Sea Plaice. Comparison between the LTEQ and the equilibrium production model (excluding discards and with a steepness of 1.0)

SOLE IN AREA IV

CURRENT PRACTICE

Status quo fishing mortality used for this analysis for North Sea sole is estimated at 0.48 and SSB is estimated at 34 000 tonnes, just above Bpa.

STRATEGIC CHOICES

The harvest control rule investigated makes use of Blim = 25 000 tonnes and a Trigger SSB set at Bpa = 35 000 tonnes. F depleted is set at 0.05, and F intermediate increases linearly from F depleted to long term F with SSB. One fleet was assumed. Table 0.1 shows the parameters used in the SPR3 software.

The exploration consists of two parts. The first part is aimed at finding the long term F with the highest long term yield (here yield in year 10) with an acceptable risk (<5%) of SSB falling below Blim (in year 10). Note that the simulation by STPR3 is limited to 10 years, while there is no guarantee that the equilibrium has been reached by year 10. The second part is aimed at finding the optimal trajectory for reaching the long term F from current F.

In these explorations an Ockham's razor recruitment function was assumed, based on Bloss (21 000 tonnes), and the geometric mean recruitment over the whole time series of the assessment (97 000 thousands).

In the exercise of searching the optimal long term F, the STPR simulations were run without constraints on year to year change. Assessment bias was set at 1.1 with a standard error of 5%. Although a 5% is small, analyses show that the simulation results are not particularly sensitive to this parameter.

Figure 0.1 indicates that the upper boundary of the 5 % risk of SSB falling below Blim is for F around 0.4. Given an assessment bias of 1.0 and implementation bias = 1.0, a long term fishing mortality of F_{LT} = 0.4 has a risk of less than 5% of SSB falling than Blim. Long Term F values around 0.6 may appear to have a higher yield in year 10, but are associated with risks up to 25%.

Table 0.1 North Sea Sole parameters used for simulation

Run settings for STPR/S3S		
Youngest/oldest age		1-10
Ref F age interval		2-6
Fsq		0.48
Blim		25 000
Trigger Biomass (B_{trig})		35 000
F-level 1 (depleted) (F_d)		0.05
F-level 2 (intermediate) (F_I)		linear
Max TAC change		Not constrained
Max F change		Not constrained
Maximum F		1.5
SRR Model		Ockhams razor
	GM	97 000 thousands
	Bloss	21 000 tonnes
	std-residuals on rec.	0.78
	max-value rec.	1.8
Assessment-bias		1.1
Assessment-st		0.05
Implementation-bias		1.0
Implementation-std		0.1

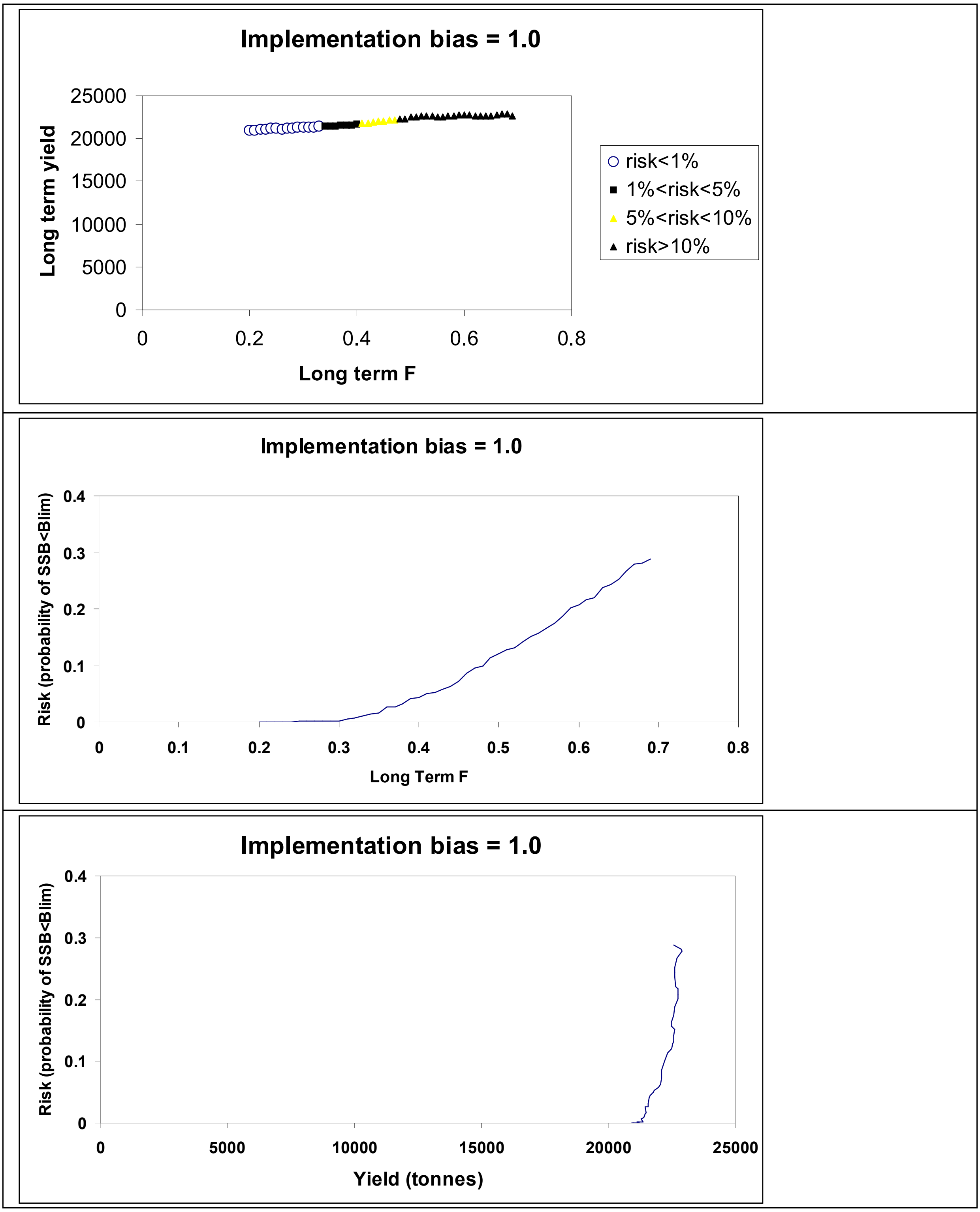


Figure 0.1 North Sea Sole. Yield in year 10 as a function of long term Fm, - Risk of SSB falling below Blim in year 10, as a function of long term F, - Risk of SSB falling below Blim in year 10, as a function of yield in year 10

SENSITIVITY ANALYSES

A scan was performed along long term F from 0.2 to 0.7, varying implementation bias between 1.0 and 1.2. The rationale for this choice of implementation bias is that it is likely that with a more restrictive management regime, implementation bias might increase in the future. Figure 0.2 indicate that not only the risk of SSB falling below Blim increases at lower long term F's, but also that yield at higher F's (0.5-0.7) in year 10 decreases when implementation bias increases.

The expected long term yields for this stock are relatively stable for different fishing mortalities from 0.2 to 0.4. The higher Fs are associated with higher risk. If implementation bias increases, the 5 % probability of SSB falling below Blim is currently obtained at a fishing mortality of around 0.4 is then found around F = 0.3, yield at these two fishing mortalities varies less than 1000 tonnes (Figure 0.2).

The overall increasing probability of SSB falling below Blim with higher implementation bias is illustrated in Figure 0.3North Sea Sole . The yield increases only very slightly as risk increases considerably and for higher implementation bias higher F is associated with higher risk and lower yield. (Figure 0.4).

The search for the optimal trajectory to get from current F to different candidates of long term F (0.2-0.4) was carried out without implementation bias. Two options for year to year decline in F were investigated. In the first option a decline over 5 years corresponds to a yearly decrease of 16%, 9% and 5% respectively for the 3 candidate F's was tested. In the second option a decline to the 3 F-candidates over a 10 years period was tested with corresponding yearly decreases of 8%, 5% and 2% respectively. Within these two options, a further investigation was done with and without a 15% TAC constrain.

Some results of these 12 exploratory runs are listed below.

Table 0.2 North Sea Sole.: results of exploratory calculations

Run Id	Long term F	Period for decline in years	Max.15% change in TAC	Risk % year 10	Median yield year 10 in tonnes	Median cumulative yield in tonnes	Median lowest yield over the 10 years in tonnes	Median first year Bpa is reached
R21	0.2	5	Yes	2.2	17 900	205 000	17 200	2004
R22	0.2	10	Yes	8.2	18 900	222 000	18 900	2004
R23	0.2	5	No	0.0	20 000	199 000	15 000	2004
R24	0.2	10	No	0.2	17 000	207 000	17 000	2004
R31	0.3	5	Yes	7.3	19 700	222 000	19 100	2004
R32	0.3	10	Yes	13.5	19 500	227 000	19 500	2004
R33	0.3	5	No	0.7	20 800	219 000	18 100	2004
R34	0.3	10	No	4.2	19 400	220 000	18 700	2004
R41	0.4	5	Yes	16.9	19 900	229 000	19 600	2004
R42	0.4	10	Yes	21.9	19 700	230 000	19 700	2004
R43	0.4	5	No	8.4	20 500	229 000	19 700	2004
R44	0.4	10	No	12.8	19 800	228 000	19 600	2004

Trajectories from Fsq to different long term F candidates over a 5 years and 10 year period are presented in Figure 0.5 North Sea Sole to Figure 0.10 North Sea Sole .

CONCLUSIONS

- simulations indicate that long term F for sole in the North Sea might be in the region between 0.2 and 0.4 (Figure 0.1).
- the expected long term yields for this stock are relatively stable for different fishing mortalities. A fishing mortality in the area of 0.2 is more risk averse than an F of 0.4 without the loss of long term yield.
- substantial implementation error has been observed for this stock in the past. Sole is a high value species that is therefore prone to implementation error under restrictive

management arrangements. Implementation error was found to have a considerable impact: - increasing the risk of biomass falling below the limit reference point at a given fishing mortality.

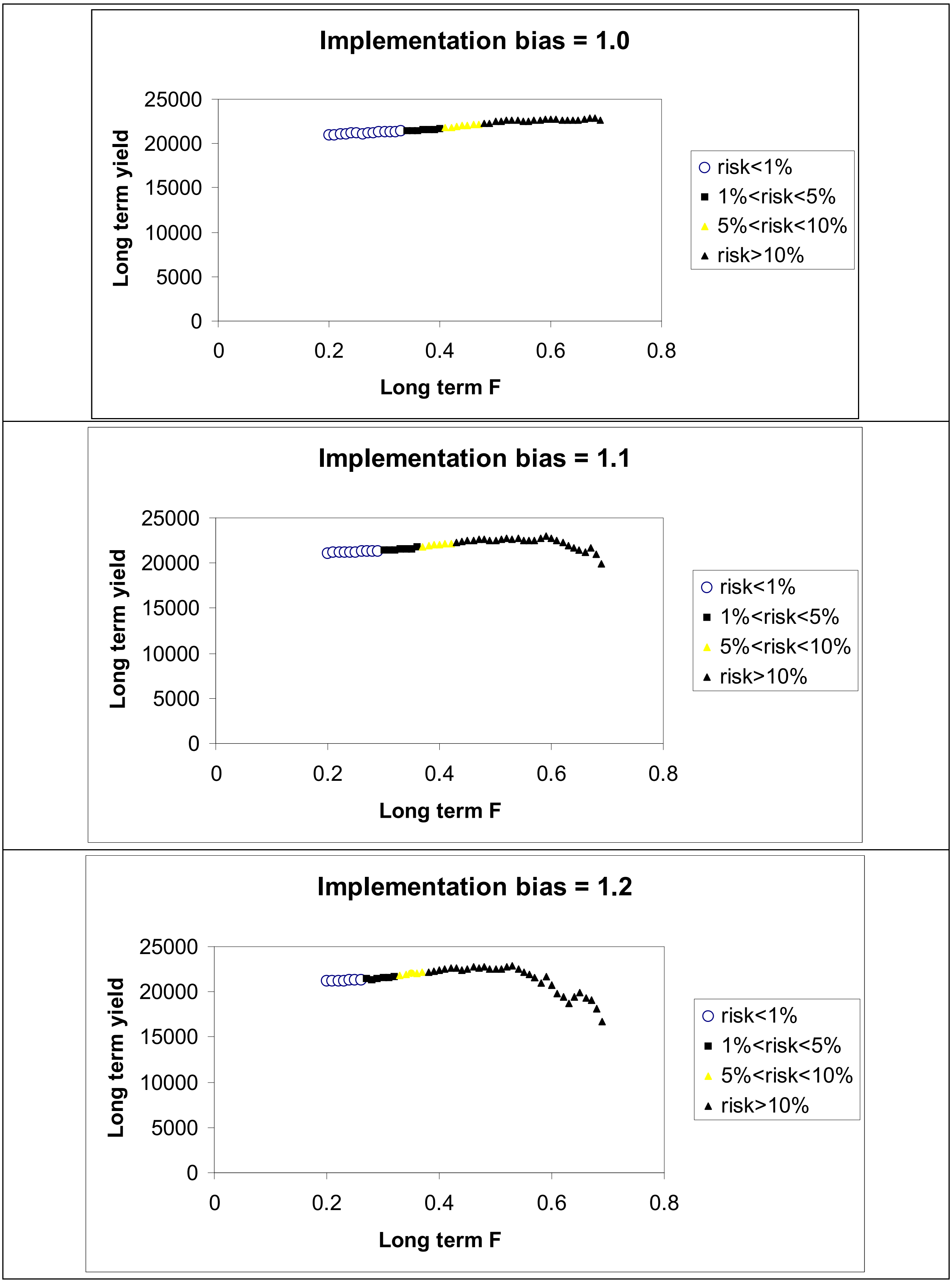


Figure 0.2 North Sea Sole Scan of long term F with different implementation bias varying between 1.0 and 1.2 (+ 0.1).

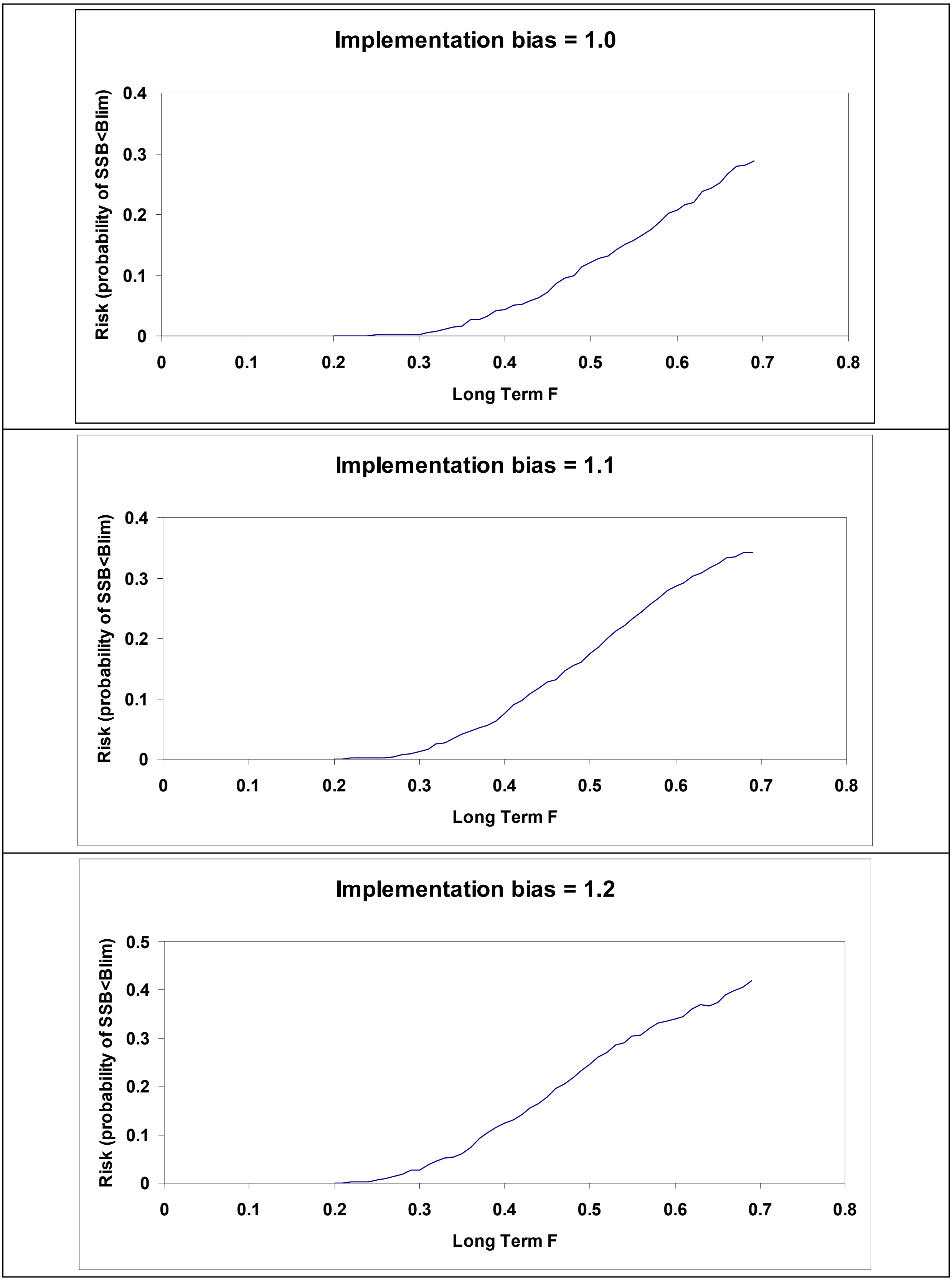


Figure 0.3North Sea Sole Risk of SSB below Blim in year 10, as a function of long term F, under different implementation bias varying between 1.0 and 1.2 (+ 0.1).

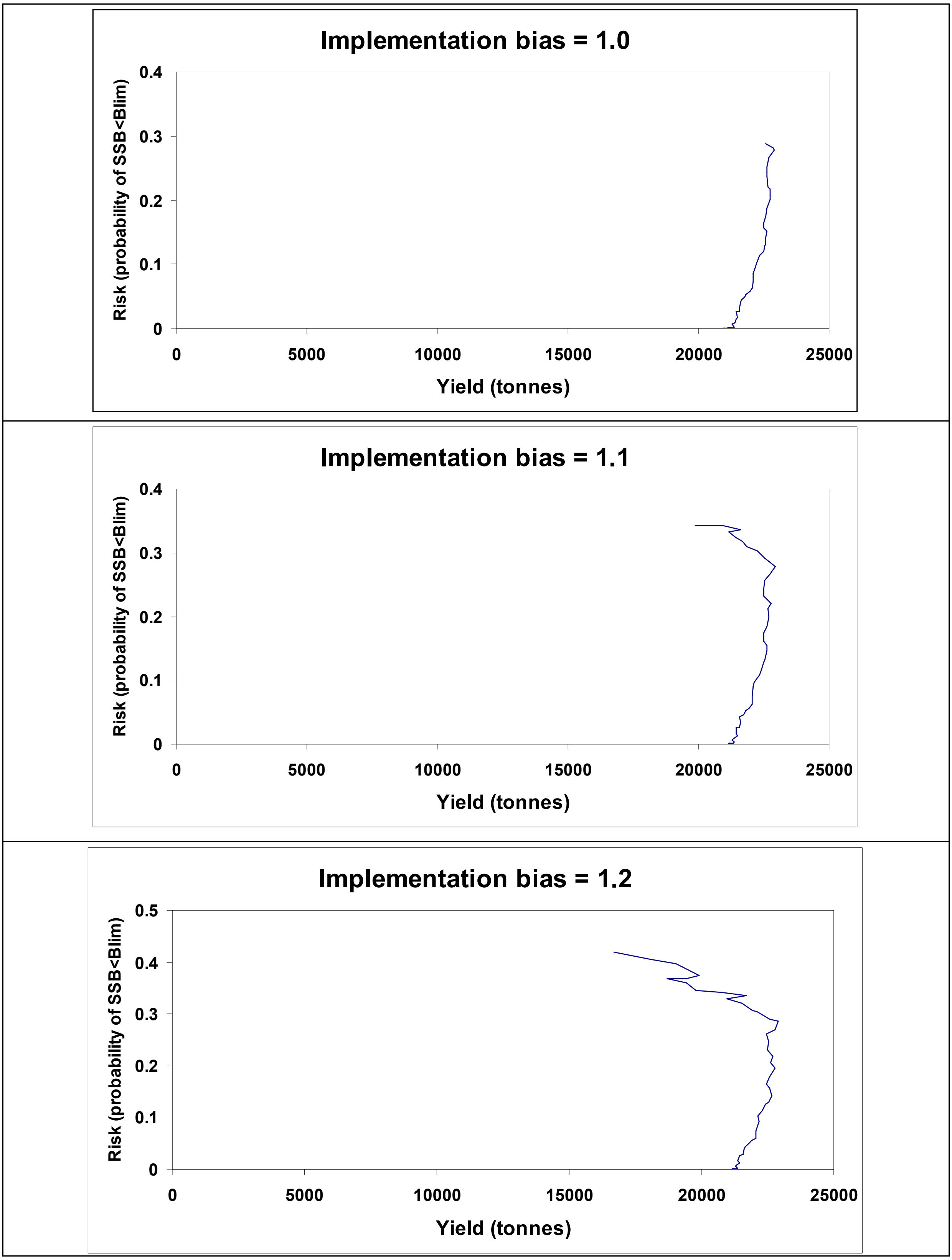


Figure 0.4 North Sea Sole. Risk of SSB below Blim in year 10, as a function of yield in year 10, under different implementation bias varying between 1.0 and 1.2 (+ 0.1).

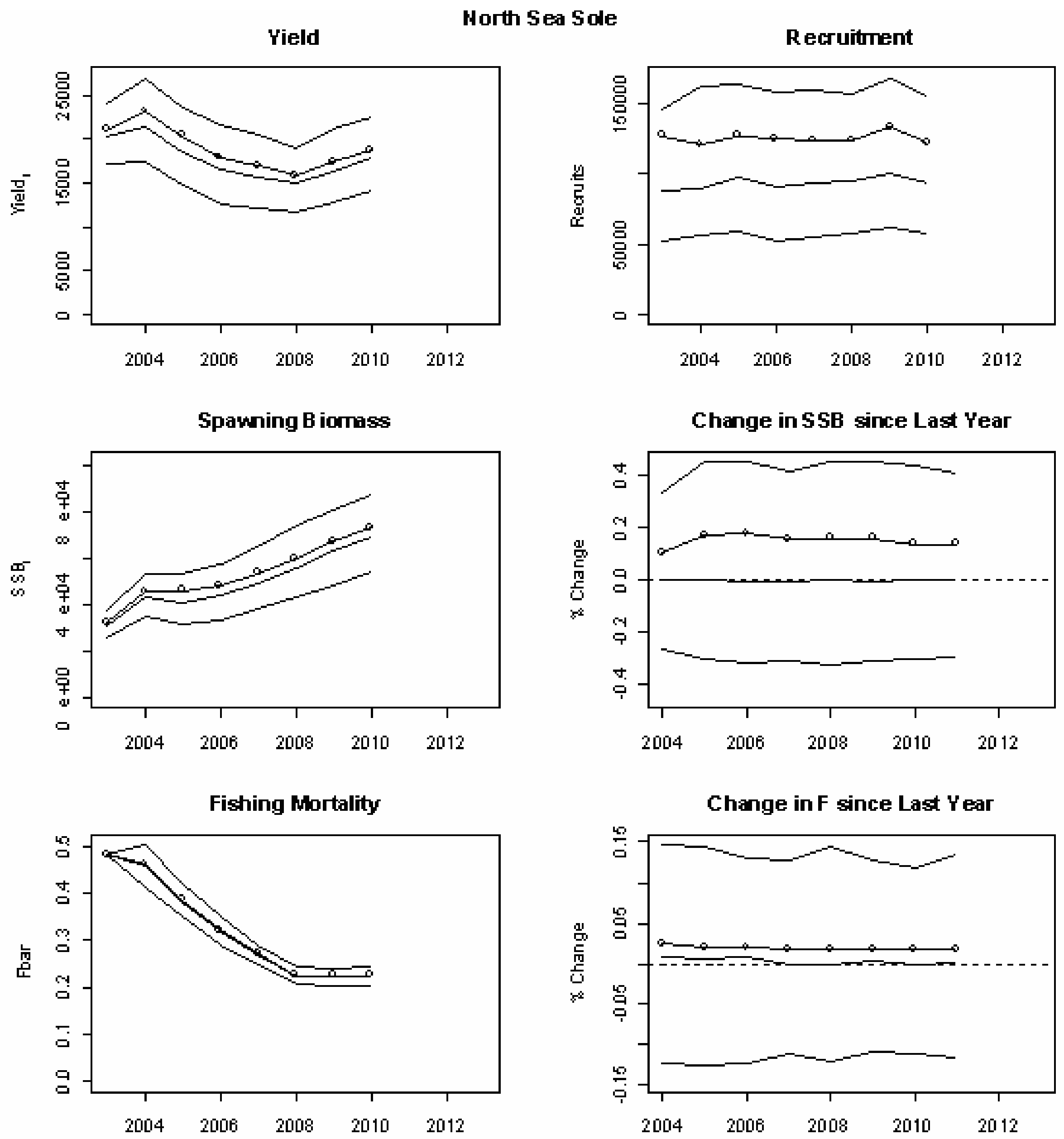


Figure 0.5 North Sea Sole (Run-id = R23) Trajectory from Fsq to long term F =0.2 in 5 years without constraint on change in TAC, with an assessment bias of 10% and no implementation bias. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. . For a full set of input and output parameters see appendix 9.

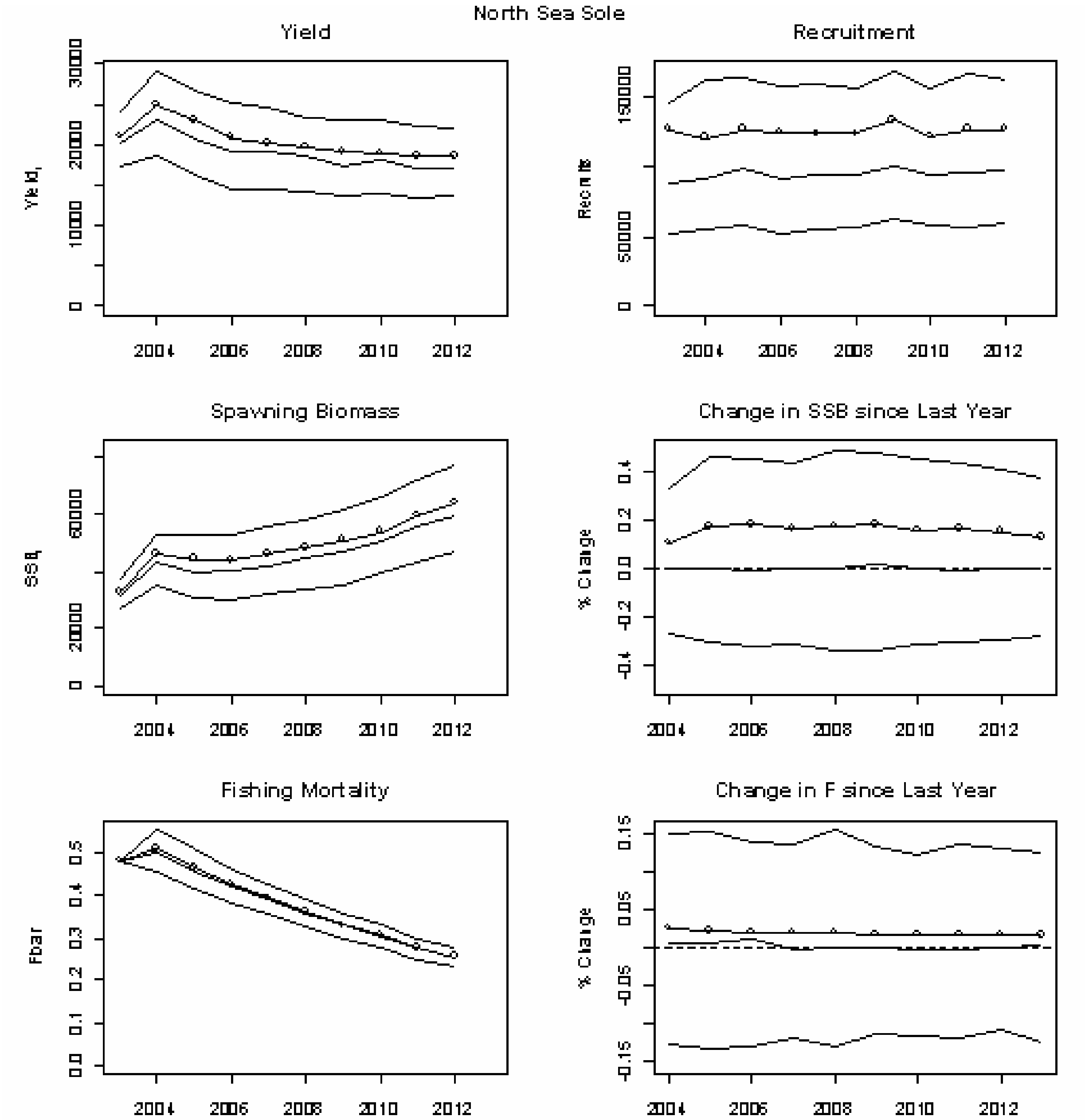


Figure 0.6 North Sea Sole (Run-id = R24) Trajectory from Fsq to long term F =0.2 in 10 years without constraint on change in TAC, with an assessment bias of 10% and no implementation bias. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. For a full set of input and output parameters see appendix 9

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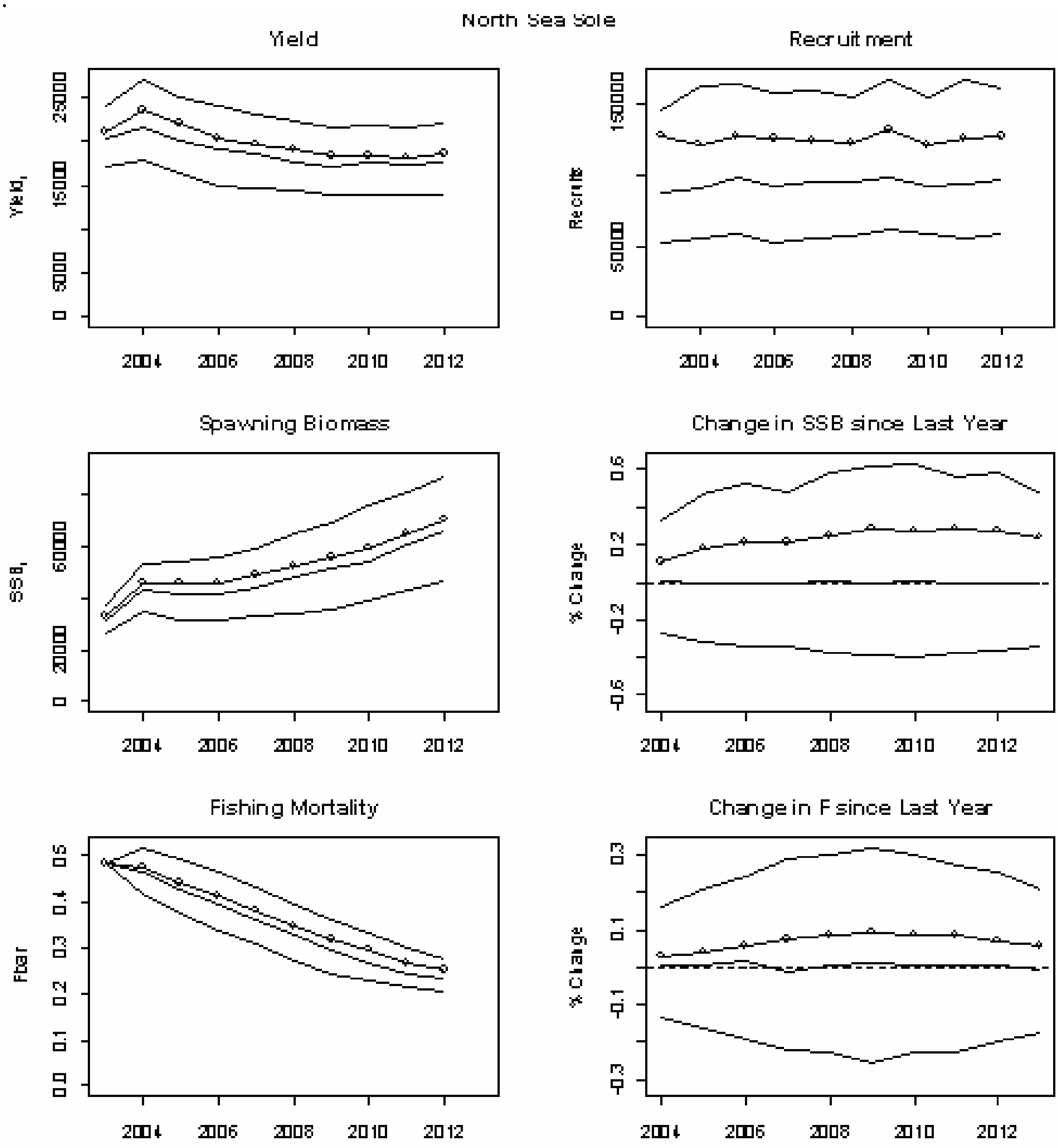


Figure 0.7 North Sea Sole (Run-id = R21) Trajectory from Fsq to long term F =0.2 in 5 years with a 15% constraint on change in TAC, with an assessment bias of 10% and no implementation bias For a full set of input and output parameters see appendix 9.

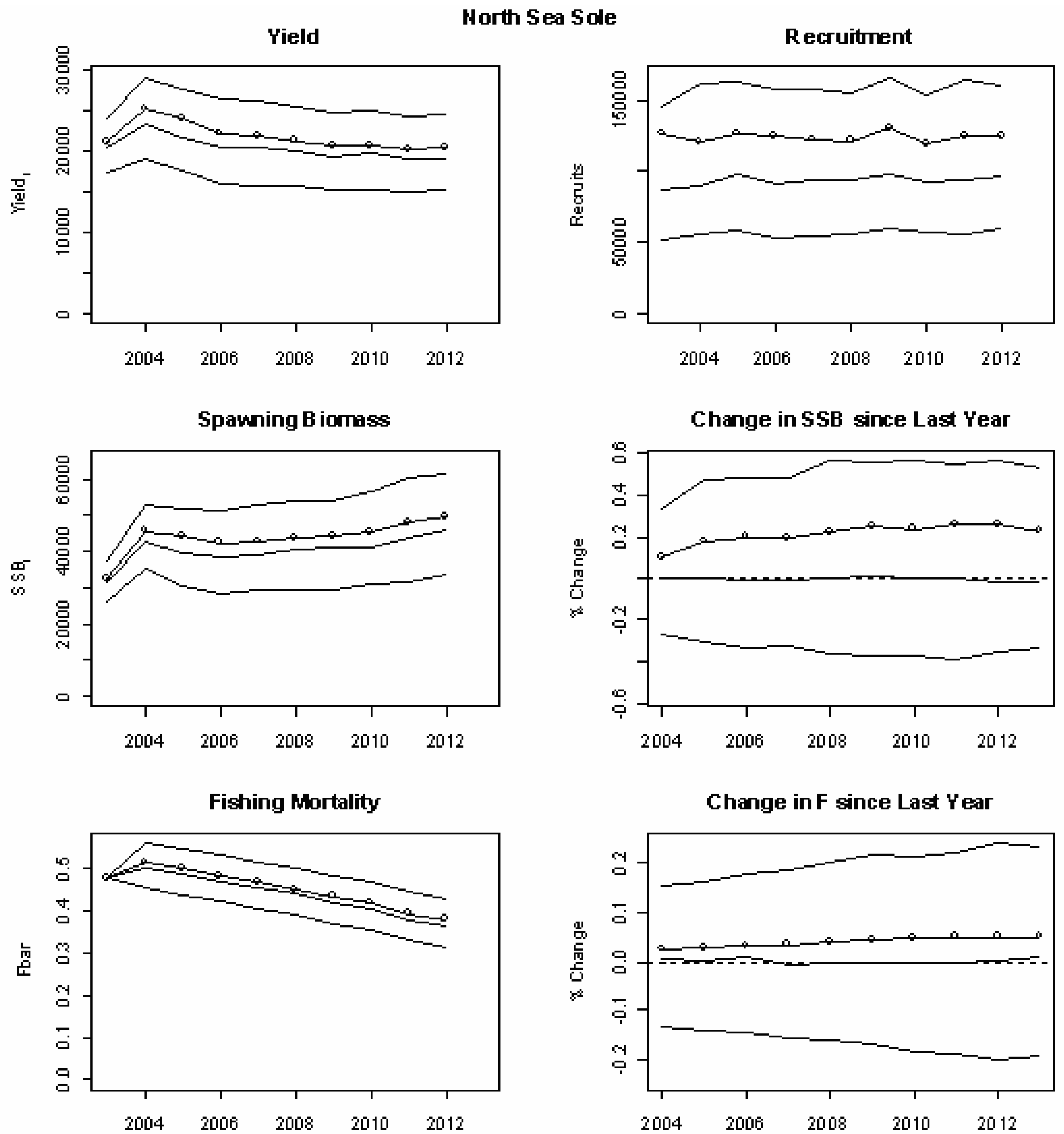


Figure 0.8 North Sea Sole (Run-id = R22) Trajectory from Fsq to long term F =0.2 in 10 years with a 15% constraint on change in TAC, with an assessment bias of 10% and no implementation bias. For a full set of input and output parameters see appendix 9

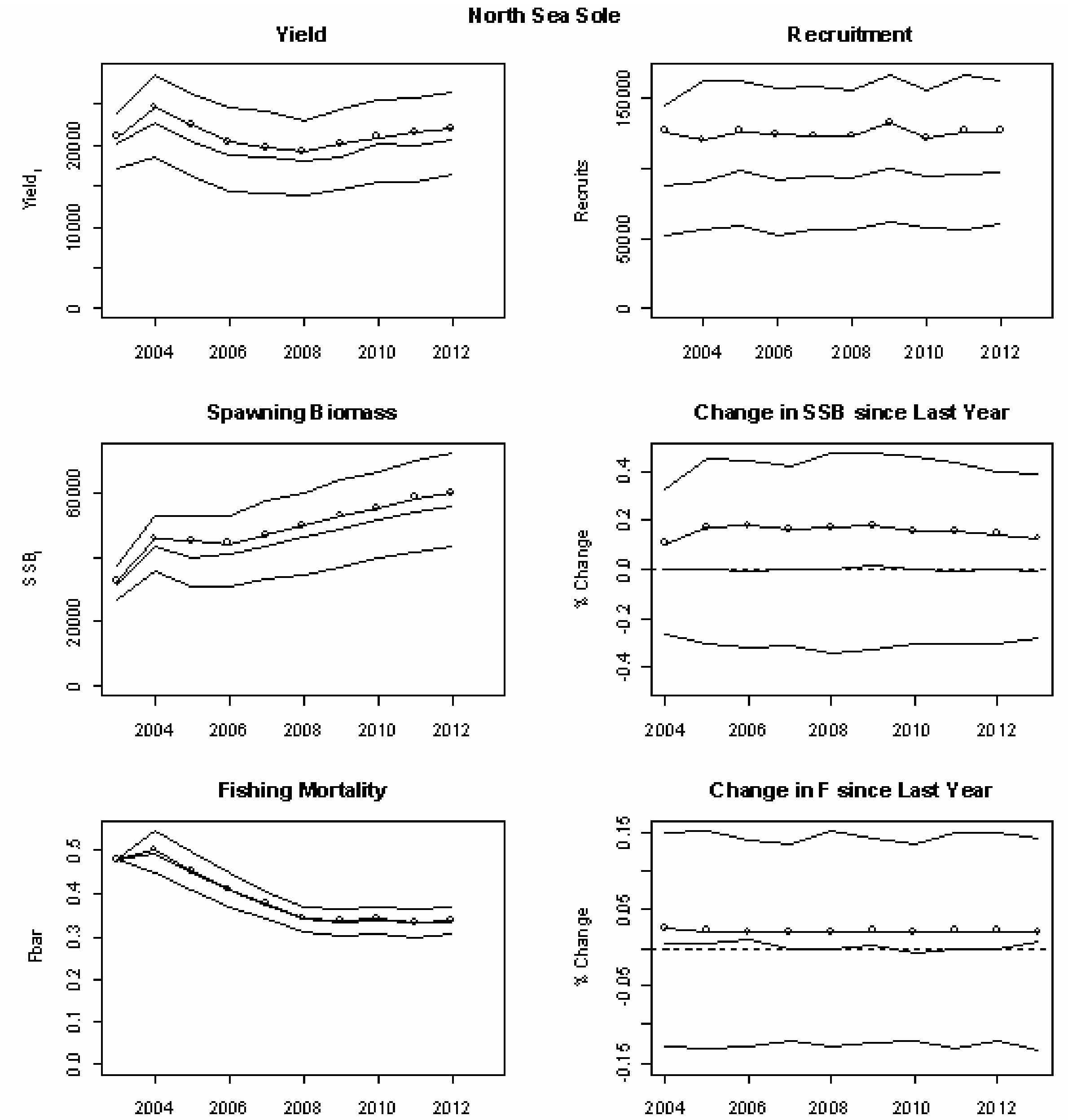


Figure 0.9 North Sea Sole (Run-id = R33) Trajectory from Fsq to long term F =0.3 in 5 years without constraint on change in TAC, with an assessment bias of 10% and no implementation bias. For a full set of input and output parameters see appendix 9

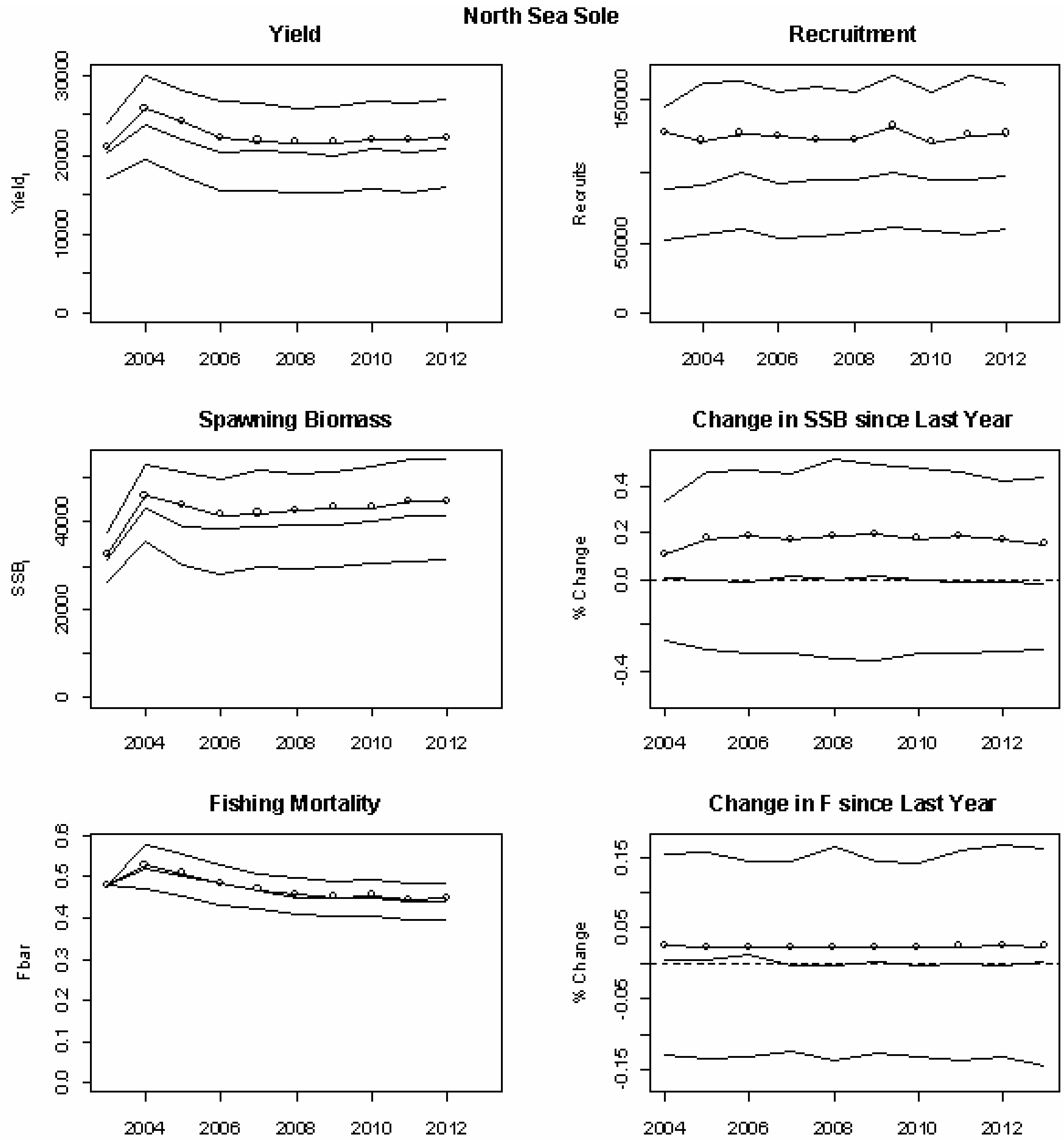


Figure 0.10 North Sea Sole Run-id = R43) Trajectory from Fsq to long term F =0.4 in 5 years without constraint on change in TAC, with an assessment bias of 10% and no implementation bias. For a full set of input and output parameters see appendix 9

NORTH SEA, SKAGERRAK AND KATTEGAT HADDOCK

The STPR3 input files for the base case (as defined below) for haddock are given in the Appendix. The source for the data used to generate these files was the report of the 2003 meeting of the ICES North Sea Demersal WG (WGNSSK; ICES 2003). The final assessment proposed by WGNSSK was used as a starting point for simulations, although it must be emphasised that this assessment is extremely uncertain. Due to this uncertainty, WGNSSK did not produce forecasts for this stock. These were generated subsequently for ACFM (Needle 2003 and pers. comm.). The exploitation patterns used in the following analyses were taken from run 21 of these forecasts (basis F_{sq}, 50% derogation uptake, 0.5 effort multiplier). Again, this is only one example from many that are available and plausible. A further complication is that haddock is taken in a mixed fishery with whiting, amongst other species. However, the available software does not allow for mixed-fisheries simulations, and so this issue has not been addressed here (see section 5).

The haddock assessment is performed on the basis of three catch components: human consumption landings, discards, and industrial bycatch. STPR3 does not model explicitly such components, only allowing for two independent fleets. Landings and discards were used for the two fleets in the STPR runs discussed below. In reality these are not independent, and as an interim measure the same HCR was used for each to fix the link between them. However, this is still an approximation as discard F is not directly proportional to landings F but is also affected by such factors as year-class size, quota availability, market prices, etc. Industrial bycatch F was added to natural mortality: This is not strictly appropriate, but accommodates the indirect way in which industrial bycatch is regulated in the small-mesh fishery. In any case the industrial-bycatch F is small, and would not make a significant difference. The CVs of XSA survivor estimates from the WGNSSK assessment were included as the diagonal entries the variance-covariance matrix for initial stock numbers at age.

Table 0.1 shows the main options used in the main STPR3 options file. The agreed TAC for 2003 (55kt) was used as the intermediate-year yield constraint for fleet 1 (landings). The estimated discards (7kt) associated with that landings TAC was used as the intermediate-year yield constraint for fleet 2 (discards). Two levels were defined in the HCR:

6) *low*, bounded above by B_{lim} = 100kt with F_{dep} = 0.1 (on the assumption that there is always likely to be *some* fishing on haddock), and
7) *high*, bounded below by B_{trig} = 140kt (B_{pa}) with F_{lt} = 0.4 (F_{msy} from the MATES report).

In the WG assessment, current fishing mortality is estimated to be in the region 0.2 – 1.0, although the most likely estimates lie towards the lower end of this range. Current SSB is also uncertain, but is probably greater than 300kt. The specific starting point used for the simulations has F values of 0.26 (landings) and 0.05 (discards), and a B of around 320kt.

F was assumed to change linearly in the region between the two biomass bounds (see Section 3.1). Landings and discards had no upper bound in simulations. In the base-case run, any year-year TAC or F changes were allowed (unconstrained variation). Implementation bias was assumed to be 1.0 (no bias), and to have an s.d. of 0.0. These values were used because the WG decided that they had no basis to assume that management in the future would lead to *changes* in fishery reporting practice. Assessment bias was assumed to be 1.0 (no bias), and to have an s.d. of 0.3, since the assessment is thought to be considerably uncertain. However, there is no objective way to set these numbers. While their specific values are arbitrary to a certain extent, the historic performance of the assessment indicates that they are at least plausible. Stochastic numbers were generated on a log scale throughout, because this approximates the skewed distribution of recruitment.

Recruitment was described by a Beverton-Holt model, fitted by RecAn (version 2.20) to the entire historical time-series. Stochastically-generated recruitment is truncated in STPR3 to lie within some range about the assumed stock-recruit curve. A suitable level of simulation truncation (see Appendix 1) was set by graphical comparison of the historical stock-recruit scatterplot with 1000 samples of STPR3 realisations using base-case parameter settings. Figure 0.1 shows this comparison on arithmetic and log scales, while Figure 0.2 shows the relative frequency distributions of historical and sampled recruitment. Although the comparison is reasonable, the sample distribution does tend to be wider (less peaked) and to have shorter tails than the historical distribution. Higher truncation might achieve larger year-classes, but at the cost of poorer replication of the historical distribution. One effect of this in simulations will be for mean recruitment to be slightly higher than seen historically, and for the occasional very large year-classes seen in the historical time-series to be lower than observed. The expected behaviour of the fishery in a situation with slightly higher and more consistent recruitment is likely to be different to that when recruitment is generally lower and more spasmodic (in the latter case large year-classes will be heavily discarded), so the range of recruitment models in STPR3 are probably not appropriate for haddock.

STRATEGIC CHOICES

Results for the base-case run (defined above) are given in Figure 0.3 With increasing long-term *F* (that is, the *F* in the high HCR regime), human-consumption yield in 2013 declines and the risk of $B < B_{\text{lim}}$ in 2013 increases. This plot suggests that a long-term *F* of < 0.3 would be required to avoid a >5% risk of *B* being below B_{lim} in 2013. A high human-consumption yield in 2013 is related to a low risk to biomass: both of these would be results of low long-term *F*.

Sensitivity analyses (see below) suggest that, of the available management decisions, TAC constraints have the most significant effect on the simulations. Figure 0.4 summarises the effect of changing TAC constraints on risk and yield in 2013, over a range of values of long-term *F*. A TAC constraint of 10% produces forecasts in which the TAC increases at a slower rate than the population, resulting in moderate to high yield and no risk to biomass. Part of this result is due to the current TAC, which is low and intentionally restrictive. Allowing annual variation in TAC of 20% leads to moderate risk to *B* (between 5% and 10%) at long-term *F* values greater than 0.4, and very large yields. A TAC constraint of 30% results in a similar relationship between risk and *F* as for the base case, although with higher yields in 2013.

Table 0.1 North Sea haddock parameters used for simulation

Run settings for STPR/S3S		
Youngest/oldest age		0 - 7
Ref F age interval		2-6
Catch constraint		55 000
Blim		100 000
Trigger Biomass (B_{trig})		140 000
F-level 1 (depleted) (F_d)		0.10
F-level 2 (intermediate) (F_I)		Linear 0.25
Max TAC change		Not constrained
Max F change		Not constrained
Maximum F		3.0
SRR Model		Beverton and Holt
	P1	25191
	P2	14.58
	std-residuals on rec.	1.1
	max-value rec.	1.5
Assessment-bias		1.1
Assessment-st		0.3
Implementation-bias		1.0
Implementation-std		0.0

SENSITIVITY ANALYSES

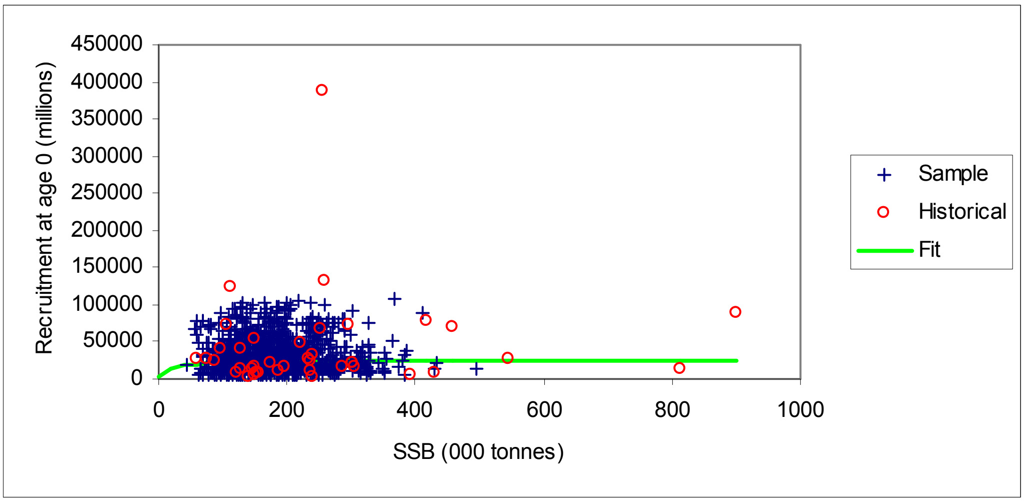
Exploratory analyses were required in order to determine which simulation settings were important in determining the risk for SS*B* less than B_{lim} for haddock. One setting was varied at a time, over ranges deemed to be reasonable. There were six settings examined in this way in all: *F* at the low level in the HCR, *F* at the high level (referred to elsewhere as the long-term *F*), and constraints of year-to-year variation in *F* and TAC, assessment SD, and whether or not F changed linearly between the low and high levels in the HCR. Following these analyses, it was clear that the most important settings were *F* at the high HCR level, the level of TAC constraints, and the size of the assumed error in the assessment. These were examined further, using the scanning facility of the S3S software. The evaluations for TAC constraints are discussed in Section 0 (Strategic Choices), since this is a factor which can be altered directly by management.

The effect of assessment uncertainty is summarised in Figure 0.5. Increasing assessment uncertainty changes forecast yield in 2013 very little, but increases the risk of B being below B_{lim} in 2013 at low levels of long-term F. While the WG could not find a quantitative basis for setting the value of uncertainty, the perception is that the assessment is uncertain and that the base-case value is more likely to be appropriate. This implies that, on this basis, a long-term F of less than 0.3 is required for risk to B to be less than 5%.

CONCLUSIONS

The analyses presented here for haddock should be viewed as being exploratory only. The sporadic nature of haddock recruitment, with occasional large year-classes, is not well modelled by the available evaluation software, and this could result in misleading conclusions. In this situation it is possible that two HCRs would be required: a standard one for the more frequent low year-classes, and a different approach for the large year-classes. There may be distinct economic advantages in temporary reduction in exploitation as large year classes recruit (to reduce mortality due to discards) and there may be some benefit in spreading the economic benefits of the large year class over longer periods with reduced F or a catch ceiling. The WG were not able to evaluate the alternative scheme. The starting point for the simulations is also very uncertain, due to difficulties both in estimating the size of the 1999 year-class, and in determining the extent to which effort has declined in recent years. Short-term forecasts are very sensitive to this uncertainty, but it is likely that long-term considerations are less so. Finally, implementation bias and uncertainty (i.e. misreporting) was not investigated. No specific correction for misreporting has been made to historical landings data for haddock, and implementation bias should only be used when there is a perception that future management actions may lead to a *change* in misreporting practice. This issue is addressed in more detail in Section 4.4 (whiting).

In summary, a long-term F of < 0.3 should lead to a low risk of B falling below B_{lim} over the next 10 years. In general, lower F leads to reduced risk and higher yield. This conclusion is strongly sensitive to assumptions about recruitment which may not be met in reality. The starting point of simulations is uncertain, but the WG conclude that long-term considerations are not highly sensitive to this uncertainty.



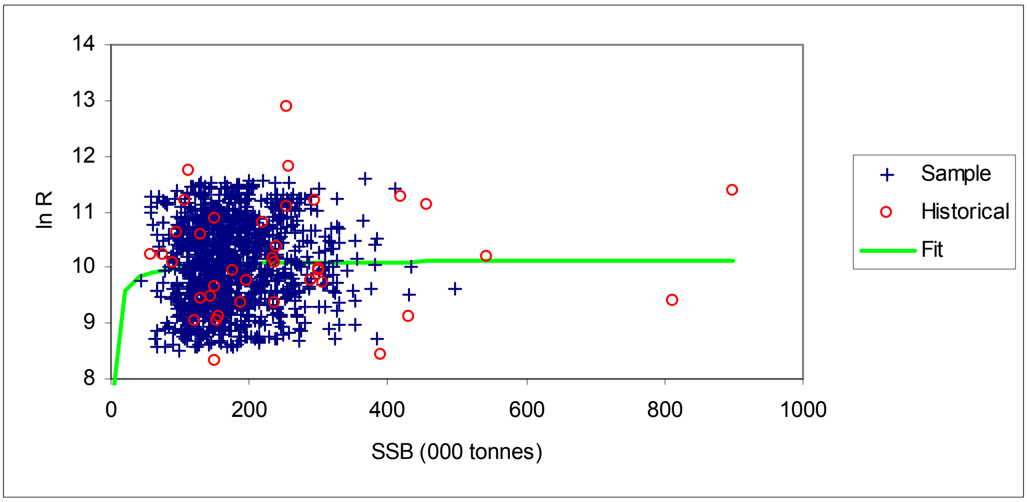


Figure 0.1 Haddock in the North Sea and Skagerrak. Comparison of historical and sample stock-recruit scatterplots (arithmetic and log recruitment scales), along with fitted Beverton-Holt curve.

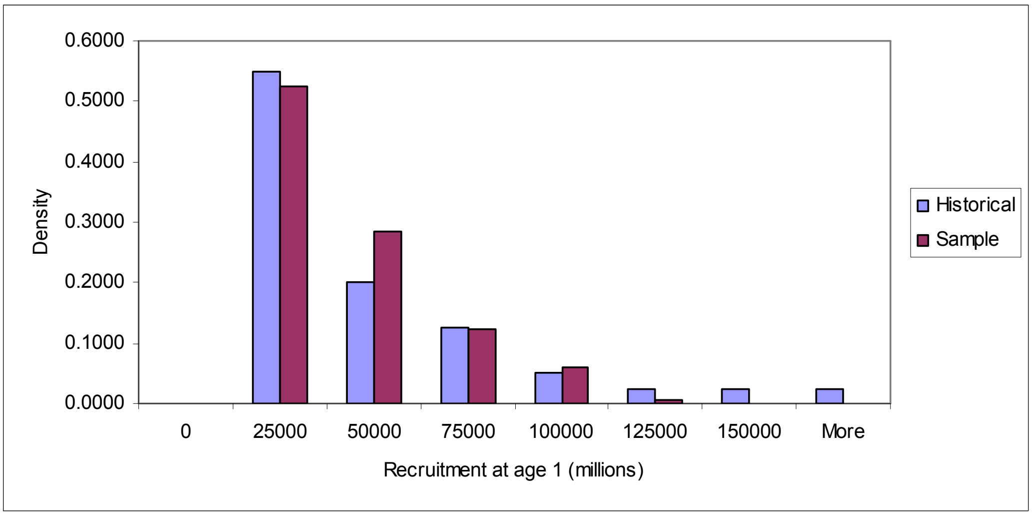
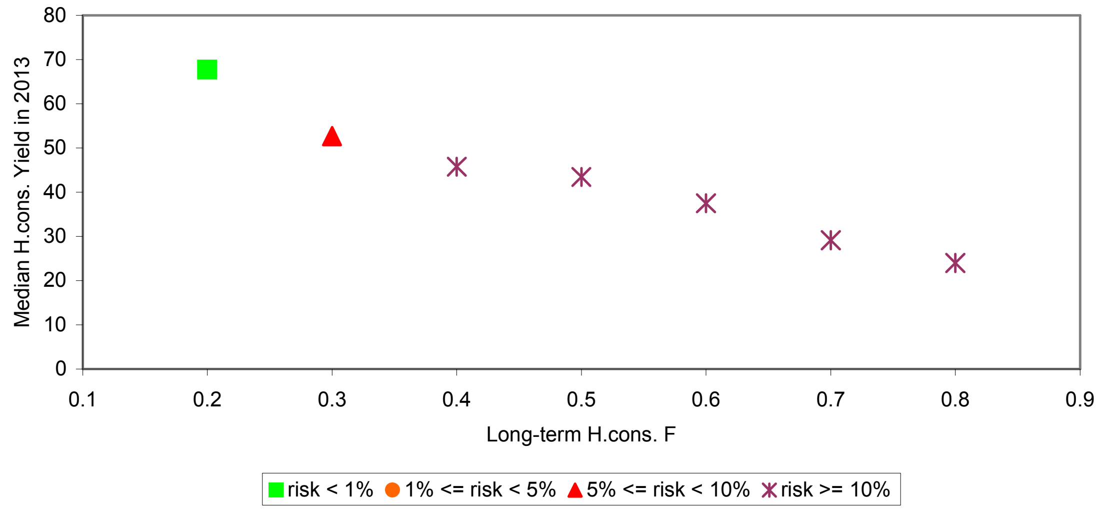
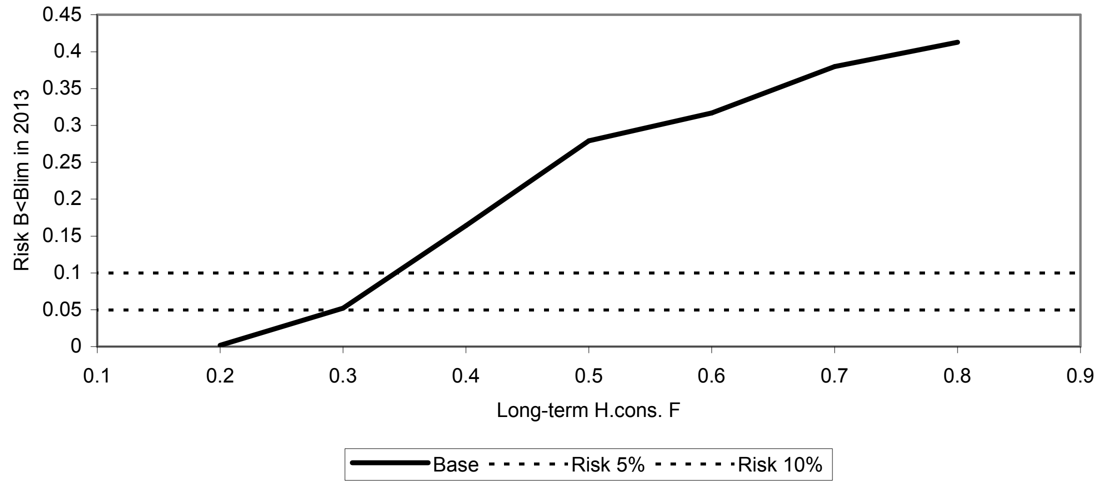


Figure 0.2 Haddock in the North Sea and Skagerrak. Frequency distributions of historical and sampled recruitment.





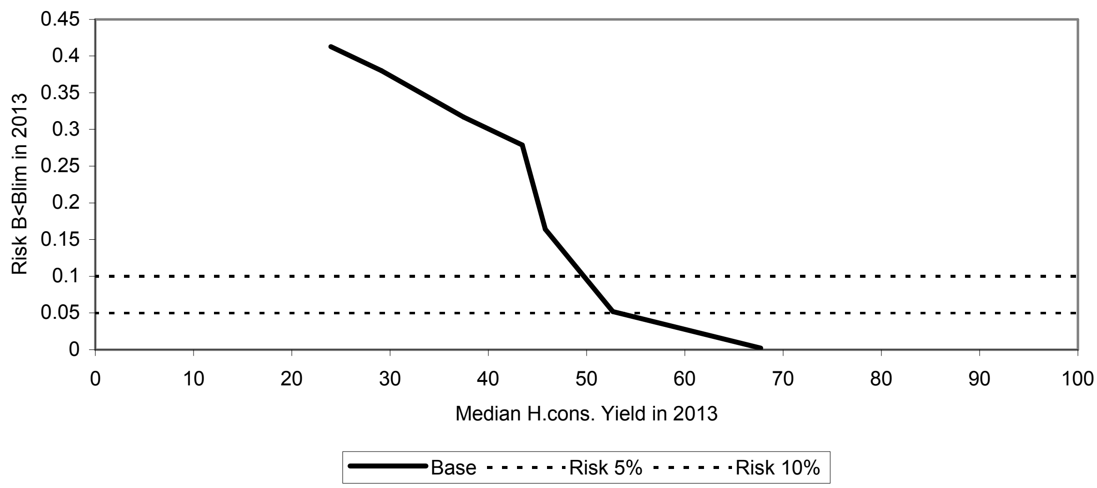


Figure 0.3 Haddock in North Sea and Skagerrak. Summary plots for S3S runs, using base-case inputs.

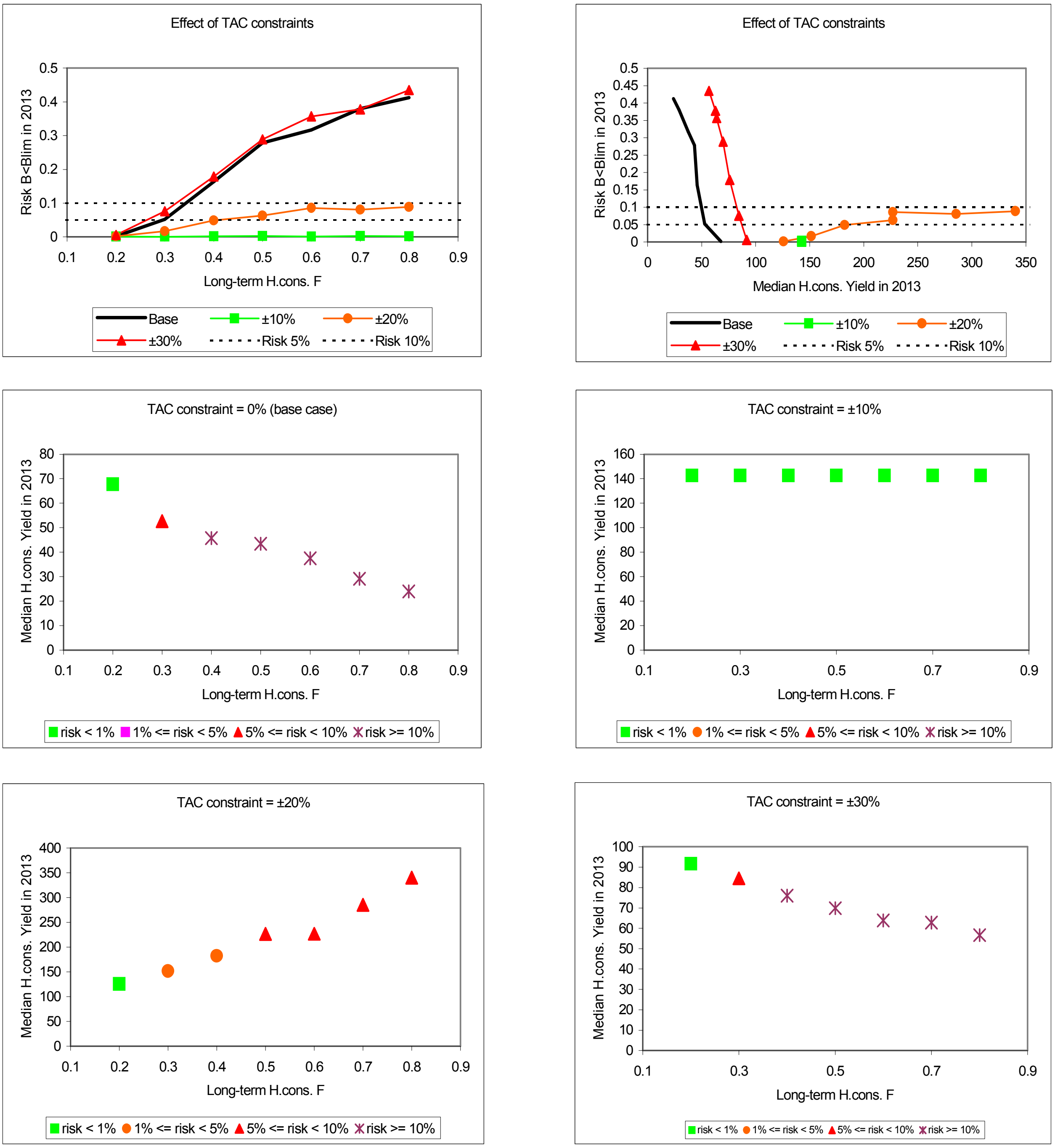


Figure 0.4 Haddock in North Sea and Skagerrak. Summary plots for S3S runs, evaluating the effect of different TAC constraints.

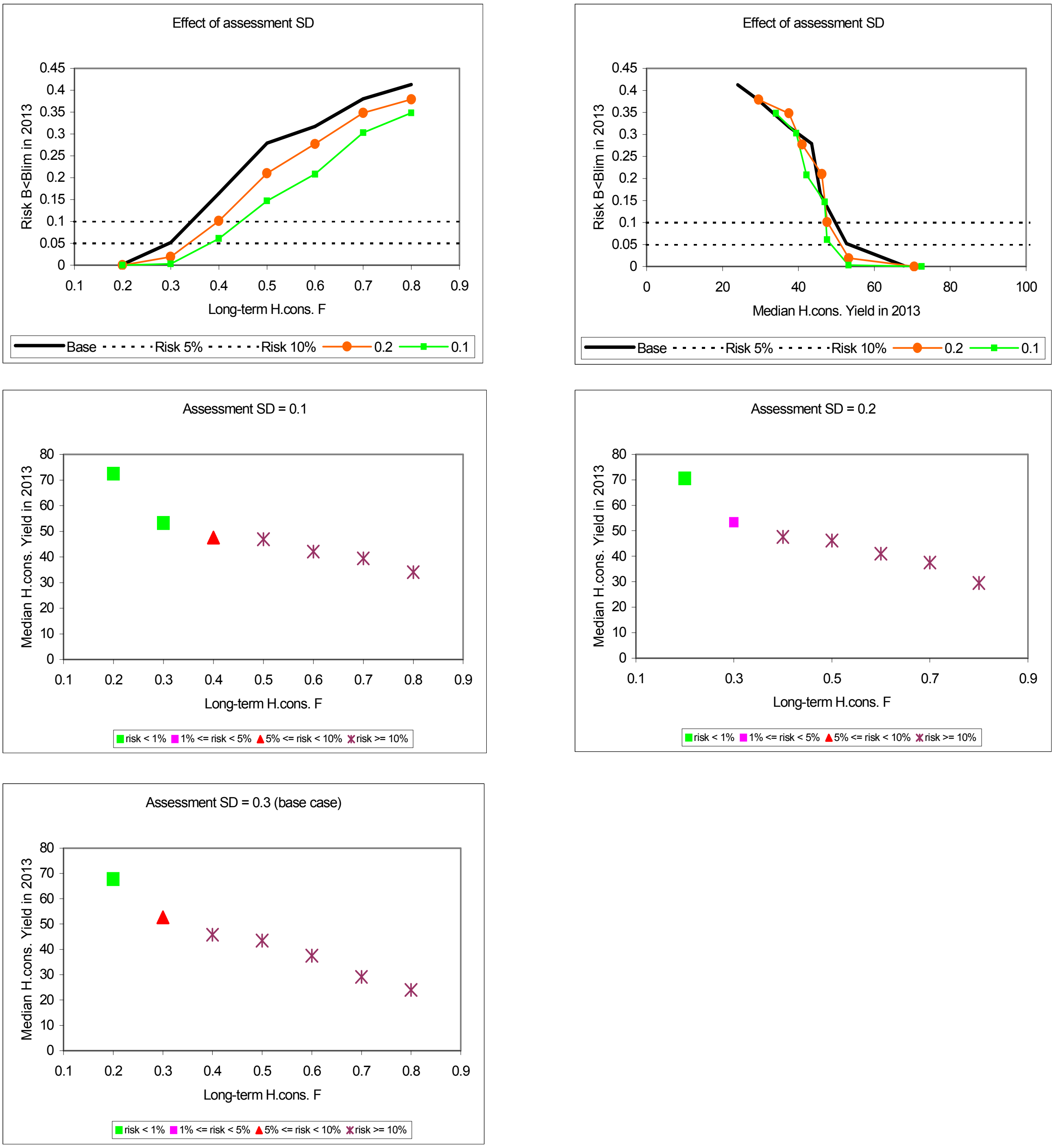


Figure 0.5 Haddock in North Sea and Skagerrak. Summary plots for S3S runs, evaluating the effect of different assessment uncertainty

NORTH SEA AND WEST OF SCOTLAND SAITHE

CURRENT STATUS

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being within safe biological limits. Fishing mortality has declined from 1986 to 2002, and is estimated below F_{pa} (0.4) in 2002. SSB has remained near or below B_{pa} (106 kt) since 1984, but it has increased in the late 1990s and is estimated to be above B_{pa} since 1999. Currently, total landings lie below TAC.

STRATEGIC CHOICES

Performance of an HCR of the type illustrated in Section 3.1 was explored for variations around a base case (parameters in Table 0.1). Some key results are illustrated in Figure 0.1. It is indicated that Fs up 0.5 carry little risk of falling below B_{lim} provided that there is no constraint on between-year variation in catches. However, when management flexibility is restricted by constraints on catch variation then lower Fs are required in order to avoid risks for the stock. There is clearly a trade-off between fishing mortality and yield stability, both in terms of risk and yield.

The pattern in Figure 0.1 (where risk is plotted against long term yield) indicates that policies that ensure high levels of SSB eventually allow large catches to be taken in the long run. But this applies to the long term only.

A HCR with a long-term F of 0.25 (close to perceived current F) and symmetric +/-10% constraint in year-to-year variation in yield (a request often voiced by the industry) carries little risk of falling below B_{lim} in the medium or long run and is considered precautionary.

Table 0.1 North Sea West of Scotland Saithe parameters used for simulation

Run settings for STPR/S3S		
Youngest/oldest age		1-10
Ref F age interval		3-6
Fsq		0.26
Blim		106 000
Trigger Biomass		200 000
F-level 1 (depleted)		0.1
F-level 2 (intermediate)		linear
Max TAC change		+/- 10%
Max F change		Not constrained
Maximum F		1.5
SRR Model		Ockham's razor
	GM	251 000 thousands
	Break point	250 000 tonnes
	Std-residuals on rec.	0.44
	max-value rec.	1.0
Assessment-bias		no
Assessment-std		0.25
Implementation-bias		1.0
Implementation-std		0.1

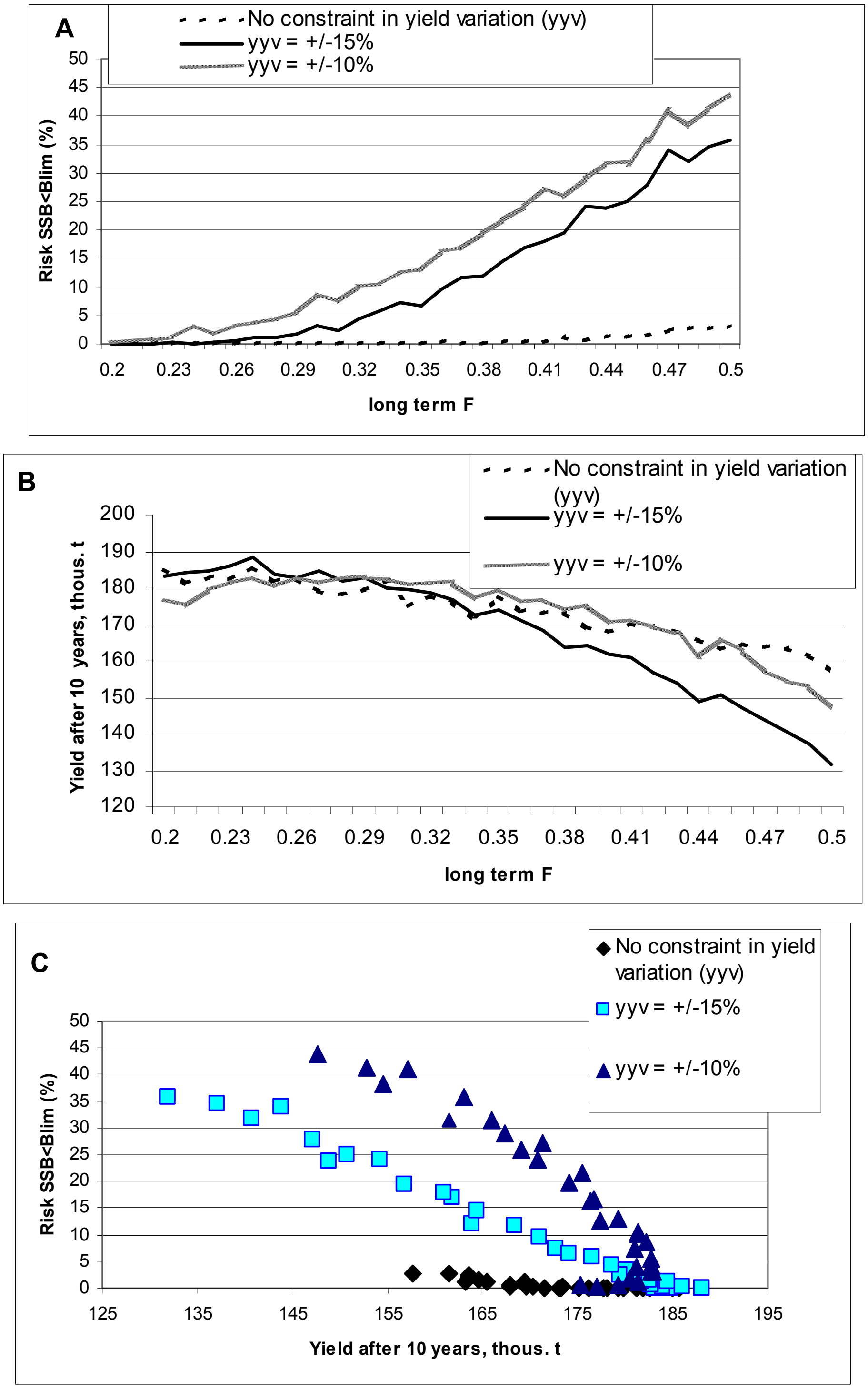


Figure 0.1 North Sea and west of Scotland Saithe. For three different levels of yield variation constraint: (A) long term fishing mortality and the probability that the spawning stock biomass falls below B_{lim} after 10 years (B) long term fishing mortality and yield after 10 years (C) yield after 10 years and the probability that the spawning stock biomass falls below B_{lim} after 10 years, when varying the fishing

SHORT TERM TRANSITION

Fishing mortality is currently very close to the long term F implied in the base case HCR (0.25), and SSB is estimated to be increasing and well above B_{lim} and $B_{trigger}$. Therefore, the

HCR stabilizes immediately both SSB and yield (Fig. 4.4.2). There would be no significant loss in yield of implementing the HCR in the short term.

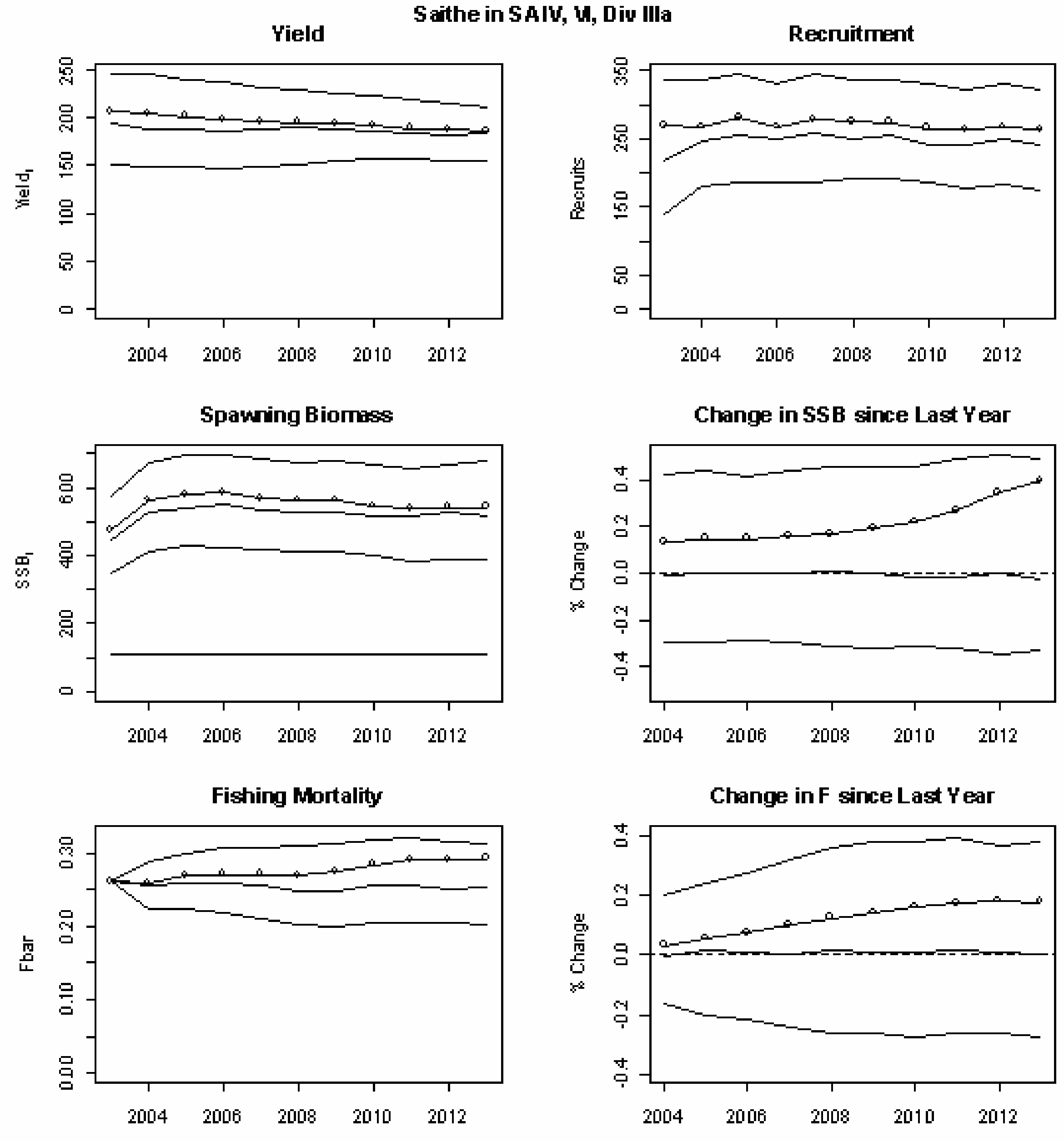


Figure 0.2 North Sea and west of Scotland Saithe Transitory effects of the base case HCR (long term F=0.25, yyv=+/-10%).

SENSITIVITY

Stock-recruitment

Initial runs were carried using the Ricker stock-recruitment model used by ICES. With the low F used in the HCR, SSB increased far above observed historic values, which led to low recruitments (section 6) and cyclic stock-recruitment dynamics. Moreover, the assumed error structure (lognormal with constant CV) implied that no above average recruitment would be possible at high levels of SSB. Altogether, these features were considered unrealistic. A preferred alternative was to use the Ockham's razor stock-recruitment model with a breakpoint of 250 000t (roughly corresponding to the peak of the fitted Ricker curve), and a constant expected recruitment equal to the observed long term geometric mean (251 m) thereafter (Figure 0.3 North Sea and west of Scotland Saithe). A segmented regression fit on historic data yielded an estimate slightly below 100 000t for the breakpoint, which was considered unrealistic since this is in the area of the lowest observed SSB. A breakpoint of 200 000t was also tried, and this had no effects on the performance of the HCR. It should be noted, however, that these choices for the breakpoint imply that few recruitments in the simulations are generated in the SSB range between 100 000t and 150 000t where most historic values lie. The MATES project has investigated several stock-recruitment models and it was found that perceptions of risks were only weakly sensitive to these choices for saithe. Nevertheless, it will be important to revisit the stock-recruitment issue if and when management along the suggested HCR brings SSB above values seen so far.

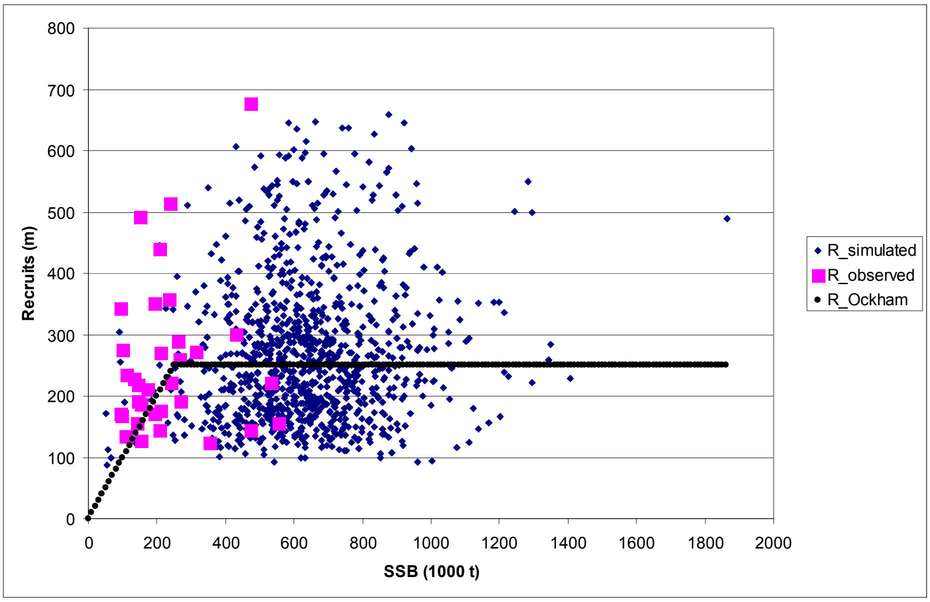


Figure 0.3 North Sea and west of Scotland Saithe Observed and simulated stock-recruitments. The base case stock-recruitment model's (Ockham's razor) expected recruitments are also shown

Mean weights

Initial runs where the mean weights (in catch and stock) were drawn from the full historic time series (1967-2002) immediately resulted in catches and SSBs well above recent values, and inconsistencies with ICES's short term predictions for 2003-2004. Analyses conducted in the MATES project indicated that weights at age had tended to decrease since the mid-1990ies. ICES also used recent weights at age in their forecasts. It was therefore decided to restrict the period from which the program draws values to 1992-2002. This range still allows some variability in mean weights.

Interim year (2003)

Staring population numbers, with their associated CVs were taken from the 2003 ICES assessment. Exploitation pattern was the average over 2000-2002 and was assumed to remain unchanged during the simulation period. Consistent with ICES, status quo F (0.26, equal to the average F in 2000-2002) was assumed for 2003. Recruitment for that year was assumed equal to the geometric mean during the period 1985-2002 (212 m). The resulting catch served as reference for the constraint on catch variation in 2004, in those runs where such a constraint was assumed.

Trigger SSB

Several values (200000, 250000 and 300000t) were tried as trigger SSB, below which F is prescribed to be reduced, These options had practically no effect on the perception of risk when managing under the HCR with a long term F of 0.25 and year-on-year variation in catch constrained to +/- 10% or unconstrained. This is because SSB below 300 000t were seldom seen with that level of F. The trigger SSB of 200 000 t (=B_{pa}) was eventually kept. Note that this is below the breakpoint in the stock-recruitment curve, which suggests that ICES reference points for this stock need to be revisited.

Long term F

A range of different long term Fs (0.2-0.5) was explored, with or without constraint on between-year variation in catches. The results are consistent with MATES' finding that F_{pa} (=0.4) could be risky in some circumstances. It should be noted that increasing F above about 0.3 leads to decreased yields in the long term (Figure 0.1).

Assessment error and bias

Based on the retrospective analyses in the last assessment conducted by ICES, there is no indication of consistent bias in the assessment over- or under-estimating the stock (although there was a tendency of underestimation of SSB and over-estimation of F in the past). Most of the uncertainty arises from problems to estimate the abundance of saithe younger than age 3, both in the terminal period and into the short term prediction period. Rapid changes in the "true" stock are often perceived with some delay. Thus, the reputation of uncertain assessment applies to the forecast rather than to the estimation of historic stock states, which is what the simulation program considers. Nevertheless, an assessment error (CV=0.25) was assumed in the base case HCR to represent a worst-case scenario. Robustness of the HCR to assessment bias was explored in a run assuming that assessments would be "optimistic" by 20%. As expected, this led to degraded performance of the HCR (the risk to the stock rose to about 5% for F=0.25).

Implementation error and bias

Runs were carried out with implementation bias in the range 1.0-1.25 and a CV of 0.2. As expected, if the realized catch exceeds the intended catch then the probability of falling below B_{lim} increases and exceeds 5% for a implementation bias in the range 10-15%. However, given the current situation where the TAC is not taken, this is unlikely to happen.

CONCLUSIONS

Precautionary management of the saithe fishery can be achieved by several combinations of long term F and constraints on year-to-year variation in yield. The stricter the constraint, the lower F must be.

There are no benefits in terms of increased long term yield to increase F above 0.3.

Several possible HCRs may increase SSB to levels not observed so far, where the effects on recruitment cannot be anticipated. The stock-recruitment issue will have to be revisited if the stock increases above observed levels.

The perception of risk from this study is contingent on the assumed B_{lim} value. This value is currently set near some of the lowest observed SSBs, rather than based on population dynamics considerations.

Since the saithe stock is in a good condition, at the current F level (equal to the level in the base case run) constraints in year to year variation in yield can be introduced in the fishery, without substantially increasing the risk.

NORTH SEA AND EASTERN CHANNEL WHITING

CURRENT STATUS

Whiting is taken in a mixed fishery with other species such as haddock. The single species Precautionary Approach reference points (unchanged since 1999) for whiting are:

B_{lim} = 225 kt, B_{pa} = 315 kt.
F_{lim} = 0.9, F_{pa} = 0.65.

There are currently no explicit management objectives for this stock.

ACFM October 2002 meeting (ICES 2003): $F_{0.1}$ = 0.270, F_{med} = 0.671, F_{max} = 0.915.

STRATEGIC CHOICES

The STPR3 input files for the base case for whiting are given in the Appendix 6. The source for the data used to generate these files was the report of the 2003 meeting of the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK; ICES 2004). A time-series analysis (TSA) assessment (ICES 2002) proposed by WGNSSK was used as a starting point for simulations, although this assessment is extremely uncertain and WGNSSK did not produce forecasts for this stock at its meeting in 2003. However, these forecasts were subsequently produced for ACFM (Needle 2003b). The exploitation patterns used in the analyses undertaken at this meeting were taken from run 6 of those forecasts - basis F(2002), 100% derogation uptake, and 1.0 effort multiplier.

Note that this is only one example from many that are available and plausible for this stock. The analyses presented in these Sections 4.5 are merely illustrative of the development of the whiting stock under a range of candidate harvest control rules. The ICES' whiting stock assessment is performed on the basis of three catch components: human consumption landings, discards, and industrial by-catch. The current implementation of STPR3 (version 3.0) does not model explicitly three such catch components but only permits two fleets which are treated independently. Landings and discards were each assigned to one of the two fleets. In reality these fleets are not independent, and the same HCR was used for each to impose a linkage between them. The low industrial by-catch F-at-age was added to the assumed natural mortality at age. The CVs of TSA survivor estimates from the WGNSSK assessment were included as the diagonal entries in the variance-covariance matrix for initial stock numbers-at-age.

In the main STPR3 options file, the agreed TAC for 2003 was used as the intermediate-year catch constraint for fleet 1 (landings). The estimated discards associated with that landings TAC was used as the intermediate-year catch constraint for fleet 2 (discards). Two levels were defined in the HCR: low, bounded above by B = 225 kt (Blim) with F = 0.1, and high, bounded below by B = 315 kt (Bpa) with an initial F = 0.65. F was assumed to change linearly in the region between the lower and upper biomass bounds.

In the base case runs, only F changes were allowed but an alternative case involving an additional maximum percentage change in TAC per year was considered. Implementation bias was assumed to be 1.0 (no bias), and to have a s.d. of 0.0. These values were used because this group decided that they had no basis to assume that management in the future would lead to changes in fishery reporting practice. Stochastic numbers were generated on a logarithmic scale throughout all simulations. The appropriate choice of the s.d. to assume for the assessment bias should be based upon any a priori belief that the choice of an appropriate stock assessment for whiting is considerably uncertain. For the base case, the assessment bias was assumed to be 1.0 (no bias) with a random error of 0% (s.d. of 0.0). For completeness, sensitivity to the choice of the assumed assessment random error and bias is discussed in Section 0.

Recruitment was described by a Ricker model, fitted by RecAn (version 2.20) to the entire historical time-series of spawning stock biomass and recruitment. A comparison of the historical stock-recruitment scatter-plot (Figure 0.1e) with 1000 samples of STPR3 realisations using the base case parameter settings indicated that the assumed recruitment model in STPR3 is appropriate for these whiting simulations.

Table 0.1 North Sea whiting parameters used for simulation

Run settings for STPR/S3S		
Youngest/oldest age		1-6
Ref F age interval		2-4
Catch constraint		16 000
Blim		225 000
Trigger Biomass (B_{trig})		315 000
F-level 1 (depleted) (F_d)		0.1
F-level 2 (intermediate) (F_I)		Linear 0.25
Max TAC change		Not constrained
Max F change		Not constrained
Maximum F		1.5
SRR Model		Ricker
	P1	13.129
	P2	0.00237
	std-residuals on rec.	0.38
	max-value rec.	1.0
Assessment-bias		1.0
Assessment-st		0.0
Implementation-bias		1.0
Implementation-std		0.0

Results for the base case run are not presented in this report because it was not possible to find a long-term F in the range explored [0.25, 0.65] that gave a risk of $B < B_{\text{lim}}$ in 2013 of less than 5%. Figure 0.1 shows the cumulative probability distribution of SSB for 8 different F from 0.1 to 0.65 with no bias and no random error in the assessment. In addition one cumulative distribution with F of 0.3 with 30% random error is also included in the plot. The 5% level can be used to infer a 5% probability of SSB below a chosen level. If the level chosen is B_{lim} = 225 t it can be seen that only for F < 0.3 derived from assessments without error is the SSB above 225 at he 5% level. With a random error of 30% and F=0.3 SSB has a 22% probability of being below B_{lim}. One possible explanation for this may be that B_{lim} has been set too high for this stock. Alternatively the catch data may not well reflect the past stock exploitation.

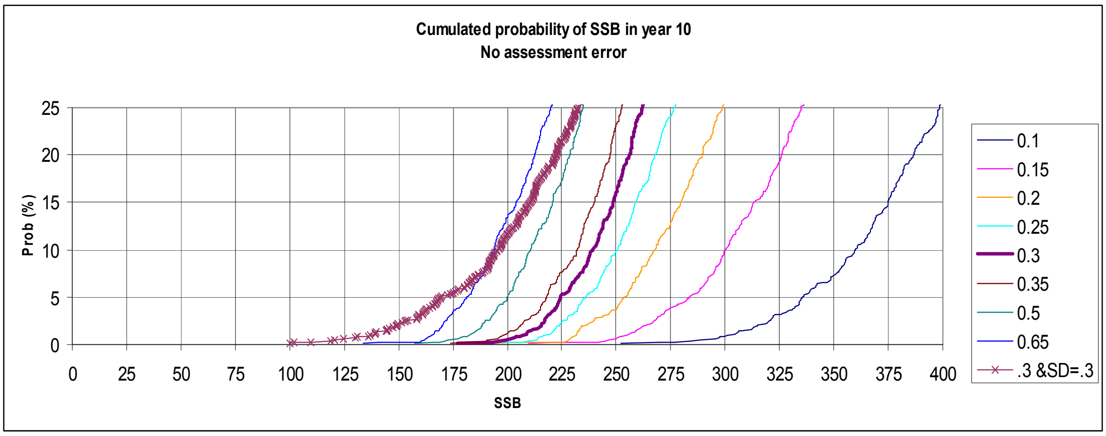


Figure 0.1 North Sea and Eastern Channel Whiting Cumulative probability distribution of SSB for 8 different Fs from 0.1 to 0.65 with no bias and no random error in the assessment. One cumulative distribution with F of 0.3 with 30% random error. The 5% level can be used to infer a 5% probability of SSB against any chosen reference SSB (for example Blim = 225 000 t)

SENSITIVITIES

Exploratory analyses were required in order to determine which simulation settings were important in determining the risk to *B* for whiting. One setting was varied at a time, over ranges deemed to be reasonable. There were four settings examined in this way in all: *F* at the high level, constraints of year-to-year TAC, assessment bias, and implementation bias.

The risk of *B* being below B_{lim} in year 10 of the simulation was most sensitive to three settings: high *F*, assessment bias, and implementation bias. Hence, these were examined further using the scanning facility of the s3s software.

Long-term F: base case

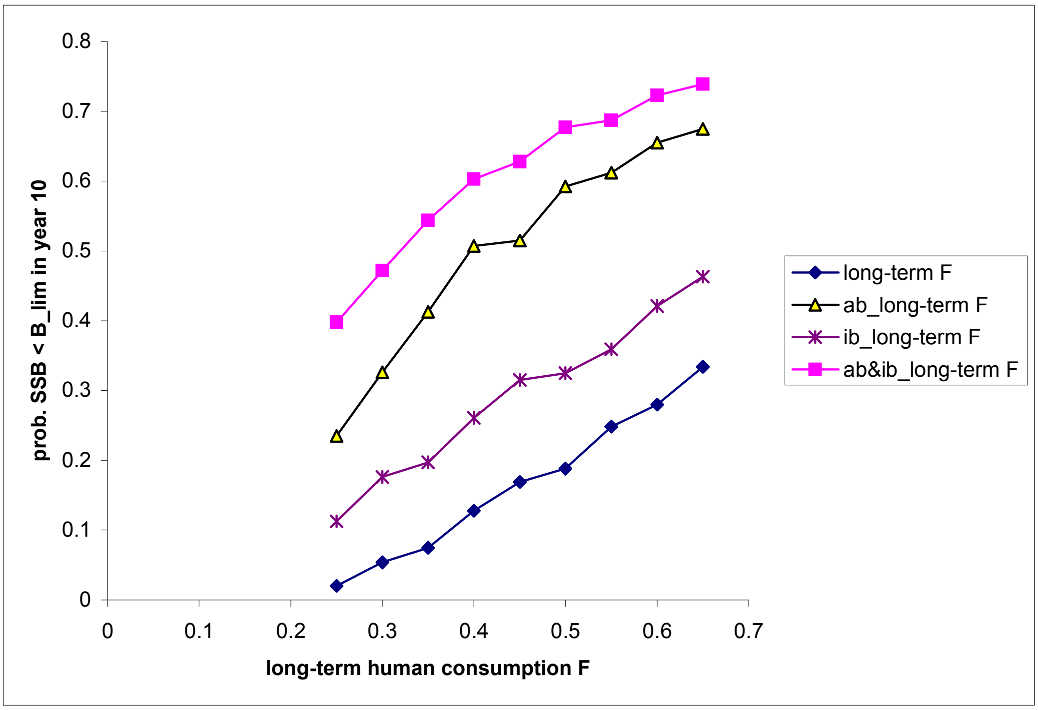
No assessment bias - As remarked in Section 4.5.1, the appropriate choice of the s.d. to assume for the assessment bias should be based upon any *a priori* belief that the choice of an appropriate stock assessment for whiting is considerably uncertain. Given the limited time available, the sensitivity to the choice of the s.d. assumed for the assessment bias was investigated with respect to the risk profile for long-term F.
Implementation bias was assumed to be 1.0 (no bias) with three assumed values of the CV (30%, 20% and 10%) …
ab(no bias, 30% CV) ~ ab(10% bias, 30% CV)
ab(no bias, 20% CV) ~ ib(10% bias, 30% CV)
ab(no bias, 10% CV) ~ Figure 0.2
In conclusion, the assessment bias and implementation bias appear confounded.

Assessment bias of 10%/Implementation bias of 10%/Both an assessment and implementation bias of 10% - The investigations presented in the base case (Sections 4.5.1) illustrate the difficulty to identify a fishing mortality that is precautionary as defined by a risk of $B < B_{lim}$ in 2013 of less than 5%. Once an assessment bias and an implementation bias are incorporated into the analyses this difficulty is further compounded (see Figure 0.3 North Sea and Eastern Channel Whiting).

Long-term F (+/- 20% TAC): alternative case

No assessment bias In the base case runs, only *F* changes were allowed but an alternative case involving an additional maximum x% change in TAC per year was considered. The group decided that an assumed

	percentage change of 30% was appropriate for the whiting stock. Results for this alternative case are given in Figure 0.3 North Sea and Eastern Channel Whiting . The whiting simulations were initialised in 2003 at the historically low agreed TAC but the results clearly illustrate that the 30% change in TAC per year determines the outcome of the simulations and that the maximum F constraint is never reached.
Assessment bias of 10%/Implementation bias of 10%/Both an assessment and implementation bias of 10% -	One might postulate that an implementation bias may become more important in the future if management strategies should be established for this stock. However, this does not have a significant impact on the risk of $B < B_{\mathrm{lim}}$ in year 10 (Figure 0.4).



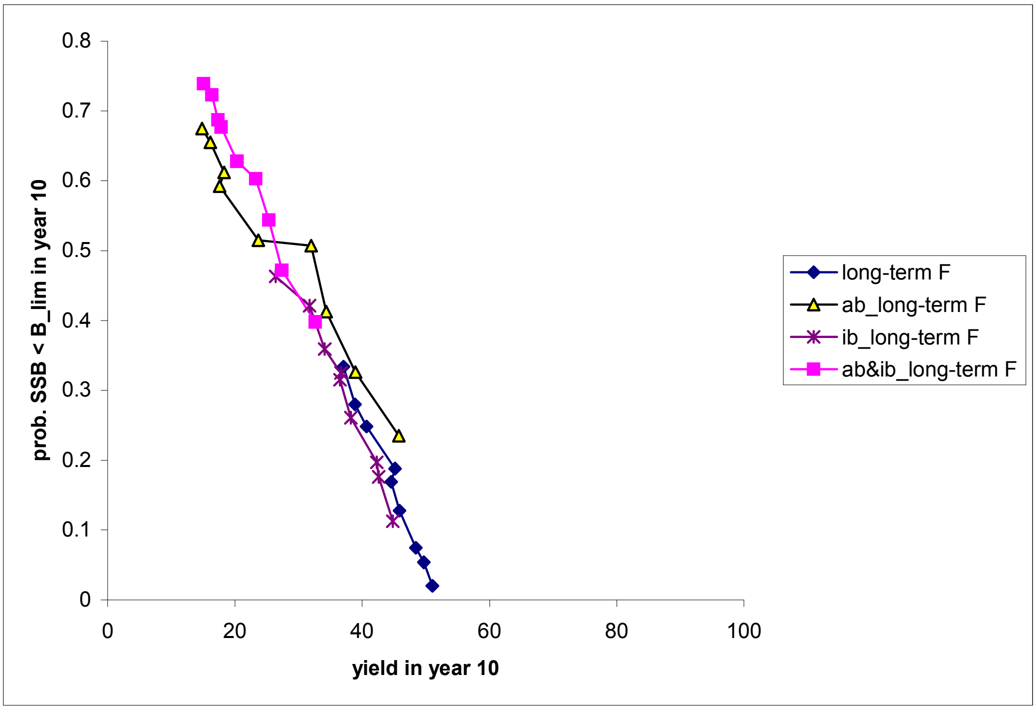


Figure 0.2 North Sea and Eastern Channel Whiting Summary graphs for s3s runs – evaluating the effect of assessment and implementation bias with long-term F.

Legend key: ab - assessment bias of 10% with a C.V. of 30%; ib – implementation bias of 10% with a C.V. of 30%; ab&ib – both assessment and implementation bias of 10% with C.V.s of 30%.

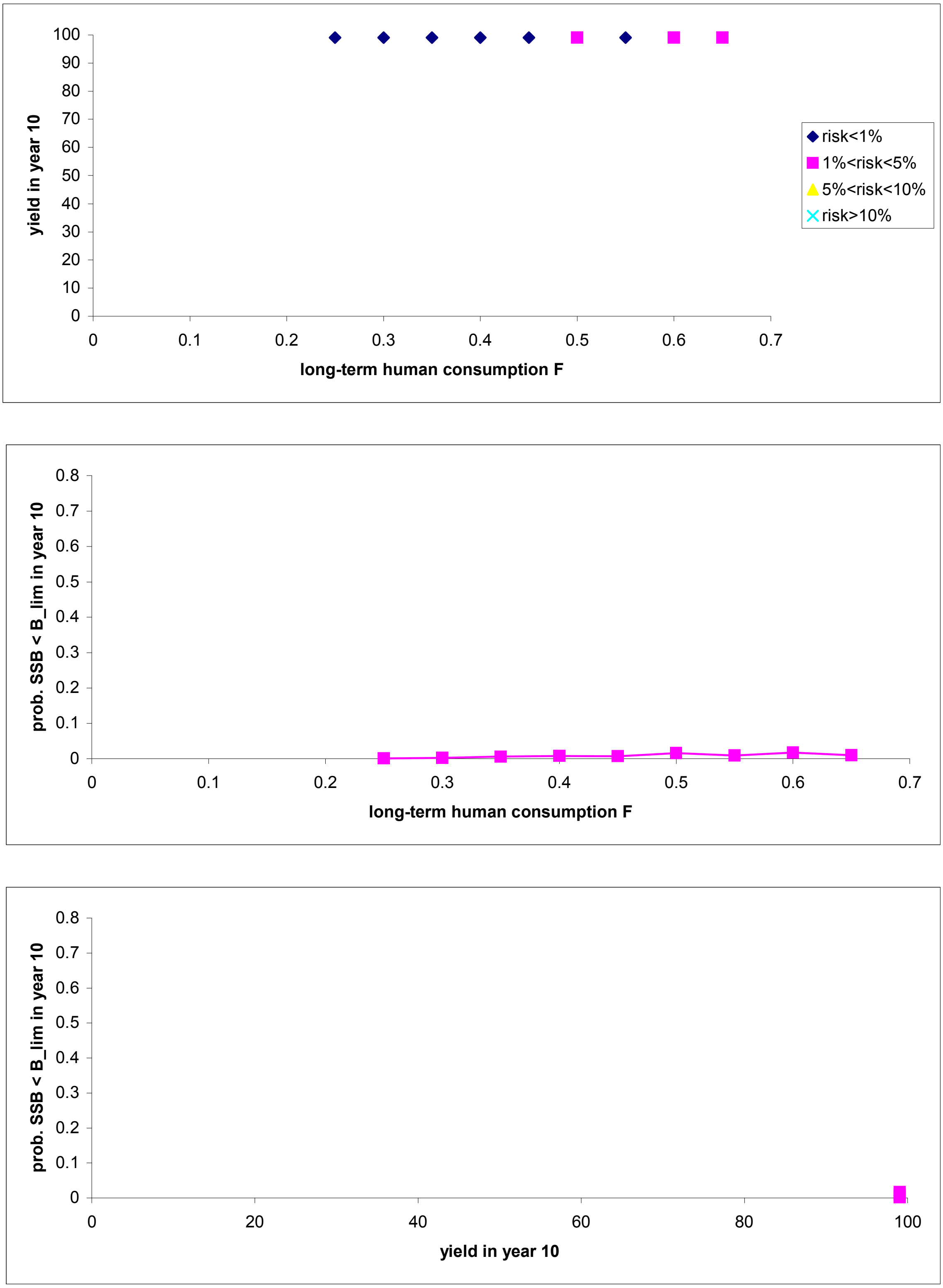
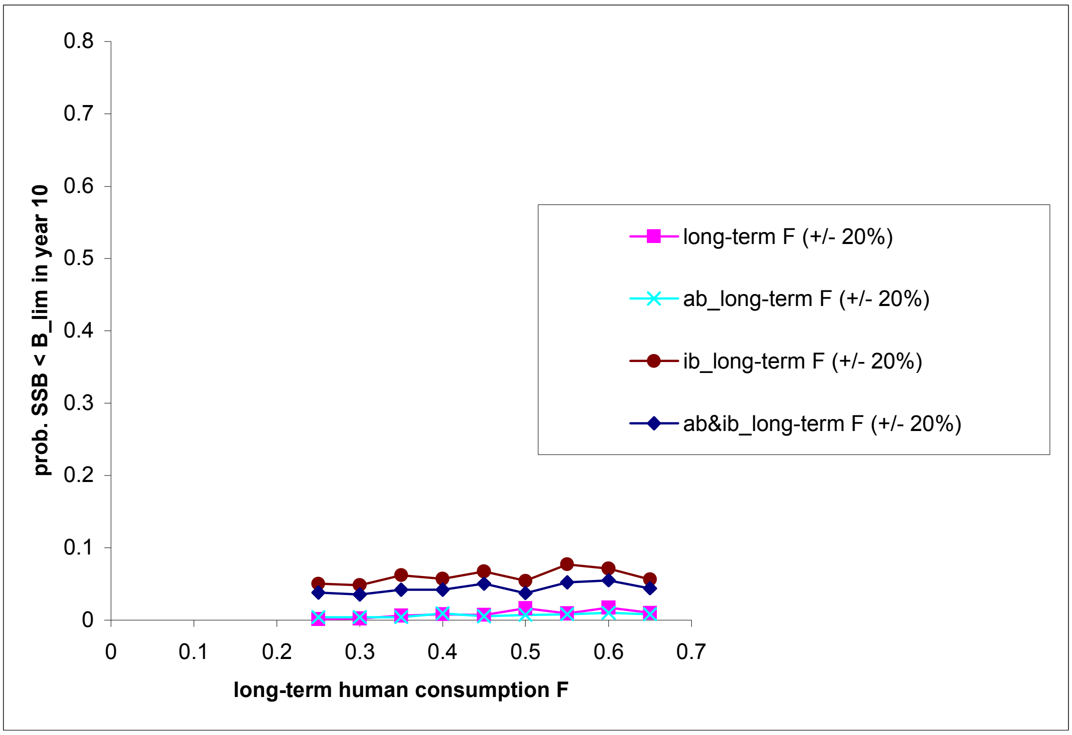


Figure 0.3 North Sea and Eastern Channel Whiting Summary graphs for s3s runs – evaluating the effect of an annual TAC constraint (alternative case).



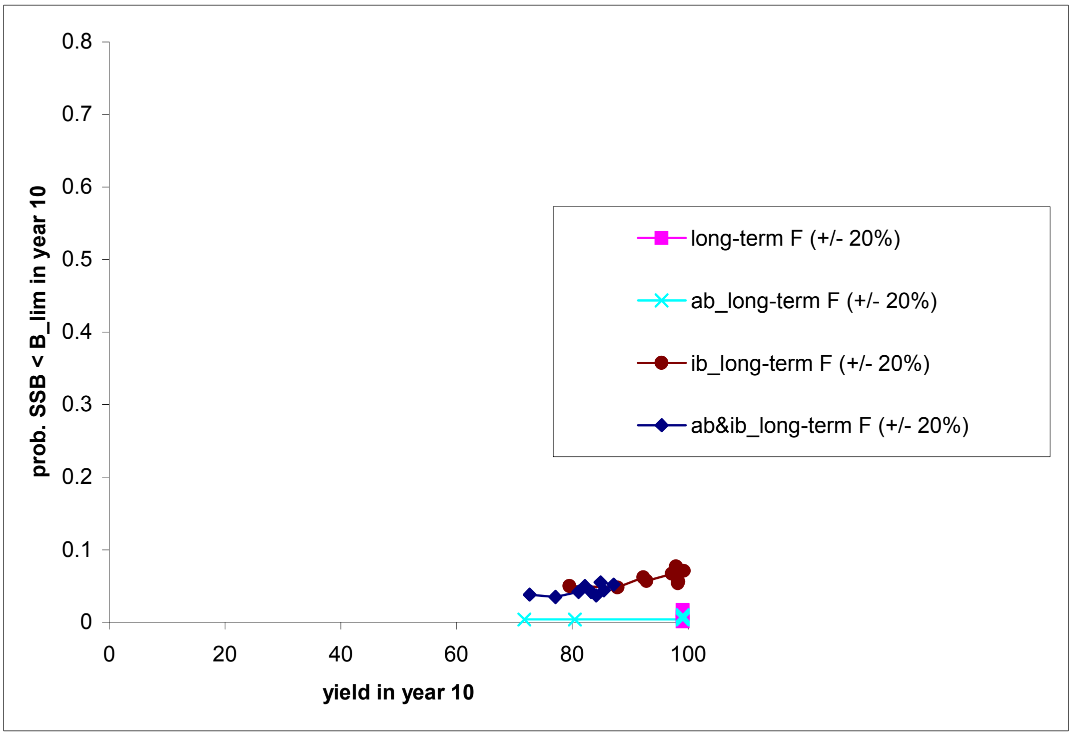


Figure 0.4 North Sea and Eastern Channel Whiting Summary graphs for s3s runs – evaluating the effect of assessment and implementation bias with long-term F (+/- 20% TAC).

Legend key: ab - assessment bias of 10% with a C.V. of 30%; ib – implementation bias of 10% with a C.V. of 30%; ab&ib – both assessment and implementation bias of 10% with C.V.s of 30%.

DISCUSSION

All the whiting simulations were initialised in 2003 at the historically low agreed TAC for that year.

Based on the uncertainty in the assessment of the whiting stock, the investigations considered in the base case illustrate the difficulty to identify a fishing mortality that is precautionary as defined by a risk of $B < B_{\text{lim}}$ in 2013 of less than 5%. One possible explanation for this is that the current B_{lim} for the whiting may be too high for this stock and it is recommended that this be considered further.

NORTH SEA (IV, IIIA & VIID) HERRING

North Sea herring is currently fished under a two fleet management agreement which has been interpreted as:

Biomass <1,300,000t	F1 <0.2	F2<0.1
Biomass > 1,300,000	F1 <0.25	F2<0.12

The fleets F1 is equivalent to the A fleet in the ACFM report and F2 is the combined B, C and D fleet Blim is 800,000 tons. Information from the herring assessment working group (HAWG) (ICES2004) suggests that the following conditions errors in the assessment and implementation are representative of recent assessments:

Assessment bias	+10%
Assessment standard deviation	20%
Implementation bias	+20%
Implementation standard deviation	10%

The use of implementation bias at 20% is chosen for this stock because the fishery has exceeded catch over the last 9 years and this yield has been included in the assessment data. Use of zero bias in implementation would result in the possibility of introducing opposite bias in the simulations unless it was believed that implementation error would be reduced to zero in the future.

The assessment data from the HAWG was used to provide a set of input data given in Appendix 7

The stock recruit relationship chosen for North Sea herring was and Ockham function with lognormal residual. The parameters were

Mean recruitment above change point	49342000
SSB change point of	537,000 t
CV of recruitment	0.578
Truncation	1.0

Values were checked by comparing cumulative probability distributions from simulated data and historic time series. There are no historic changes in development though there is some evidence of a single very big year class showing density dependent growth.

Historic variability in weight at age and maturity were included in the simulations. No long term trends have been observed so none were tested.

The yield per recruit curve for herring is flat-topped but with a maximum at around 0.4. (assuming Exploitation by fisheries on juveniles (Fleet 2) remains similar) The current F is at 0.24 . Harvest control rules were evaluated for F <= 0.4.

STPR was used to evaluate risk of SSB <Blim in year 10 as asymptotic or equilibrium value for this stock.

STRATEGIC CHOICES

Table 0.1 North Sea herring parameters used for simulation

Run settings for STPR/S3S		
Youngest/oldest age		0-9
Ref F age interval		2-6
Fsq	Fleet1	0.2326
	Fleet2	0.0369
Blim		800 000
Trigger Biomass (B_{trig})		1 300 000
F-level 1 (depleted) (F_d)		0.20
F-level 2 (intermediate) (F_I)		Fixed 0.20
Max TAC change		not constrained
Max F change		not constrained
Maximum F		1.5
SRR Model		Ockhams razor
	GM	49 342 millions
	Bloss	537 000 tonnes
	std-residuals on rec.	0.578
	max-value rec.	1.0
Assessment-bias		1.1
Assessment-st		0.2
Implementation-bias		1.2
Implementation-std		0.1

Table 0.1 shows the main options used in the SPR3 software. To provide a range of strategic options the following spread of values for the harvest control rule were tested:

F options Fleet 1	0.15 to 0.40
F options Fleet 2	0.00 to 0.18
Fixed yield in Fleet 2	30 to 100 thousand tonnes
Fixed level of F in the intermediate stage.	0.2
Linear F change through the intermediate stage.	0.15 to 0.25

The results of these options are summarised in figures below.

Figure 0.2 shows North Sea herring yield in human consumption Fleet A against fishing mortality (F) for four levels of fishing mortality in juvenile Fleets (F_{juv} = 0.00, 0.06, 0.12, 0.18). The figure also shows risk classes as probability of SSB being less than Blim in year 10. This is contrasted by the yield of North Sea herring human consumption Fleet A against F for four levels of fixed yield in juvenile fleets with yield of 30, 50, 70 and 100 t in Figure 0.3. This also shows risk classes as probability of SSB being less than B_{lim} in year 10.

The trade off between juvenile and adult F and risk of SSB < Blim is shown in Figure 0.4. Risk against yield for Fleet A (adult) for four levels of fishing mortality in juvenile fleets 0, 0.06, 0.12, 0.18 for adult F 0.15 to 0.40 is given in Figure 0.5. There is little increased yield but steady increased risk as F is increased. Only at low yields of juveniles is there much increase in yield for little increase in risk.

The management and yield is also affected by the amount of time the stock is exploited below Btrig of 1300,000 t. For these harvest rules the probability of SSB being below Btrig, (1300,000) is shown in Figure 0.6 and Figure 0.7 for the different controls for the juvenile fleet. There is quite a high probability of SSB being below Btrig, the transition biomass to the long term F part of the harvest control rule. The current rule is thought to give a risk of 41% that SSB will be below Btrig. This thought to because of the combination of assessment and implementation bias.

As there is a reasonable probability of SSB being below Btrig, an alternative strategy of linear reduction in F with SSB Btrig has been tested. Figure 0.7 shows yield in human consumption fleet A against F for four levels of fishing mortality in juvenile fleets 0.00, 0.06, 0.12, 0.18 showing risk classes of the probability of SSB being less than Btrig in year 10. Figure 0.8 shows North Sea herring yield in human consumption fleet A against fishing mortality (F) for four levels of fixed yield in juvenile fleets 30, 50, 70, 100 t showing risk classes as probability of SSB being less than Btrig in year 10. The change in strategy makes no difference to the probability of being below Btrig. The spread in yield for this strategy is greater than for the flat level.

The range of possibilities is extensive and represented by the Figures discussed above. A small number of runs have been selected to illustrate options. Table 0.1 shows the settings for selected options, Table 4.6.2 shows a small range of output data from these options.

TRANSITION

No transition period is anticipated for this stock and just as an example STPR was used to give an indication of development under the current harvest rule (Fig 4.6.9). For comparison a run with no implementation error is included for reference Fig 4.6.10).

Slow change in catch was evaluated for the current harvest control rule. Because the stock is expected to decline over next 10 years from a high, a constraint on yield change was tested. This increase yield but also increase risk. At this level of harvest control rule only a constraint of <5% of increase combined with >15% of reduction have a risk level below 5% of SSB<Blim. Other options at lower overall F could be examined if reduced exploitation was desirable but have not been evaluated here. However, because the yield is currently expected to rise and then have to fall for 2 to 3 years, a constraint to a maximum catch at the current level of Fleet A <460,000 t and Fleet BCD at <100,000 is the simplest method of stabilising yield over the next 5 years. This is illustrated in Figure 0.11. Although this is illustrated for 10 years if recruitment in 2004 or 5 is seen to be good catches may be allowed to rise again in 2008 or 2009. The yield here can be compared with yield in Figure 0.9 for the current annually unconstrained rule.

SENSITIVITY

The sensitivity of the risk was tested for the current rule by varying

assessment bias	+ 5 to +20%
assessment standard deviation	10 to 30%
implementation bias	+5 +25%
implementation standard deviation	5 to 20%

The risk associated with the current harvest control rule was not particularly sensitive to random errors of these magnitudes but was particularly sensitive to assessment bias and implementation error. When the combination of these is kept below 30% the simulations show risks below 5%. However, the risk of SSB < Blim rises rapidly if there is greater exploitation or implementation error.

While the stock recruit relationship is important for estimating the expected yield, the flat characteristics of the Ockham function provides a compromise between the other possible models for equilibrium SSB at the level expected for this stock.

SUMMARY NORTH SEA HERRING

The current harvest control rule and setting seems to be functioning well according to these simulations.. However, there are some matters for consideration.

Exceeding the levels of assessment and implementation error observed over the last 5-10 years are likely to result in an increased risk of SSB < Blim. They are probably responsible for the relatively high proportion of time (41%) when biomass is found below 1,300,000 t in the intermediate part of the harvest control regime. Moderate improvement in assessment error which is possible in a more stable exploitation regime, or if moderate reduction in implementation bias yields are high, the risks seen here will be overestimates.

The option of a linear F to biomass function between the depleted and long term regions of the HCR provides a 5% higher median yield than the constant F=0.2 setting at a slightly lower risk of SSB<Blim,. However, But at a slightly wider spread of yield but similar year on year change in yield. The abrupt change in yield at SSB=1300,000 is reduced but lower yields are obtained if SSB <1150,000 t.

There is a trade off between juvenile yield and adult yield. At comparable low levels of risk of SSB <Blim the total yield are higher when herring are taken as adult. This illustrated in table in table 4.6.2, for scenarios B1, B2 and B3.

Table 0.2 Nort Sea herring. The baseline settings for selected options in Table 0.3(data are given in appendix 6)

Rule	Biomass Trigger (000s)	F1< B trig	F2<B trig	Transition type	F1>B trig	F2> B trig	Yield Change Y-Y	F Change Y-Y
B1	1,300	0.200	0.050	Fixed	0.375	0.00	None	None
B2	1,300	0.200	0.050	Fixed	0.325	0.05	None	None
B3	1,300	0.200	0.050	Fixed	0.250	0.12	None	None
B4	1,300	0.200	0.050	Fixed	0.300	0.15	None	None
B5	1,300	0.150	0.050	Fixed	0.200	0.17	None	None
B6	1,300	0.100	0.000	Linear	0.250	0.12	None	None

Table 0.3 North Sea herring. Median values for yield and y-y change for selected options (Table 0.2)

Rule	F1 Yield	F2 Yield	F1 Y-Y change yield	F2 Y-Y change yield	Risk B<Blim
B1	768,000	0	55	0	1%
B2	631,000	93,000	37	42	1%
B3	481,000	198,000	35	52	2%
B4	482,000	225,000	51	70	6%
B5	383,000	263,000	32	49	1%
B6	465,000	210,000	38	50	1%

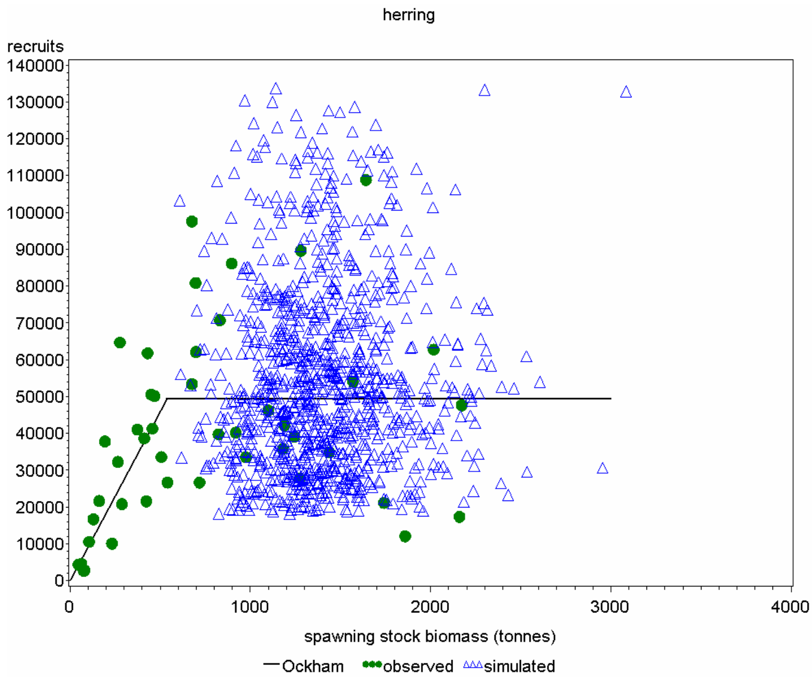


Figure 0.1 North Sea Herring Observed recruitment 1960-2004 compared to those in the simulations.

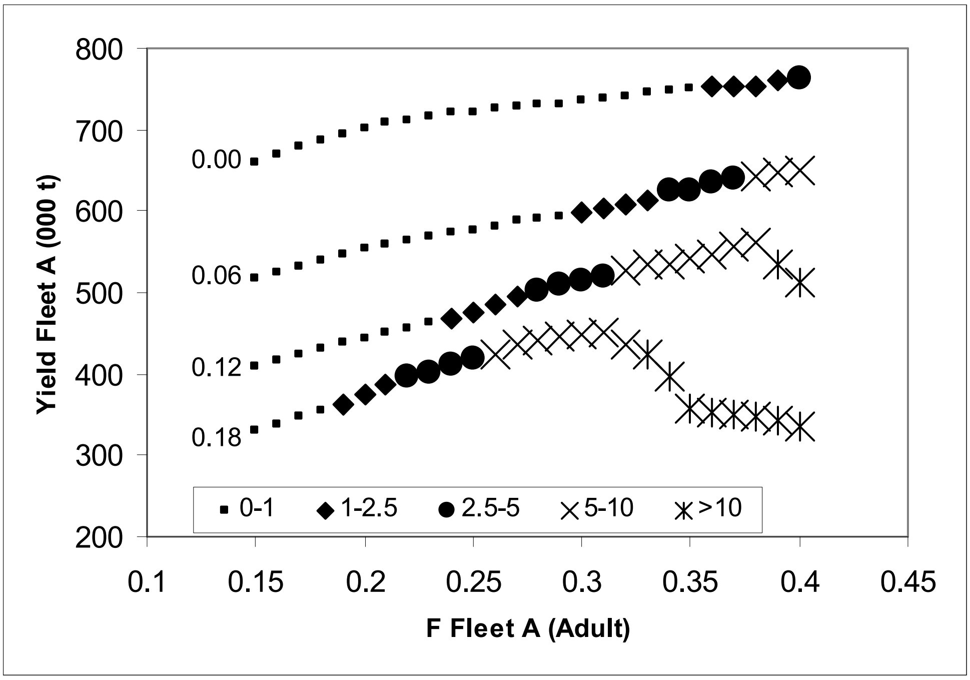


Figure 0.2 North Sea herring yield in human consumption fleet A against f for four levels of fishing mortality in juvenile fleets 0, 0.06, 0.12, 0.18 showing risk classes as probability of SSB being less than Blim in year 10. Intermediate stage F=0.2.

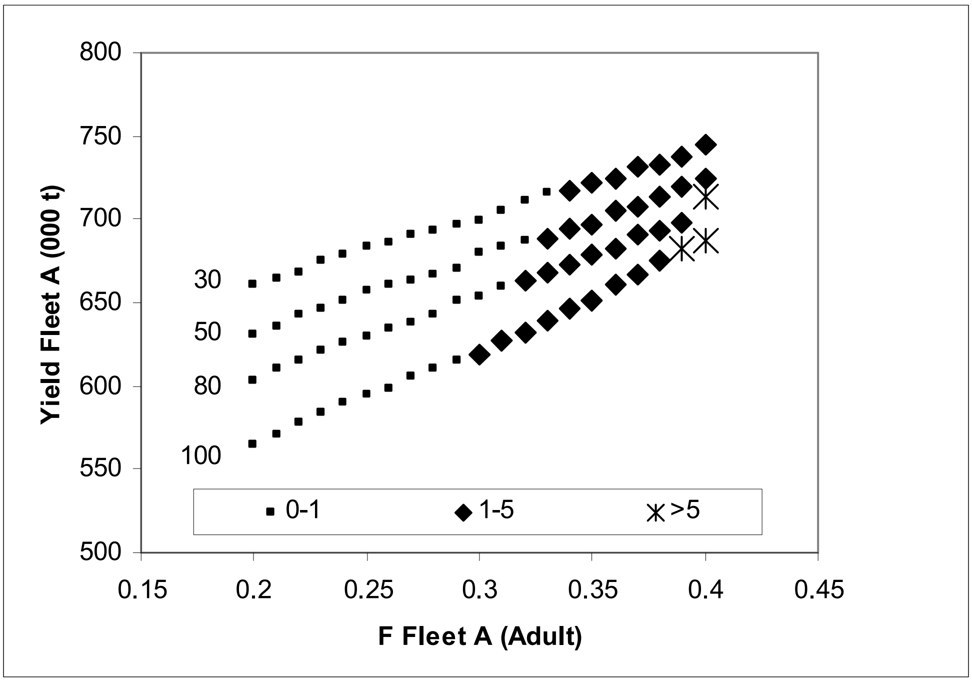


Figure 0.3 North Sea herring yield in human consumption fleet A against f for four levels of fixed yield in juvenile fleets 30, 50, 100 and 100 showing risk classes as probability of SSB being less than Blim in year 10. Intermediate stage F=0.2.

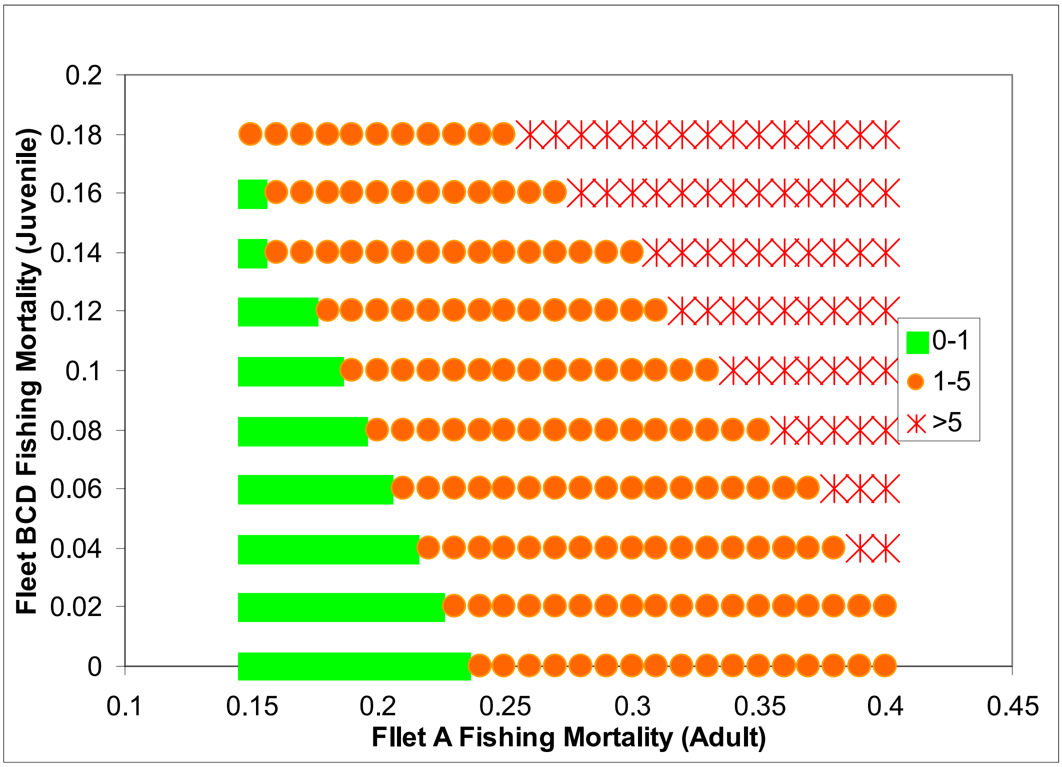


Figure 0.4 North Sea herring: Risk class 0-1, 1-5, >5 for a range of fishing mortality for fleet BCD against fishing mortality for fleet A four levels of fixed yield in juvenile fleets 0, 0.06, 0.12, 0.18 showing risk classes as probability of SSB being less than Blim in year 10. Intermediate stage F=0.2.

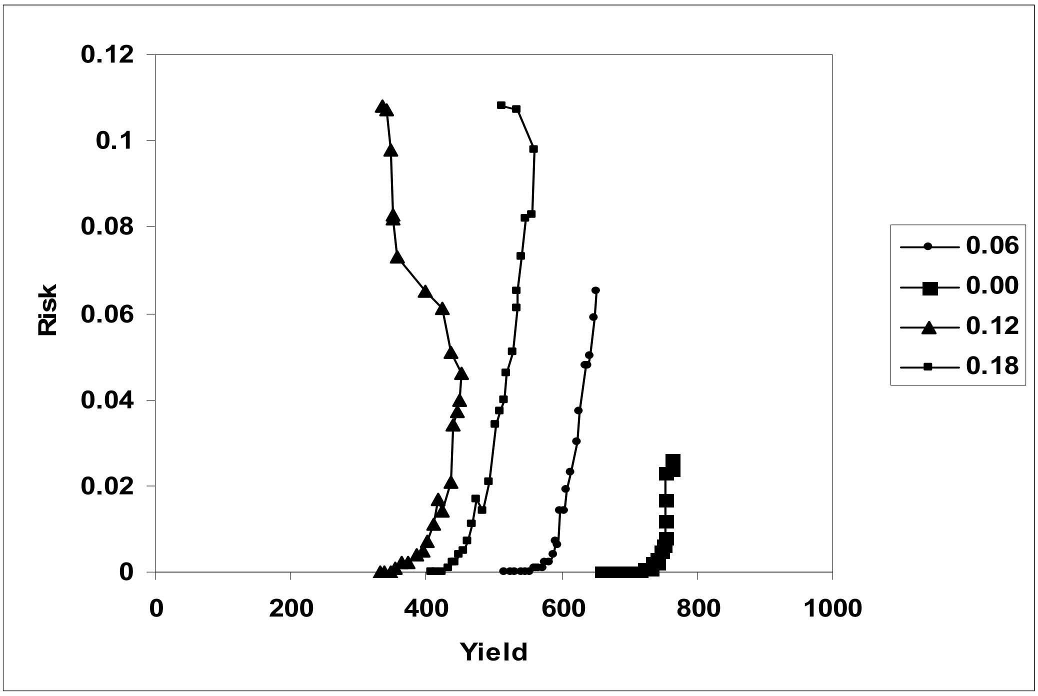


Figure 0.5 North Sea herring Risk against yield for Fleet A (adult) for four levels of fishing mortality in juvenile fleets 0, 0.06, 0.12, 0.18 for a range of adult F 0.15 to 0.40 upwards along each line. Intermediate stage F=0.2.

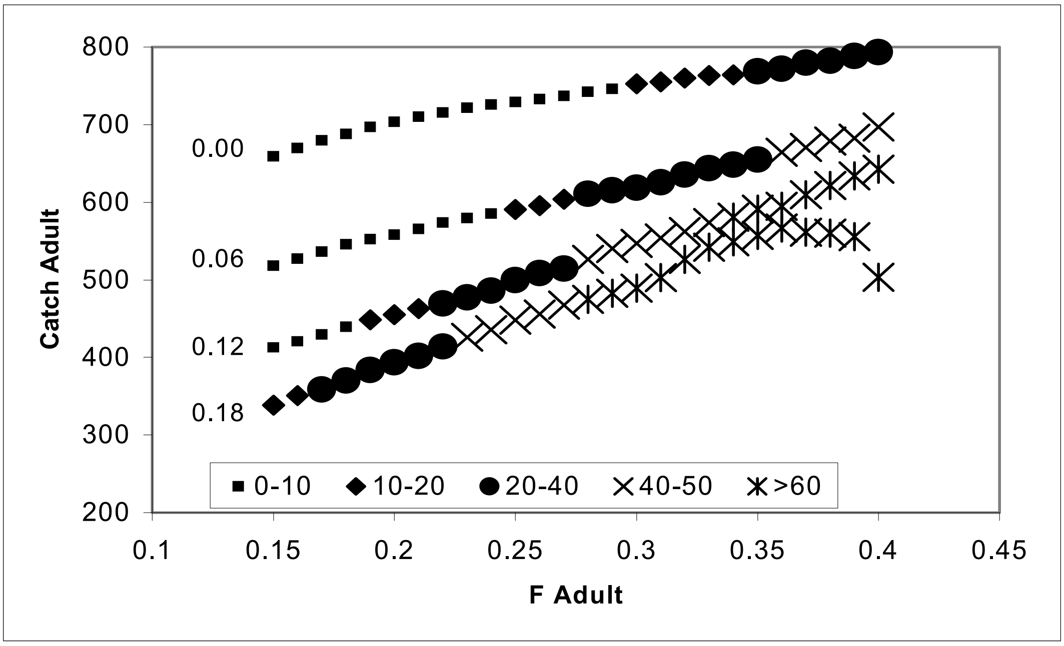


Figure 0.6 North Sea herring yield in human consumption fleet A against f for four levels of fishing mortality in juvenile fleets 0, 0.06, 0.12, 0.18 showing risk classes as probability of SSB being less than Btrig (1300,000 t) in year 10 Intermediate stage F=0.2.

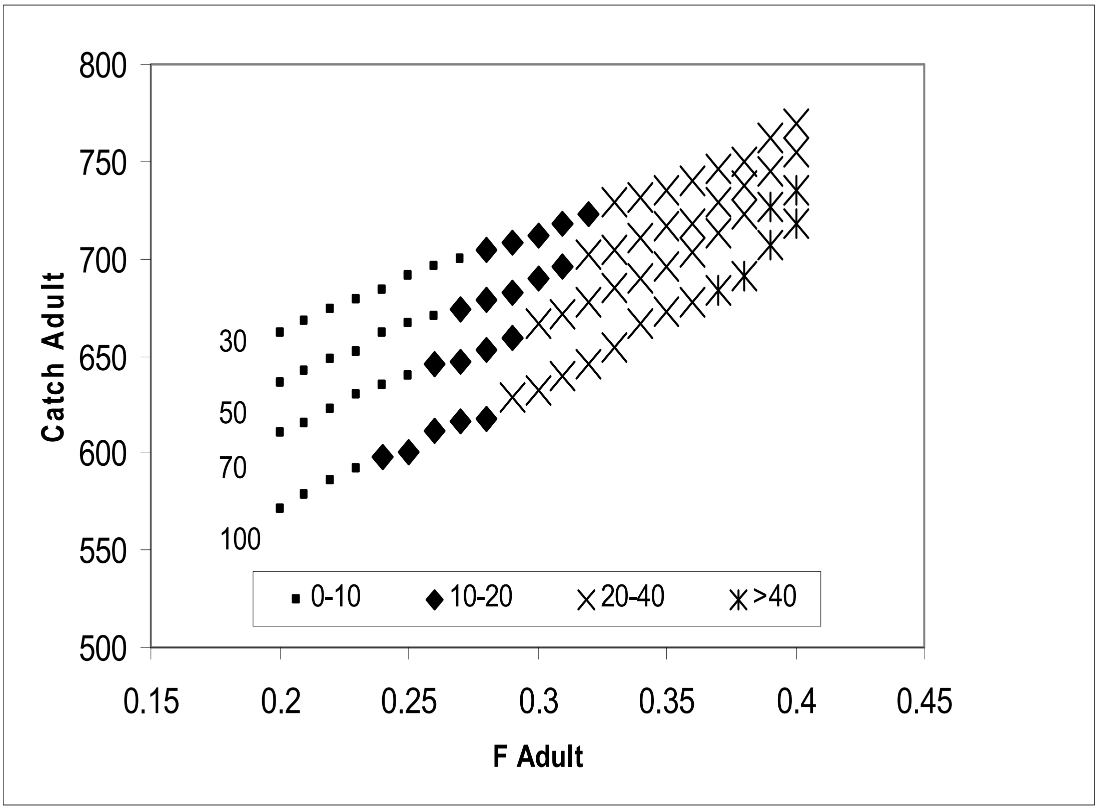


Figure 0.7 North Sea herring yield in human consumption fleet A against f for four levels of fixed yield in juvenile fleets 30, 50, 70, 100 t showing risk classes as probability of SSB being less than Btrig in year 10 Intermediate stage F=0.2.

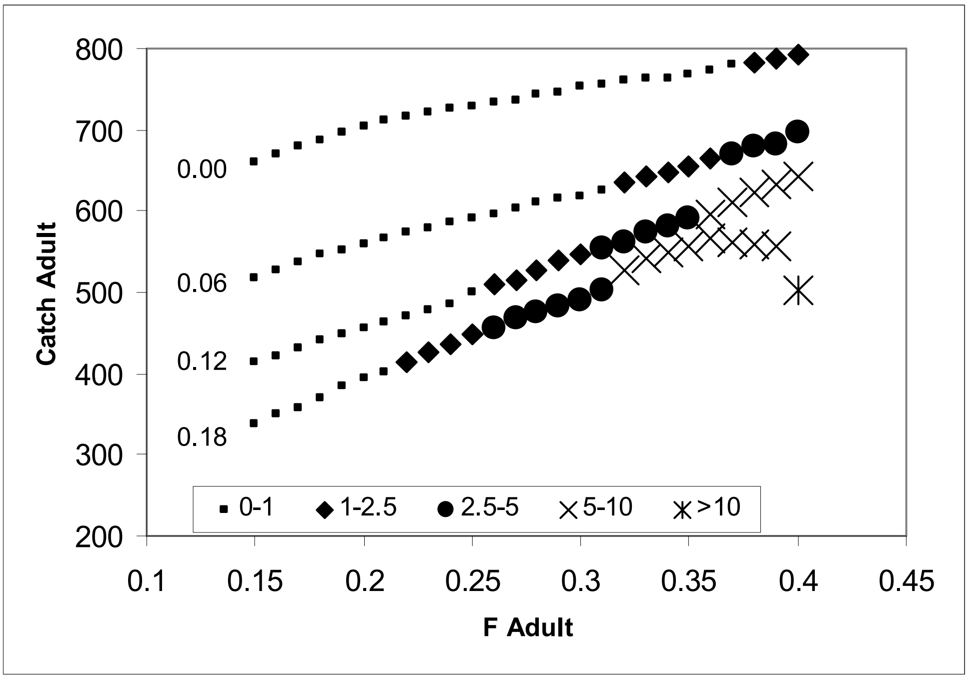


Figure 0.8North Sea herring yield in human consumption fleet A against f for four levels of fishing mortality in juvenile fleets 0, 0.06, 0.12, 0.18 showing risk classes as probability of SSB being less than Blim in year 10. Intermediate stage as linear function

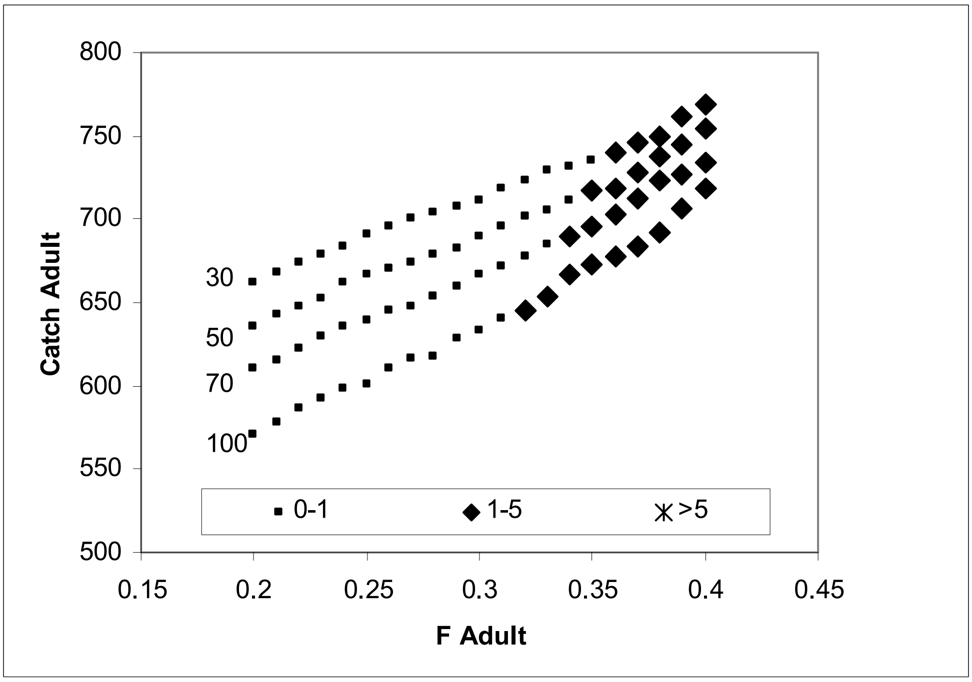


Figure 0.9 North Sea Herring. yield in human consumption fleet A against f for four levels of fixed yield in juvenile fleets 30, 50, 70 and 100 showing risk classes as probability of SSB being less than Blim in year 10 Intermediate stage as linear function.

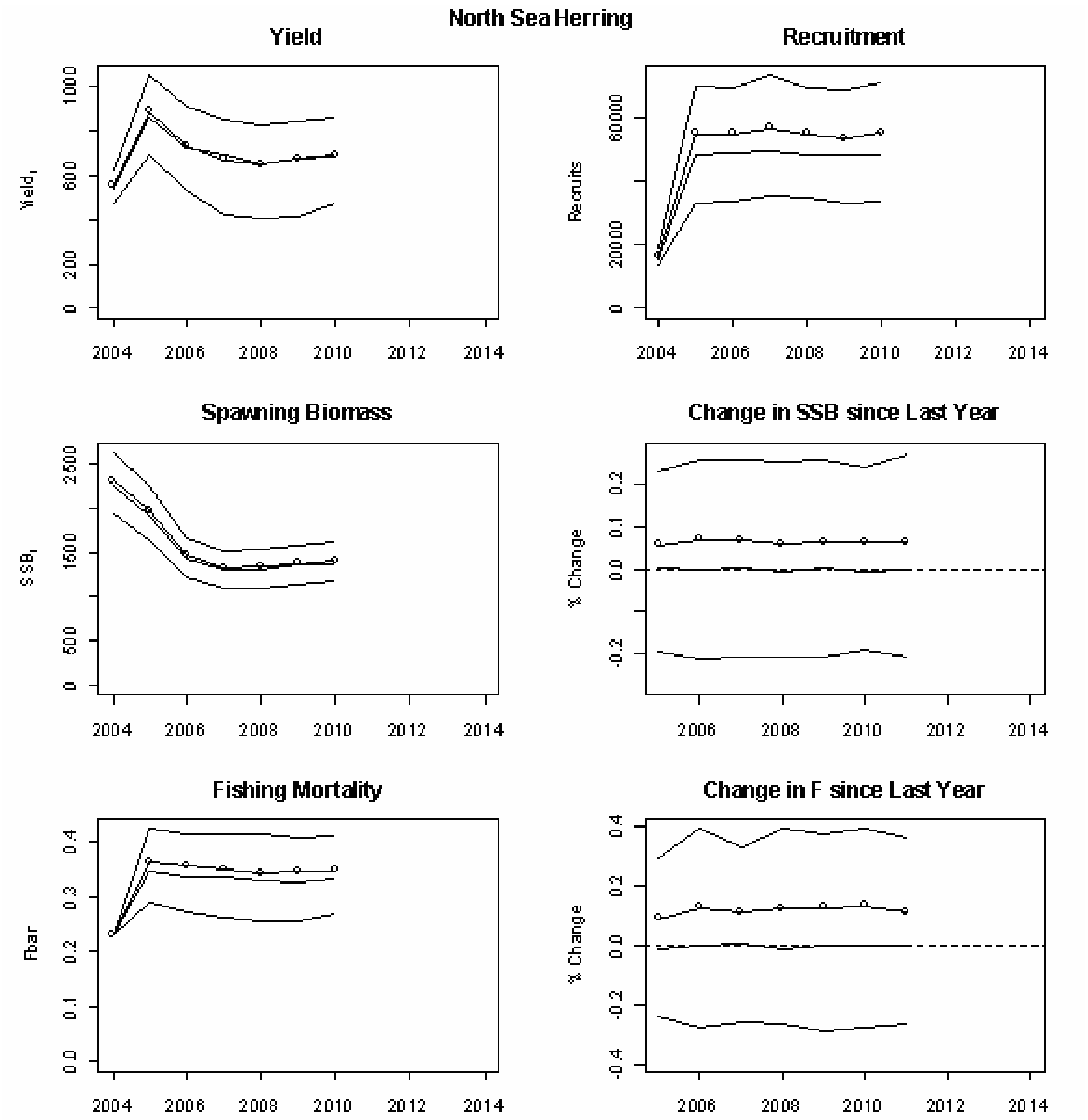


Figure 0.10 North Sea Herring Trajectory for 10 years with current EU Norway harvest control rule without constraint on change in TAC, with an assessment bias of 10% and implementation bias of 20%. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. , for NS herring the stock is already recovered. Full input and output for this case is given in appendix 11

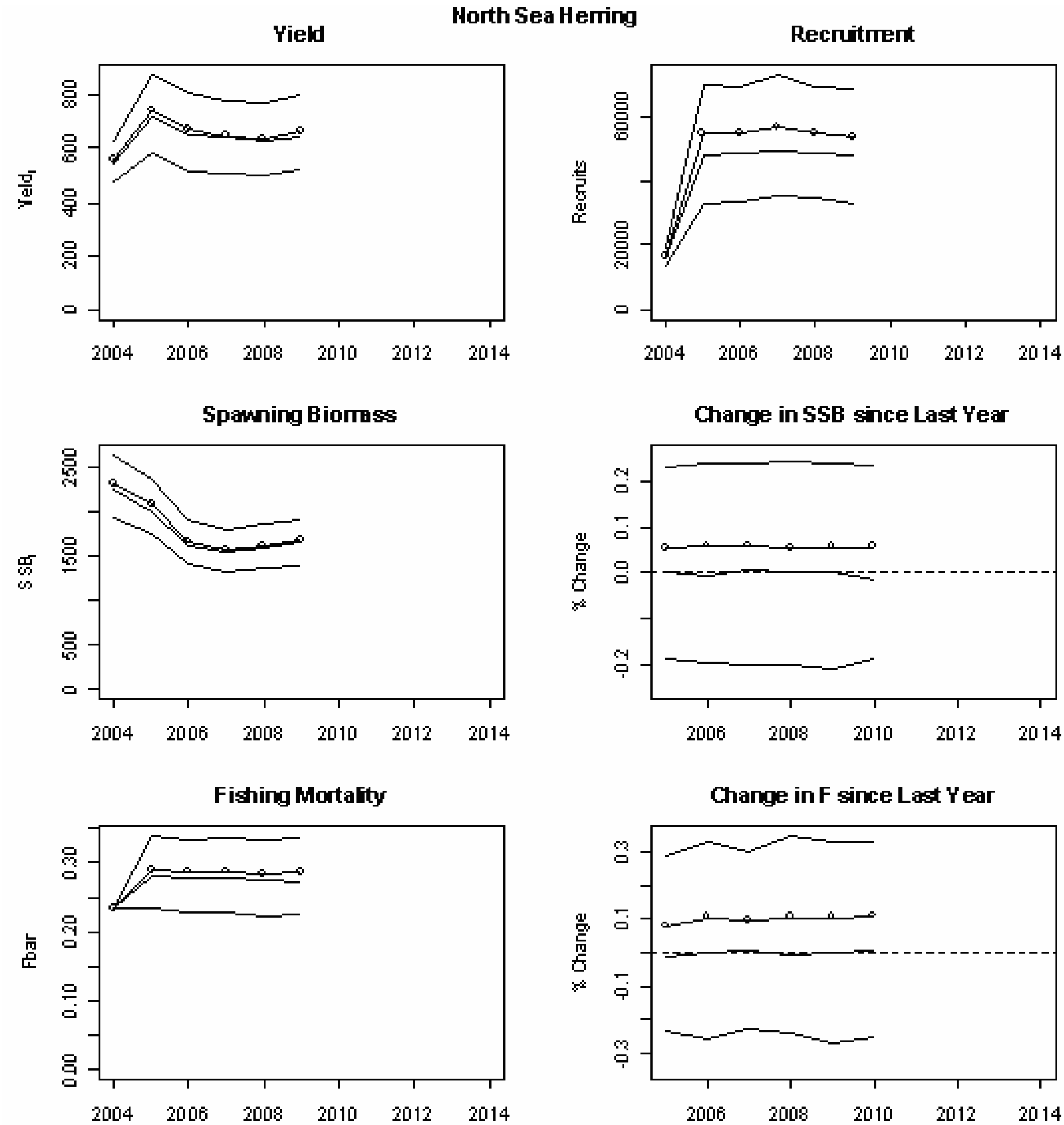


Figure 0.11 North Sea Herring Trajectory for 10 years with current EU Norway harvest control rule without constraint on change in TAC, with an assessment bias of 10% and no implementation bias. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. , for NS herring the stock is already recovered. Full input and output for this case is given in appendix 11

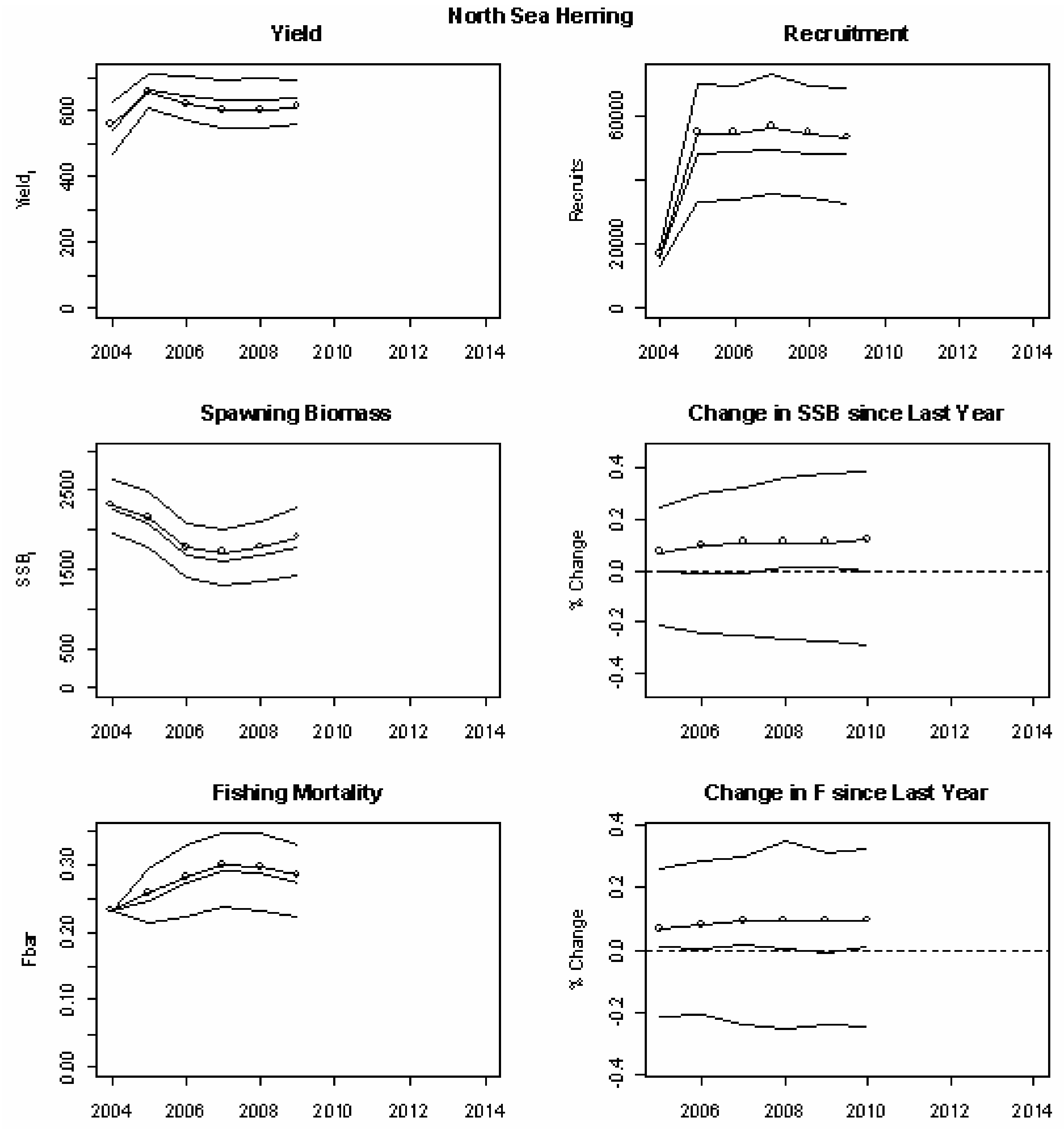


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Figure 0.12 North Sea Herring Trajectory for 10 years with current EU Norway harvest control rule maximum constraint on TAC of 460,000 t Fleet 1 and 100,000 t Fleet 2, with an assessment bias of 10% and implementation bias of 20%. Trajectories show 25, 50 and 75 percentiles and the mean value (line with symbols) for parameters of interest over the projection period. , for NS herring the stock is already recovered. Full input and output for this case is given in appendix 11

5. Mixed fishery issues

The harvest control rules considered by the current WG are all on a single stock basis. To a large extent this reflects the fact that the stocks are assessed separately but at the same time it disregards the fact that most of the species are caught in mixed-species fisheries, which limits the extent to which the fisheries on each stock can be managed separately. One approach would be to include extra rules within the HCR so that fishing opportunities for species A might also be determined by the relative state of stock of the associated species B. However, this raises questions about the extent to which the fishery for species B is associated with that for species A, and the relative priority assigned to each species. This is the classical mixed-fisheries problem which applies equally to the current system of annual assessments and advice on a stock by stock basis.

A key aspect of the mixed fisheries problem is the difficulties which arise through trying to regulate fishing activity through catch limits when vessels are targeting a number of different species, and are thus likely to continue fishing and catching all of these species, even when their quotas for one or more species are exhausted. The situation becomes more straightforward if fishing activity is regulated by fishing effort rather than species catches, as the problem becomes one of identifying a single level of fishing effort for a fleet rather than a set of species-specific quotas.

Vinther et al (2003) have recently developed an approach which can be used to derive management advice which accounts for mixed-fishery effects, based on single species assessments and advice. The approach, known as MTAC, uses explicit species weightings and catch data by fleet to arrive at overall fleet effort or total catch advice which represents an overall compromise across the advice given separately for each stock. The MTAC approach is intended as a pragmatic first step towards giving advice on a fishery basis rather than a stock basis. As such, the MTAC approach may also provide a practical basis for accounting for mixed-fishery effects using single species harvest control rules.

One of the key problems in accounting for mixed fishery effects is to allocate relative priorities to the different species involved. Within the context of a harvest control rule, the natural way to do this would be to allocate weightings according to the state of the stock with respect to the reference points incorporated in the HCR. Thus a stock which was below its Blim would receive a higher weighting than one which was above its Blim but below its trigger SSB, and this in turn would receive a higher weighting than a stock which was assessed to be above its trigger SSB. It might also be necessary to apply some *a priori* species-specific weights reflecting, e.g. the commercial value of each species, and the political reality that a high value target species such as cod or sole is likely to be considered to be more important than associated bycatch species such as whiting or plaice. The overall weighting applied would then be a combination of the *a priori* species weighting, and the annual value assigned on the basis of the state of the stock.

By analogy with the MTAC approach, the procedure for determining annual fishing opportunities (expressed in effort or catch) might then be as follows :

1. Run stock assessments to determine current state of each stock with respect to HCR reference points
2. Determine stock weightings based on states of stock and *a priori* weightings
3. Use stock weightings and fleet catch data to obtain fleet-based estimates of catch opportunities based on the individual stock HCRs.

Overall, the fleet-based estimates of fishing opportunities obtained in this way would represent a compromise across the different fleet catches implied by the single stock HCRs analogous to the values resulting from MTAC using short-term forecasts. By extension, the values have similar problems to estimates from MTAC, particularly with regard to problems in implementing fleet-based management when national quota shares are fixed through relative stability.

To extend the approach it would be necessary to update the fleet catch data on an annual basis in order that the fleet allocations would be based on the most recently available data, and thus could track to some extent changes in fleet targeting. Further extensions might include the definition of F targets and/or catch constraints on a fleet rather than a stock basis. This could permit a more direct approach to addressing mixed fishery problems by ensuring that the fishing opportunities for different species available to a given fleet are coherent across species. This is clearly a desirable feature, but it is potentially problematic if fleet composition or behaviour changes with time.

A simulation study on the mixed flatfish fishery in the North Sea was recently concluded (S.B.M. Kraak et al. (2004) A simulation study of the effect of management choices on the sustainability and economic performance of a mixed fishery. Draft RIVO report). This study was collaboration between fishery biologists and economists and was aimed at explored consequences of different management scenarios in managing a mixed fishery in which one of the species is much higher valued than the other species. The modelling approach was similar to the approach described in section 7 of this report (see also MATACS and MATES). The results indicated that management measures that aim to reduce fishing effort in line with the most vulnerable species provide both better biological sustainable fisheries and better economic returns. The simulations also showed the detrimental effects of assuming shrinkage within the XSA model, which introduced considerable cycling in the stocks due to lags in the knowledge about the true stock dynamics.

The harvest control rules investigated by the current WG imply substantial reductions in fishing mortality for most species. This may change the nature of the mixed species problem, particularly if it changes the abundance of the different species relative to each other. However, if the result is that all species are exploited at or below their long-term fishing mortalities, it would be much less critical to account for mixed-fishery effects in management. If the reduced Fs are achieved, another consequence would be that predator-prey interactions between and within species would have a more substantial influence on stock dynamics.

6. Sensitivity analyses regarding recruitment functions and their parameters used in STPR3

INTRODUCTION

Undoubtedly recruitment simulation is the main source of uncertainty in medium term stock and yield projections, especially in cases of high mortality rates at young ages. Significant differences between generated and observed recruitment dynamics would immediately result in a wrong perception of possible future developments applying certain harvest rules. The group therefore analysed the various parameters which can be set in order to generate recruits in the STPR3 project as a function of SSB in comparison with recruitment values estimated historically.

The programme offers four different parameters to simulate recruitment (s. Annex 1), namely a variety of SBB/recruitment functions (1), two different distribution types around that function (2), a sigma value (3) and a truncation value (4) to scale the variation of the simulated recruitment. These effects of the four different parameters were analysed by a total of 16 program runs defined in Table 0.1. The base run defined is using saithe data and identical to the base run defined for this stock's specific analyses of harvest control rules given in this report (section 4.4) regarding the entire list of parameters.

Table 0.1 16 sensitivity analyses of 4 different parameters with varying settings to be used in the STPR3 program for medium term harvest control rules. Saithe data were used for the base run. Other model parameters are given for the base run for saithe in Section 4.4

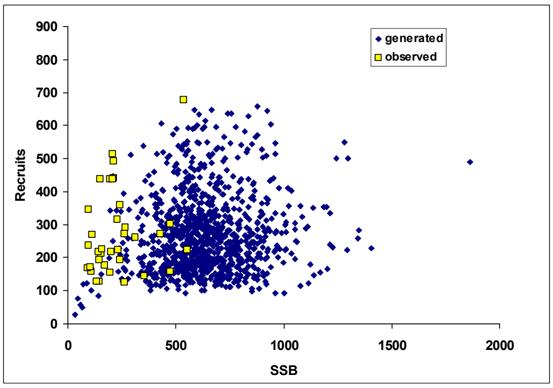
run no.	Function	Distribution type	P1	P2	P3	Sigma	Truncation	base run
saithe1	2	1	251	250	0	0.44	1	x
saithe2	1	1	315	51	0	0.44	1	
saithe3	3	1	2.817	0.0032	0	0.44	1	
saithe4	5	1	3.929	107.408	1.175	0.44	1	
saithe5	2	1	251	250	0	0.44	1	x
saithe6	2	2	251	250	0	0.44	1	
saithe7	2	1	251	250	0	0.24	1	
saithe8	2	1	251	250	0	0.34	1	
saithe9	2	1	251	250	0	0.44	1	x
saithe10	2	1	251	250	0	0.54	1	
saithe11	2	1	251	250	0	0.64	1	
saithe12	2	1	251	250	0	0.44	0.6	
saithe13	2	1	251	250	0	0.44	0.8	
saithe14	2	1	251	250	0	0.44	1	x
saithe15	2	1	251	250	0	0.44	1.2	
saithe16	2	1	251	250	0	0.44	1.4	

EFFECT OF DIFFERENT RECRUITMENT FUNCTIONS

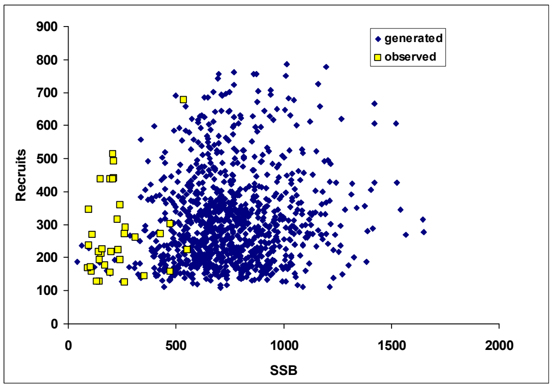
The STPR3 program offers 6 different recruitment functions to simulate future recruitment as a function of SSB, of which 4 were used. The base run saithe 1 is applying Ockham's razor. Figure 6.1 displays comparisons between the generated and historically estimated saithe recruitment. The four program modules generate a reasonable fit to the estimated recruitment over the historically estimated SSB range to 600,000 t. Beyond this, the functions Ockham's razor, Beverton and Holt, Sheperd are very similar and only the Ricker function simulates a significant recruitment decrease with further increasing SSB.

Figure 6.2 displays the resulting 5 %, 25%, 50 %, 75% and 95 % fractals of fishing mortalities, yields and SSB after a projection period of 10 years. The projection results are very similar for all four functions tested. Only the Ricker function projects insignificantly higher fishing mortality, lower yield and SSB as this function implies reduced recruitment at a range of SSB over 600.000 t . This level of SSB has not been experienced in recent recorded history.

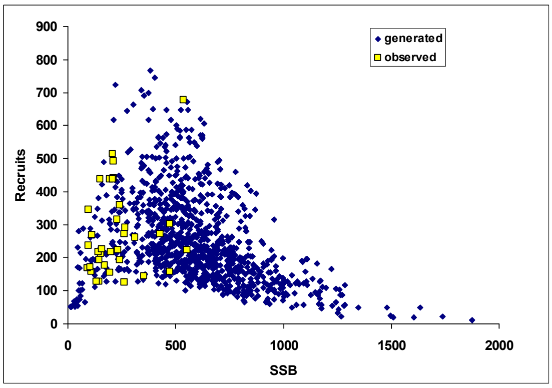
Run saithe 1 base run Ockhams razor



run saithe 2 Beverton and Holt



Run saithe 3 Ricker



run saithe 4 Shepherd

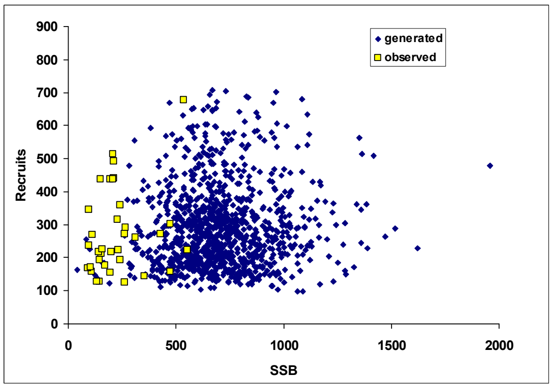


Figure 0.1 Observed and generated recruitment using 4 different recruitment functions (see Table X1 for parameter specifications of runs saithe 1-4).

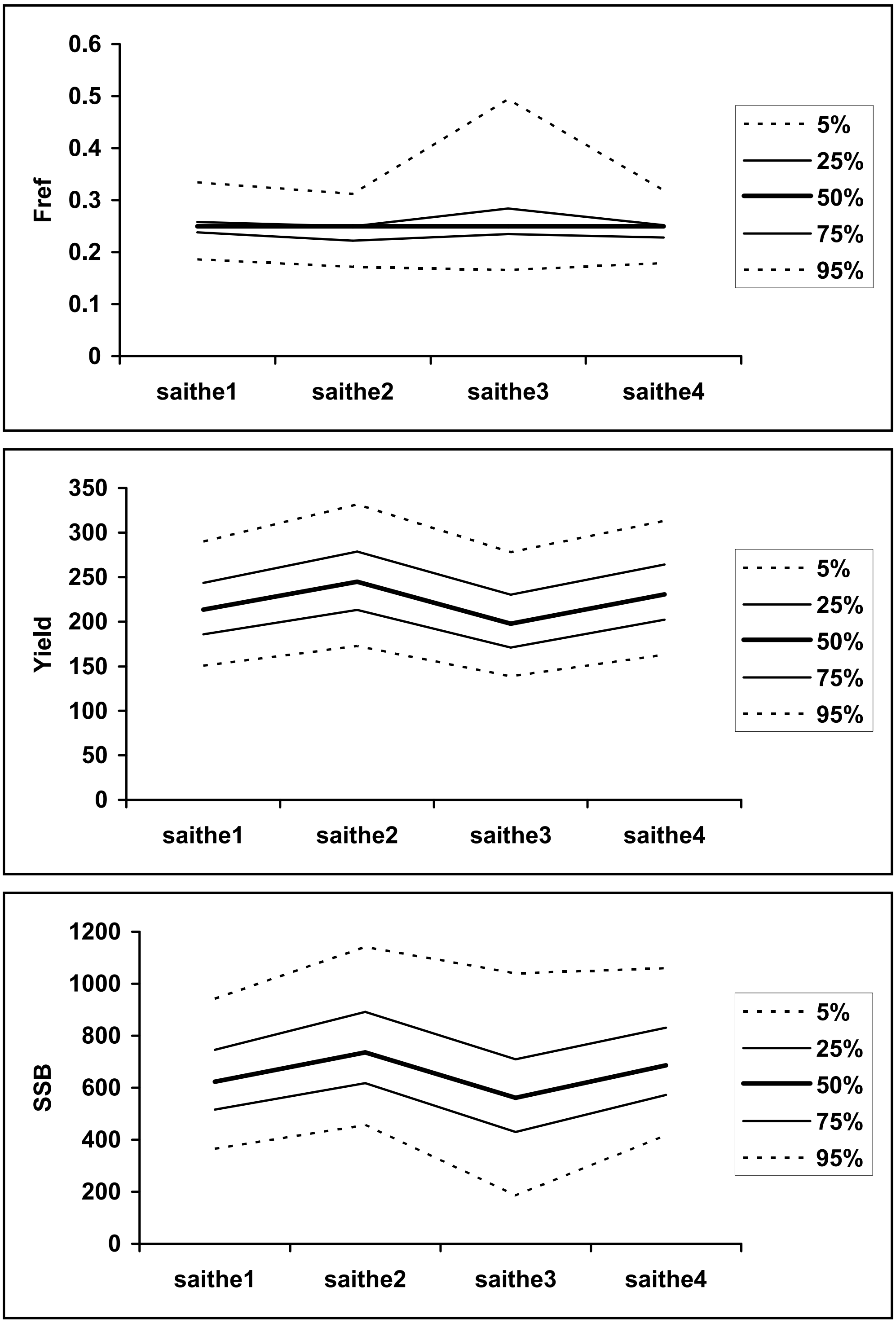
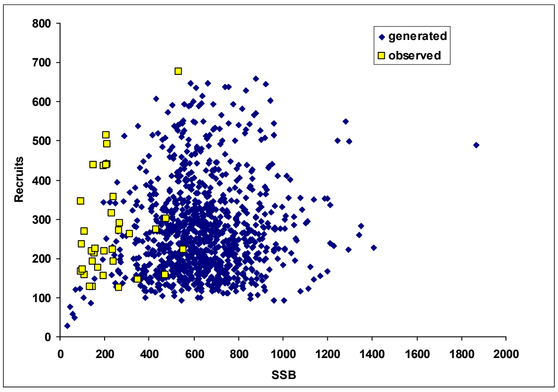


Figure 0.2 Resulting fishing mortality, yield and SSB after 10 years using 4 different recruitment functions (see Table X1 for parameter specifications of runs saithe 1-4).

EFFECT OF DIFFERENT DISTRIBUTIONS AROUND THE RECRUITMENT FUNCTION

Lognormal distribution around the recruitment function fits well with the distribution of historically estimated recruitment (Fig. 6.3). In contrast, a distribution formulation based on a constant coefficient of variation (CV, option 2) creates significantly lower recruitment variation and at a higher level at SSB around 600,000 t. However, this does not result in significant differences in the projections of fishing mortality, yield and SSB after 10 years (Fig. 6.4).

Run saithe 5 base run lognormal distribution   run saithe 6 constant CV distribution



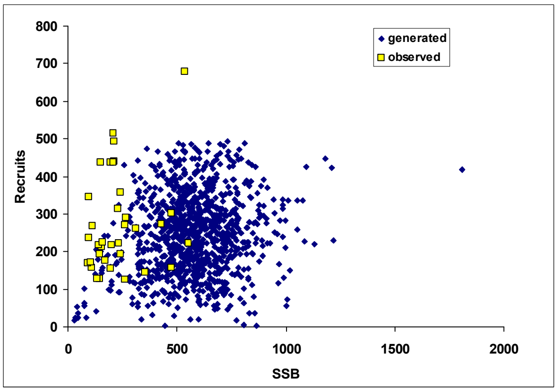


Figure 0.1 Observed and generated recruitment in using 2 different distribution types for recruitment simulation (see Table X1 for parameter specifications in runs saithe 5 and saithe 6).

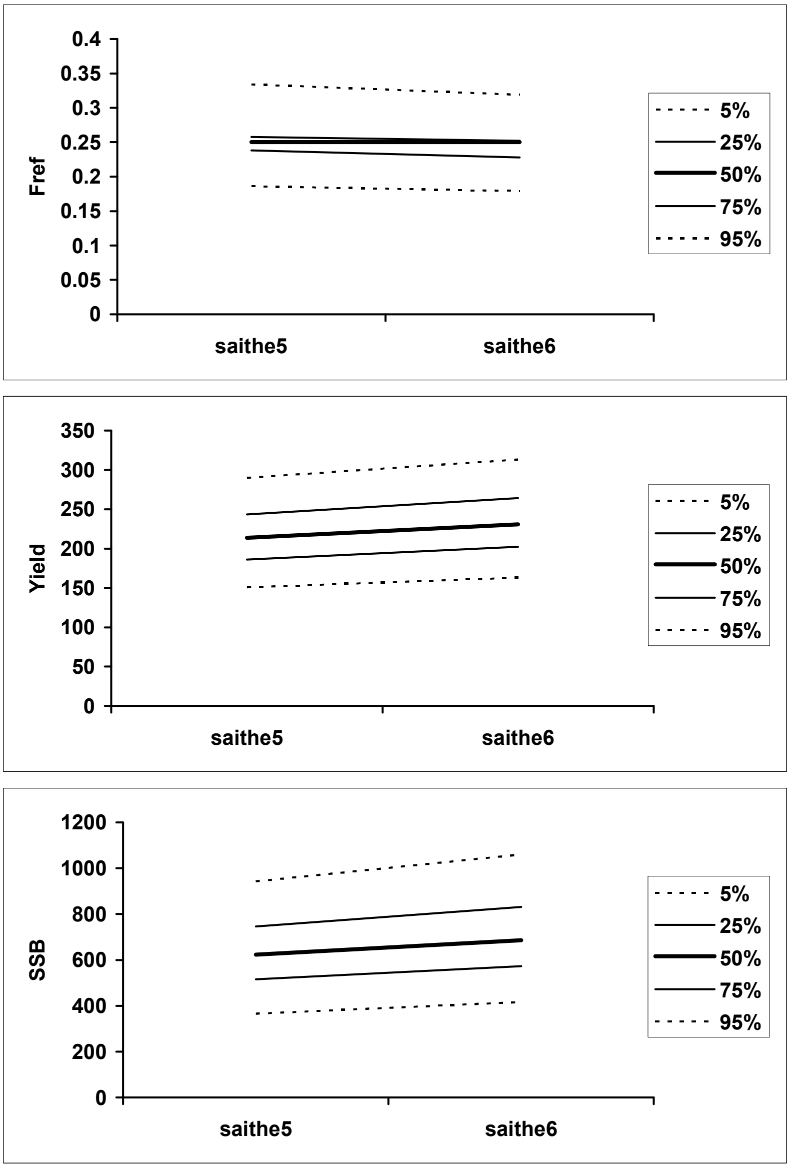
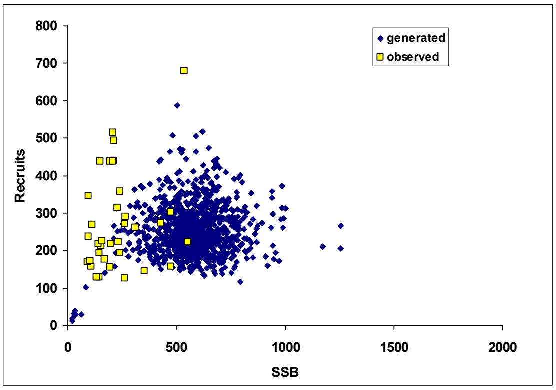


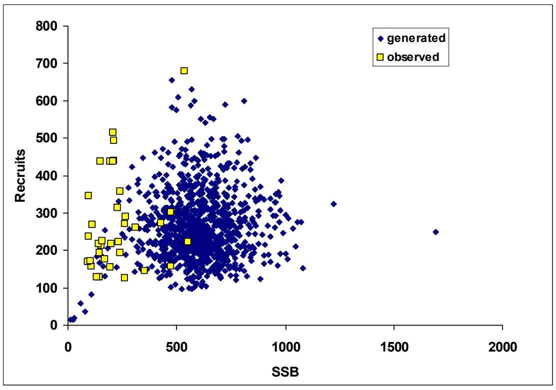
Figure 0.2 Resulting fishing mortality, yield and SSB after 10 years using 2 different distribution types for recruitment simulation (see Table X1 for parameter specifications in runs saithe 5 and 6).

EFFECT OF INCREASING SIGMA VALUES

The sigma values to be defined by the user of STPR3 represents a scaling factor to the variation of the generated recruitment based on their log transformed standard error. Obviously, the variation increases with increasing sigma from 0.24 to 0.64 as illustrated in Fig. 6.5. However, after a projection period of 10 years, such scaling of the variation does not result in significant differences in terms of fishing mortality, yield or SSB (Fig. 6.6).

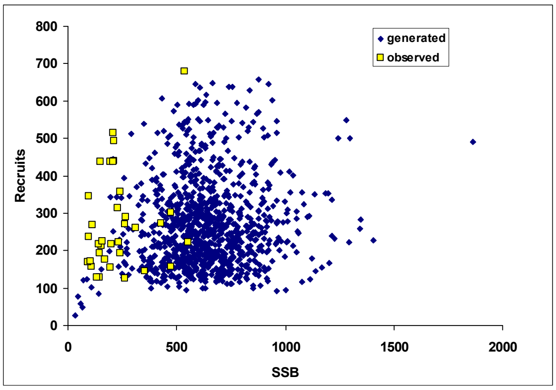
Run saithe 7 sigma=0.24 run saithe 8 sigma=0.34

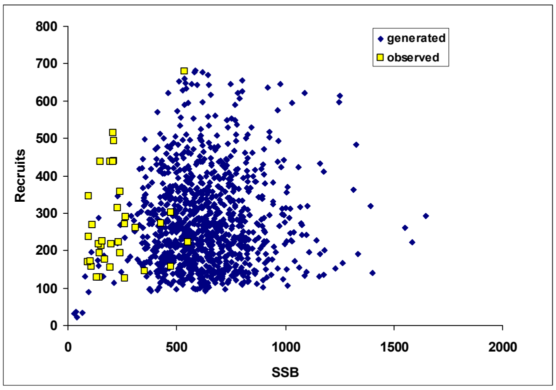




Run saithe 9 base run sigma 0.44

run saithe 10 sigma 0.54





run saithe 11 sigma 0.64

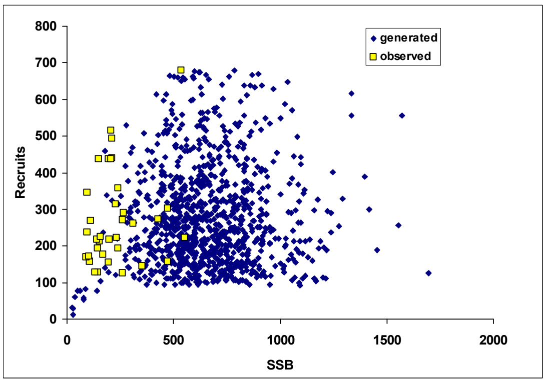


Figure 0.1 Observed and generated recruitment using a range of sigma values from 0.24 to 0.64 for recruitment simulation (see Table X1 for parameter specifications in runs saithe 7-11).

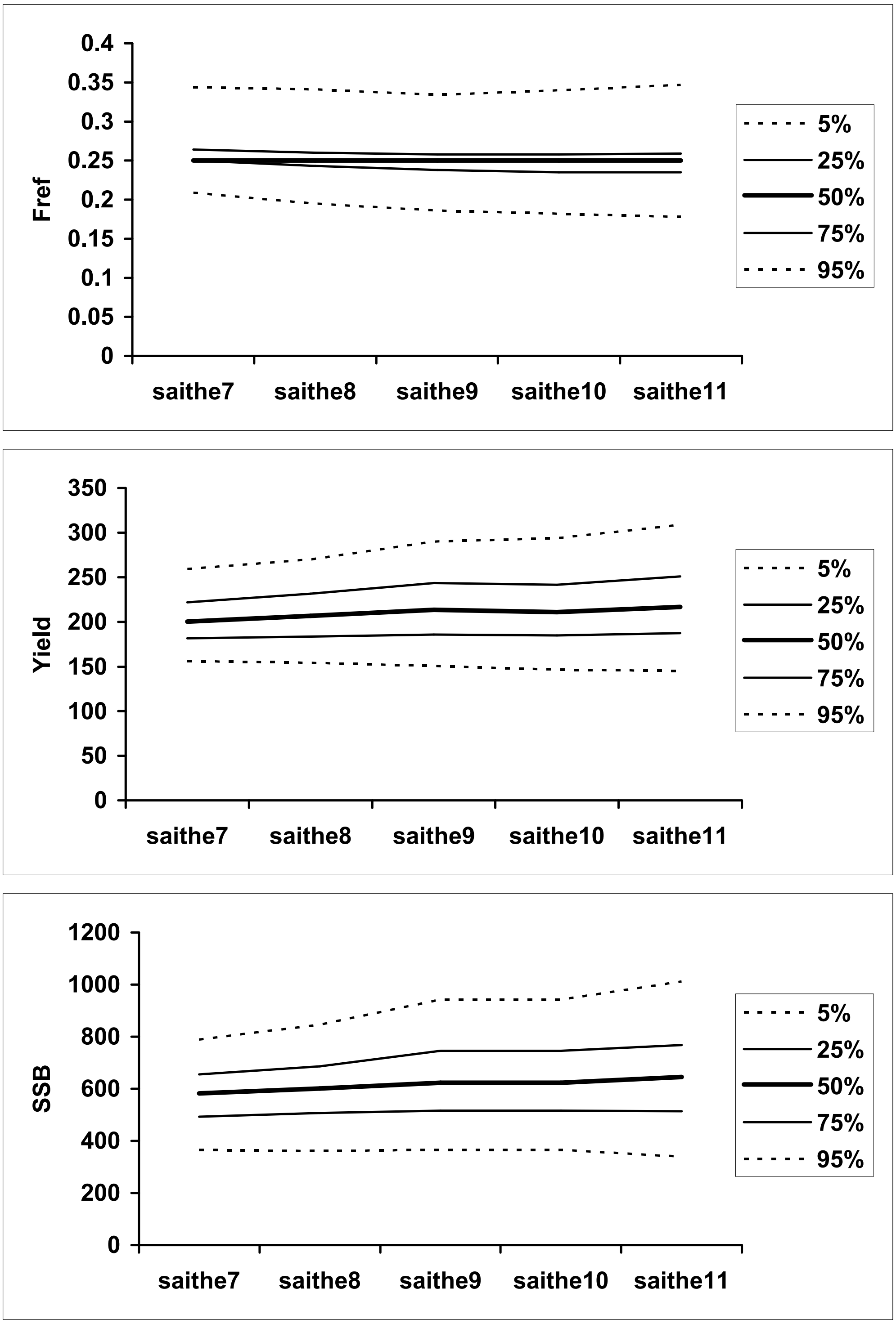
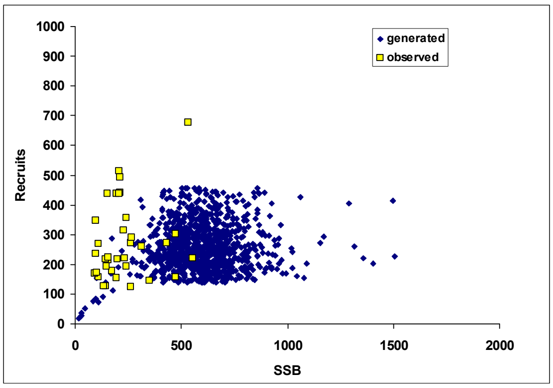


Figure 0.2 Resulting fishing mortality, yield and SSB after 10 years using a range of sigma values from 0.24 to 0.64 for recruitment simulation (see Table X1 for parameter specifications in runs saithe 7-11).

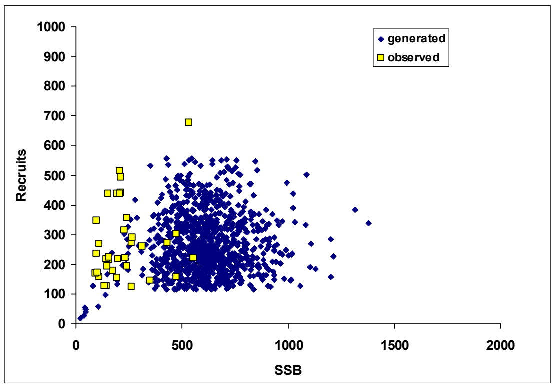
EFFECT OF INCREASING TRUNCATION VALUES

The setting of a truncation values by the user of STPR3 generally creates similar effects on the process of recruitment simulation as the sigma value, a pronounced increase in recruitment variation with increasing truncation from 0.6 to 1.4 (Fig. 6.7). A truncation value of 1 fits best with the minimum and maximum recruitment as historically estimated. This value is defined for the base run. Again there is only an insignificant effect of changes in the truncation values simulated after a projection period of 10 years (Fig. 6.8).

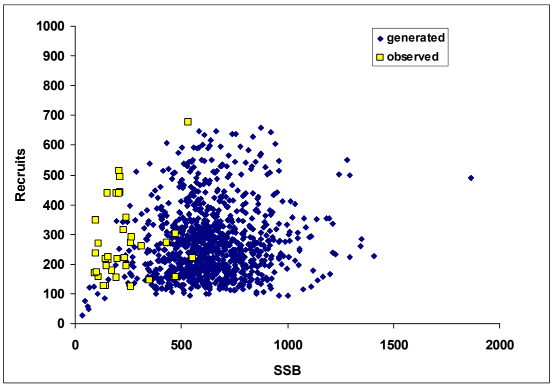
Run saithe 12 truncation 0.6



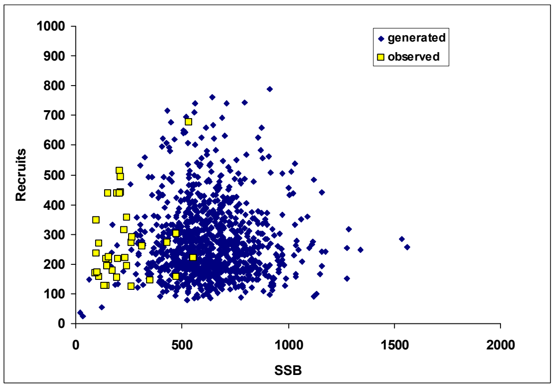
run saithe 13 truncation 0.8



Run saithe 14 base run truncation 1.0



run saithe 15 truncation 1.2



run saithe 16 truncation 1.4

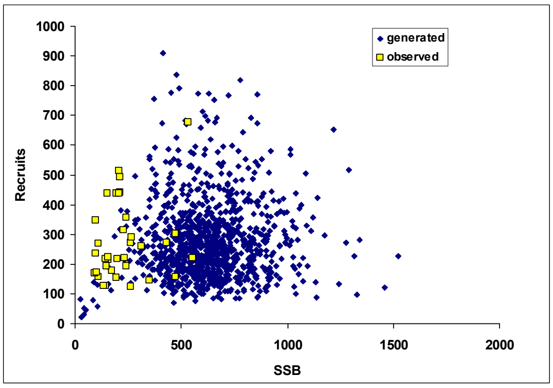


Figure 0.1 Observed and generated recruitment using a range of truncation values from 0.6 to 1.4 for recruitment simulation (see Table X1 for parameter specifications in runs saithe 12-16).

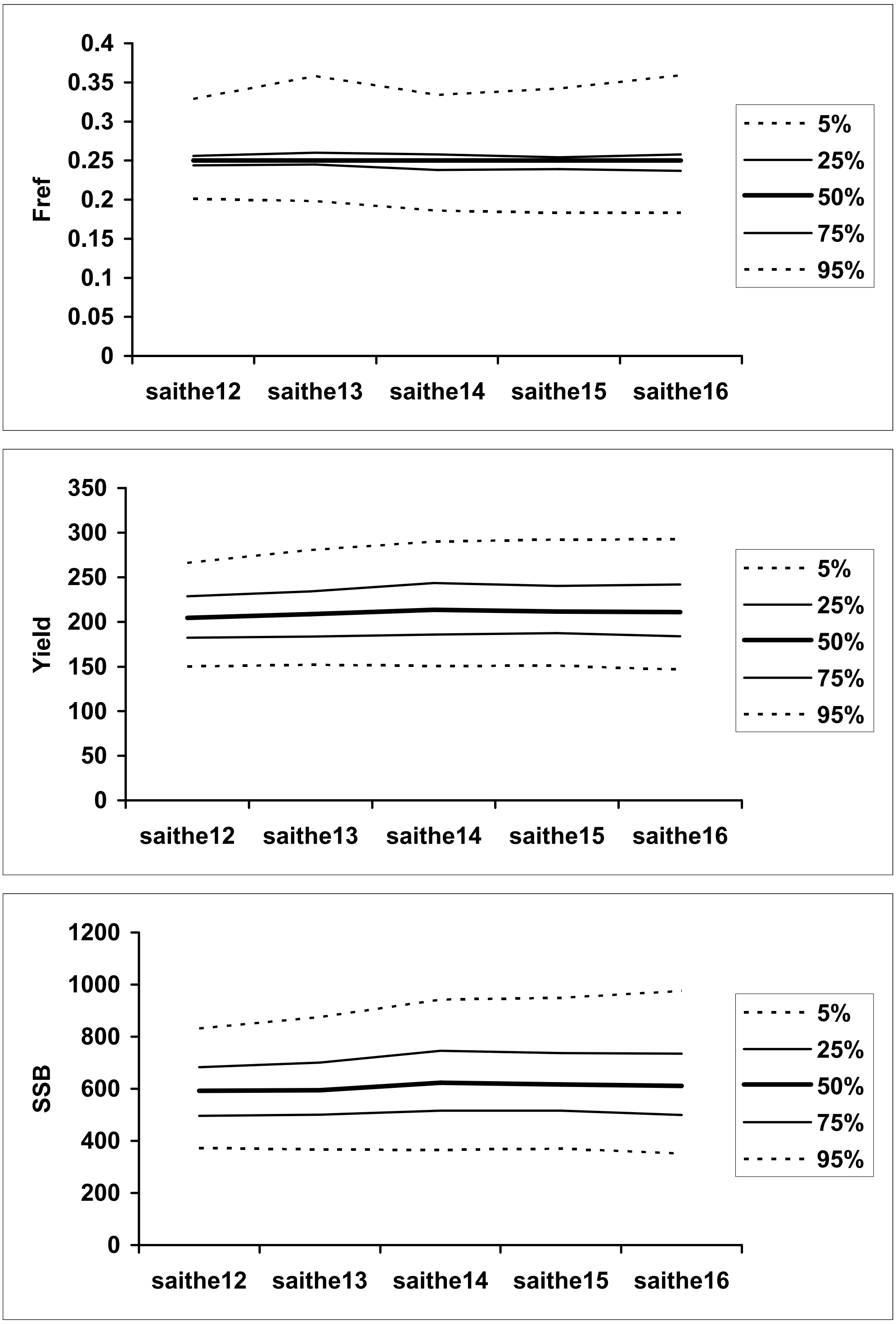


Figure 0.2 Resulting fishing mortality, yield and SSB after 10 years using a range of truncation values from 0.6 to 1.4 for recruitment simulation (see Table X1 for parameter specifications in runs saithe 12-16).

GENERAL CONCLUSIONS

The present sensitivity analyses of all four parameters of the functions in the STPR3 indicate a fairly robust recruitment simulation during medium term projections as resulting fishing mortality, yield and SSB after 10 years appear very similar. This is the case especially over the low range of historically estimated SSB. However, simulating recruitment at high SSB requires serious inspections about how the model settings chosen behave in relation to observed recruitment variations.

7. Modelling the feedback in the management procedure; going beyond the STPR approach

1.1 INTRODUCTION

The experience of developing harvest rules for these 6 stock has illustrated some of the important issues for evaluation of harvest control rules (sections 4-6). In this section we will briefly describe one of those issues: how feedback between science and management can be addressed.

The STPR model applied in section 4 is based on the assumption that management scenario's can be evaluated using a simulated population (operating model) and a perceived population (perception model) which is conforms closely to the true population. Although biases can be introduced in the perception model (e.g. assessment bias) these have to be fixed in advance and do not reflect the actual bias if this is dynamic. This is because there is no dynamic feedback in STPR in the sense that although assessment error in any one year affects the management decision as modelled in a harvest control rule the influence of the management decision on the subsequent error is not included.

1.2 DESCRIPTION OF THE MODEL

A preliminary model was developed during the meeting to explore some aspects of dynamic error resulting from the management procedure and how that affects the modelled population. The performance of the management procedure that is implicit within the ICES framework of advice for North Sea plaice was incorporated into this integrated modelling approach. Both the 'real' and observed systems and the interactions between the system components were modelled including the stock assessment process currently used by the working group WGNSSK (ICES 2003). The model incorporated two fleets: one carrying out a mixed flatfish fishery (on sole and plaice) and the other which was characterised as a directed plaice fishery. The discarding process was included into the simulation model.

1.3 RESULTS

Simulations with full feedback between operating model and management procedure were not conclusive, because the model formulation could not be adequately tested during the course of the meeting. The results presented below are considered to be examples of the type of results that can be achieved in an integrated modelling environment. Two examples are presented: a fixed F scenario (i.e. without feedback) and a full-feedback scenario.

FIXED F SCENARIO

Simulations for a fixed effort scenario based on perfect management (i.e. without management feedback) are shown in figure 7.3.1 (results from a single realisation). Both the actual and the perceived Fs are shown.In this case effort was constrained to be constant, but there was process error on the relationship between F and effort leading to small fluctuation in F. In this example the discarding process was included in the operating model but not in the assessment procedure. The management scenario consisted of a constant F regime (i.e. it was possible to manage F without any implementation error) and assessments were then carried out on the landings (i.e. catch – undersized fish) and tuning data from research surveys.

In the first panel the actual ('true') fishing mortality is compared to the time series of mortality as estimated in 2033 and to the fishing mortality in the year of estimation from 2003 through 2033. It can be seen that the time series of perceived fishing mortality as estimated in 2033 is less than the actual fishing mortality and has a bias of around 30%, which is caused by not taking discards into account in the assessment model. However, the biases observed in the year of assessments can be substantially larger and the direction of the bias appears to vary in a cyclical fashion.

The second panel shows a similar plot for SSB and it can be seen that there is a lag between actual and perceived SSB. When the stock is increasing the bias in SSB is negative, and when the stock is decreased, the bias is positive, Though the estimate of SSB both in the long term and the assessment year is much more reliable than for F. This scenario has been carried out at a true F of approximately 0.55, The magnitude of the errors in F and SSB will dependon the exploitation level. While there is no reason to believe the simulation is incorrect it has not be fully verified

FULL FEEDBACK SCENARIO

Within the example modelled above, there was limited feedback between the assessment and the exploitation, since a constant fishing mortality was implemented independently of the perceived stock size. When feedback was introduced and fishing mortality was set via a TAC estimated by VPA and a short-term projection in the management procedure, large discrepancies were observed in the simulated and assessed stocks. Results are not presented here because it is not clear whether some of the results could be caused by model misspecification.

In general, feedback is expected to lead to directed bias in the management procedure. For example, if fishing mortality is overestimated and SSB underestimated, then a lower quota than required to achieve the desired fishing mortality would be set. This would cause SSB to increase and F to decrease resulting in even larger bias. This process could introduce important lags in the management procedure which would show up as period of over- and underestimating stock size. The magnitude of these errors in F is likely to be lower at lower exploitation levels.

In a real fishery some dynamic implementation error should be expected, the reaction of fleets to variation in TACs and the resultant variation in effort depends upon economic considerations. For example, when the stock size and the TAC are overestimated, then the quota may not be taken since either the capacity of the fleet might not be adequate or else revenues might fall before the quota is taken making fishing unprofitable. Likewise when the management implements reductions in fishing mortality (via lower quota), effort may not be reduced as intended.

1.4 DISCUSSION

There are two main reasons for concern in the longterm with the STPR approach which has been applied in the main part of this report. One reason is the possible dynamic interaction between stock fluctuations and bias, including the effects of delayed response, and the other is the effect of not taking discards into account. None of these problems are straightforward to solve.

The discard has been addressed in this section where it was shown that not accounting for (variable) discarding could induce substantial biases in the perception of stock status. However, it is hard to verify the discard model with the sparse data that is available. In an assessment context, the loss not accounted for in the catches leads to underestimation of the true recruitment, and thus the true potential yield, however, the influence of discarding on the choice of suitable F for older fish is small. An important point here is that the extent of potential gains in yield following from improving selection or reducing the overall F cannot be estimated without knowing something about the amounts discarded. The absolute levels of the biomass limits in the HCR depend on the exclusion or inclusion of discards. In addition the biomass levels included in an HCR would be much more robust if they take into account discards.

The performance of harvest control rules depends both upon the true dynamics and our perception of them. A constant bias will have less effect than a bias that is varying in magnitude and direction depending upon both the evolution of the stock and management action as shown by MATACS (Kell et al. 2001) and MATES (Kell et al. 2002). The MATACS/MATES work showed that when managing stocks it has to be recognised that the data collection regimes, choice of biological reference points, assessment methods and management options form part of an inter-related procedure. The choice of assessment method will dictate the types of data required and the type of biological reference points that can be derived. However, the biases observed during this working group could be model-specific (because only one assessment model has been implemented). Work is currently ongoing (EFIMAS/COMMIT/FISBOAT) to improve the methodology to incorporate feedback in management procedures in HCR evaluations. These EU funded projects are expected to deliver their final results in 3-4 years from now, but intermediate results will be useful in the updated process of setting up or evaluating HCR's. These projects will go into more detail on how bias and assessment error are generated, and how it depends on assessment method approaches, for example the use of shrinkage, CPUE data (using the same age structured data in the VPA and in the tuning), and the statistical properties of the tuning data (e.g. clustering and year effects), etc. The effects of various kinds of discard dynamics will also be part of that analysis.

It is important to consider how the findings presented in this section relate to section 4.1 where an F-level in the order of 0.25 is was presented as a strategy which would give a low probability of falling (staying) below Blim in the longer term. The results of the full-feedback simulations and the discards-included simulations do not indicate that F=0.25 is an unwise target. However it does make clear that the actual benefits (how much is going to be gained by achieving F=0.25) are very difficult to predict. The actual gains in yield will of course depend largely on how far the effective effort is reduced, and how much of the effort is diverted to fishing for discarding. If discarding can be effectively reduced, through a real reduction in effort, improved exploitation or both, there will probably be a greater gain in terms of long term yield.

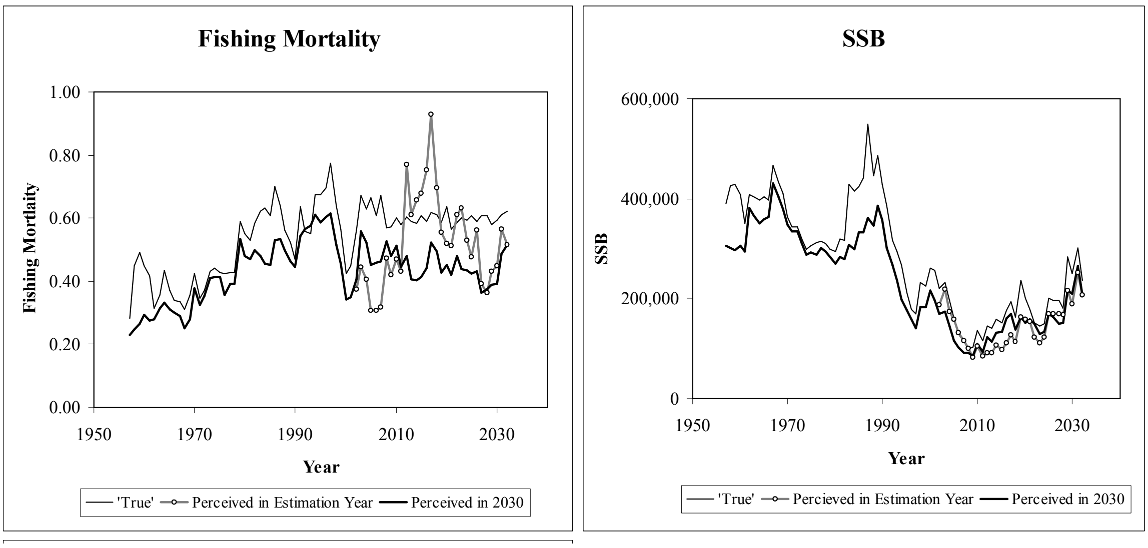


Figure 1.4.1 Simulations without additional management feedbackF

8. ComMents on the EVALUATION Procedure

The experience of developing harvest rules for these 6 stock has illustrated some of the main issues for evaluation of harvest control rules. There are two main approaches to the provision of scientific advice on the merits of harvest rules. This could be described as either management down, or science up. The two methods are:-

1) Management down: Managers define some well described rules and clear criteria for evaluation. The managers might specify rules which are considered to be of suitable type with a range of attributes such as :- simple to understand, suitable for agreement among stakeholders, method of enforcement (effort or catch control). The criteria might be yield, stability of yield, precautionary. Scientists can evaluate these and provide information on their performance against these explicit criteria. These rules can be compared with one another by the managers based on the requested criteria. There will need to be agreement on what is precautionary, and what range of variation in yield against loss of yield is of interest.
2) Science up: Managers request harvest optimum harvest control rules to deliver performance against criteria such as yield, stability of yield, precautionary nature with clear guidance for the tradeoffs required between the criteria. Scientists do exploration of a range of options and provide optimised solutions.

These two approaches each have their problems and benefits; the first will give less than optimal rules but may be much more rapid; the second should give optimum rules but may be complex and will take longer to produce.

The current approach has been a set in a time frame suited to the former and couched in TOR more suited to the latter. This caused some difficulties as the WG tried to respond to the TOR. The process could be much improve with close co-operation between managers and scientists.

The process carried out suggests a number of specific areas for improvement. There is a need dialogue throughout the process, each group working in isolation is likely to misunderstand one another and either waste time or give inappropriate advice. For scientists there is a desire for rigorous testing procedures of harvest rules with respect to pre-agreed objectives. For managers optimum solutions without the need to pre-select objectives. Testing may necessitate an exhaustive search over an appropriate parameter space of harvest rules for stocks. Experimental design for the computer-based simulations should include:

- a clear statement of the harvest rule to be tested;
- those factors to be included in the simulations;
- an agreed rationale to change factors (e.g. a factorial design);
- the range of variation of each factor;
- the outcome variables to be measured; and
- The tolerance or precision of the required output information.

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APPENDIX 1 PROGRAMS FOR STOCHASTIC PREDICTION AND MANAGEMENT SIMULATION (STPR3 AND LTEQ)

1.1 INTRODUCTION

This is a set of programs for making stochastic predictions of fish stocks and for evaluating management decision rules. The programs include:

- A medium term prediction program (***STPR3***) with simulation of management rules.
- A long term stochastic equilibrium program (***LTEQ***).

As a supplement, a spreadsheet for estimating parameters in a stochastic stock-recruitment relationship is provided. The programs are independent of the program used to generate the input to the predictions. However, the AMCI program can generate most of the input files directly.

These programs were first developed in connection with the development of a revised management regime for North Sea herring, which was finally established late 1997. The STPR program was developed to evaluate simple harvest control rules (HCRs), defined separately for each of two different fleets. The harvest control rules were related to 3 different levels of SSB, corresponding to reference points such as Blim and Bpa. For each level, fishing mortalities and/or maximum allowable catches were defined. An important aspect was to evaluate the risks associated with the various management regimes. These risks depend on known variability, e.g. in initial numbers, future recruitment etc, but also on unknown errors in the assessments and in adherence to the quotas. The approach taken was to examine thow robust a proposed regime would be to such problems in the medium term, rather than to evaluate the risk conditional on formal estimates of the assessment bias and the overfishing. Thus, future assessments were not simulated.

As a basis to establish safe levels of fishing mortalities, the LTEQ program was developed to calculate long term distributions of SSB for a range of fishing mortalities, taking the variation of the recruitment around a stock-recruitment relationship, as well as variations in weights and maturity, into account.

Later on, these programs have been used occasionally in ICES Working Groups, in particular in cases where the standard software (in particular ICP) failed or could not be adapted to the required specifications. The STPR medium prediction program (with some minor modifications) was one of the programs considered by the EU concerted action FAIR-PL98-4231_on Evaluation and Comparison of Methods for Estimating Uncertainty in Harvesting Fish from Natural Populations. An evaluation of the performance of the program can be found in Patterson & al, (ICES C.M.2000 V:06)

Version 3 of STPR (2002) has several extensions from the previous versions and large parts of the code has been rewritten. The new features include the possibility to specify the model run options interactively and the use of initial stock numbers from bootstrap runs (e.g. by AMCI), as an alternative to drawing them from parametric distributions. Additional management decision rules have been included, with constraints on year-to-year variations in catches and in SSB.

The long term equilibrium program LTEQ has also been revised. The format for input data has been changed so that it now is equal to that for STPR. Random weights and maturities are obtained by drawing a year and using the historical data from that year. In the present version, the same year is used for both weights and maturities.

Since 2002, some minor modifications have been made. The present version of this manual refers to the state of the program by June 2004.

1.2 GENERAL OUTLINE OF THE PROGRAM MEDIUM TERM PREDICTION (STPR – VERSION 3)

The program performs stock projections where the probability distributions of the interest parameters that are induced by stochastic input terms, are evaluated by bootstrapping. The program is designed to simulate two independent fishing fleets. The variables that are treated as stochastic are:

- Recruitment as a function of the SSB, with optional autoregressive terms
- Weights at age and maturity at age, drawn from historical values
- Initial stock numbers, either according to a vector of point estimates with a variance-covariance matrix, or generated by bootstrap runs of an assessment model.

The projections are made conditional on the following fixed parameters:

- Natural mortality
- Selection at age by fleet (2 fleets)
- Yearly level of fishing mortality or catch, according to the HCR that is simulated.

In addition, the medium term simulations can include:

- Discrepancy between the perceived state of the stock, on which management decisions are based, and the true state of the stock.
- Deviation of the actual catch from the recommended catch according to the HCR.

The program projects the true year-classes forwards in time, reducing them by the removals emerging from the implementation of a management decision rule, and add recruiting year-classes. Yield and SSB is derived by multiplying yearly catches in numbers at age wirth yearly fractions mature at age and weights at age. The decision rule is primarily expressed as a basic harvest control rule (HCR) which can be F-constraints, catch constraints or combinations of these, for two fleets separately. This basic HCR can be modified by constraints on year-to-year variation in catches, fishing mortalities and in SSB, within a permissible range of fishing mortalities.

The decision rules derive TACs for the coming year based on the projected value of SSB in the TAC year. The performance of each fleet is characterised by the selections at age, which are input and stable over the simulation period. The decision rules determine fleetwise fishing mortality levels and/or constraints on the catches on a year-to-year basis. Weights and maturities at age, although stochastic, are assumed to be known correctly to the decision makers. The basis for managers decisions is the state of the stock at the beginning of the TAC year. As described below, this information may be distorted, and the assumed error should include error in the 'intermediate' year.

No attempt is made to simulate future assessments as part of the projection. However, the yearly perceived state of the stock (i.e. the SSB), which is the basis for decisions, can be treated as stochastic with a specified distribution, conditional on the true model SSB. The decisions on TACs are made on the faulty data, and these catches are subsequently removed from the true stock. The idea is that instead of attempting to estimate the uncertainty in future assessments, we examine the robustness of the regime to biased assessments. If e.g. the experience from previous assessments is that one has tended to overestimate the stock for the recent years, one should not accept a regime that will break down once the stock estimate happens to be too high. In practise, this implies a need for a sufficient buffer stock to withstand systematic errors in the assessments. For the management, the trade-off between robustness to bias in the assessments and loss of yield may be more important than the variance of the stock estimates as such.

Deviation of actual catches from the computed quotas can also be simulated. This is done the same way as for assessment error – a stochastic multiplier is used to get the catches that are subsequently removed from the stock.

1.3 THE MODEL

The program STPR3 performs 10 years projections of the stock, and derives catches for 2 fleets according to specified management decision rules. It works as a bootstrap simulation, by performing 1000 projections with randomly drawn numbers for the values that are treated as stochastic. The program keeps track of the actual population. If the quota decisions are to be taken on data that deviate from the true ones, such data (i.e. SSB and stock numbers) are drawn randomly according to a specified distribution. TACs are derived by applying the management decision rule to the assumed stock data. These catches, with possible stochastic deviations from the decided TAC's, are removed from the true population.

POPULATION MODEL

For each year class, the number N of individuals at the start of the year is reduced each year by the total mortality Z, which is a sum of the fishing mortality F and the natural mortality M. The fishing mortality for each fleet is a product of a fleet specific year factor *Fy(year,fleet)*, which emerges from the management decision rule, and a fleet specific selection at age *Sa(age, fleet),* which is input. The overall fishing mortality is the sum of the fleetwise fishing mortalities, thus:

$$F(year,age) = \Sigma_{Fleet=1,2}\, Sa(age,fleet)*Fy(year,fleet)$$

The natural mortality *M(age)* is input by age
The total mortality *Z(year age)* is the sum

$$Z(year,age) = F(year,age) + M(age)$$

All mortalities are on a yearly time scale.
The stock numbers are reduced each year by

$$N(year+1,age+1) = N(year,age) * \exp(-Z(year,age))$$

The N-values in the next year are increased in age by one, and the recruitment is added as the N at the lowest age.

The oldest age group (A) is treated as a dynamic plus group. At the start of the year, this group includes both the fish that enter the plus group from the oldest true age, and those left over in the plus group from last year, i.e.

$$N(year+1,A) = N(year,A-1) * \exp(-Z(year,A-1)) + N(year,A) * \exp(-Z(year,A))$$

The catches in numbers by fleet at age are

$$C(year,age,fleet) = F(year,age,fleet)*N(year,age)*(1-\exp(-Z(year,age)))/Z(year,age)$$

where

$$F(age,year,fleet) = Sa(age,fleet)*Fy(year,fleet)$$

The yield is calculated as the sum of products over ages of the catches and the catch weights, i.e.

$$Yield(year,fleet) = \Sigma_{ages}\, C(year,age,fleet)*Weight(year,age,fleet)$$

The spawning stock biomass S is computed as the sum of products of stock number reduced by the fraction of the mortality realised before spawning (*propm* and *propf*), and the weight at age in the stock and the proportion mature at each age, i.e.:

$S = \Sigma_{ages}\, N(year,age)*exp[-F(year,age)*propf - M(age)*propm] * Weight(year,age) * Prop.mat.\ (year,age)$

The process starts at the beginning of the year intermediate between assessment and the first TAC year and is carried forward for 10 TAC years. Stochastic elements are drawn as they are needed. The results are assembled for each year. A total of 1000 such 10 year projections are made, and statistics of the results are presented.

STOCHASTIC ELEMENTS.

Recruitments.

Recruitments are generated for each year y in each simulation by applying one of the functions 1-6 below to the current spawning stock biomass S. The general form, including autoregressive terms α_1 .. α_p is:

$R(y) = f(S(y-iv)) * exp(\xi(y))$ (log-normal distribution)

or optionally:

$R(y) = f(S(y-iv))*(1+\xi(y))$ (normal distribution with constant CV)

where

$\xi(y) = \alpha_1*\xi(y-1) + ... + \alpha_p*\xi(y-p) + \varepsilon(y)$

and iv is the number of years between spawning and recruitment.

Here, ε is a random number drawn from a normal distribution with mean = 0 and a specified σ. The ξ values for the years prior to the start of the simulation are calculated from log residuals of input stock-recruit pairs for those years. If values of ξ fall outside a specified range (the truncation level), a new number is drawn. The parameters in the function $f(S)$ as well as the α's are input to the model. A spreadsheet program that can be used to estimate these parameters, is supplied along with the prediction programs.

The following stock-recruitment functions, with parameters $p1, p2, p3$ are implemented:

1: Beverton Holt function:

$f(S) = p1*S/(S+p2)$

2: 'Ockhams razor':

$f(S) = p1 \quad ; S > p2$

$f(S) = p1*S/p2 \quad ; S < p2$

3: Ricker function:

$f(S) = p1*S*exp(-p2*S)$

4: Cushing function:

$f(S) = p1*S^{p2}$

5: Shepherd function:

$$f(S) = p1*S/(1+(S/p2)^{p3}$$

6: Deriso – Schnute function:

$$f(S) = p1*S*(1-p2*p3*s)^{(1/p3)}$$

Weights at age and maturity at age.

Input data includes these values for a range of years back in time. Random values are obtained by drawing a year and using the data for that year. This way, correlations between e.g. weights at age at different ages within the year are preserved, but correlations between years are not.

Initial stock numbers.

These are taken from the assessment. The following options are implemented:

0. Deterministic numbers
1. If the assessment provides a variance-covariance matrix of the log numbers at age, the logarithms of the initial numbers can be drawn as a random vector according to a normal distribution with that variance-covariance matrix.
2. If the assessment provides a variances and covariances of the numbers at age, the initial numbers can be drawn as a random vector according to a normal distribution with that variance-covariance matrix. In this case, the program interprets the input 'variance-covariance'-matrix as one with coefficients of variation along the diagonal and coefficients of correlations in the other entries.
3. If the assessment provides a set of vectors of initial numbers at age from bootstrapping, these vectors can be used. If the number of vectors is insufficient, the set is drawn over again.

Error in future assessments.

The SSB-values and stock numbers to which the HCR is applied, can be altered with a randomly drawn multiplier. The multiplier is drawn from a truncated normal distribution with specified mean and standard deviation. A mean different from 1.0 would indicate that bias in the assessments is assumed. The multiplier is primarily applied to the stock numbers, and the SSB is derived from them.

If an error is assumed in future assessments, it is logical that this error also applies to the initial numbers. Therefore, these numbers are adjusted by *dividing* by the assessment error multiplier.

Deviation of the actual catch from that decided by applying the HCR

can be included just the same way as for the SSB. Thus, the catch actually taken may deviate from the decided TAC, which again may be derived from a faulty assessment In the further simulation, the catch derived this way is removed from the true stock.

FIXED INPUTS.

The ***selection pattern*** *Sf(age,fleet)* for each fleet and the ***natural mortality*** *M(a)* at age are fixed inputs.

A ***reference age interval*** is stated for each fleet. The selections at age are rescaled by the program so that the fishing mortalities in the harvest control rule are interpreted as the average partial fishing mortality for the fleet over that age interval.

The parameters in the stock – recruitment relationship are fixed inputs. Also, the SSB and recruitment in years prior to the prediction period are input. Thus, if an autoregressive model is applied, the terms in that model originating from historic stock-recruitment pairs will not be stochastic.

1.4 MANAGEMENT DECISION RULES

The management decision rules for setting TACs are implemented in two steps. First, a basic harvest control rule (HCR) is applied, Then, this can be modified according to constraints on the year to year change in catches, fishing mortalities and in SSB.

The form of the ***basic HCR*** is: Apply a certain fishing mortality, depending on the spawning stock biomass (SSB) (see below), but do not allow more than a certain catch. This allows for catch constraint regulation (give a very high F by which the catch constraints becomes limiting unless there is insufficient fish left), F regulation (give a very high constraining catch) or combinations of these.

Three levels of SSB are defined: A low level where the fishery typically will be closed or kept very low, a high level where a 'standard' fishing mortality or catch apply, and an intermediate level. In the intermediate level, the fishing mortality can be reduced gradually according to the actual SSB, or kept constant. The SSB used in the decision process is the projected SSB for the year when the catch is to be taken, adjusted with the error factor if so whished.

In some cases, applying the HCR corresponding to a low level may give an SSB at a higher level, while applying the HRC according to the higher level may give an SSB at the lower level. The implementation here is conservative in the sense that the HCR according to the lower level is applied in such cases. The catches used in this process are always the ones calculated from the assumed stock abundance - if the actual catch deviates from this (misreporting), this will only affect the subsequent development of the stock.

The program takes into account the link between catch and SSB, when the gradually increasing F rule is applied at intermediate SSB levels. This is done by a searching routine to find corresponding values of F and SSB.

Schematically, the decision process is as follows:

BASIC HCR:

Choose the largest TAC that satisfies all requirements at the SSB level.

SSBLevel	SSB in projection year	F fleet 1	F fleet 2	Catch fleet 1	Catch fleet 2
1	SSB < Slim 1	$\leq F_{11}$	$\leq F_{21}$	$\leq C_{11}$	$\leq C_{21}$
2	Slim 1 < SSB < Slim 2	$\leq F_{12}$*	$\leq F_{22}$*	$\leq C_{12}$	$\leq C_{22}$
3	Slim 2 < SSB	$\leq F_{13}$	$\leq F_{23}$	$\leq C_{13}$	$\leq C_{23}$

* These F-values may be a linear function of the ensuing SSB

Since the projected SSB is dependent on the mortality in the projection year, the following algorithm is used to decide the level:

```
Try level 3.      If that leads to SSB in level 3, keep level 3

if not,

try level 1 If that leads to level 1, keep level 1

if not,

try level 2 If that leads to level 1, use level 1
            If that leads to level 2, keep level 2
            If that leads to level 3, keep level 2
```

```
2. Constraints on year-to-year variations
```

A constraint on change in catch has the form:

```
Min c-change <  (Catch this year- Catch previous year )/Catch previous year   < Max
c-change
```

The comparison is between **percieved** catch last year and **proposed** catch this year. This constraint can be defined for one of the fleets, or for the sum over both. Attempting to restrict the reduction in catch from one year to the next by a minimum C-ratio may lead to fishing mortalities higher than those stated in the basic HCR. A maximum permissible fishing mortality is defined as part of the run options.

A constraint on change in Fishing mortality has the form:

Min F-change < (F this year- F previous year)/F previous year < Max F-change

The comparison is between the **percieved** F last year and the **proposed** F this year. This constraint can be defined for one of the fleets, or for both. Attempting to restrict the reduction in fishing mortality from one year to the next by a minimum F-ratio may lead to fishing mortalities higher than those stated in the basic HCR. A maximum permissible fishing mortality is defined as part of the run options.

A constraint on SSB variation has the form:

SSB this year/SSB previous year $\geq$ S-ratio

This constraint applies only in levels 1 and 2. It has to be stated whether this is to be achieved by reducing the fishery by fleet 1, fleet 2 or both.

These constraints modify the fishing mortalities that have been decided (or derived) according to the basic HCR above, in the following sequence:

```
Catch variation (checked first)
      If the catch increases too much, reduce F
      If the catch decreases too much, increase F,
      but not above the F set as the highest permissible F.

F-variation
      If the F increases too much, reduce F
      If the F decreases too much, increase F,
      but not above the F set as the highest permissible F.

SSB increase (checked last)
      If SSB ratio is too low, reduce F (levels 1 and 2 only)
```

Some practical advice about implementation of management rules is given later on.

RULES FOR THE INTERMEDIATE YEAR.

Usually, the prediction period of interest starts with the year after the assessment has been done, while the assessment estimates the stock at the start of the year when the assessment is done. The year when the assessment is done thus becomes an intermediate year. In this year, the fishery has already started, and decisions on regulations have should already have been made.

For this year (the year 0), the usual management decision rules do not apply. Rather, the stock is projected through that year either with catch constraint corresponding to a TAC that has been decided already, or assuming a certain F-constraint. The constraint is specified for each fleet. Faulty future assessments are not taken into account in this year – assessment uncertainty in this year is supposed to be covered by the input data. The rules below for handling catch constraints if there is shortage of fish apply even here.

PROTECTION AGAINST RUNNING OUT OF FISH.

With constraints on catches there is a possibility that there will not be sufficient fish to take this catch. For each fleet, there is specified a maximum fishing mortality *Fmax(fleet)* that the fleet is able to generate. To cope with various possible combinations of failure to take the catch constraint *Cc(fleet)*, the following rules apply:

CATCH CONSTRAINT ON ONE FLEET (FLEET A), F CONSTRAINT ON THE OTHER (FLEET B):

```
Keep the F on fleet B,
if,
Fleet A can take Cc(A)
     take the Cc
else
     apply Fmax for fleet A

Catch constraint on both fleets:

If
Both Fleets can reach their Cc:
Both take the Cc

else if
Fleet A cannot reach Cc(A) even if Fleet B does not fish
and
Fleet B cannot reach Cc(B) even if Fleet A does not fish.
Both fish at their respective Fmax

else
Starting at Fmax for both fleets, both Fs are reduced proportionally until
one of the fleets reaches the Cc.
```

The last option applies if one fleet can reach its *Cc* and the other cannot, or if each of the fleets can each their *Cc* provided the other fleet takes less than its *Cc*.

PRINTOUTS

The standard printout to the file xxx.out (see Section III for file naming conventions) includes yearly fractiles of SSB, recruitments, fishing mortalities and catches by fleet, and fractiles of average catch by fleet over the first 5 years and over the whole simulation period. Furthermore, it tabulates the yearly probabilities of being in each of the SSB-levels, and of shifts between levels, both in the true world and in the virtual world seen by the decision makers, and the fractiles of the first year when the stock is in SSB-level 3. Finally, the fractiles of a stability measure for the quotas are printed. This measure is the range of the catches over the last 5 simulation years, as percentage of the mean in that period.

During the simulation, the essential yearly results from each projection are written to an intermediate file (xxx.tmp), which is read later on by the printout routine. This file can be used for other analyses of the data if needed.

1.5 DESIGN OF MANAGEMENT DECISION RULES

The system for management decisions during the simulations in STPR is quite complicated, to allow the user to explore a rather wide range of such rules. Here, we give some hints and examples of how to use the options to specify management rules:

In gross terms, the decision rules consist of

1. A basic harvest control rule (HCR) that specifies F-constraints and catch constraints at each of 3 levels of projected SSB
2. Subsequent constraints on year-to-year variation in catches and in SSB.
3. A final check that fishing mortalities do not exceed specified upper bounds

The program is intended for simulating a fishery by two fleets. Each fleet is characterised by its selection at age, and they may have different catch weights at age. The HCR specifies separate rules for each fleet. The constraints on year to year variations may apply to one fleet or to the two fleets combined.

SIMULATING ONLY ONE FLEET:

If you have only one fleet, the selection at age in the input *.adt* file should be 0 at all ages. You should also set all F-constraints and catch constraints to 0 for the fleet that you do not use.

SPECIFICATION OF HIGHEST POSSIBLE F AND HIGHEST PERMITTED F:

The two sets of bounds are used to cope with situations where there is shortage of fish. Their roles are somewhat different:

THE HIGHEST POSSIBLE F

is used whenever a catch that has been decided, is too large for the stock. This can happen if there are catch constraints, but also if there are constraints on the SSB-variation, and if the decisions have been made with biased data, and it is impossible to get the decided catch out of the real stock. As a guideline, the value should correspond to the maximum fishing mortality that the fleet is able to induce. For pelagic fisheries this may be very high, but for many demersal fishery, this may correspond to the historic $F_{status\ quo}$ in situations where the TAC's have not been restrictive.

THE HIGHEST PERMITTED F

is only used when the reduction in the catches or F from one year to the next is restricted. These are the only cases that may lead to deciding on a higher fishing mortality than emerging from the basic HCR, and the highest permitted F will restrict this increase in F. Typically, the value should correspond to Fpa, and it should not be higher than the highest possible F

SIMULATING A PURE F-REGIME:

Set the catch constraints so high that you will never reach them and do not use the constraining options.

SIMULATING A PURE CATCH CONSTRAINT REGIME:

Set the fishing mortalities in the harvest control rule very high. Then, the catch constraint will usually be restrictive. The value of the high fishing mortality determines what to do if the stock becomes small. The catch will be restricted by the highest possible F anyway, so there is no point in using a value higher than that. If the F-value specified in the HCR is lower than the highest possible F, the HCR value will be restrictive. The option to let the F increase gradually with the SSB in level 2 should be used with some care in this case, since F-range will be from the F at level 1 to the F at level 3.

SIMULATING A MIXED F-CATCH REGIME:

By specifying both an F and a catch at 'plausible' levels, the specified catch becomes restrictive if the F leads to a higher catch, i.e. the HCR will get the form: 'Fish at the fishing mortality F, but do not allow the catch to exceed C'. This is sometimes termed an 'F regime with a catch ceiling'.

USING THE GRADUAL INCREASE IN F AT LEVEL 2.

This rule is sometimes suggested by managers to avoid large changes in F due to small changes in SSB. If it is requested, the program will iterate until the projected SSB balances the F derived from the SSB. The F will increase linearly with SSB from the F in level 1 to the F in level 3 within the SSB interval defining level 2. The fishing mortality specified for level 2 will not be used as part of the HCR. It should have some sensible value, however, because it may be used internally by the program to start iterative processes.

CONSTRAINING YEAR-TO-YEAR CHANGE IN THE CATCH:

This may be used to improve stability in the catches by avoiding a rapid increase in the catch once a good year class comes into the fishery. It is applied by specifying a number other than 0 for the maximum and/or minimum relative change in catch. If you want to have tha cathces virtually stable, use a very small non-zero number.

CONSTRAINING YEAR-TO-YEAR CHANGE IN THE F:

This has been suggested as a way to make a 'painless' recovery, by gradually decreasing F. It is applied by specifying a number other than 0 for the maximum and/or minimum relative change in F. Typically, one will set a low F in the basic rule, and allow not more than a certain (0.1, say) annual decrease.

CONSTRAINING SSB - VARIATION:

This option only applies in SSB levels 1 and 2, i.e. in a rebuilding situation, and is intended to ensure that the SSB will increase. The SSB is here the expected SSB in the year after the decision year compared to the expected SSB in the decision year, since the SSB in the decision year usually is not much influenced by the catch in the same year. The requested increase in SSB is obtained by reducing the fishing mortality as necessary. If there is no scope for such an increase in the SSB, the catches are set to zero by this rule. It may therefore often be practical to combine it with the option below.

EXAMPLES OF MORE ELABORATE DECISION RULES:

In a rebuilding situation, one may want to ensure that the stock increases by a lower bound on the increase in SSB. However, one would like to exploit strong year classes once they appear, rather than preserving them for building up the SSB later on. Thus, one would like to have the SSB increase by a certain fraction, no more and no less. This can be obtained by specifying an F in the HCR at the maximum possible F, together with the constraint on the SSB variation.

1. For a stock in a good shape, one may want to stabilise the catches. A first attempt could be to have a quite high F and a catch constraint at the desired catch level in the basic HCR, at least for SSB at level 3. At lower SSB levels, some low F may be suggested to ensure rapid rebuilding if the stock declines. Alternatively, one could have 'sensible' F and no

catch constraints in the basic HCR, but constrain the year to year variation in the catch. This would give some flexibility in the TAC's but would apply to all levels of SSB, i.e. the protection offered by a low F in levels 1 and 2 would be lost.

1.6 LONG TERM STOCHASTIC EQUILIBRIUM (LTEQ)

OUTLINE OF THE PROGRAM

The purpose of this program is to find the stochastic analogue to an equilibrium between SSB and recruitment. This would correspond to combining SSB per recruit with a stock recruit function, but the deterministic equilibrium is here substituted by stationary distributions.

The SSB is the sum of the contributions from each year class. These contributions are the initial year class abundance in numbers, reduced by the cumulated total mortality at that age and multiplied by the weight at age and maturity at age. Thus, the SSB is a weighted sum of past recruitments, and the weighting is in general independent of the recruitment as such. The idea is then that, when there to each SSB value corresponds a stationary distribution of recruitments, and the SSB is a weighted sum of previous recruitments, a stationary distribution of SSB's should transform into a stationary distribution of recruitments and *vice versa*. Accordingly, the program just does a transform back and forth between the distribution of SSB's and the distribution of the recruitments until both distributions are stable.

The stochastic variables are

- Recruitments, according to a given stock recruitment function and a given distribution of the residuals.
- Weights and maturities at age, which are drawn randomly from historical values.

The weights and maturities at age are drawn from a collection of data for a range of years, by drawing a year and using the data from that year. The weights and maturities are not dependent on the current SSB, i.e. no denity dependence is accounted for.

The projections are made conditional on the following fixed parameters:

- Natural mortality
- Selection at age by fleet (2 fleets)
- Fixed yearly level of fishing mortality by fleet

The program computes the long term stationary distributions of recruitments and SSB's at given levels of F, and computes the corresponding distributions of catches for two separate fleets. The F's are specified as average F's over reference age intervals for the two fleets respectively, and refer to scaling of a given fishing pattern for each of the fleets.

PROCESS MODEL

The underlying principle is that since the SSB is a weighted sum of previous recruitments, and the recruitment is a stochastic function of SSB, and all distributions are stationary in time, the distribution of recruitments transforms into a distribution of SSB's, and the distribution of SSB's transforms into a distribution of recruitments, and both distributions are stationary.

The program starts with a distribution of SSB. The algorithm is as follows:

```
Make an initial cumulated SSB-distribution (uniform)
New distribution loop:
     Repeat 1000  times:
```

```
      Draw weights and maturities at age from the collection
      Compute SSB/R at age
      Draw an SSB from the old distribution.
      Loop over ages
            Draw recruitments assuming that SSB, as many as there are ages.
            Multiply these recruitments with the SSB/R at age
            Sum to get a new SSB
      end age loop
      end repeat
      sort the SSB’s to get a new cumulated distribution
end new distribution loop

check if the SSB distribution has changed
if so,
       repeat  new distribution loop
else
Compute new recruitments, compute catches, transfer catches, SSB’s and
recruitments for printout.
end
```

The convergence is usually very rapid, unless the stock becomes extinct. To ensure consistency between the distribution loops, the random number seed is reset at each start of the loop. If convergence is not complete after 100 iterations, the process is broken.
The convergence criteria are:

1. Sign criterium: The number of cases where the previous cumulated distribution was above the present and the number of cases where it was below, shall not differ by more than 0.1% of the number of iterations.
2. Diffmax: In the cumulated distribution of SSB, the maximum absolute difference at similar cumulated probabilities between two subsequent distribution loops shall be smaller than 0.1% of the mean SSB

Normally, the diffmax is satisfied first, the sign criterium may take some more rounds. If convergence is poor, the mean SSB typically goes towards zero indicating that no SSB is sustainable, and the diffmax does not improve. The values of the criteria, the mean SSB and mean SSB per recruit are printed to the screen for each round.

RUN OPTIONS.

The program is made to screen over a range of fishing mortalities for the two fleets. For each pair of mortalities, the equilibrium is generated and the results are printed.

The fishing mortalities is specified as the arithmetic mean partial fishing mortality over an age range, which is specific for each fleet. The selection at age for each fleet is input and deterministic.

The weights and maturities at age are taken from historical values, and in each computation of SSB and catch, all these data are taken from the same year. Thus, within year correlations are preserved, while between years correlations are not.

The Stock-recruitment functions are parametric. At present, the Beverton –Holt, ‘Ockhams razor’ and the Ricker functions are implemented. Recruitments are assumed to be lognormally distributed with uniform variance on the log scale. No autocorrelations are implemented.. The two parameters for the stock-recruit functions are stochastic themselves, with input variance for each and covariance between them. In addition, the lognormal residuals are stochastic with specified variance. The distribution of the residuals can be truncated – if the absolute value exceeds a given limit, a new value is drawn.

An additional run option is to correct for bias in the recruitment distribution. This is not done automatically, but by manual input of a bias multiplier.

OUTPUT

Two output files are produced. A standard output files gives for each set of F’s, mean values of SSB, recruitment and catches as well as tables of percentiles for these parameters. A summary file gives the same percentiles plus SSB per recruit, all in one line for each set of F's. This file is intended primarily for importing into spreadsheets etc.

1.7 INSTALLING AND RUNNING THE PROGRAMS

Both programs are written largely in standard Fortran 77. No external libraries are needed. For use on PC's, the program has been compiled with the Lahey LF95 compiler. The compiled program does not need additional .dll files or the like. I have found it most convenient to run the programs in a DOS window. The program prints to the screen names of input files as they are opened, run options if read from the options file, as well as some error messages. LTPR also prints some intermediate results to the screen. This information can be useful if the program crashes, but if that happens, the window just closes if the program has been started from Windows, e.g. from the File Manager.

If the programs are to be used on other platforms than PC's, they must be compiled. Any compiler that accepts Fortran 77 should probably do, and no additional libraries are needed. However, the date_and_time function used to generate the run id is not part of F77 standard, and may have to be commented out.

The STPR3 software is distributed as a file stpr3.exe. A set of input files (Blue whiting starting in 2001) is also provided. The source code stpr3.for and an include file called stokpred.inc with common variables are also provided.

The LTEQ is distributed as a file lteq.exe, together with the source code lteq.for and a set of input files.

The ***input and output files*** in STPR3 have ***standard names*** of the form xxx.yyy. The xxx is a 3-letter code for the stock, which is given by the user. The yyy are standard file types that the program expects. The file formats are described below. The LTEQ uses files with the same format but without this naming convention.

Both programs generate a ***run identifier***, which is the date and time when the program is started. This run id appears in the first line in the standard output files.

The files can be space or comma separated. If data are missing, the programs may produce unpredictable or misleading results. ***Not ready yet:*** *A program is provided which extracts all files needed for STPR3 except the .opt file, from ICA output files, provided the standard ICA printout options are used. In AMCI, one printout option is to generate input files for STPR3. AMCI can also generate an .nbs file from a bootstrap run (this works already, but requires a small change in the AMCI code and recompiling, and some post-processing).*

RUNNING STPR3.

The program is started by typing *stpr3*. The options are given in a dialogue. This dialogue is logged to a file xxx.opt, which can be read instead of repeating the whole dialogue. It is recommended that the dialogue procedure is used for the first run, to get the file right. Later on, it may be more feasible just to adjust the file.

When starting the program you specify the three-letter code xxx, go through the options dialogue (or state that you take it from the .opt file, the rest goes automatically. The program may take some 10-15 seconds to run on a fast (by 2001 standards) PC, depending on how elaborate management rules you have specified.

The printout goes to the file xxx.out. Intermediate results from each bootstrap replica are stored in xxx.tmp. A scratch file named kladd is also generated. It may contain error messages, but is not used normally. Old printout files are overwritten without warning.

RUNNING LTEQ

The program is started by typing *lteq*. The name of the options file, and the value of the recruitment bias factor are input. The program prints essential values and convergence criteria after each SSB distribution loop, to follow the convergence. Slow convergence generally indicates that the stock is collapsing, i.e. the applied fishing mortalities always lead to a reduced SSB from one generation to the next.

Output goes to files in the parent directory. There is one file with a standard output, and one where the main results are printed in a form that should be easy to read into a spreadsheet.

1.8 FILES FOR STPR3

The ***input files*** needed for STPR3 are the following:

.adt: *Age structured data.*
The first line: Proportion of M and of F that is realised before spawning
The subsequent lines : Age M Selection fleet 1 Selection fleet 2
The **.adt** file looks like this:

```
0.67 0.67
0 1.00  0.062   0.000
1 1.00  0.194   0.000
2 0.30  0.000   0.309
3 0.20  0.000   0.350
4 0.10  0.000   0.372
5 0.10  0.000   0.356
6 0.10  0.000   0.353
7 0.10  0.000   0.348
8 0.10  0.000   0.372
9 0.10  0.000   0.372
```

.ydt: *Yearly SSB and Recruitments*. These are primarily used when an autoregressive model is applied for recruitments, but there may also be a need for SSB data for recent year to calculate recruitments in the first years. Therefore, the program always expects to find such a file with at least one line. The year is the actual year when the numbers apply – a delay between spawning and recruitment is taken care of by the program.
Years earlier than 10 years back are skipped.
Each line: Year Recruitment SSB

The .ydt file looks like this:

```
1995   44377.8     480.4
1996   56121.9     483.8
1997   31660.9     584.3
1998   26359.5     781.5
1999   75812.3     935.1
2000   48333.0     943.4
2001   83504.0    1428.1
```

.wc: *Weights at age in the catch by fleet.* These are historical values, up to 50 years of data are permitted.
Each line: Year Fleet Weight first age ….. Weight last age

The **.wc,** file looks like this:

```
1992  1   .010   .053   .102   .175   .189   .207   .223   .237   .249   .287
1993  1   .010   .033   .115   .145   .189   .204   .228   .244   .256   .310
1994  1   .006   .056   .130   .159   .181   .214   .240   .255   .273   .281
1995  1   .009   .048   .136   .167   .196   .200   .247   .249   .278   .287
1996  1   .016   .010   .123   .160   .192   .207   .211   .252   .254   .281
1992  2   .010   .053   .102   .175   .189   .207   .223   .237   .249   .287
1993  2   .010   .033   .115   .145   .189   .204   .228   .244   .256   .310
1994  2   .006   .056   .130   .159   .181   .214   .240   .255   .273   .281
1995  2   .009   .048   .136   .167   .196   .200   .247   .249   .278   .287
1996  2   .016   .010   .123   .160   .192   .207   .211   .252   .254   .281
```

.ws: *Weights at age in the stock*. These are historical values, up to 50 years of data are permitted.
Each line: Year Weight first age ….. Weight last age

.prm: *Proportion mature at age*. These are historical values, up to 50 years of data are permitted.
Each line: Year Prop. first age ….. Prop last age

The **.ws** and **.prm** files have a format like this:

```
1992    0      0     .510      1        1        1        1        1        1        1
1993    0      0     .470   .630        1        1        1        1        1        1
1994    0      0     .730   .860        1        1        1        1        1        1
1995    0      0     .730   .950        1        1        1        1        1        1
1996    0      0     .610   .980        1        1        1        1        1        1
```

The data in the files .wc, .ws and .prm are used to draw historical data randomly. Since the random variable is the year, and all data are taken from that year, only years that appear in all three files are used.
At least one year must be represented.

For ***initial stock numbers at age***, there are several alternatives. In all cases, the numbers apply to the start of the intermediate year. Optionally, the number at the youngest age may be substituted by a simulated recruitment, but some number must be present on the file anyway.

.nin: Stock numbers at age, with optional variance - covariance or correlations matrix.
Each line: Age Stock number Row in the var-covar matrix
The entries in the var-covar matrix are optional, but are needed unless deterministic initial N's are used (see also the description of the .opt file).

A **.nin** file may look like this:

```
0 60000  0.300   0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
1 22066  0.001   0.030   0.004   0.004   0.004   0.003   0.003   0.003   0.003   0.000
2  4303  0.000   0.004   0.020   0.006   0.005   0.005   0.004   0.004   0.004   0.000
3  1427  0.000   0.004   0.006   0.020   0.008   0.007   0.006   0.005   0.005   0.000
4   922  0.000   0.004   0.005   0.008   0.022   0.011   0.010   0.009   0.007   0.000
5   459  0.000   0.003   0.005   0.007   0.011   0.028   0.016   0.016   0.016   0.000
6   123  0.000   0.003   0.004   0.006   0.010   0.016   0.034   0.021   0.020   0.000
7    56  0.000   0.003   0.004   0.005   0.009   0.016   0.021   0.041   0.028   0.000
8    25  0.000   0.003   0.004   0.005   0.007   0.016   0.020   0.028   0.050   0.000
9    57  0.000   0.000   0.000   0.000   0.000   0.000   0.000    0.000   0.000   0.050
```

Notice:
If a log-normal distribution is requested, the entries in the matrix are treated as variances and covariances on a log scale. If a normal distribution is requested, the entries are treated as coefficients of variation along the diagonal, and correlation coefficients for the rest of the matrix.
If the .nin file is generated by AMCI, variances will not have been filled in. Unless you use deterministic N's, this will generate the error message 'Singular matrix' by STPR.

Alternatively, one can have a **.nbs** file:

.nbs: Initial stock numbers from bootstrap assessment runs. If the number of replicas are less than the number of replicas (1000) in STPR, the file is just read over again.
One line for each bootstrap replica: N first age ….. N last age

Example:

```
 9158.2  5894.8  7788.5  6562.2  1708.8  1660.4  1756.0  539.6   82.9  26.1
  15006.6  11817.4  75610.9  33523.9   8400.3   7477.7   8566.8  2599.9   400.2 174.3
  13190.9   9785.1  20561.9  12139.3   3195.3   3062.4   3329.1  1038.9   160.8  58.5
   4844.7   3190.9   8666.5   6984.1   1842.9   1805.0   1911.7   594.1    91.6  29.6
  25372.7  19343.2  29687.7  15991.4   4201.3   3981.3   4384.8  1370.5   212.5  82.1
   8763.8   6402.9  17050.9  10581.0   2791.5   2693.2   2908.3   907.9   140.5  49.7
   8070.8   6029.9  20666.7  12026.1   3159.5   3024.8   3287.4  1024.3   158.5  57.5
etc
```

opt

This file contains the options for the run. It is generated through the dialogue at the start of the program, but if the file exists, it can be read by the program so that you do not have to enter everything over again. Often, just a few changes are needed between each run, and than it may be more feasible to do that directly on the file. Below is an example of such a file. The comments in *italics* are explanations that do not normally appear on the file. It is permitted to put comments behind the numbers on the file, with at least one space between, but new lines are not permitted. Open lines, which are put in here just for clarity, are not permitted on the file. The entries that actually appear on the file are written in **bold**.

0 10 *Youngest and oldest(=+) age*
0 *Number of years between spawning and recruitment*
3 7 *Reference age interval for F for fleet 1*
1 1 *Reference age interval for F for fleet 2*
2001 *The intermediate year ('year 0')*
C *Consraint for fleet 1 in year 0 (C=catch, F= fishing mortality)*
1**400** *Value of constraint for fleet 1*
C *Consraint for fleet 2 in year 0 (C=catch, F= fishing mortality)*
400 *Value of constraint for fleet 2*

The next three lines specifies the harvest control rule. There are 3 levels of SSB, with one line for each level. Each line has the following format:

Lower SSB bound Max. F fleet 1 Max F fleet 2 Max Catch fl.1 Max catch fle. 2
0.00000 0.20000000 0.00000000 10000.0000 10000.0000
1500.00000 0.20000000 0.00000000 10000.0000 10000.0000
2250.00000 0.20000000 0.00000000 10000.0000 10000.0000
0 *Linear increase of F in level 2? (0 = no, 1 = yes)*

The nest two lines specify permissible year to year variation in the catches
This may apply to either fleet 1, fleet 2 or both
Both fleets Fleet 1 Fleet 2
0.00000000 0.00000000 0.00000000 *Max increase (only one nonzero permitted)*
0.00000000 0.00000000 0.00000000 *Max decrease (only one nonzero permitted)*
The nest two lines specify permissible year to year variation in the fishing mortalities
This may apply to either fleet 1, fleet 2 or both
Both fleets Fleet 1 Fleet 2
0.00000000 0.00000000 0.00000000 *Max increase (only one nonzero permitted)*
0.00000000 0.00000000 0.00000000 *Max decrease (only one nonzero permitted)*
0.0000000 0 *Min. increase in SSB, which fleet takes the burden (0=both)*
1.5 1.0 *Max. possible fishing mortality by fleet*
1.5 1.0 *Max.permitted fishing mortality by fleet*
2 1 11915.0000 1500.00000 0.00000000 0.485 1.00000000
Recruitment model, Function for stochastic initial numbers (0: determ, 1: lognorm, 2: normal 3 parameters, sigma and truncation
5 *Number of autoregressive terms for recruitment*
0.460 -0.502 0.062 -0.188 -0.238 *Terms in autoregressive model*
1 *Apply the S-R relation in year 0? (1=yes, 0=no)*
1.00000000 0.00000000 *Assessment bias multiplier (mean and SD)*
1.00000000 0.00000000 *TAC deviation multiplier (mean and SD)*
1 *Function for stochastic initial numbers (0: determ, 1: lognorm, 2: normal, 3: from bootsrtrap assessment*

When setting up the .opt file, notice in particular that SSBs, recruitments and catches must be on the same scale as the data in the .nin, .ws, .wc and .nbs files. Notice also that since STPR uses formatted file for temporary storage of data, there are limitations to the number of digits that can be represented. Thus, recruitments or SSBs represented by numbers $>10^{10}$ may create problems. The recipe is to move the decimal point for all relevant numbers in the files.

The input files can be generated by AMCI. However, these files must be regarded as templates. In particular, be aware of the scaling as mentioned above, and that AMCI does not include variance-covariance values, and may leave out the recruitment in the last year in the .nin file.

OUTPUT.

The standard output is on a file xxx.out. In addition, a file is produced with the stock-recruit pairs for the last year, i.e. recruits in year 10 and SSB that generated these recruitments.

Files for LTEQ

The input data files for LTEQ are similar to those used for STPR3, so the same files can be used. Different file names are permitted. Only the following file types are needed:

.wc
.ws
.prm
.adt

In addition, an options file is needed, which is different from that in STPR3. So far, this file has to be set up separately, the example below should serve as a template. Notice that each line has a specific interpretation. Comments are permitted after the numbers (but not after file names). These comments are written in *italics* here.

Line 1: Stock identifier, which is for the users book-keeping only.
Line 2: Age range for the population. Recruitment takes place at the lowest of these ages. The upper age is a plus age. The age range on the data files must include this range of ages.
Lines 3 and 4: Range of fishing mortalities to be screened and the reference age range for the fishing mortality, for fleets 1 and 2 respectively.
Line 5: Limits for SSB. The output gives probabilities of being below each of these limits.
Line 6: Parameters for the stock recruit function:

Function number:1= Beverton-Holt, 2= Ockham, 3= Ricker
Parameters a and b in the stock-recruit function (notation as for STPR3)
var(loga),var(logb),cov(logalogb), SD for recruitment function residuals, truncation level for residuals

Lines 7-10: Data input files (as for STPR3. Different names are permitted, but the sequence must be right.
Lines 11-12: Output file names: Standard output and summary output.

Example:

```
Blue whiting combined stock. Ockham limit at 1000
0 10 Recr-age, Oldest age
0.15 0.50 0.01 3 7 Fleet 1: Startf,Endf,Interval,Ref.ages
0.0 0.30 0.1 0 1   Fleet 2: Startf,Endf,Interval,Ref.ages
1500 2250 Two limits for SSB (f.ex. Blim and Bpa)
2 12400.0 1000.0 0.0 0.0 0.0 0.485 1.0 SR-funktion specification
bwh.wc
bwh.ws
bwh.prm
bwh.adt
ltout
ltsum
```

A SPREADSHEET PROGRAM FOR S-R PARAMETER ESTIMATION.

The input is pairs of SSB's and recruitments from a historical assessment, adjusted in time so that the recruitments are those which were generated by the SSB's.

For given values of the Beverton -Holt parameters a and b, the corresponding recruitment and the log residuals ε are computed. For the years where this can apply, the autoregressive prediction of ε and the corresponding residuals ξ are computed for given values of the autoregressive coefficients αi. The parameters a, b and the αi are estimated using the Solver optimisation routine in Excel, by minimising the variance of the ξ.

In the prediction programs, the ξ are assumed to be normally distributed with zero mean. The mean can actually be chosen freely, because it would just lead to another value of the Beverton-Holt parameter a. To check that the model (Beverton - Holt and normal distribution with the estimated parameters) is adequate, the ranks of the residuals ξ are computed. Assuming that each residual has equal probability, these ranks, divided by the number of observations, are taken as cumulated probabilities in the distribution of the residuals, and the corresponding values $\bar{\bar{\xi}}$ of the residuals according to a normal distribution with the estimated σ are computed. These derived residuals can be compared with the primary ones, or they can be converted to derived recruitment values and compared at that level. Plots are provided for these comparisons. If the pairs deviate considerably from the diagonal, this should be taken as an indication that the normal distribution may not be adequate. There is also a Kolmogorov goodness of fit criterium computed, using the deviation between the rank derived probabilities and the probabilities according to the assumed normal distribution of the observed values of ξ.

Thinking of the residuals as a measure of recruitment success, one may argue that extreme residuals, if they occur, appear when the conditions for recruitment are exceptional. In such years, the recruitment may be limited by quite different factors than those dominating under ordinary conditions. It is not obvious that the recruitment success is such exceptional years is adequately described by the tail of a log-normal distribution, even though this distribution is adequate under ordinary circumstances. Moreover, such year-classes are so poorly represented in most stock-recruitment time series that very little can be said about their statistical properties. One should, however, when making simulations, hesitate to accept year-classes many times the largest one observed. Therefore, in the simulations the distribution of the residuals can truncated. Truncation levels should correspond approximately to the largest and smallest residuals in the material.

A further control is simply to compute the correlation between the ξ and the SSB's. Since the ξ are drawn randomly in simulations, and are converted to recruitment numbers as a function of the SSB, it is mandatory that they do not themselves depend on the SSB. Zero correlation may actually be used a a constraint in the optimisation. This would lead to a set of parameters $\theta = \{a,b,\sigma,\alpha_1,..,\alpha p\}$ in the relation $R(\xi,SSB;\theta)$ which eliminates the empirical correlation between ξ and SSB when the present data are applied, but gives no guarantee that the model would leave these variables uncorrelated in general. Thus, it is probably more appropriate to just compute the correlation, and reject the model if the correlation is not close to zero. Figure 2 shows the residuals ξ when no constraint on the correlation is applied.

The autoregressive model was included because for some stocks, good yearclasses tend to appear at more or less regular intarvals, and for some stocks, a large yearclasses almost invariably is followed by a poor one. To my knowledge, there is no universal rule for determining whether such terms should be included. The STPR model permits doing so, and it may be advisable if the model fit is improved, as expressed e.g. by the SSQ of the residuals or some significance test derived from that.

There is a close relation between the oscillatory properties of a time series and the coefficients of an autoregressive model for the series. The spreadsheet provides plots of the power spectra corresponding to the autoregressive coefficients.

APPENDIX 2 NORTH SEA PLAICE INPUT DATA FILES

2.1 ADT FILE

```
 0.00 0.00
1  0.1000 0.02 0.001
2  0.1000 0.16 0.02
3  0.1000 0.40 0.08
4  0.1000 0.60 0.25
5  0.1000 0.70 0.36
6  0.1000 0.67 0.34
7  0.1000 0.63 0.29
8  0.1000 0.43 0.28
9  0.1000 0.47 0.38
10 0.1000 0.47 0.38
```

2.2 NIN FILE

```
1    394686  0.41 0 0 0 0 0 0 0 0 0
2    396233  0 0.43 0 0 0 0 0 0 0 0
3     97264  0 0 0.24 0 0 0 0 0 0 0
4     92730  0 0 0 0.15 0 0 0 0 0 0
5     59132  0 0 0 0 0.13 0 0 0 0 0
6     46028  0 0 0 0 0 0.12 0 0 0 0
7     38896  0 0 0 0 0 0 0.16 0 0 0
8      4599  0 0 0 0 0 0 0 0.18 0 0
9      2948  0 0 0 0 0 0 0 0 0.20 0
10 5159  0 0 0 0 0 0 0 0 0 0.20
```

2.3 PRM FILE

```
1957  0     0.5   0.5   1     1     1     1     1     1     1
1958  0     0.5   0.5   1     1     1     1     1     1     1
1959  0     0.5   0.5   1     1     1     1     1     1     1
1960  0     0.5   0.5   1     1     1     1     1     1     1
1961  0     0.5   0.5   1     1     1     1     1     1     1
1962  0     0.5   0.5   1     1     1     1     1     1     1
1963  0     0.5   0.5   1     1     1     1     1     1     1
1964  0     0.5   0.5   1     1     1     1     1     1     1
1965  0     0.5   0.5   1     1     1     1     1     1     1
1966  0     0.5   0.5   1     1     1     1     1     1     1
1967  0     0.5   0.5   1     1     1     1     1     1     1
1968  0     0.5   0.5   1     1     1     1     1     1     1
1969  0     0.5   0.5   1     1     1     1     1     1     1
1970  0     0.5   0.5   1     1     1     1     1     1     1
1971  0     0.5   0.5   1     1     1     1     1     1     1
1972  0     0.5   0.5   1     1     1     1     1     1     1
1973  0     0.5   0.5   1     1     1     1     1     1     1
1974  0     0.5   0.5   1     1     1     1     1     1     1
1975  0     0.5   0.5   1     1     1     1     1     1     1
1976  0     0.5   0.5   1     1     1     1     1     1     1
1977  0     0.5   0.5   1     1     1     1     1     1     1
1978  0     0.5   0.5   1     1     1     1     1     1     1
1979  0     0.5   0.5   1     1     1     1     1     1     1
1980  0     0.5   0.5   1     1     1     1     1     1     1
1981  0     0.5   0.5   1     1     1     1     1     1     1
1982  0     0.5   0.5   1     1     1     1     1     1     1
1983  0     0.5   0.5   1     1     1     1     1     1     1
```

1984	0	0.5	0.5	1	1	1	1	1	1	1
1985	0	0.5	0.5	1	1	1	1	1	1	1
1986	0	0.5	0.5	1	1	1	1	1	1	1
1987	0	0.5	0.5	1	1	1	1	1	1	1
1988	0	0.5	0.5	1	1	1	1	1	1	1
1989	0	0.5	0.5	1	1	1	1	1	1	1
1990	0	0.5	0.5	1	1	1	1	1	1	1
1991	0	0.5	0.5	1	1	1	1	1	1	1
1992	0	0.5	0.5	1	1	1	1	1	1	1
1993	0	0.5	0.5	1	1	1	1	1	1	1
1994	0	0.5	0.5	1	1	1	1	1	1	1
1995	0	0.5	0.5	1	1	1	1	1	1	1
1996	0	0.5	0.5	1	1	1	1	1	1	1
1997	0	0.5	0.5	1	1	1	1	1	1	1
1998	0	0.5	0.5	1	1	1	1	1	1	1
1999	0	0.5	0.5	1	1	1	1	1	1	1
2000	0	0.5	0.5	1	1	1	1	1	1	1
2001	0	0.5	0.5	1	1	1	1	1	1	1
2002	0	0.5	0.5	1	1	1	1	1	1	1

2.4 WC FILE

1957	1	0	0.165	0.201	0.258	0.353	0.456	0.533	0.589	0.396	0.998
1958	1	0	0.198	0.221	0.259	0.337	0.453	0.513	0.615	0.665	0.992
1959	1	0	0.218	0.246	0.293	0.362	0.473	0.592	0.623	0.75	0.9996
1960	1	0	0.2	0.236	0.289	0.386	0.485	0.601	0.683	0.724	1.0937
1961	1	0	0.191	0.233	0.302	0.412	0.509	0.604	0.671	0.812	1.0712
1962	1	0	0.211	0.248	0.3	0.4	0.541	0.57	0.692	0.777	1.1274
1963	1	0	0.253	0.286	0.319	0.399	0.533	0.624	0.667	0.715	1.0281
1964	1	0	0.25	0.273	0.312	0.388	0.487	0.628	0.7	0.737	1.0049
1965	1	0	0.242	0.282	0.321	0.385	0.471	0.539	0.663	0.726	0.8866
1966	1	0	0.232	0.27	0.348	0.436	0.484	0.559	0.624	0.69	0.9332
1967	1	0	0.232	0.279	0.322	0.425	0.547	0.597	0.662	0.738	0.9781
1968	1	0	0.267	0.298	0.331	0.366	0.517	0.59	0.596	0.686	0.9109
1969	1	0.217	0.294	0.31	0.333	0.359	0.412	0.573	0.655	0.658	0.8934
1970	1	0.315	0.286	0.318	0.356	0.419	0.443	0.499	0.672	0.744	0.8916
1971	1	0.256	0.318	0.356	0.403	0.448	0.514	0.542	0.607	0.699	0.8906
1972	1	0.246	0.296	0.352	0.428	0.493	0.541	0.608	0.646	0.674	0.9388
1973	1	0.272	0.316	0.344	0.405	0.486	0.539	0.605	0.627	0.677	0.8417
1974	1	0.285	0.311	0.354	0.405	0.476	0.554	0.609	0.693	0.707	0.9256
1975	1	0.249	0.3	0.33	0.42	0.495	0.587	0.636	0.703	0.783	1.0187
1976	1	0.265	0.295	0.338	0.375	0.513	0.594	0.641	0.705	0.741	0.9802
1977	1	0.254	0.323	0.353	0.38	0.418	0.556	0.647	0.721	0.715	0.9781
1978	1	0.244	0.315	0.369	0.397	0.438	0.491	0.609	0.687	0.776	0.9498
1979	1	0.235	0.311	0.349	0.388	0.429	0.474	0.55	0.675	0.796	0.9603
1980	1	0.238	0.286	0.344	0.401	0.473	0.545	0.588	0.662	0.772	1.013
1981	1	0.237	0.274	0.329	0.416	0.505	0.558	0.604	0.642	0.725	1.0072
1982	1	0.279	0.262	0.311	0.424	0.514	0.608	0.664	0.712	0.738	0.9838
1983	1	0.2	0.25	0.3	0.383	0.515	0.604	0.677	0.771	0.815	0.9838
1984	1	0.233	0.263	0.283	0.375	0.491	0.613	0.684	0.725	0.837	1.0347
1985	1	0.247	0.264	0.29	0.337	0.462	0.577	0.678	0.729	0.804	1.0213
1986	1	0.221	0.269	0.304	0.347	0.425	0.488	0.675	0.751	0.853	1.0132
1987	1	0.221	0.249	0.3	0.351	0.402	0.504	0.583	0.728	0.829	0.9901
1988	1	0.221	0.254	0.278	0.352	0.453	0.512	0.608	0.699	0.813	1.0144
1989	1	0.236	0.28	0.309	0.332	0.392	0.533	0.603	0.67	0.792	0.9427
1990	1	0.271	0.285	0.298	0.317	0.366	0.447	0.597	0.692	0.761	1.004
1991	1	0.227	0.286	0.294	0.306	0.365	0.455	0.528	0.671	0.747	0.9206
1992	1	0.251	0.263	0.29	0.318	0.341	0.425	0.531	0.605	0.715	0.891
1993	1	0.249	0.273	0.289	0.326	0.356	0.423	0.518	0.631	0.721	0.8558
1994	1	0.229	0.263	0.286	0.339	0.397	0.449	0.502	0.611	0.732	0.9066
1995	1	0.272	0.277	0.301	0.338	0.402	0.454	0.528	0.611	0.734	0.9081
1996	1	0.24	0.28	0.307	0.355	0.42	0.486	0.499	0.589	0.72	0.8576

1997	1	0.208	0.271	0.313	0.364	0.457	0.524	0.603	0.616	0.683	0.9242
1998	1	0.152	0.26	0.31	0.394	0.497	0.607	0.633	0.695	0.7	0.9141
1999	1	0.245	0.253	0.28	0.355	0.455	0.547	0.63	0.682	0.752	0.813
2000	1	0.228	0.267	0.284	0.314	0.432	0.5	0.684	0.71	0.751	0.8873
2001	1	0.238	0.267	0.292	0.309	0.365	0.482	0.592	0.708	0.795	0.8006
2002	1	0.22	0.243	0.268	0.297	0.33	0.419	0.496	0.662	0.74	0.8781
1957	2	0	0.165	0.201	0.258	0.353	0.456	0.533	0.589	0.396	0.998
1958	2	0	0.198	0.221	0.259	0.337	0.453	0.513	0.615	0.665	0.992
1959	2	0	0.218	0.246	0.293	0.362	0.473	0.592	0.623	0.75	0.9996
1960	2	0	0.2	0.236	0.289	0.386	0.485	0.601	0.683	0.724	1.0937
1961	2	0	0.191	0.233	0.302	0.412	0.509	0.604	0.671	0.812	1.0712
1962	2	0	0.211	0.248	0.3	0.4	0.541	0.57	0.692	0.777	1.1274
1963	2	0	0.253	0.286	0.319	0.399	0.533	0.624	0.667	0.715	1.0281
1964	2	0	0.25	0.273	0.312	0.388	0.487	0.628	0.7	0.737	1.0049
1965	2	0	0.242	0.282	0.321	0.385	0.471	0.539	0.663	0.726	0.8866
1966	2	0	0.232	0.27	0.348	0.436	0.484	0.559	0.624	0.69	0.9332
1967	2	0	0.232	0.279	0.322	0.425	0.547	0.597	0.662	0.738	0.9781
1968	2	0	0.267	0.298	0.331	0.366	0.517	0.59	0.596	0.686	0.9109
1969	2	0.217	0.294	0.31	0.333	0.359	0.412	0.573	0.655	0.658	0.8934
1970	2	0.315	0.286	0.318	0.356	0.419	0.443	0.499	0.672	0.744	0.8916
1971	2	0.256	0.318	0.356	0.403	0.448	0.514	0.542	0.607	0.699	0.8906
1972	2	0.246	0.296	0.352	0.428	0.493	0.541	0.608	0.646	0.674	0.9388
1973	2	0.272	0.316	0.344	0.405	0.486	0.539	0.605	0.627	0.677	0.8417
1974	2	0.285	0.311	0.354	0.405	0.476	0.554	0.609	0.693	0.707	0.9256
1975	2	0.249	0.3	0.33	0.42	0.495	0.587	0.636	0.703	0.783	1.0187
1976	2	0.265	0.295	0.338	0.375	0.513	0.594	0.641	0.705	0.741	0.9802
1977	2	0.254	0.323	0.353	0.38	0.418	0.556	0.647	0.721	0.715	0.9781
1978	2	0.244	0.315	0.369	0.397	0.438	0.491	0.609	0.687	0.776	0.9498
1979	2	0.235	0.311	0.349	0.388	0.429	0.474	0.55	0.675	0.796	0.9603
1980	2	0.238	0.286	0.344	0.401	0.473	0.545	0.588	0.662	0.772	1.013
1981	2	0.237	0.274	0.329	0.416	0.505	0.558	0.604	0.642	0.725	1.0072
1982	2	0.279	0.262	0.311	0.424	0.514	0.608	0.664	0.712	0.738	0.9838
1983	2	0.2	0.25	0.3	0.383	0.515	0.604	0.677	0.771	0.815	0.9838
1984	2	0.233	0.263	0.283	0.375	0.491	0.613	0.684	0.725	0.837	1.0347
1985	2	0.247	0.264	0.29	0.337	0.462	0.577	0.678	0.729	0.804	1.0213
1986	2	0.221	0.269	0.304	0.347	0.425	0.488	0.675	0.751	0.853	1.0132
1987	2	0.221	0.249	0.3	0.351	0.402	0.504	0.583	0.728	0.829	0.9901
1988	2	0.221	0.254	0.278	0.352	0.453	0.512	0.608	0.699	0.813	1.0144
1989	2	0.236	0.28	0.309	0.332	0.392	0.533	0.603	0.67	0.792	0.9427
1990	2	0.271	0.285	0.298	0.317	0.366	0.447	0.597	0.692	0.761	1.004
1991	2	0.227	0.286	0.294	0.306	0.365	0.455	0.528	0.671	0.747	0.9206
1992	2	0.251	0.263	0.29	0.318	0.341	0.425	0.531	0.605	0.715	0.891
1993	2	0.249	0.273	0.289	0.326	0.356	0.423	0.518	0.631	0.721	0.8558
1994	2	0.229	0.263	0.286	0.339	0.397	0.449	0.502	0.611	0.732	0.9066
1995	2	0.272	0.277	0.301	0.338	0.402	0.454	0.528	0.611	0.734	0.9081
1996	2	0.24	0.28	0.307	0.355	0.42	0.486	0.499	0.589	0.72	0.8576
1997	2	0.208	0.271	0.313	0.364	0.457	0.524	0.603	0.616	0.683	0.9242
1998	2	0.152	0.26	0.31	0.394	0.497	0.607	0.633	0.695	0.7	0.9141
1999	2	0.245	0.253	0.28	0.355	0.455	0.547	0.63	0.682	0.752	0.813
2000	2	0.228	0.267	0.284	0.314	0.432	0.5	0.684	0.71	0.751	0.8873
2001	2	0.238	0.267	0.292	0.309	0.365	0.482	0.592	0.708	0.795	0.8006
2002	2	0.22	0.243	0.268	0.297	0.33	0.419	0.496	0.662	0.74	0.8781

2.5 WS FILE

1957	0.141	0.2	0.268	0.238	0.325	0.485	0.719	0.682	0.844	1.1428
1958	0.141	0.2	0.197	0.226	0.303	0.442	0.577	0.778	0.793	1.1117
1959	0.141	0.146	0.194	0.24	0.329	0.47	0.65	0.686	0.908	1.0422
1960	0.141	0.19	0.208	0.24	0.364	0.469	0.633	0.726	0.845	1.0899
1961	0.141	0.126	0.202	0.254	0.337	0.483	0.579	0.691	0.779	1.0673
1962	0.141	0.187	0.258	0.306	0.424	0.573	0.684	0.806	0.873	1.3029
1963	0.141	0.2	0.232	0.29	0.378	0.54	0.663	0.788	0.882	1.2523

1964	0.141	0.2	0.228	0.276	0.373	0.477	0.645	0.673	0.845	1.2325
1965	0.141	0.2	0.246	0.274	0.333	0.43	0.516	0.601	0.722	0.9089
1966	0.141	0.2	0.243	0.301	0.403	0.455	0.503	0.565	0.581	0.9844
1967	0.141	0.203	0.246	0.281	0.442	0.528	0.585	0.65	0.703	0.9848
1968	0.141	0.2	0.265	0.301	0.344	0.532	0.592	0.362	0.667	0.8873
1969	0.175	0.203	0.258	0.297	0.344	0.39	0.565	0.621	0.679	0.8575
1970	0.175	0.25	0.261	0.311	0.369	0.41	0.468	0.636	0.732	0.8964
1971	0.175	0.248	0.305	0.363	0.413	0.489	0.512	0.583	0.696	0.8769
1972	0.175	0.274	0.321	0.401	0.473	0.534	0.579	0.606	0.655	0.9293
1973	0.175	0.264	0.322	0.38	0.468	0.521	0.566	0.583	0.617	0.8036
1974	0.17	0.234	0.304	0.375	0.437	0.524	0.57	0.629	0.652	0.8519
1975	0.17	0.275	0.294	0.417	0.483	0.544	0.61	0.668	0.704	0.9429
1976	0.17	0.217	0.281	0.332	0.484	0.55	0.593	0.658	0.694	0.9307
1977	0.16	0.25	0.309	0.364	0.405	0.551	0.627	0.69	0.667	0.9384
1978	0.15	0.242	0.336	0.367	0.411	0.467	0.547	0.63	0.704	0.9431
1979	0.15	0.243	0.303	0.363	0.414	0.459	0.543	0.667	0.764	1.0044
1980	0.15	0.229	0.307	0.372	0.444	0.524	0.582	0.651	0.778	1.0582
1981	0.15	0.25	0.282	0.378	0.473	0.536	0.57	0.624	0.707	1.0328
1982	0.15	0.242	0.265	0.381	0.49	0.589	0.631	0.679	0.726	0.9809
1983	0.15	0.211	0.248	0.329	0.494	0.559	0.624	0.712	0.754	0.9173
1984	0.15	0.203	0.242	0.338	0.464	0.571	0.649	0.692	0.787	1.0288
1985	0.15	0.208	0.243	0.31	0.452	0.536	0.635	0.656	0.764	1.0114
1986	0.15	0.195	0.253	0.336	0.44	0.533	0.692	0.779	0.888	1.0919
1987	0.15	0.194	0.265	0.33	0.401	0.503	0.573	0.711	0.747	0.9843
1988	0.15	0.212	0.238	0.315	0.426	0.467	0.547	0.644	0.706	0.9732
1989	0.15	0.215	0.248	0.282	0.362	0.484	0.553	0.616	0.759	0.8836
1990	0.15	0.245	0.272	0.281	0.342	0.421	0.555	0.648	0.713	0.991
1991	0.131	0.208	0.263	0.275	0.34	0.4	0.463	0.64	0.658	0.853
1992	0.131	0.262	0.266	0.3	0.316	0.402	0.501	0.575	0.696	0.8739
1993	0.131	0.257	0.264	0.301	0.328	0.391	0.491	0.595	0.646	0.86
1994	0.131	0.222	0.249	0.302	0.366	0.41	0.467	0.548	0.679	0.871
1995	0.124	0.245	0.265	0.311	0.401	0.451	0.52	0.607	0.705	0.8496
1996	0.124	0.245	0.282	0.329	0.39	0.464	0.49	0.572	0.689	0.8782
1997	0.124	0.217	0.254	0.342	0.442	0.491	0.563	0.586	0.684	0.9032
1998	0.124	0.205	0.269	0.362	0.471	0.578	0.588	0.657	0.676	0.8698
1999	0.124	0.211	0.251	0.346	0.436	0.524	0.591	0.68	0.696	0.8274
2000	0.124	0.224	0.236	0.29	0.409	0.468	0.687	0.742	0.707	0.8971
2001	0.124	0.213	0.247	0.273	0.331	0.452	0.56	0.641	0.798	0.8297
2002	0.124	0.204	0.227	0.271	0.319	0.403	0.446	0.612	0.685	0.8729

2.6 YDT FILE

```
2000 250524  198676
2001 143288  176891
2002 329316  142271
```

2.7 OPT FILE

```
 1 10
 1
 2 6
 2 6
 2003
F
 0.51
F
 0.0
 0.0         0.05 0.0  300000.0  300000.0
 210000.0    0.2  0.0  300000.0  300000.0
 300000.0    0.2  0.0  300000.0  300000.0
 1
```

```
0.0  0.0 0.0
0.0  0.0 0.0
0.0  0.0 0.0
0.0  0.0 0.0
0.0000000 0
1.5 1.0
1.5 1.0
2 1 305553.2 134383 0.00000000 0.426272 1.20000000
0
0.0 0.0 0.0 0.0 0.0
0
1.0000000 0.1000000
1.0000000 0.0500000
1
```

APPENDIX 3 NORTH SEA SOLE INPUT DATA FILES

3.1 ADT FILE

```
 0.00 0.00
1  0.1000 0.01 0.001
2  0.1000 0.24 0.02
3  0.1000 0.53 0.08
4  0.1000 0.60 0.25
5  0.1000 0.52 0.36
6  0.1000 0.50 0.34
7  0.1000 0.56 0.29
8  0.1000 0.56 0.28
9  0.1000 0.40 0.38
10 0.1000 0.40 0.38
```

3.2 NIN FILE

```
1     96762  0.79 0 0 0 0 0 0 0 0 0
2    179249  0 0.21 0 0 0 0 0 0 0 0
3     40227  0 0 0.19 0 0 0 0 0 0 0
4     39766  0 0 0 0.15 0 0 0 0 0 0
5     13844  0 0 0 0 0.14 0 0 0 0 0
6     14035  0 0 0 0 0 0.13 0 0 0 0
7     14233  0 0 0 0 0 0 0.14 0 0 0
8       902  0 0 0 0 0 0 0 0.15 0 0
9       956  0 0 0 0 0 0 0 0 0.14 0
10 959  0 0 0 0 0 0 0 0 0 0.16
```

3.3 PRM FILE

```
1957  0     0     1     1     1     1     1     1     1     1
1958  0     0     1     1     1     1     1     1     1     1
1959  0     0     1     1     1     1     1     1     1     1
1960  0     0     1     1     1     1     1     1     1     1
1961  0     0     1     1     1     1     1     1     1     1
1962  0     0     1     1     1     1     1     1     1     1
1963  0     0     1     1     1     1     1     1     1     1
1964  0     0     1     1     1     1     1     1     1     1
1965  0     0     1     1     1     1     1     1     1     1
1966  0     0     1     1     1     1     1     1     1     1
1967  0     0     1     1     1     1     1     1     1     1
1968  0     0     1     1     1     1     1     1     1     1
1969  0     0     1     1     1     1     1     1     1     1
1970  0     0     1     1     1     1     1     1     1     1
1971  0     0     1     1     1     1     1     1     1     1
1972  0     0     1     1     1     1     1     1     1     1
1973  0     0     1     1     1     1     1     1     1     1
1974  0     0     1     1     1     1     1     1     1     1
1975  0     0     1     1     1     1     1     1     1     1
1976  0     0     1     1     1     1     1     1     1     1
1977  0     0     1     1     1     1     1     1     1     1
1978  0     0     1     1     1     1     1     1     1     1
1979  0     0     1     1     1     1     1     1     1     1
1980  0     0     1     1     1     1     1     1     1     1
1981  0     0     1     1     1     1     1     1     1     1
```

1982	0	0	1	1	1	1	1	1	1	1
1983	0	0	1	1	1	1	1	1	1	1
1984	0	0	1	1	1	1	1	1	1	1
1985	0	0	1	1	1	1	1	1	1	1
1986	0	0	1	1	1	1	1	1	1	1
1987	0	0	1	1	1	1	1	1	1	1
1988	0	0	1	1	1	1	1	1	1	1
1989	0	0	1	1	1	1	1	1	1	1
1990	0	0	1	1	1	1	1	1	1	1
1991	0	0	1	1	1	1	1	1	1	1
1992	0	0	1	1	1	1	1	1	1	1
1993	0	0	1	1	1	1	1	1	1	1
1994	0	0	1	1	1	1	1	1	1	1
1995	0	0	1	1	1	1	1	1	1	1
1996	0	0	1	1	1	1	1	1	1	1
1997	0	0	1	1	1	1	1	1	1	1
1998	0	0	1	1	1	1	1	1	1	1
1999	0	0	1	1	1	1	1	1	1	1
2000	0	0	1	1	1	1	1	1	1	1
2001	0	0	1	1	1	1	1	1	1	1
2002	0	0	1	1	1	1	1	1	1	1

3.4 WC FILE

1957	1	0	0.154	0.177	0.204	0.248	0.279	0.29	0.335	0.436	0.4081
1958	1	0	0.145	0.178	0.22	0.254	0.273	0.314	0.323	0.388	0.4135
1959	1	0	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.4262
1960	1	0	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.4177
1961	1	0	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.4193
1962	1	0	0.155	0.165	0.208	0.241	0.295	0.32	0.321	0.334	0.4119
1963	1	0	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.4846
1964	1	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.4805
1965	1	0	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.4797
1966	1	0	0.177	0.19	0.18	0.301	0.332	0.429	0.399	0.449	0.5015
1967	1	0	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.4912
1968	1	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.5075
1969	1	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.5227
1970	1	0.154	0.212	0.218	0.285	0.35	0.404	0.441	0.463	0.443	0.5326
1971	1	0.145	0.193	0.237	0.322	0.358	0.425	0.42	0.49	0.534	0.5471
1972	1	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.6291
1973	1	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.5858
1974	1	0.164	0.192	0.233	0.338	0.418	0.448	0.52	0.559	0.609	0.6533
1975	1	0.129	0.182	0.225	0.32	0.406	0.456	0.529	0.595	0.629	0.6693
1976	1	0.143	0.19	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.6647
1977	1	0.147	0.188	0.236	0.307	0.369	0.424	0.43	0.52	0.562	0.6194
1978	1	0.152	0.196	0.231	0.314	0.37	0.426	0.466	0.417	0.572	0.6663
1979	1	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.763
1980	1	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.55	0.598	0.6841
1981	1	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.6302
1982	1	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.58	0.6557
1983	1	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.6422
1984	1	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.6339
1985	1	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.6447
1986	1	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.6096
1987	1	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.6569
1988	1	0.127	0.175	0.217	0.27	0.354	0.428	0.484	0.521	0.559	0.7124
1989	1	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.47	0.6111
1990	1	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.6198
1991	1	0.127	0.186	0.21	0.263	0.315	0.436	0.443	0.467	0.507	0.5579
1992	1	0.146	0.178	0.213	0.258	0.298	0.38	0.409	0.46	0.487	0.5557
1993	1	0.097	0.167	0.196	0.239	0.264	0.3	0.338	0.441	0.496	0.6031
1994	1	0.143	0.18	0.202	0.228	0.257	0.3	0.317	0.432	0.409	0.5101

1995	1	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.5914
1996	1	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.37	0.39	0.5943
1997	1	0.151	0.18	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.4396
1998	1	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.5039
1999	1	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.4527
2000	1	0.145	0.17	0.2	0.248	0.29	0.299	0.323	0.368	0.402	0.4274
2001	1	0.143	0.185	0.202	0.27	0.275	0.333	0.391	0.414	0.433	0.4935
2002	1	0.128	0.166	0.192	0.224	0.257	0.284	0.339	0.294	0.529	0.5019
1957	2	0	0.154	0.177	0.204	0.248	0.279	0.29	0.335	0.436	0.4081
1958	2	0	0.145	0.178	0.22	0.254	0.273	0.314	0.323	0.388	0.4135
1959	2	0	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.4262
1960	2	0	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.4177
1961	2	0	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.4193
1962	2	0	0.155	0.165	0.208	0.241	0.295	0.32	0.321	0.334	0.4119
1963	2	0	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.4846
1964	2	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.4805
1965	2	0	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.4797
1966	2	0	0.177	0.19	0.18	0.301	0.332	0.429	0.399	0.449	0.5015
1967	2	0	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.4912
1968	2	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.5075
1969	2	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.5227
1970	2	0.154	0.212	0.218	0.285	0.35	0.404	0.441	0.463	0.443	0.5326
1971	2	0.145	0.193	0.237	0.322	0.358	0.425	0.42	0.49	0.534	0.5471
1972	2	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.6291
1973	2	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.5858
1974	2	0.164	0.192	0.233	0.338	0.418	0.448	0.52	0.559	0.609	0.6533
1975	2	0.129	0.182	0.225	0.32	0.406	0.456	0.529	0.595	0.629	0.6693
1976	2	0.143	0.19	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.6647
1977	2	0.147	0.188	0.236	0.307	0.369	0.424	0.43	0.52	0.562	0.6194
1978	2	0.152	0.196	0.231	0.314	0.37	0.426	0.466	0.417	0.572	0.6663
1979	2	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.763
1980	2	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.55	0.598	0.6841
1981	2	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.6302
1982	2	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.58	0.6557
1983	2	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.6422
1984	2	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.6339
1985	2	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.6447
1986	2	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.6096
1987	2	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.6569
1988	2	0.127	0.175	0.217	0.27	0.354	0.428	0.484	0.521	0.559	0.7124
1989	2	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.47	0.6111
1990	2	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.6198
1991	2	0.127	0.186	0.21	0.263	0.315	0.436	0.443	0.467	0.507	0.5579
1992	2	0.146	0.178	0.213	0.258	0.298	0.38	0.409	0.46	0.487	0.5557
1993	2	0.097	0.167	0.196	0.239	0.264	0.3	0.338	0.441	0.496	0.6031
1994	2	0.143	0.18	0.202	0.228	0.257	0.3	0.317	0.432	0.409	0.5101
1995	2	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.5914
1996	2	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.37	0.39	0.5943
1997	2	0.151	0.18	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.4396
1998	2	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.5039
1999	2	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.4527
2000	2	0.145	0.17	0.2	0.248	0.29	0.299	0.323	0.368	0.402	0.4274
2001	2	0.143	0.185	0.202	0.27	0.275	0.333	0.391	0.414	0.433	0.4935
2002	2	0.128	0.166	0.192	0.224	0.257	0.284	0.339	0.294	0.529	0.5019

3.5 WS FILE

1957	0.025	0.07	0.147	0.187	0.208	0.253	0.262	0.355	0.39	0.3652
1958	0.025	0.07	0.164	0.205	0.226	0.228	0.297	0.318	0.393	0.4215
1959	0.025	0.07	0.159	0.198	0.239	0.271	0.292	0.276	0.303	0.4258
1960	0.025	0.07	0.163	0.207	0.234	0.24	0.268	0.242	0.36	0.4313
1961	0.025	0.07	0.148	0.206	0.235	0.232	0.259	0.274	0.281	0.3964

```
1962  0.025 0.07  0.148 0.192 0.24  0.301 0.293 0.282 0.273 0.4414
1963  0.025 0.07  0.148 0.193 0.243 0.275 0.311 0.363 0.329 0.4654
1964  0.025 0.07  0.159 0.214 0.24  0.291 0.305 0.306 0.365 0.4739
1965  0.025 0.14  0.198 0.223 0.251 0.297 0.337 0.358 0.526 0.4605
1966  0.025 0.07  0.16  0.149 0.389 0.31  0.406 0.377 0.385 0.5045
1967  0.025 0.177 0.164 0.235 0.242 0.399 0.362 0.283 0.381 0.4591
1968  0.025 0.122 0.171 0.248 0.312 0.28  0.629 0.416 0.41  0.4856
1969  0.025 0.137 0.174 0.252 0.324 0.364 0.579 0.415 0.469 0.5211
1970  0.025 0.137 0.201 0.275 0.341 0.367 0.423 0.458 0.39  0.5544
1971  0.034 0.148 0.213 0.313 0.361 0.41  0.432 0.474 0.483 0.5325
1972  0.038 0.155 0.218 0.313 0.419 0.443 0.443 0.443 0.508 0.6018
1973  0.039 0.149 0.226 0.322 0.371 0.433 0.452 0.472 0.446 0.5355
1974  0.035 0.146 0.218 0.329 0.408 0.429 0.499 0.565 0.542 0.618
1975  0.035 0.148 0.206 0.311 0.403 0.446 0.508 0.582 0.58  0.6501
1976  0.035 0.142 0.201 0.301 0.379 0.458 0.508 0.517 0.644 0.6648
1977  0.035 0.147 0.202 0.291 0.365 0.409 0.478 0.487 0.531 0.6443
1978  0.035 0.139 0.211 0.29  0.365 0.429 0.427 0.385 0.542 0.6444
1979  0.045 0.148 0.211 0.3   0.352 0.429 0.521 0.562 0.567 0.7434
1980  0.039 0.157 0.2   0.304 0.345 0.394 0.489 0.537 0.579 0.6451
1981  0.05  0.137 0.2   0.305 0.364 0.402 0.454 0.522 0.561 0.6221
1982  0.05  0.13  0.193 0.27  0.359 0.411 0.429 0.476 0.583 0.6422
1983  0.05  0.14  0.2   0.285 0.329 0.435 0.464 0.483 0.51  0.6362
1984  0.05  0.133 0.203 0.268 0.348 0.386 0.488 0.591 0.567 0.6636
1985  0.05  0.127 0.185 0.267 0.324 0.381 0.38  0.626 0.554 0.6423
1986  0.05  0.133 0.191 0.278 0.345 0.423 0.495 0.487 0.587 0.6863
1987  0.05  0.154 0.191 0.262 0.357 0.381 0.406 0.454 0.332 0.6196
1988  0.05  0.133 0.193 0.26  0.335 0.409 0.417 0.474 0.486 0.6543
1989  0.05  0.133 0.195 0.29  0.35  0.34  0.411 0.475 0.419 0.5946
1990  0.05  0.148 0.203 0.294 0.357 0.447 0.399 0.494 0.481 0.6528
1991  0.05  0.139 0.184 0.254 0.301 0.413 0.447 0.522 0.548 0.5733
1992  0.05  0.156 0.194 0.257 0.307 0.398 0.406 0.472 0.5   0.5401
1993  0.05  0.128 0.184 0.229 0.265 0.293 0.344 0.482 0.437 0.5833
1994  0.05  0.143 0.174 0.209 0.257 0.326 0.349 0.402 0.494 0.4589
1995  0.05  0.151 0.179 0.24  0.253 0.321 0.365 0.357 0.545 0.5452
1996  0.05  0.147 0.178 0.208 0.274 0.268 0.321 0.375 0.402 0.5465
1997  0.05  0.15  0.19  0.225 0.252 0.303 0.319 0.325 0.36  0.424
1998  0.05  0.14  0.173 0.234 0.267 0.281 0.328 0.273 0.336 0.4548
1999  0.05  0.131 0.187 0.216 0.259 0.296 0.34  0.322 0.369 0.4639
2000  0.05  0.139 0.185 0.226 0.264 0.275 0.287 0.337 0.391 0.3762
2001  0.05  0.144 0.185 0.223 0.263 0.319 0.327 0.421 0.41  0.5302
2002  0.05  0.133 0.178 0
.22   0.241 0.242 0.274 0.279 0.405 0.4111
```

3.6 YDT FILE

```
2000 132431  43690
2001 64233   35861
2002 198412  34241
```

3.7 OPT FILE

```
 1 10
 1
 2 6
 2 6
 2003
F
 0.48
F
 0.0
 0.0      0.05 0.0  100000.0  100000.0
 25000.0 0.3  0.0  100000.0  100000.0
```

```
35000.0 0.2  0.0  100000.0  100000.0
1
0.0 0.0 0.0
0.0 0.0 0.0
0.0 0.0 0.0
0.0 0.0 0.0
0.0000000 0
1.5 1.0
1.5 1.0
2 1 96762 21296 0.00000000 0.7797 1.80000000
0
0.0 0.0 0.0 0.0 0.0
0
1.1000000 0.0500000
1.0000000 0.1000000
1
```

APPENDIX 4 NORTH SEA HADDOCK DATA FILES

4.1 ADT FILE

```
0      0
0      2.06  0.000 0.000
1      1.68  0.001 0.017
2      0.42  0.051 0.104
3      0.29  0.215 0.100
4      0.26  0.386 0.051
5      0.20  0.308 0.008
6      0.20  0.351 0.002
7      0.20  0.348 0.007
```

4.2 NIN FILE

```
0      6233.45     1.22  0.00  0.00  0.00  0.00  0.00  0.00  0.00
1      573.69      0.00  0.41  0.00  0.00  0.00  0.00  0.00  0.00
2      45.99       0.00  0.00  0.17  0.00  0.00  0.00  0.00  0.00
3      316.67      0.00  0.00  0.00  0.14  0.00  0.00  0.00  0.00
4      898.06      0.00  0.00  0.00  0.00  0.12  0.00  0.00  0.00
5      5.42        0.00  0.00  0.00  0.00  0.00  0.15  0.00  0.00
6      2.25        0.00  0.00  0.00  0.00  0.00  0.00  0.19  0.00
7      2.10        0.00  0.00  0.00  0.00  0.00  0.00  0.00  0.20
```

4.3 PRM FILE

```
1963    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1964    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1965    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1966    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1967    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1968    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1969    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1970    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1971    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1972    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1973    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1974    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1975    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1976    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1977    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1978    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1979    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1980    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1981    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1982    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1983    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1984    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1985    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1986    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1987    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1988    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1989    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1990    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1991    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
    1992    0.00    0.01    0.32    0.71    0.87    0.95    1.00    1.00
```

1993	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
1994	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
1995	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
1996	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
1997	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
1998	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
1999	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
2000	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
2001	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00
2002	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00

4.4 WC FILE

```
1963       1   0.000   0.233   0.326   0.512   0.715   0.817   1.009
1.179
   1964       1   0.000   0.221   0.313   0.459   0.695   0.870   0.934
1.351
   1965       1   0.000   0.310   0.357   0.410   0.679   0.907   1.242
1.361
   1966       1   0.000   0.301   0.384   0.416   0.553   0.995   1.288
1.665
   1967       1   0.000   0.260   0.404   0.510   0.614   0.645   1.063
1.792
   1968       1   0.000   0.256   0.361   0.591   0.761   0.863   0.846
1.722
   1969       1   0.000   0.178   0.302   0.506   0.870   0.984   1.065
1.115
   1970       1   0.000   0.242   0.310   0.403   0.786   0.949   1.235
1.458
   1971       1   0.000   0.256   0.335   0.399   0.524   0.905   1.281
1.366
   1972       1   0.000   0.244   0.329   0.421   0.523   0.609   1.003
1.635
   1973       1   0.000   0.225   0.315   0.406   0.606   0.663   0.726
1.176
   1974       1   0.000   0.275   0.320   0.389   0.585   0.908   0.954
0.984
   1975       1   0.000   0.258   0.345   0.408   0.487   0.686   1.248
1.169
   1976       1   0.000   0.250   0.344   0.467   0.516   0.614   0.923
1.521
   1977       1   0.000   0.286   0.362   0.396   0.614   0.630   0.817
1.338
   1978       1   0.000   0.275   0.356   0.457   0.470   0.725   0.789
1.112
   1979       1   0.000   0.274   0.361   0.468   0.642   0.668   0.935
1.326
   1980       1   0.000   0.299   0.367   0.526   0.750   1.056   0.934
1.534
   1981       1   0.000   0.339   0.385   0.525   0.754   1.149   1.481
1.224
   1982       1   0.000   0.300   0.364   0.507   0.818   1.237   1.441
1.555
   1983       1   0.000   0.312   0.387   0.482   0.663   0.925   1.243
1.343
   1984       1   0.000   0.281   0.376   0.515   0.677   0.810   1.097
1.383
   1985       1   0.000   0.277   0.359   0.502   0.671   0.871   1.051
1.593
   1986       1   0.000   0.276   0.351   0.433   0.613   0.863   1.257
1.335
```

1987	1	0.000	0.274	0.345	0.451	0.622	1.029	1.276	1.567
1988	1	0.000	0.258	0.324	0.445	0.619	0.752	1.284	1.525
1989	1	0.000	0.310	0.388	0.415	0.617	0.810	0.982	1.515
1990	1	0.000	0.308	0.379	0.484	0.516	0.802	1.039	1.334
1991	1	0.000	0.319	0.377	0.480	0.643	0.653	1.042	1.465
1992	1	0.000	0.336	0.379	0.510	0.751	1.017	0.904	1.637
1993	1	0.000	0.326	0.393	0.483	0.684	0.896	1.173	1.295
1994	1	0.000	0.288	0.390	0.482	0.617	0.962	1.296	1.601
1995	1	0.000	0.312	0.396	0.421	0.603	0.767	1.099	1.642
1996	1	0.000	0.342	0.359	0.462	0.515	0.780	0.870	0.991
1997	1	0.000	0.333	0.396	0.412	0.601	0.618	0.909	1.081
1998	1	0.000	0.263	0.361	0.429	0.460	0.657	0.762	1.155
1999	1	0.000	0.286	0.347	0.416	0.482	0.510	0.717	0.790
2000	1	0.000	0.298	0.366	0.419	0.520	0.622	0.653	1.140
2001	1	0.000	0.378	0.348	0.439	0.498	0.714	0.754	1.117
2002	1	0.000	0.356	0.429	0.394	0.554	0.730	0.889	1.366
1963	2	0.064	0.139	0.218	0.327	0.397	0.321	0.321	0.000
1964	2	0.065	0.177	0.249	0.306	0.337	0.321	0.321	0.000
1965	2	0.064	0.131	0.200	0.341	0.613	0.321	0.321	0.000
1966	2	0.063	0.141	0.208	0.244	0.310	0.321	0.321	0.000
1967	2	0.064	0.171	0.209	0.274	0.306	0.321	0.321	0.000
1968	2	0.063	0.186	0.212	0.256	0.318	0.321	0.321	0.000
1969	2	0.064	0.129	0.216	0.237	0.301	0.321	0.321	0.000
1970	2	0.063	0.129	0.210	0.238	0.263	0.321	0.321	0.000
1971	2	0.063	0.134	0.201	0.242	0.263	0.321	0.321	0.000
1972	2	0.063	0.139	0.206	0.237	0.261	0.321	0.321	0.000
1973	2	0.063	0.131	0.201	0.235	0.263	0.321	0.321	0.000
1974	2	0.062	0.145	0.200	0.233	0.259	0.321	0.321	0.000
1975	2	0.050	0.123	0.200	0.257	0.275	0.348	0.000	0.000
1976	2	0.079	0.176	0.197	0.237	0.292	0.337	0.000	0.000

1977	2	0.071	0.196	0.197	0.216	0.309	0.347	0.000	0.000
1978	2	0.037	0.180	0.199	0.222	0.224	0.265	0.284	0.000
1979	2	0.053	0.118	0.219	0.242	0.259	0.340	0.000	0.000
1980	2	0.051	0.149	0.231	0.274	0.324	0.000	0.000	0.000
1981	2	0.073	0.160	0.198	0.290	0.650	0.727	0.000	0.000
1982	2	0.072	0.197	0.248	0.271	0.264	0.000	0.000	0.000
1983	2	0.067	0.187	0.237	0.347	0.476	0.711	0.792	0.000
1984	2	0.046	0.162	0.245	0.317	0.300	0.314	0.000	0.000
1985	2	0.040	0.155	0.214	0.264	0.336	0.423	0.421	0.000
1986	2	0.045	0.138	0.184	0.245	0.408	0.329	0.000	0.000
1987	2	0.023	0.159	0.200	0.225	0.287	0.000	0.000	0.000
1988	2	0.063	0.172	0.170	0.238	0.254	0.360	0.000	0.000
1989	2	0.085	0.187	0.229	0.268	0.335	0.708	0.844	2.810
1990	2	0.046	0.196	0.229	0.249	0.266	0.290	0.333	0.000
1991	2	0.065	0.179	0.243	0.344	0.464	0.493	0.000	0.000
1992	2	0.043	0.137	0.246	0.286	0.347	0.000	0.415	0.000
1993	2	0.027	0.142	0.237	0.287	0.344	0.369	0.000	0.369
1994	2	0.044	0.126	0.211	0.269	0.306	0.304	0.270	0.000
1995	2	0.064	0.131	0.251	0.275	0.363	0.384	0.000	0.000
1996	2	0.046	0.138	0.219	0.279	0.297	0.358	0.000	0.000
1997	2	0.063	0.161	0.254	0.286	0.321	0.385	0.000	0.000
1998	2	0.041	0.162	0.231	0.293	0.315	0.391	0.428	0.000
1999	2	0.049	0.183	0.217	0.273	0.307	0.304	0.250	0.000
2000	2	0.030	0.129	0.246	0.281	0.319	0.355	0.287	0.000
2001	2	0.045	0.116	0.205	0.307	0.308	0.364	0.000	0.413
2002	2	0.042	0.166	0.222	0.267	0.351	0.377	0.000	0.357

4.5 WS FILE

1963	0.012	0.123	0.253	0.473	0.695	0.807	1.004	1.179
1964	0.011	0.118	0.239	0.403	0.664	0.814	0.908	1.350
1965	0.010	0.069	0.225	0.366	0.648	0.844	1.193	1.353
1966	0.010	0.088	0.247	0.367	0.533	0.949	1.266	1.662
1967	0.011	0.115	0.281	0.461	0.594	0.639	1.057	1.792
1968	0.010	0.126	0.253	0.509	0.731	0.857	0.837	1.718
1969	0.011	0.063	0.216	0.406	0.799	0.891	1.031	1.107

1970	0.013	0.073	0.222	0.352	0.735	0.873	1.191	1.458
1971	0.011	0.107	0.247	0.362	0.506	0.887	1.267	1.366
1972	0.024	0.116	0.242	0.388	0.506	0.606	1.000	1.635
1973	0.044	0.112	0.240	0.372	0.586	0.649	0.725	1.176
1974	0.024	0.128	0.226	0.343	0.548	0.891	0.895	0.973
1975	0.020	0.101	0.241	0.356	0.449	0.680	1.245	1.173
1976	0.013	0.125	0.224	0.401	0.512	0.588	0.922	1.521
1977	0.019	0.108	0.241	0.345	0.601	0.613	0.802	1.340
1978	0.011	0.144	0.253	0.418	0.441	0.719	0.742	1.114
1979	0.009	0.095	0.290	0.443	0.637	0.664	0.933	1.326
1980	0.012	0.104	0.283	0.486	0.732	1.046	0.936	1.542
1981	0.009	0.074	0.262	0.476	0.745	1.147	1.479	1.226
1982	0.011	0.100	0.292	0.460	0.784	1.166	1.441	1.558
1983	0.022	0.135	0.297	0.448	0.651	0.915	1.214	1.366
1984	0.010	0.141	0.300	0.489	0.670	0.805	1.097	1.389
1985	0.013	0.149	0.279	0.480	0.668	0.857	1.049	1.594
1986	0.025	0.124	0.242	0.397	0.613	0.863	1.257	1.348
1987	0.008	0.126	0.265	0.406	0.615	1.029	1.276	1.592
1988	0.024	0.165	0.217	0.417	0.589	0.748	1.284	1.565
1989	0.027	0.197	0.300	0.372	0.605	0.811	0.982	1.520
1990	0.044	0.194	0.292	0.430	0.473	0.771	0.967	1.309
1991	0.029	0.177	0.320	0.472	0.639	0.650	1.042	1.468
1992	0.018	0.107	0.306	0.486	0.748	1.016	0.896	1.637
1993	0.010	0.115	0.280	0.447	0.680	0.894	1.173	1.288
1994	0.017	0.116	0.250	0.419	0.597	0.943	1.208	1.606
1995	0.013	0.102	0.297	0.363	0.592	0.763	1.099	1.644
1996	0.019	0.127	0.246	0.388	0.483	0.780	0.870	0.999
1997	0.021	0.133	0.277	0.359	0.579	0.615	0.909	1.092
1998	0.023	0.153	0.252	0.392	0.440	0.651	0.760	1.163
1999	0.023	0.168	0.243	0.361	0.473	0.498	0.680	0.791
2000	0.048	0.119	0.253	0.367	0.498	0.615	0.650	1.142
2001	0.021	0.109	0.216	0.309	0.466	0.697	0.754	1.111
2002	0.016	0.088	0.252	0.325	0.526	0.725	0.889	1.262

4.6 YDT FILE

```
1993  12644.96    129.447
1994  53283.16    149.969
1995  12908.813   145.035
1996  20817.624   175.524
1997  11818.64    187.619
1998  9203.476    157.236
1999  123566.752  111.992
2000  24000.498   88.412
2001  2194.9      239.109
2002  4597.802    391.067
```

4.7 OPT FILE

```
0     7
0
2     6
2     6
2003
C
55.0
C
7.0
0.0   0.1   0.1   1000.0      1000.0
100.0 0.25  0.25  1000.0      1000.0
140.0 0.8   0.8   1000.0      1000.0
1
```

```
0.0   0.0   0.0
0.0   0.0   0.0
0.0   0.0   0.0
0.0   0.0   0.0
0.0   0
5.0   5.0
3.0   3.0
1     1     25191.4     14.581      0.0   1.106 1.5
0
-0.018      0.00  0.00  0.00  0.00
0
1.0   0.3
1.0   0.0
1
```

APPENDIX 5 NORTH SEA AND WEST OF SCOTLAND SAITHE DATA FILES

5.1 ADT FILE

```
 0.00 0.00
1  0.2000 0.001 0
2  0.2000 0.02 0
3  0.2000 0.08 0
4  0.2000 0.25 0
5  0.2000 0.36 0
6  0.2000 0.34 0
7  0.2000 0.29 0
8  0.2000 0.28 0
9  0.2000 0.38 0
10 0.2000 0.38 0
```

5.2 NIN FILE

```
1   212.194  0.38 0 0 0 0 0 0 0 0 0
2   173.175  0 0.20 0 0 0 0 0 0 0 0
3   136.155  0 0 0.20 0 0 0 0 0 0 0
4   220.603  0 0 0 0.20 0 0 0 0 0 0
5   143.167  0 0 0 0 0.20 0 0 0 0 0
6    27.313  0 0 0 0 0 0.20 0 0 0 0
7    25.397  0 0 0 0 0 0 0.20 0 0 0
8     5.858  0 0 0 0 0 0 0 0.20 0 0
9     7.966  0 0 0 0 0 0 0 0 0.20 0
10 4.884  0 0 0 0 0 0 0 0 0 0.20
```

5.3 PRM FILE

```
   1992      0      0      0   0.15    0.7    0.9      1      1      1
1
   1993      0      0      0   0.15    0.7    0.9      1      1      1
1
   1994      0      0      0   0.15    0.7    0.9      1      1      1
1
   1995      0      0      0   0.15    0.7    0.9      1      1      1
1
   1996      0      0      0   0.15    0.7    0.9      1      1      1
1
   1997      0      0      0   0.15    0.7    0.9      1      1      1
1
   1998      0      0      0   0.15    0.7    0.9      1      1      1
1
   1999      0      0      0   0.15    0.7    0.9      1      1      1
1
   2000      0      0      0   0.15    0.7    0.9      1      1      1
1
   2001      0      0      0   0.15    0.7    0.9      1      1      1
1
   2002      0      0      0   0.15    0.7    0.9      1      1      1
1
```

5.4 WC FILE

```
  1992  2  0.619  0.63  0.964  1.189  1.607  2.242  3.668  4.33  5.412
7.045
  1993  2  0.358  0.744  0.899  1.26  1.754  2.636  3.185  3.98  5.08
6.891
  1994  2  0.287  0.697  0.944  1.119  1.601  2.434  3.617  4.787  6.548
8.326
  1995  2  0.502  0.759  1.002  1.294  1.816  2.562  3.555  4.767  5.267
7.891
  1996  2  0.28  0.51  0.967  1.187  1.807  2.368  2.952  4.705  6.092
8.382
  1997  2  0.432  0.436  0.905  1.145  1.452  2.587  3.556  4.525  6.158
8.866
  1998  2  0.603  0.659  0.892  0.966  1.393  1.744  2.949  3.883  4.996
7.227
  1999  2  0.519  0.589  0.881  1.061  1.211  1.754  2.337  3.493  4.844
6.745
  2000  2  0.563  0.803  1.027  1.127  1.539  1.684  2.594  3.084  4.773
7.461
  2001  2  0.508  0.73  0.796  1.071  1.303  2.057  2.569  3.523  4.173
6.193
  2002  2  0.715  0.777  0.804  0.857  1.323  1.755  2.275  3.119  3.938
4.575
  1992  1  0.619  0.63  0.964  1.189  1.607  2.242  3.668  4.33  5.412
7.045
  1993  1  0.358  0.744  0.899  1.26  1.754  2.636  3.185  3.98  5.08
6.891
  1994  1  0.287  0.697  0.944  1.119  1.601  2.434  3.617  4.787  6.548
8.326
  1995  1  0.502  0.759  1.002  1.294  1.816  2.562  3.555  4.767  5.267
7.891
  1996  1  0.28  0.51  0.967  1.187  1.807  2.368  2.952  4.705  6.092
8.382
  1997  1  0.432  0.436  0.905  1.145  1.452  2.587  3.556  4.525  6.158
8.866
  1998  1  0.603  0.659  0.892  0.966  1.393  1.744  2.949  3.883  4.996
7.227
  1999  1  0.519  0.589  0.881  1.061  1.211  1.754  2.337  3.493  4.844
6.745
  2000  1  0.563  0.803  1.027  1.127  1.539  1.684  2.594  3.084  4.773
7.461
  2001  1  0.508  0.73  0.796  1.071  1.303  2.057  2.569  3.523  4.173
6.193
  2002  1  0.715  0.777  0.804  0.857  1.323  1.755  2.275  3.119  3.938
4.575
```

5.5 WS FILE

```
  1992     0.619  0.63  0.964  1.189  1.607  2.242  3.668  4.33  5.412
7.045
  1993     0.358  0.744  0.899  1.26  1.754  2.636  3.185  3.98  5.08
6.891
  1994     0.287  0.697  0.944  1.119  1.601  2.434  3.617  4.787  6.548
8.326
  1995     0.502  0.759  1.002  1.294  1.816  2.562  3.555  4.767  5.267
7.891
  1996      0.28  0.51  0.967  1.187  1.807  2.368  2.952  4.705  6.092
8.382
  1997     0.432  0.436  0.905  1.145  1.452  2.587  3.556  4.525  6.158
8.866
```

```
  1998     0.603  0.659  0.892  0.966  1.393  1.744  2.949  3.883  4.996
7.227
  1999     0.519  0.589  0.881  1.061  1.211  1.754  2.337  3.493  4.844
6.745
  2000     0.563  0.803  1.027  1.127  1.539  1.684  2.594  3.084  4.773
7.461
  2001     0.508  0.73  0.796  1.071  1.303  2.057  2.569  3.523  4.173
6.193
  2002     0.715  0.777  0.804  0.857  1.323  1.755  2.275  3.119  3.938
4.575
```

5.6 YDT FILE (MISSING)

5.7 OPT FILE

```
 1 10
 1
 3 6
 3 6
 2003
F
 0.26
F
 0.0
 0.0   0.10 0.0 10000.00 10000.00
 106.0  1.0 0.0 10000.00 10000.0
 200.0  0.25 0.0 10000.00 10000.0
 1
 0.100000000 0.00000000 0.00000000
 0.100000000 0.0000000 0.00000000
 0.000000000 0.0000000 0.00000000
 0.000000000 0.0000000 0.00000000
 0.0000000 0
 1.5 1.0
 1.5 1.0
 2 1 251 250 0.0 0.44 1.0      3 1 2.4090 0.00310 0.00000000 0.44 .00000000
 0
 0.0 0.0 0.0 0.0 0.0
 0
 1.0000000 0.2500000
 1.0000000 0.0000000
 1
```

APPENDIX 6 NORTH SEA WHITING DATA FILES

6.1 ADT FILE

```
0    0
1  0.97  0.004  0.011
2  0.47  0.025  0.054
3  0.38  0.085  0.084
4  0.32  0.143  0.036
5  0.26  0.155  0.020
6  0.26  0.165  0.019
```

6.2 NIN FILE

```
1 1459.533  0.284  0.00  0.00  0.00  0.00  0.00
2 545.759  0.00  0.26  0.00  0.00  0.00  0.00
3 259.221  0.00  0.00  0.14  0.00  0.00  0.00
4 170.085  0.00  0.00  0.00  0.12  0.00  0.00
5 71.342  0.00  0.00  0.00  0.00  0.11  0.00
6 19.022  0.00  0.00  0.00  0.00  0.00  0.12
```

6.3 WC FILE

```
1980  0.11  0.92  1.00  1.00  1.00  1.00
1981  0.11  0.92  1.00  1.00  1.00  1.00
1982  0.11  0.92  1.00  1.00  1.00  1.00
1983  0.11  0.92  1.00  1.00  1.00  1.00
1984  0.11  0.92  1.00  1.00  1.00  1.00
1985  0.11  0.92  1.00  1.00  1.00  1.00
1986  0.11  0.92  1.00  1.00  1.00  1.00
1987  0.11  0.92  1.00  1.00  1.00  1.00
1988  0.11  0.92  1.00  1.00  1.00  1.00
1989  0.11  0.92  1.00  1.00  1.00  1.00
1990  0.11  0.92  1.00  1.00  1.00  1.00
1991  0.11  0.92  1.00  1.00  1.00  1.00
1992  0.11  0.92  1.00  1.00  1.00  1.00
1993  0.11  0.92  1.00  1.00  1.00  1.00
1994  0.11  0.92  1.00  1.00  1.00  1.00
1995  0.11  0.92  1.00  1.00  1.00  1.00
1996  0.11  0.92  1.00  1.00  1.00  1.00
1997  0.11  0.92  1.00  1.00  1.00  1.00
1998  0.11  0.92  1.00  1.00  1.00  1.00
1999  0.11  0.92  1.00  1.00  1.00  1.00
2000  0.11  0.92  1.00  1.00  1.00  1.00
2001  0.11  0.92  1.00  1.00  1.00  1.00
2002  0.11  0.92  1.00  1.00  1.00  1.00
```

6.4 WS FILE

```
1980  0.075  0.176  0.252  0.328  0.337  0.465
1981  0.083  0.168  0.242  0.321  0.379  0.425
1982  0.061  0.184  0.253  0.314  0.376  0.497
1983  0.107  0.191  0.273  0.325  0.384  0.439
1984  0.089  0.188  0.271  0.337  0.382  0.409
1985  0.094  0.192  0.284  0.332  0.402  0.444
1986  0.105  0.183  0.255  0.318  0.378  0.482
1987  0.077  0.148  0.247  0.297  0.375  0.435
1988  0.054  0.146  0.223  0.301  0.346  0.455
```

```
1989  0.070  0.157  0.225  0.267  0.318  0.395
1990  0.083  0.137  0.209  0.250  0.279  0.437
1991  0.103  0.169  0.218  0.290  0.307  0.343
1992  0.082  0.185  0.257  0.277  0.332  0.339
1993  0.073  0.175  0.252  0.319  0.329  0.366
1994  0.080  0.170  0.254  0.323  0.371  0.371
1995  0.087  0.181  0.258  0.341  0.385  0.431
1996  0.093  0.167  0.236  0.302  0.387  0.414
1997  0.091  0.178  0.243  0.295  0.333  0.385
1998  0.091  0.180  0.236  0.281  0.314  0.339
1999  0.076  0.174  0.233  0.256  0.289  0.303
2000  0.113  0.182  0.238  0.288  0.287  0.277
2001  0.072  0.191  0.227  0.283  0.270  0.296
2002  0.066  0.156  0.222  0.281  0.314  0.359
```

6.5 YDT FILE

```
1993 1811.07 225.44
1994 1602.31 234.86
1995 1118.99 204.45
1996 806.48 177.08
1997 1091.16 147.32
1998 1846.55 150.15
1999 1992.55 201.31
2000 1710.43 239.34
2001 1411.06  243.1
2002 779.59 260.55
```

6.6 OPT FILE

```
    1    6
    1
    2    4
    2    4
  2003
C
  16.0
C
   6.0
   0.0   0.1   0.1  10000.0  10000.0
  225.0  0.25  0.25  10000.0  10000.0
  315.0  0.65  0.65  10000.0  10000.0
    1
   0.0  0.0   0.0
   0.0  0.0   0.0
   0.0   0.0   0.0
   0.0   0.0   0.0
   0.0    0
   5.0   5.0
   3.0   3.0
    3    1 13.129 0.002373   0.0  0.38   1.0
    0
  0.00  0.00  0.00  0.00  0.00
    0
  1.0  0.0
   1.0   0.0
    1
```

APPENDIX 7 NORTH SEA HERRING DATA FILES

7.1 ADT FILE

```
 0.6700 0.6700
0 1.0000 0.00013 0.0268
1 1.0000 0.00499 0.0471
2 0.3000 0.10909 0.0288
3 0.2000 0.22251 0.0066
4 0.1000 0.27178 0.0070
5 0.1000 0.28464 0.0026
6 0.1000 0.27477 0.0039
7 0.1000 0.26850 0.0038
8 0.1000 0.27668 0.0021
9 0.1000 0.27879 0.0000
```

7.2 NIN FILE

```
0 17371.000 0.025 0.001 0.001 0.001 0.001 0.001 0.000 0.000 0.000 0.000
1   7581.200 0.001 0.019 0.001 0.001 0.001 0.001 0.001 0.001 0.001 0.000
2   6766.800 0.001 0.001 0.012 0.003 0.003 0.003 0.002 0.001 0.001 0.000
3   7212.300 0.001 0.001 0.003 0.010 0.004 0.004 0.004 0.003 0.003 0.000
4   2047.000 0.001 0.001 0.003 0.004 0.010 0.006 0.006 0.006 0.005 0.000
5   2385.700 0.001 0.001 0.003 0.004 0.006 0.014 0.009 0.010 0.010 0.000
6    569.410 0.000 0.001 0.002 0.004 0.006 0.009 0.017 0.013 0.015 0.000
7    303.440 0.000 0.001 0.001 0.003 0.006 0.010 0.013 0.026 0.021 0.000
8    345.670 0.000 0.001 0.001 0.003 0.005 0.010 0.015 0.021 0.039 0.000
9    119.180 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.100
```

7.3 PRM FILE

```
 1984  0.000  0.000  0.820  1.000  1.000  1.000  1.000  1.000  1.000  1.000
 1985  0.000  0.000  0.700  1.000  1.000  1.000  1.000  1.000  1.000  1.000
 1986  0.000  0.000  0.750  1.000  1.000  1.000  1.000  1.000  1.000  1.000
 1987  0.000  0.000  0.800  1.000  1.000  1.000  1.000  1.000  1.000  1.000
 1988  0.000  0.000  0.850  0.930  1.000  1.000  1.000  1.000  1.000  1.000
 1989  0.000  0.000  0.820  0.940  1.000  1.000  1.000  1.000  1.000  1.000
 1990  0.000  0.000  0.910  0.970  1.000  1.000  1.000  1.000  1.000  1.000
 1991  0.000  0.000  0.860  0.990  1.000  1.000  1.000  1.000  1.000  1.000
 1992  0.000  0.000  0.500  0.990  1.000  1.000  1.000  1.000  1.000  1.000
 1993  0.000  0.000  0.470  0.610  1.000  1.000  1.000  1.000  1.000  1.000
 1994  0.000  0.000  0.730  0.930  1.000  1.000  1.000  1.000  1.000  1.000
 1995  0.000  0.000  0.670  0.950  1.000  1.000  1.000  1.000  1.000  1.000
 1996  0.000  0.000  0.610  0.980  1.000  1.000  1.000  1.000  1.000  1.000
 1997  0.000  0.000  0.640  0.940  1.000  1.000  1.000  1.000  1.000  1.000
 1998  0.000  0.000  0.640  0.890  1.000  1.000  1.000  1.000  1.000  1.000
 1999  0.000  0.000  0.690  0.910  1.000  1.000  1.000  1.000  1.000  1.000
 2000  0.000  0.000  0.670  0.960  1.000  1.000  1.000  1.000  1.000  1.000
 2001  0.000  0.000  0.770  0.920  1.000  1.000  1.000  1.000  1.000  1.000
 2002  0.000  0.000  0.870  0.970  1.000  1.000  1.000  1.000  1.000  1.000
 2003  0.000  0.000  0.430  0.930  1.000  1.000  1.000  1.000  1.000  1.000
```

7.4 WC FILE

```
 1981 1  0.007  0.049  0.118  0.142  0.189  0.211  0.222  0.267  0.271
0.271
 1982 1  0.010  0.059  0.118  0.149  0.179  0.217  0.238  0.265  0.274
0.275
```

```
 1983 1  0.010  0.059  0.118  0.149  0.179  0.217  0.238  0.265  0.274
0.275
 1984 1  0.010  0.059  0.118  0.149  0.179  0.217  0.238  0.265  0.274
0.275
 1985 1  0.009  0.036  0.128  0.164  0.194  0.211  0.220  0.258  0.270
0.292
 1986 1  0.006  0.067  0.121  0.153  0.182  0.208  0.221  0.238  0.252
0.262
 1987 1  0.011  0.035  0.099  0.150  0.180  0.211  0.234  0.258  0.277
0.299
 1988 1  0.011  0.055  0.111  0.145  0.174  0.197  0.216  0.237  0.253
0.263
 1989 1  0.017  0.043  0.115  0.153  0.173  0.208  0.231  0.247  0.265
0.259
 1990 1  0.019  0.055  0.114  0.149  0.177  0.193  0.229  0.236  0.250
0.287
 1991 1  0.017  0.058  0.130  0.166  0.184  0.203  0.217  0.235  0.259
0.271
 1992 1  0.010  0.053  0.102  0.175  0.189  0.207  0.223  0.237  0.249
0.287
 1993 1  0.010  0.033  0.115  0.145  0.189  0.204  0.228  0.244  0.256
0.310
 1994 1  0.006  0.056  0.130  0.159  0.181  0.214  0.240  0.255  0.273
0.281
 1995 1  0.009  0.042  0.130  0.169  0.198  0.207  0.243  0.247  0.283
0.276
 1996 1  0.015  0.018  0.112  0.156  0.188  0.204  0.212  0.261  0.280
0.288
 1997 1  0.015  0.044  0.108  0.148  0.195  0.227  0.226  0.235  0.244
0.291
 1998 1  0.021  0.051  0.114  0.145  0.183  0.219  0.238  0.247  0.289
0.283
 1999 1  0.009  0.045  0.115  0.151  0.171  0.207  0.233  0.245  0.261
0.301
 2000 1  0.015  0.033  0.113  0.157  0.179  0.201  0.216  0.246  0.275
0.262
 2001 1  0.012  0.048  0.117  0.149  0.177  0.197  0.212  0.237  0.267
0.286
 2002 1  0.012  0.037  0.116  0.151  0.169  0.198  0.214  0.228  0.250
0.253
 2003 1  0.014  0.037  0.104  0.157  0.173  0.184  0.204  0.221  0.232
0.253
 1981 2  0.007  0.049  0.118  0.142  0.189  0.211  0.222  0.267  0.271
0.271
 1982 2  0.010  0.059  0.118  0.149  0.179  0.217  0.238  0.265  0.274
0.275
 1983 2  0.010  0.059  0.118  0.149  0.179  0.217  0.238  0.265  0.274
0.275
 1984 2  0.010  0.059  0.118  0.149  0.179  0.217  0.238  0.265  0.274
0.275
 1985 2  0.009  0.036  0.128  0.164  0.194  0.211  0.220  0.258  0.270
0.292
 1986 2  0.006  0.067  0.121  0.153  0.182  0.208  0.221  0.238  0.252
0.262
 1987 2  0.011  0.035  0.099  0.150  0.180  0.211  0.234  0.258  0.277
0.299
 1988 2  0.011  0.055  0.111  0.145  0.174  0.197  0.216  0.237  0.253
0.263
 1989 2  0.017  0.043  0.115  0.153  0.173  0.208  0.231  0.247  0.265
0.259
```

```
 1990 2  0.019  0.055  0.114  0.149  0.177  0.193  0.229  0.236  0.250
0.287
 1991 2  0.017  0.058  0.130  0.166  0.184  0.203  0.217  0.235  0.259
0.271
 1992 2  0.010  0.053  0.102  0.175  0.189  0.207  0.223  0.237  0.249
0.287
 1993 2  0.010  0.033  0.115  0.145  0.189  0.204  0.228  0.244  0.256
0.310
 1994 2  0.006  0.056  0.130  0.159  0.181  0.214  0.240  0.255  0.273
0.281
 1995 2  0.009  0.042  0.130  0.169  0.198  0.207  0.243  0.247  0.283
0.276
 1996 2  0.015  0.018  0.112  0.156  0.188  0.204  0.212  0.261  0.280
0.288
 1997 2  0.015  0.044  0.108  0.148  0.195  0.227  0.226  0.235  0.244
0.291
 1998 2  0.021  0.051  0.114  0.145  0.183  0.219  0.238  0.247  0.289
0.283
 1999 2  0.009  0.045  0.115  0.151  0.171  0.207  0.233  0.245  0.261
0.301
 2000 2  0.015  0.033  0.113  0.157  0.179  0.201  0.216  0.246  0.275
0.262
 2001 2  0.012  0.048  0.117  0.149  0.177  0.197  0.212  0.237  0.267
0.286
 2002 2  0.012  0.037  0.116  0.151  0.169  0.198  0.214  0.228  0.250
0.253
 2003 2  0.014  0.037  0.104  0.157  0.173  0.184  0.204  0.221  0.232
0.253
```

7.5 WS FILE

```
 1982  0.015  0.050  0.155  0.187  0.223  0.239  0.276  0.299  0.306  0.312
 1983  0.017  0.057  0.150  0.190  0.230  0.243  0.282  0.311  0.338  0.347
 1984  0.016  0.056  0.138  0.187  0.232  0.247  0.275  0.321  0.341  0.365
 1985  0.014  0.061  0.130  0.183  0.232  0.252  0.273  0.315  0.332  0.392
 1986  0.009  0.050  0.122  0.170  0.212  0.230  0.242  0.275  0.268  0.343
 1987  0.008  0.048  0.123  0.166  0.208  0.229  0.248  0.259  0.263  0.325
 1988  0.008  0.044  0.122  0.165  0.205  0.228  0.252  0.261  0.277  0.315
 1989  0.012  0.052  0.126  0.174  0.212  0.244  0.270  0.284  0.298  0.331
 1990  0.011  0.059  0.139  0.184  0.212  0.239  0.265  0.280  0.300  0.328
 1991  0.010  0.064  0.137  0.194  0.214  0.234  0.253  0.271  0.291  0.312
 1992  0.006  0.061  0.134  0.184  0.213  0.235  0.262  0.273  0.302  0.320
 1993  0.007  0.060  0.127  0.192  0.214  0.240  0.275  0.291  0.309  0.338
 1994  0.006  0.057  0.130  0.186  0.211  0.224  0.268  0.293  0.318  0.346
 1995  0.006  0.054  0.130  0.199  0.228  0.234  0.274  0.301  0.324  0.344
 1996  0.005  0.049  0.123  0.183  0.230  0.237  0.257  0.280  0.303  0.334
 1997  0.006  0.047  0.116  0.187  0.241  0.264  0.284  0.287  0.301  0.342
 1998  0.006  0.051  0.116  0.179  0.226  0.256  0.273  0.276  0.270  0.318
 1999  0.006  0.051  0.116  0.184  0.221  0.248  0.279  0.286  0.281  0.303
 2000  0.006  0.051  0.122  0.172  0.210  0.233  0.255  0.275  0.274  0.280
 2001  0.006  0.047  0.128  0.172  0.205  0.228  0.248  0.270  0.289  0.275
 2002  0.007  0.047  0.123  0.173  0.202  0.222  0.242  0.266  0.285  0.283
 2003  0.006  0.046  0.121  0.179  0.202  0.219  0.245  0.271  0.285  0.278
```

7.6 YDT FILE

```
 1960 12088.6360  1860.0940
 1961 108847.5600  1643.0720
 1962 46273.7950  1101.3490
 1963 47657.5640  2172.9460
 1964 62785.0200  2018.2960
 1965 34894.6520  1438.3210
```

```
 1966 27857.8960  1274.2520
 1967 40255.5180  919.6770
 1968 38698.4230  412.2050
 1969 21581.3040  423.7420
 1970 41071.6840  374.5950
 1971 32305.1370  265.9430
 1972 20859.1070  288.2420
 1973 10096.6590  233.2740
 1974 21690.1600  161.8890
 1975  2808.0590   81.4160
 1976  2713.0920   77.5710
 1977  4320.6400   47.0070
 1978  4587.3600   64.1230
 1979 10595.7940  106.2730
 1980 16706.9770  130.0340
 1981 37847.4590  194.5100
 1982 64722.2960  277.3170
 1983 61788.6920  430.9630
 1984 53423.4200  677.2950
 1985 80868.8490  697.3440
 1986 97576.9730  677.1850
 1987 86155.6710  897.8690
 1988 42248.1530  1191.1020
 1989 39143.9900  1245.6010
 1990 35833.6560  1180.6360
 1991 33583.4970  976.0150
 1992 62143.4320  699.4640
 1993 50194.3770  468.8420
 1994 33620.2870  507.3510
 1995 41344.6750  457.8450
 1996 50583.4480  451.9020
 1997 26678.4880  541.5890
 1998 26655.4700  719.3140
 1999 70754.2620  831.9260
 2000 39795.7170  823.9430
 2001 89616.0410  1281.5660
 2002 54089.2970  1571.0360
 2003 21170.5950  1742.4360
 2004 17371.0000  2161.5180
```

7.7 OPT FILE

```
 0 9
 1
 2 6
0 1
 2004
F
 0.2326
F
 0.0369
0.0 0.200 0.050 10000.00 10000.00
1.0 800.0  0.200 0.050 10000.00 10000.00
 1300.0 0.250 0.120 10000.00 10000.00
 0
 0.00000000 0.00000000 0.00000000
 0.00000000 0.00000000 0.00000000
 0.00000000 0.00000000 0.00000000
 0.00000000 0.00000000 0.00000000
 0.0000000 0
 1.5 1.0
 1.0 1.0
```

```
2 1 49342.0000 537.00000 0.00000000 0.578 1.00000000
0
0.0 0.0 0.0 0.0 0.0
0
1.10000000 0.20000000
1.20000000 0.10000000
1
```

APPENDIX 8 RESULTS OF CALCULATIONS FOR NORTH SEA PLAICE

8.1 TRAJECTORY FROM FSQ TO LONG TERM F =0.25 IN 5 YEARS WITHOUT CONSTRAINT ON CHANGE IN TAC, WITHOUT ASSESSMENT BIAS AND IMPLEMENTATION BIAS.

This run is shown graphically in Figure 0.5

```
Run id 20040617  124746.855
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file ple.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   300000.0 300000.0
  2210000.0      0.250    0.000   300000.0 300000.0
  3300000.0      0.250    0.000   300000.0 300000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.509999990
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=        134383.
Recr. level= 305553.188
Stochastic term x has normal distribution with sigma= 0.4263
truncated at:  1.20
```

Stock-recruit function not applied in year 0
Weights at age and maturity ogive were drawn from historical values
Assumed faulty assessment with factor: 1.000 +/- 0.100
Assumed overfishing of quotas with factor: 1.000 +/- 0.050
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	74.0	21.0	5.0	0.1	0.0
2005	59.8	28.9	11.3	0.0	0.0
2006	48.1	36.7	15.2	0.0	0.0
2007	39.9	43.8	16.3	0.0	0.0
2008	29.5	52.0	18.5	0.0	0.0
2009	19.8	53.9	26.3	0.0	0.0
2010	8.5	52.9	38.6	0.0	0.0
2011	4.0	42.0	54.0	0.0	0.0
2012	0.9	33.2	65.9	0.0	0.0
2013	0.8	31.1	68.1	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	74.9	22.0	3.1	0.0	0.0
2004	74.9	21.1	4.0	0.1	0.0
2005	59.7	31.3	9.0	0.0	0.0
2006	49.0	37.3	13.7	0.0	0.0
2007	40.8	44.4	14.8	0.0	0.0
2008	28.4	53.5	18.1	0.0	0.0
2009	17.1	59.3	23.6	0.0	0.0
2010	6.8	58.0	35.2	0.0	0.0
2011	2.5	43.1	54.4	0.0	0.0
2012	0.1	32.5	67.4	0.0	0.0
2013	0.0	26.3	73.7	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	17.0	2.0	5.6	4.7	0.1	1.2
2006	17.1	1.6	6.1	6.9	0.1	3.7

2007	16.5	1.1	6.8	8.7	0.7	6.1
2008	17.8	1.0	8.6	7.9	0.5	6.9
2009	14.2	2.1	13.4	6.3	0.3	7.4
2010	12.6	2.6	20.0	3.2	0.7	9.6
2011	5.5	1.5	25.4	2.1	0.4	11.1
2012	2.6	1.1	24.4	0.4	0.2	13.4
2013	0.6	0.3	19.0	0.3	0.5	16.6

Percent prob. of level 2,3 => level 1 at least once: 37.4
Percent prob. of level 3 => level 2 at least once: 56.2

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	16.9	0.2	5.3	2.0	0.0	0.6
2006	16.4	0.2	6.1	5.0	0.0	1.7
2007	15.5	0.1	5.7	5.7	0.1	4.8
2008	16.9	0.2	7.7	5.2	0.0	4.8
2009	13.4	0.6	10.1	4.5	0.0	5.3
2010	10.8	0.4	17.1	1.9	0.0	6.1
2011	4.2	0.3	24.2	1.1	0.0	5.3
2012	1.5	0.1	21.0	0.1	0.0	8.1
2013	0.1	0.0	16.6	0.0	0.0	10.3

Percent prob. of level 2,3 => level 1 at least once: 22.8
Percent prob. of level 3 => level 2 at least once: 38.3

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	118747.2	148142.8	176363.0	210110.0	279170.8

2004	113043.8	144102.3	172025.6	210018.0	286038.1
2005	117149.7	157905.4	191692.6	238046.8	335992.0
2006	130087.6	173432.5	211285.6	262177.5	367998.4
2007	144861.0	188313.3	222124.9	270427.9	362200.8
2008	160211.8	204998.6	237721.7	280262.5	355192.6
2009	179479.5	221817.2	255597.7	296676.8	375849.2
2010	203104.6	248623.4	283364.7	320500.3	393309.3
2011	225893.4	270270.0	304889.8	342313.8	404105.1
2012	247484.2	287866.0	322865.9	356386.9	418576.8
2013	255974.4	298167.8	328499.3	365128.8	429694.0

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2005	2008	2011	2012	2014

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	128613.7	259047.4	390083.2	598373.3	1085329.6
2004	152023.5	226992.4	297889.6	400798.8	620019.3
2005	148697.4	225355.6	304246.0	397845.3	631605.1
2006	141582.7	220203.0	297687.6	399819.1	588820.4
2007	158444.3	229412.7	302031.9	398514.4	610040.6
2008	147952.2	225245.4	302084.6	399165.0	616013.1
2009	151902.9	227587.4	306645.8	405135.8	621765.9
2010	153708.7	237511.2	307260.0	397366.5	616199.6
2011	155189.3	233087.1	308952.0	405301.8	620269.3
2012	156235.0	225650.7	298574.4	407736.4	606259.7
2013	149874.1	229223.3	306760.2	411696.0	605887.8

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	56450.5	70258.4	82526.1	97128.9	125202.1
2004	46931.2	62665.1	76536.7	95733.3	138499.0
2005	41326.6	60339.6	76674.6	99885.6	143739.5
2006	43751.3	60391.0	74680.0	93218.3	138323.4
2007	42579.8	57713.2	71285.9	86753.7	118494.8
2008	42111.8	55951.9	66918.8	79876.1	102651.2
2009	40770.6	52087.2	61729.8	79525.8	103705.1
2010	40923.3	51269.9	63878.8	86099.7	109100.0
2011	39885.4	57985.8	79251.5	93687.0	113350.7
2012	43897.3	66299.2	84051.5	94989.6	114691.7
2013	49775.4	68324.7	85014.4	96516.1	119715.5

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	38.8	53.9	68.9	86.6	120.9
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	9.9	15.2	20.6	26.1	35.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	49083.4	62236.9	74060.5	89263.1	120343.5
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	52441.3	64842.0	73809.0	83815.1	99806.9
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.510	0.510	0.510	0.510	0.510
2004	0.354	0.403	0.443	0.485	0.559
2005	0.311	0.353	0.389	0.424	0.485
2006	0.264	0.305	0.336	0.369	0.425

2007	0.237	0.268	0.292	0.319	0.370
2008	0.205	0.234	0.254	0.280	0.320
2009	0.179	0.206	0.228	0.255	0.298
2010	0.163	0.187	0.215	0.254	0.302
2011	0.150	0.192	0.236	0.268	0.307
2012	0.152	0.211	0.243	0.270	0.304
2013	0.166	0.212	0.244	0.267	0.310

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.444	0.444	0.444	0.444	0.444
2005	0.386	0.386	0.386	0.386	0.386
2006	0.336	0.336	0.336	0.336	0.336
2007	0.292	0.292	0.292	0.292	0.292
2008	0.254	0.254	0.254	0.254	0.254
2009	0.221	0.221	0.221	0.250	0.250
2010	0.192	0.192	0.218	0.250	0.250
2011	0.167	0.205	0.250	0.250	0.250
2012	0.164	0.218	0.250	0.250	0.250
2013	0.189	0.229	0.250	0.250	0.250

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000

```
 2010      0.000      0.000      0.000      0.000      0.000
 2011      0.000      0.000      0.000      0.000      0.000
 2012      0.000      0.000      0.000      0.000      0.000
 2013      0.000      0.000      0.000      0.000      0.000
```

8.2 TRAJECTORY FROM FSQ TO LONG TERM F =0.25 IN 10 YEARS WITHOUT CONSTRAINT ON CHANGE IN TAC, WITHOUT ASSESSMENT BIAS OR IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.1.6

```
Run id 20040617  124525.802
 ************************************************
 *  Results of stochastic medium term simulation  *
 *                                              *
 ************************************************

 Options from file ple.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   300000.0 300000.0
  2210000.0      0.250    0.000   300000.0 300000.0
  3300000.0      0.250    0.000   300000.0 300000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.509999990
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=        134383.
Recr. level= 305553.188
Stochastic term x has normal distribution with sigma= 0.4263
truncated at:  1.20
```

Stock-recruit function not applied in year 0
Weights at age and maturity ogive were drawn from historical values
Assumed faulty assessment with factor: 1.000 +/- 0.100
Assumed overfishing of quotas with factor: 1.000 +/- 0.050
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	74.0	21.0	5.0	0.1	0.0
2005	61.9	28.9	9.2	0.2	0.0
2006	57.4	30.4	12.2	0.0	0.0
2007	53.9	35.8	10.3	0.0	0.0
2008	52.5	41.1	6.4	0.0	0.0
2009	49.1	42.2	8.7	0.0	0.0
2010	40.8	49.3	9.9	0.0	0.0
2011	27.4	58.2	14.4	0.0	0.0
2012	19.9	58.3	21.8	0.0	0.0
2013	12.8	58.0	29.2	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	74.9	22.0	3.1	0.0	0.0
2004	74.9	21.1	4.0	0.1	0.0
2005	62.7	29.2	8.1	0.2	0.0
2006	56.8	32.1	11.1	0.0	0.0
2007	57.1	34.6	8.3	0.0	0.0
2008	53.5	40.9	5.6	0.0	0.0
2009	50.2	43.9	5.9	0.0	0.0
2010	37.8	53.5	8.7	0.0	0.0
2011	27.7	60.6	11.7	0.0	0.0
2012	17.2	64.2	18.6	0.0	0.0
2013	9.1	64.2	26.7	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	15.7	1.7	4.3	5.2	0.1	1.7
2006	13.8	1.3	5.6	10.2	0.4	3.5

2007	13.4	1.1	3.7	9.9	1.1	5.6
2008	14.6	0.7	2.9	12.4	1.5	6.0
2009	16.0	1.3	4.9	13.2	0.7	3.2
2010	20.3	1.0	5.6	12.1	0.9	4.5
2011	21.2	1.9	7.9	9.5	0.2	5.1
2012	15.1	1.2	13.7	8.4	0.4	7.1
2013	11.7	1.7	15.5	6.1	0.2	9.6

Percent prob. of level 2,3 => level 1 at least once: 64.4
Percent prob. of level 3 => level 2 at least once: 35.8

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	15.5	0.0	4.6	2.7	0.0	0.7
2006	12.6	0.4	4.6	6.9	0.1	2.0
2007	11.9	0.1	2.8	9.4	0.6	5.2
2008	14.7	0.3	1.6	8.6	0.1	4.5
2009	13.6	0.2	2.9	10.0	0.0	2.8
2010	20.0	0.1	4.9	8.5	0.0	2.3
2011	16.8	0.3	6.7	7.1	0.0	4.0
2012	14.5	0.2	10.7	4.9	0.0	4.1
2013	9.1	0.0	13.8	2.7	0.0	5.9

Percent prob. of level 2,3 => level 1 at least once: 46.8
Percent prob. of level 3 => level 2 at least once: 25.1

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	118747.2	148142.8	176363.0	210110.0	279170.8

2004	113043.8	144102.3	172025.6	210018.0	286038.1
2005	114595.8	154197.1	188072.9	233824.3	330393.0
2006	122175.3	163755.0	198743.1	248107.7	348830.3
2007	130840.3	168855.2	200827.7	244816.3	322720.0
2008	135831.5	176396.9	204839.9	240962.9	305217.5
2009	145609.1	181821.1	209563.3	245128.0	306938.3
2010	156785.1	194615.7	224415.5	256339.8	317301.8
2011	165317.5	207198.4	238603.8	271386.4	327124.4
2012	184333.8	221614.5	253520.1	286961.2	343062.3
2013	191665.4	237212.3	266146.0	301620.7	363891.4

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2005	2011	2014	2014	2014

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	128613.7	259047.4	390083.2	598373.3	1085329.6
2004	152023.5	226992.4	297889.6	400798.8	620019.3
2005	148697.4	225355.6	304246.0	397845.3	631605.1
2006	141582.7	219005.3	297631.5	398409.6	588820.4
2007	155962.9	227134.1	301062.9	397557.6	608520.9
2008	147952.2	224808.5	301533.6	397537.8	616013.1
2009	151162.4	226797.8	305584.8	403903.5	621765.9
2010	153515.0	234951.8	306420.3	397294.1	616199.6
2011	155189.3	233087.1	308952.0	402938.4	620269.3
2012	156235.0	225020.7	298574.4	407736.4	606259.7
2013	149874.1	229223.3	306760.2	411696.0	605887.8

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	56450.5	70258.4	82526.1	97128.9	125202.1
2004	49590.8	66114.0	80842.1	101142.6	146223.7
2005	44826.4	65907.4	83658.6	109268.5	156838.4
2006	48639.1	67030.5	83157.5	104375.9	151587.7
2007	48261.3	65274.6	80441.4	97939.5	133550.4
2008	47578.9	63937.2	77315.5	92247.5	117757.6
2009	46849.4	60745.7	72454.7	87234.3	108926.7
2010	48750.1	60753.9	71111.4	83323.0	107000.2
2011	47729.8	61614.4	72226.5	84493.1	104211.4
2012	48410.3	61361.6	71429.1	82424.2	100885.9
2013	47484.1	60061.5	70108.9	82193.1	102889.3

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	29.8	44.6	57.5	74.2	119.4
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	9.8	15.1	20.7	26.1	35.8
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	54687.7	69192.6	82000.0	98382.1	131510.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	55694.9	65578.6	73423.9	82091.5	97187.8
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.510	0.510	0.510	0.510	0.510
2004	0.377	0.430	0.474	0.519	0.600
2005	0.353	0.403	0.445	0.486	0.558
2006	0.320	0.372	0.410	0.452	0.524

2007	0.306	0.349	0.381	0.418	0.490
2008	0.283	0.325	0.354	0.392	0.452
2009	0.263	0.302	0.329	0.360	0.409
2010	0.248	0.279	0.305	0.332	0.382
2011	0.231	0.264	0.287	0.313	0.357
2012	0.218	0.245	0.267	0.291	0.323
2013	0.201	0.225	0.246	0.268	0.309

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.474	0.474	0.474	0.474	0.474
2005	0.441	0.441	0.441	0.441	0.441
2006	0.410	0.410	0.410	0.410	0.410
2007	0.382	0.382	0.382	0.382	0.382
2008	0.355	0.355	0.355	0.355	0.355
2009	0.330	0.330	0.330	0.330	0.330
2010	0.307	0.307	0.307	0.307	0.307
2011	0.285	0.285	0.285	0.285	0.285
2012	0.265	0.265	0.265	0.265	0.265
2013	0.247	0.247	0.247	0.250	0.250

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000

2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

```
Run id 20040617  105427.748
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file ple.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   300000.0 300000.0
  2210000.0      0.250    0.000   300000.0 300000.0
  3300000.0      0.250    0.000   300000.0 300000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.509999990
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=        134383.
Recr. level= 305553.188
Stochastic term x has normal distribution with sigma= 0.4263
truncated at:  1.20

 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.000 +/- 0.100
Assumed overfishing of quotas with factor:  1.000 +/- 0.050
 Stochastic initial stock numbers - lognormal distribution

 **************************************************


 Probabilities of APPLIED levels and limits:
```

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	74.0	21.0	5.0	0.1	0.0
2005	61.0	28.1	10.9	0.0	0.0
2006	52.2	33.6	14.2	0.0	0.0
2007	50.9	36.2	12.9	0.0	0.0
2008	48.8	39.5	11.7	0.0	0.0
2009	46.5	40.3	13.2	0.0	0.0
2010	43.7	39.2	17.1	0.0	0.0
2011	36.0	42.2	21.8	0.0	0.0
2012	31.6	40.5	27.9	0.0	0.0
2013	28.2	37.1	34.7	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	74.9	22.0	3.1	0.0	0.0
2004	74.9	21.1	4.0	0.1	0.0
2005	61.4	30.0	8.6	0.0	0.0
2006	54.0	33.6	12.4	0.0	0.0
2007	51.5	37.3	11.2	0.0	0.0
2008	50.9	38.2	10.9	0.0	0.0
2009	48.6	39.7	11.7	0.0	0.0
2010	41.0	43.5	15.5	0.0	0.0
2011	35.9	43.7	20.4	0.0	0.0
2012	29.8	41.4	28.8	0.0	0.0
2013	26.8	38.6	34.6	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	16.1	1.7	5.5	4.7	0.1	1.2
2006	15.0	1.2	5.8	7.3	0.1	3.6
2007	11.1	0.6	5.1	9.7	0.7	6.3
2008	12.0	0.4	5.2	9.2	1.1	5.7
2009	12.3	0.4	7.0	10.0	0.4	5.5
2010	11.7	1.1	9.1	9.7	0.3	6.0
2011	13.2	0.8	9.8	6.0	0.3	5.6
2012	10.4	0.4	12.8	6.0	0.4	6.7

2013	7.5	1.0	13.1	5.0	0.1	7.2

Percent prob. of level 2,3 => level 1 at least once: 53.0
Percent prob. of level 3 => level 2 at least once: 36.3

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	16.0	0.2	5.0	2.1	0.0	0.6
2006	14.4	0.3	5.0	5.4	0.0	1.6
2007	10.7	0.1	3.7	7.0	0.2	4.9
2008	11.6	0.1	4.0	8.4	0.2	4.3
2009	12.0	0.2	4.9	7.9	0.1	4.3
2010	11.7	0.2	7.8	4.9	0.1	4.1
2011	10.4	0.2	7.9	4.3	0.0	3.2
2012	9.0	0.1	11.6	3.0	0.0	3.3
2013	6.4	0.0	11.0	3.6	0.0	5.2

Percent prob. of level 2,3 => level 1 at least once: 37.1
Percent prob. of level 3 => level 2 at least once: 26.5

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	118747.2	148142.8	176363.0	210110.0	279170.8
2004	113043.8	144102.3	172025.6	210018.0	286038.1
2005	112276.5	153311.9	188452.0	236468.5	335992.0
2006	115809.8	160472.1	202765.8	256713.0	365576.9
2007	114725.3	166831.7	207307.1	257648.8	340681.5
2008	113657.4	170624.3	208857.7	255029.2	332343.6
2009	106397.6	172620.3	213290.9	261771.4	339058.0
2010	106878.3	178181.3	225706.0	273177.0	356753.9
2011	100111.4	184596.2	239395.5	284367.5	367737.8
2012	96581.1	200648.3	253363.5	308257.8	383034.4
2013	91430.6	206337.2	268657.1	320924.0	398295.3

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2005	2009	2014	2014	2014

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	128613.7	259047.4	390083.2	598373.3	1085329.6
2004	152023.5	226992.4	297889.6	400798.8	620019.3
2005	148697.4	225355.6	304246.0	397845.3	631605.1
2006	138028.3	218291.4	297273.7	397221.8	588820.4
2007	150384.2	224834.1	300700.7	395833.1	608520.9
2008	145761.0	220680.4	297925.2	394456.2	610716.4
2009	147874.5	222672.7	302758.5	396674.7	620903.2
2010	148233.6	226734.3	301529.1	388729.3	603919.0
2011	146177.2	225580.5	304047.0	396034.7	613218.8
2012	147777.9	215939.3	289805.5	394314.0	605492.6
2013	134070.5	218968.6	298461.0	407870.3	596129.9

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	56450.5	70258.4	82526.1	97128.9	125202.1
2004	52387.6	67385.4	79887.0	98774.5	138499.0
2005	49859.8	66828.1	81411.1	103532.4	148955.3
2006	49694.2	67777.4	82046.6	101137.8	146389.4
2007	50767.6	66784.8	79427.2	97913.0	134025.2
2008	50400.8	64700.9	77248.8	93077.1	120931.3
2009	48663.5	62195.3	73692.9	88122.1	112614.8
2010	48454.6	61042.5	72569.7	86448.9	108977.3
2011	47463.5	61420.9	73382.0	86169.8	106925.4
2012	46795.9	61234.0	72678.8	85835.8	104035.9
2013	47034.0	60529.5	72715.0	85361.6	105237.9

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0

2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	26.2	38.0	48.6	62.5	99.5
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	8.2	12.0	15.2	18.6	24.5
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	54231.1	68699.6	80483.5	97265.5	131118.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	52558.7	64850.8	74248.9	85589.3	103001.1
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.510	0.510	0.510	0.510	0.510
2004	0.363	0.422	0.466	0.520	0.625
2005	0.332	0.381	0.422	0.484	0.636
2006	0.297	0.343	0.387	0.458	0.630
2007	0.271	0.316	0.369	0.450	0.657
2008	0.240	0.292	0.347	0.430	0.701
2009	0.217	0.271	0.331	0.416	0.744
2010	0.203	0.250	0.304	0.399	0.749
2011	0.192	0.239	0.286	0.376	0.752
2012	0.179	0.228	0.271	0.356	0.816
2013	0.178	0.220	0.260	0.330	0.848

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%

2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.444	0.444	0.444	0.468	0.623
2005	0.386	0.386	0.394	0.462	0.634
2006	0.336	0.336	0.377	0.452	0.631
2007	0.292	0.309	0.359	0.445	0.641
2008	0.254	0.289	0.343	0.431	0.694
2009	0.233	0.266	0.324	0.421	0.738
2010	0.209	0.250	0.304	0.402	0.777
2011	0.200	0.241	0.279	0.376	0.713
2012	0.189	0.232	0.258	0.353	0.772
2013	0.178	0.227	0.250	0.327	0.790

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

8.3 TRAJECTORY FROM FSQ TO LONG TERM F =0.25 IN 5 YEARS WITH NO CONSTRAINT ON CHANGE IN TAC, WITH ASSESS`MENT BIAS AND IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.1.8

Run id 20040617 105351.336

```
 ************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 ************************************************

 Options from file ple.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   300000.0 300000.0
  2210000.0      0.250    0.000   300000.0 300000.0
  3300000.0      0.250    0.000   300000.0 300000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.509999990
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=        134383.
Recr. level= 305553.188
Stochastic term x has normal distribution with sigma= 0.4263
truncated at:  1.20

 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.000 +/- 0.100
Assumed overfishing of quotas with factor:  1.000 +/- 0.050
 Stochastic initial stock numbers - lognormal distribution

 ************************************************


 Probabilities of APPLIED levels and limits:
```

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	74.0	21.0	5.0	0.1	0.0
2005	62.8	28.4	8.8	0.2	0.0
2006	60.5	28.1	11.4	0.0	0.0
2007	61.4	30.7	7.9	0.0	0.0
2008	67.9	28.1	4.0	0.0	0.0
2009	70.7	25.1	4.2	0.0	0.0
2010	72.0	23.8	4.2	0.0	0.0
2011	70.3	24.5	5.2	0.0	0.0
2012	69.6	25.7	4.7	0.0	0.0
2013	67.0	27.5	5.5	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	74.9	22.0	3.1	0.0	0.0
2004	74.9	21.1	4.0	0.1	0.0
2005	63.5	28.7	7.8	0.2	0.0
2006	60.4	29.6	10.0	0.0	0.0
2007	63.7	30.2	6.1	0.0	0.0
2008	69.2	27.9	2.9	0.0	0.0
2009	73.3	24.2	2.5	0.0	0.0
2010	72.3	24.4	3.3	0.0	0.0
2011	73.1	23.9	3.0	0.0	0.0
2012	68.7	28.0	3.3	0.0	0.0
2013	67.8	27.7	4.5	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	15.1	1.4	4.2	5.2	0.1	1.7
2006	12.2	1.1	5.2	10.6	0.4	3.3
2007	11.0	0.3	2.9	11.3	0.9	5.8
2008	7.9	0.6	1.8	13.6	1.4	4.9
2009	9.2	0.5	2.5	11.9	0.6	2.2
2010	9.9	0.4	2.2	10.9	0.7	1.9
2011	8.5	0.7	3.0	7.3	0.2	2.5
2012	9.5	0.5	2.2	8.5	0.8	2.4

```
 2013       9.1       0.5       3.1       6.8       0.2
2.6

Percent prob. of level 2,3 => level 1 at least once: 66.6
Percent prob. of level   3 => level 2 at least once: 23.5


 Probabilities of shifts of TRUE level:
 (from previous year to present year)

 Year   %L 1=>2   %L 1=>3   %L 2=>3   %L 2=>1   %L 3=>1
%L3=>2
 2005      14.9       0.0       4.4       2.7       0.0
0.7
 2006      10.9       0.3       3.9       7.3       0.1
2.0
 2007       8.5       0.1       1.8      10.0       0.6
5.2
 2008       7.8       0.2       1.0      11.3       0.1
4.3
 2009       8.2       0.1       1.2      10.5       0.1
1.6
 2010       9.5       0.0       1.6       7.5       0.0
0.8
 2011       7.5       0.0       1.6       6.9       0.0
1.9
 2012       9.5       0.0       1.9       5.4       0.0
1.6
 2013       8.1       0.0       2.7       6.0       0.0
1.5

Percent prob. of level 2,3 => level 1 at least once: 54.3
Percent prob. of level   3 => level 2 at least once: 17.2


 Fractiles for SSB:

 Year        5%        25%        50%        75%        95%
 2003  118747.2  148142.8  176363.0  210110.0  279170.8
 2004  113043.8  144102.3  172025.6  210018.0  286038.1
 2005  110981.9  151326.4  185080.5  232513.5  330393.0
 2006  111542.9  154331.6  193594.1  242825.3  345264.8
 2007  104599.5  151781.7  189163.7  235194.8  307905.2
 2008   96993.1  147196.1  181536.9  220539.5  284209.8
 2009   84435.3  138630.6  175620.9  215889.2  281654.6
 2010   73180.6  132344.6  173738.1  214972.5  287937.4
 2011   63403.1  125964.9  172358.2  213986.1  284695.0
 2012   48672.8  124098.9  171709.5  221059.5  289037.6
 2013   41806.3  114505.6  173315.2  227021.9  296266.8
```

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2005	2014	2014	2014	2014

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	128613.7	259047.4	390083.2	598373.3	1085329.6
2004	152023.5	226992.4	297889.6	400798.8	620019.3
2005	148697.4	225355.6	304246.0	397845.3	631605.1
2006	137732.7	217831.6	297273.7	396943.7	588820.4
2007	149943.6	222590.5	298870.0	394889.4	603174.8
2008	144297.8	218976.8	294682.0	392790.4	609338.3
2009	137938.0	220716.9	298387.8	391620.8	617655.4
2010	136097.0	219083.6	291600.3	376638.3	595630.1
2011	121812.3	208877.5	289475.1	382887.9	583411.7
2012	119242.6	197220.1	276871.1	378413.6	598305.2
2013	95506.3	194865.6	278123.1	381524.8	581446.3

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	56450.5	70258.4	82526.1	97128.9	125202.1
2004	53512.0	69502.0	83487.3	102806.7	146223.7
2005	52606.1	71327.1	87386.4	111571.3	160587.7
2006	53306.2	73769.4	89688.3	111154.4	159692.3
2007	55239.1	73852.3	88202.6	107766.2	146404.3
2008	55116.6	71994.7	86194.9	102694.5	132193.8
2009	53309.0	69508.5	82551.3	97486.0	124757.1
2010	53824.4	68195.6	79987.9	94783.4	118983.8
2011	50750.0	67215.2	80031.8	93625.5	116165.2
2012	46451.2	65497.8	77982.3	91108.5	111730.6
2013	40178.4	63341.1	74905.8	88721.6	112151.0

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0

2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	26.3	38.3	49.9	66.4	115.8
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	8.4	12.3	15.8	19.4	25.7
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	58495.1	74374.6	86897.2	105365.1	140220.1
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	56434.4	71501.9	81733.4	92443.5	110307.1
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.510	0.510	0.510	0.510	0.510
2004	0.386	0.447	0.490	0.543	0.644
2005	0.372	0.426	0.475	0.534	0.678
2006	0.352	0.406	0.461	0.541	0.730
2007	0.348	0.402	0.467	0.569	0.866
2008	0.328	0.396	0.465	0.590	1.015
2009	0.309	0.393	0.481	0.623	1.167
2010	0.301	0.374	0.474	0.644	1.282
2011	0.293	0.362	0.473	0.661	1.372
2012	0.270	0.354	0.469	0.696	1.481
2013	0.263	0.342	0.460	0.735	1.437

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%

2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.474	0.474	0.474	0.474	0.623
2005	0.441	0.441	0.441	0.496	0.681
2006	0.410	0.410	0.440	0.522	0.729
2007	0.382	0.388	0.448	0.558	0.850
2008	0.355	0.386	0.460	0.585	0.995
2009	0.330	0.383	0.471	0.622	1.264
2010	0.307	0.378	0.476	0.643	1.370
2011	0.295	0.364	0.465	0.660	1.395
2012	0.284	0.353	0.461	0.696	1.500
2013	0.269	0.344	0.453	0.740	1.500

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

APPENDIX 9 RESULTS OF CALCULATIONS FOR NORTH SEA SOLE

9.1 TRAJECTORY FROM FSQ TO LONG TERM F =0.2 IN 5 YEARS WITHOUT CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.2.5

```
Run id 20040617  160503.767
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sol.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   100000.0 100000.0
  2 25000.0      0.200    0.000   100000.0 100000.0
  3 35000.0      0.200    0.000   100000.0 100000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.479999989
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=         21296.
Recr. level=  96762.000
Stochastic term x has normal distribution with sigma= 0.7797
truncated at:  1.80
```

Stock-recruit function not applied in year 0
Weights at age and maturity ogive were drawn from historical values
Assumed faulty assessment with factor: 1.100 +/- 0.050
Assumed overfishing of quotas with factor: 1.000 +/- 0.100
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	1.1	15.6	83.3	0.0	0.0
2005	3.7	19.9	76.4	0.0	0.0
2006	4.0	16.9	79.1	0.0	0.0
2007	2.1	10.4	87.5	0.0	0.0
2008	0.8	6.5	92.7	0.0	0.0
2009	0.2	3.2	96.6	0.0	0.0
2010	0.0	1.6	98.4	0.0	0.0
2011	0.0	0.6	99.4	0.0	0.0
2012	0.0	0.5	99.5	0.0	0.0
2013	0.0	0.2	99.8	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	17.8	48.2	34.0	0.0	0.0
2004	2.7	21.5	75.8	0.0	0.0
2005	6.7	25.3	68.0	0.0	0.0
2006	5.9	22.7	71.4	0.0	0.0
2007	3.4	15.3	81.3	0.0	0.0
2008	1.7	9.1	89.2	0.0	0.0
2009	0.6	5.2	94.2	0.0	0.0
2010	0.0	3.1	96.9	0.0	0.0
2011	0.0	1.3	98.7	0.0	0.0
2012	0.0	0.8	99.2	0.0	0.0
2013	0.0	0.3	99.7	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.7	0.3	8.4	1.8	1.8	13.8
2006	1.3	1.1	11.3	2.2	0.5	9.2

```
 2007       1.6       2.0      11.8       1.0       0.7
4.7
 2008       1.0       0.8       7.9       0.4       0.1
3.4
 2009       0.4       0.3       5.1       0.1       0.0
1.5
 2010       0.1       0.1       2.7       0.0       0.0
1.0
 2011       0.0       0.0       1.5       0.0       0.0
0.5
 2012       0.0       0.0       0.6       0.0       0.0
0.5
 2013       0.0       0.0       0.5       0.0       0.0
0.2

Percent prob. of level 2,3 => level 1 at least once:  8.3
Percent prob. of level   3 => level 2 at least once: 30.1


 Probabilities of shifts of TRUE level:
 (from previous year to present year)

 Year   %L 1=>2   %L 1=>3   %L 2=>3   %L 2=>1   %L 3=>1
%L3=>2
 2005       1.3       0.9       9.1       3.7       2.3
15.5
 2006       2.5       1.5      13.0       3.0       0.6
10.5
 2007       2.6       2.1      14.1       1.9       0.3
6.0
 2008       1.3       0.8      10.7       0.7       0.2
3.4
 2009       0.4       0.7       6.4       0.4       0.0
2.1
 2010       0.1       0.5       3.9       0.0       0.0
1.7
 2011       0.0       0.0       2.8       0.0       0.0
1.0
 2012       0.0       0.0       1.2       0.0       0.0
0.7
 2013       0.0       0.0       0.8       0.0       0.0
0.3

Percent prob. of level 2,3 => level 1 at least once:  9.2
Percent prob. of level   3 => level 2 at least once: 35.5


 Fractiles for SSB:

 Year        5%       25%       50%       75%       95%
 2003   21046.4   26574.3   31518.1   37506.2   47302.2
```

2004	26382.3	35324.4	43018.6	52952.0	72029.6
2005	23834.4	32303.9	41453.4	54051.5	85293.5
2006	23829.0	33373.3	44684.0	57638.9	86656.8
2007	26472.0	38741.1	49679.6	65041.3	94585.0
2008	29584.8	43732.9	56604.7	73781.4	104186.9
2009	34002.1	48304.3	63359.3	81364.9	118309.5
2010	37888.6	54225.6	69621.5	87525.0	122531.5
2011	41867.9	58961.0	75271.8	94877.0	131945.0
2012	44225.2	62099.8	78503.0	99570.9	136020.3
2013	48115.0	66014.3	81798.8	102014.5	135790.0

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2007

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	22140.7	51702.9	87468.6	145315.7	385527.4
2004	28627.2	55716.1	90201.1	162308.2	297343.4
2005	29026.4	58986.6	98417.6	163628.3	323161.0
2006	26989.7	53138.7	91360.9	157956.1	360260.5
2007	30533.6	55348.2	94546.8	158954.8	336683.7
2008	28578.4	57620.1	94762.3	156397.8	312948.1
2009	31374.3	61920.2	100090.7	168541.7	344775.5
2010	28275.1	58092.8	94424.7	155774.5	302635.1
2011	26216.1	57259.9	95352.8	166939.5	329087.1
2012	26001.1	59451.6	96998.3	162294.0	327819.2
2013	29547.7	57708.4	96267.4	160084.6	338338.8

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	13817.1	17226.9	20355.7	23999.1	30332.6
2004	13020.0	17356.7	21384.2	27032.2	38762.1
2005	10493.6	14695.1	18494.7	23695.5	36951.9
2006	9144.1	12627.0	16543.7	21564.6	31488.8
2007	8153.0	12113.2	15810.7	20534.1	28833.8
2008	7813.0	11613.6	15012.4	19036.4	27135.6
2009	8755.9	12808.0	16201.3	21115.9	29633.3
2010	9607.7	14075.5	17889.8	22494.3	30886.6
2011	10548.4	14558.6	18462.2	23339.4	32739.3
2012	11152.1	15615.7	19116.2	24500.4	33519.1
2013	11342.0	15905.5	19982.1	24700.7	33983.3

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	38.5	60.3	78.5	103.2	162.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	12.7	19.4	24.7	30.7	41.4
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	11480.1	14871.2	17951.1	21705.5	29422.4
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	11620.7	15511.5	18308.5	21876.6	27855.7
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.480	0.480	0.480	0.480	0.480
2004	0.353	0.414	0.454	0.503	0.583
2005	0.298	0.347	0.380	0.421	0.477
2006	0.255	0.290	0.319	0.348	0.395

2007	0.215	0.246	0.269	0.291	0.335
2008	0.181	0.206	0.225	0.245	0.278
2009	0.179	0.204	0.224	0.242	0.275
2010	0.183	0.205	0.224	0.245	0.279
2011	0.180	0.202	0.221	0.242	0.273
2012	0.182	0.205	0.223	0.244	0.273
2013	0.181	0.205	0.223	0.241	0.275

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.403	0.403	0.403	0.403	0.403
2005	0.339	0.339	0.339	0.339	0.339
2006	0.285	0.285	0.285	0.285	0.285
2007	0.239	0.239	0.239	0.239	0.239
2008	0.201	0.201	0.201	0.201	0.201
2009	0.200	0.200	0.200	0.200	0.200
2010	0.200	0.200	0.200	0.200	0.200
2011	0.200	0.200	0.200	0.200	0.200
2012	0.200	0.200	0.200	0.200	0.200
2013	0.200	0.200	0.200	0.200	0.200

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000

```
 2010      0.000      0.000      0.000      0.000      0.000
 2011      0.000      0.000      0.000      0.000      0.000
 2012      0.000      0.000      0.000      0.000      0.000
 2013      0.000      0.000      0.000      0.000      0.000
```

9.2 TRAJECTORY FROM FSQ TO LONG TERM F =0.2 IN 10 YEARS WITHOUT CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.2.6

```
Run id 20040617  160624.583
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sol.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   100000.0 100000.0
  2 25000.0      0.200    0.000   100000.0 100000.0
  3 35000.0      0.200    0.000   100000.0 100000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.479999989
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=         21296.
Recr. level=  96762.000
Stochastic term x has normal distribution with sigma= 0.7797
truncated at:  1.80
```

Stock-recruit function not applied in year 0
Weights at age and maturity ogive were drawn from historical values
Assumed faulty assessment with factor: 1.100 +/- 0.050
Assumed overfishing of quotas with factor: 1.000 +/- 0.100
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	1.1	15.6	83.3	0.0	0.0
2005	4.6	23.0	72.4	0.0	0.0
2006	6.9	22.9	70.2	0.0	0.0
2007	6.0	17.7	76.3	0.0	0.0
2008	4.5	16.0	79.5	0.0	0.0
2009	3.1	13.7	83.2	0.0	0.0
2010	1.7	10.1	88.2	0.0	0.0
2011	0.7	7.5	91.8	0.0	0.0
2012	0.7	3.8	95.5	0.0	0.0
2013	0.1	1.8	98.1	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	17.8	48.2	34.0	0.0	0.0
2004	2.7	21.5	75.8	0.0	0.0
2005	8.7	27.3	64.0	0.0	0.0
2006	11.3	25.9	62.8	0.0	0.0
2007	9.8	21.7	68.5	0.0	0.0
2008	7.2	20.4	72.4	0.0	0.0
2009	4.6	19.5	75.9	0.0	0.0
2010	3.7	13.7	82.6	0.0	0.0
2011	1.5	10.7	87.8	0.0	0.0
2012	0.9	6.1	93.0	0.0	0.0
2013	0.2	3.6	96.2	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.6	0.3	7.4	2.1	2.3	16.3
2006	1.9	1.1	11.0	3.5	1.8	12.5

2007	2.9	2.1	13.2	3.0	1.1	8.1
2008	2.7	1.9	9.8	2.1	1.0	7.5
2009	2.2	1.2	9.7	1.3	0.7	6.5
2010	1.3	1.2	9.6	0.7	0.4	5.4
2011	0.7	0.8	6.6	0.4	0.1	3.7
2012	0.2	0.5	5.6	0.5	0.2	2.2
2013	0.3	0.4	3.4	0.1	0.0	1.2

Percent prob. of level 2,3 => level 1 at least once: 18.1
Percent prob. of level 3 => level 2 at least once: 50.2

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	1.3	0.8	7.7	4.3	3.4	16.9
2006	3.5	1.8	12.5	5.1	2.3	13.2
2007	4.6	3.5	13.2	3.8	1.8	9.2
2008	4.2	2.5	12.0	2.6	1.1	9.5
2009	3.4	1.6	11.4	2.2	0.4	9.1
2010	1.8	1.4	12.5	1.7	0.7	6.5
2011	1.9	0.9	9.3	0.7	0.4	4.6
2012	0.4	1.0	7.7	0.8	0.1	3.4
2013	0.4	0.5	5.3	0.2	0.0	2.6

Percent prob. of level 2,3 => level 1 at least once: 18.2
Percent prob. of level 3 => level 2 at least once: 57.5

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	21046.4	26574.3	31518.1	37506.2	47302.2

2004	26382.3	35324.4	43018.6	52952.0	72029.6
2005	22770.3	30773.3	39716.6	52141.6	82710.4
2006	21015.9	30156.7	40480.4	52096.2	78000.7
2007	22050.5	32451.6	41931.9	55791.4	82620.3
2008	23078.5	33727.5	44740.2	58046.9	85534.4
2009	25202.3	35346.8	46686.8	61086.7	91677.0
2010	26196.2	39064.7	50481.4	65602.9	93658.7
2011	29334.6	42753.1	55270.1	71875.4	103150.5
2012	32355.0	46812.8	59354.0	76802.7	108208.1
2013	36736.1	50687.5	64522.0	82047.9	113460.6

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2008

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	22140.7	51702.9	87468.6	145315.7	385527.4
2004	28627.2	55716.1	90201.1	162308.2	297343.4
2005	29026.4	58986.6	98417.6	163628.3	323161.0
2006	26989.7	53138.7	91224.8	157240.7	360260.5
2007	30269.8	55251.1	94373.0	158931.8	332988.5
2008	28407.9	56811.6	94202.8	156274.7	308407.8
2009	31264.3	61568.5	99563.9	167938.5	343509.1
2010	28275.1	58092.8	94424.7	155774.5	302635.1
2011	26172.7	57126.1	95352.8	166939.5	329087.1
2012	26001.1	59451.6	96998.3	162294.0	327819.2
2013	29547.7	57708.4	96267.4	160084.6	338338.8

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	13817.1	17226.9	20355.7	23999.1	30332.6
2004	14020.8	18666.1	22997.5	29087.5	41687.6
2005	11794.6	16483.1	20742.2	26707.8	41807.8
2006	10369.7	14528.2	19108.1	25077.7	36315.1
2007	9615.6	14459.8	19006.5	24646.7	34271.6
2008	9595.5	14264.9	18525.6	23331.6	33720.7
2009	9667.5	13829.7	17510.4	23069.9	33278.2
2010	9485.8	13911.4	17935.0	22962.2	31535.8
2011	9719.4	13518.9	17177.0	22329.4	31187.0
2012	9547.8	13768.1	17118.0	22038.8	30379.2
2013	9544.9	13424.1	16956.4	21822.2	30447.5

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	41.3	62.3	82.2	109.0	183.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	12.2	18.8	24.8	31.3	42.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	13175.0	17055.1	20759.3	25045.4	33748.0
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	11418.5	15324.6	18192.9	21902.0	28291.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.480	0.480	0.480	0.480	0.480
2004	0.386	0.453	0.499	0.554	0.645
2005	0.356	0.417	0.458	0.509	0.582
2006	0.333	0.381	0.422	0.462	0.530

2007	0.308	0.355	0.389	0.423	0.493
2008	0.283	0.326	0.357	0.391	0.450
2009	0.266	0.298	0.328	0.358	0.410
2010	0.246	0.276	0.302	0.331	0.380
2011	0.223	0.250	0.274	0.300	0.340
2012	0.206	0.233	0.254	0.277	0.312
2013	0.189	0.214	0.232	0.252	0.287

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.442	0.442	0.442	0.442	0.442
2005	0.406	0.406	0.406	0.406	0.406
2006	0.374	0.374	0.374	0.374	0.374
2007	0.344	0.344	0.344	0.344	0.344
2008	0.316	0.316	0.316	0.316	0.316
2009	0.291	0.291	0.291	0.291	0.291
2010	0.268	0.268	0.268	0.268	0.268
2011	0.246	0.246	0.246	0.246	0.246
2012	0.227	0.227	0.227	0.227	0.227
2013	0.209	0.209	0.209	0.209	0.209

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000

```
 2010     0.000     0.000     0.000     0.000     0.000
 2011     0.000     0.000     0.000     0.000     0.000
 2012     0.000     0.000     0.000     0.000     0.000
 2013     0.000     0.000     0.000     0.000     0.000
```

9.3 TRAJECTORY FROM FSQ TO LONG TERM F =0.2 IN 5 YEARS WITH A 15% CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.2.7

```
Run id 20040617  153807.363
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sol.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   100000.0 100000.0
  2 25000.0      0.200    0.000   100000.0 100000.0
  3 35000.0      0.200    0.000   100000.0 100000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.479999989
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=         21296.
Recr. level=  96762.000
Stochastic term x has normal distribution with sigma= 0.7797
truncated at:  1.80

 Stock-recruit function not applied in year 0
```

Weights at age and maturity ogive were drawn from historical values
Assumed faulty assessment with factor: 1.100 +/- 0.050
Assumed overfishing of quotas with factor: 1.000 +/- 0.100
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	1.1	15.6	83.3	0.0	0.0
2005	4.8	20.9	74.3	0.0	0.0
2006	7.5	19.4	73.1	0.0	0.0
2007	7.1	15.8	77.1	0.0	0.0
2008	6.9	14.2	78.9	0.0	0.0
2009	6.4	12.6	81.0	0.0	0.0
2010	5.4	8.1	86.5	0.0	0.0
2011	3.8	7.9	88.3	0.0	0.0
2012	2.5	6.8	90.7	0.0	0.0
2013	1.7	4.3	94.0	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	17.8	48.2	34.0	0.0	0.0
2004	2.7	21.5	75.8	0.0	0.0
2005	8.5	25.2	66.3	0.0	0.0
2006	11.4	22.7	65.9	0.0	0.0
2007	10.6	18.8	70.6	0.0	0.0
2008	10.2	16.2	73.6	0.0	0.0
2009	8.8	14.7	76.5	0.0	0.0
2010	6.9	12.3	80.8	0.0	0.0
2011	5.8	9.2	85.0	0.0	0.0
2012	3.3	7.6	89.1	0.0	0.0
2013	2.2	5.5	92.3	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.7	0.2	7.7	2.3	2.3	14.6
2006	1.4	1.2	9.6	3.9	1.4	10.6
2007	1.9	2.5	10.7	2.9	1.1	8.1

2008	2.3	1.3	7.8	2.6	0.8	6.5
2009	2.5	1.2	7.2	2.4	0.8	5.5
2010	1.3	1.5	8.4	1.4	0.4	4.0
2011	1.9	0.9	5.1	0.8	0.4	3.8
2012	1.2	1.4	3.2	1.2	0.1	2.1
2013	0.6	0.8	4.6	0.6	0.0	2.1

```
Percent prob. of level 2,3 => level 1 at least once: 21.4
Percent prob. of level   3 => level 2 at least once: 45.5
```

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	1.3	0.7	8.4	4.8	2.5	16.1
2006	2.5	1.5	11.7	5.2	1.6	12.0
2007	3.3	3.4	10.9	3.9	1.2	8.4
2008	3.1	2.6	8.6	3.3	1.0	7.2
2009	3.4	2.6	7.0	3.4	0.6	6.1
2010	2.0	1.7	7.9	2.0	0.4	4.9
2011	2.4	1.0	7.0	1.4	0.2	3.6
2012	2.0	1.7	5.0	1.0	0.1	2.5
2013	0.7	1.2	4.7	0.6	0.1	2.6

```
Percent prob. of level 2,3 => level 1 at least once: 21.7
Percent prob. of level   3 => level 2 at least once: 51.6
```

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	21046.4	26574.3	31518.1	37506.2	47302.2
2004	26382.3	35324.4	43018.6	52952.0	72029.6
2005	22860.4	31648.3	41345.9	53880.6	85275.0

2006	20915.8	31043.7	41607.7	55325.4	84333.0
2007	21266.3	32775.3	43993.0	59489.2	90474.5
2008	21638.4	34025.4	48205.2	64771.0	93998.5
2009	21343.7	35738.6	51490.6	68820.0	104341.5
2010	21982.8	38870.3	54385.8	76301.8	108399.1
2011	24287.6	43149.9	60722.3	81056.0	118465.7
2012	27190.1	46683.4	65417.4	86591.0	125779.6
2013	30296.1	51010.2	71725.0	92100.9	129693.0

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2008

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	22140.7	51702.9	87468.6	145315.7	385527.4
2004	28627.2	55716.1	90201.1	162308.2	297343.4
2005	29026.4	58986.6	98417.6	163628.3	323161.0
2006	26989.7	53138.7	91080.5	157315.8	360260.5
2007	29860.9	55044.7	94293.6	158931.8	332170.8
2008	28407.9	56419.3	94181.6	155219.7	307115.0
2009	31212.6	60370.3	98798.5	167727.8	343509.1
2010	27949.5	58092.8	92861.5	155123.0	302635.1
2011	25484.2	56001.9	94011.4	166890.3	329087.1
2012	26001.1	59163.9	96296.3	160686.5	327819.2
2013	29432.7	57482.5	96140.9	160084.6	338338.8

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	13817.1	17226.9	20355.7	23999.1	30332.6
2004	13698.9	17839.7	21728.2	27254.2	38762.1
2005	12287.5	16467.0	20023.5	25239.0	37741.0
2006	11063.2	15081.1	18965.0	24010.3	34498.5
2007	10587.3	14684.5	18478.8	23271.1	32881.0
2008	10308.1	14339.9	17723.4	22327.2	31693.5
2009	10045.2	13918.9	17151.0	21774.9	30409.2
2010	9748.2	13951.3	17703.0	21876.6	28953.9
2011	9638.2	13857.8	17350.6	21684.5	29206.0
2012	10061.1	13993.1	17596.6	22129.5	29262.9
2013	9818.3	14286.5	17944.4	22358.7	29757.0

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%

2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	33.2	51.5	68.3	90.2	155.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	9.6	15.0	19.6	24.6	32.9
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	13243.3	16402.1	19843.4	24062.5	31972.4
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	11166.3	15326.0	17952.1	21544.3	27002.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.480	0.480	0.480	0.480	0.480
2004	0.358	0.418	0.464	0.518	0.630
2005	0.319	0.374	0.426	0.495	0.620
2006	0.276	0.340	0.393	0.466	0.609
2007	0.250	0.307	0.363	0.432	0.572
2008	0.219	0.273	0.325	0.396	0.536

2009	0.198	0.244	0.294	0.362	0.501
2010	0.193	0.229	0.265	0.334	0.479
2011	0.177	0.213	0.245	0.297	0.430
2012	0.172	0.207	0.235	0.277	0.381
2013	0.170	0.201	0.227	0.256	0.344

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.403	0.403	0.403	0.403	0.495
2005	0.339	0.339	0.359	0.435	0.468
2006	0.285	0.299	0.356	0.393	0.514
2007	0.239	0.272	0.330	0.371	0.463
2008	0.201	0.245	0.282	0.346	0.451
2009	0.200	0.224	0.259	0.320	0.439
2010	0.185	0.200	0.235	0.286	0.415
2011	0.168	0.200	0.215	0.261	0.371
2012	0.167	0.200	0.200	0.235	0.347
2013	0.164	0.193	0.200	0.224	0.302

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000

```
 2012     0.000     0.000     0.000     0.000     0.000
 2013     0.000     0.000     0.000     0.000     0.000
```

9.4 TRAJECTORY FROM FSQ TO LONG TERM F =0.2 IN 10 YEARS WITH A 15% CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.2.8

```
Run id 20040617  154737.422
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sol.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   100000.0 100000.0
  2 25000.0      0.200    0.000   100000.0 100000.0
  3 35000.0      0.200    0.000   100000.0 100000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.479999989
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=          21296.
Recr. level=  96762.000
Stochastic term x has normal distribution with sigma= 0.7797
truncated at:  1.80

 Stock-recruit function not applied in year 0
```

Weights at age and maturity ogive were drawn from historical values
Assumed faulty assessment with factor: 1.100 +/- 0.050
Assumed overfishing of quotas with factor: 1.000 +/- 0.100
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	1.1	15.6	83.3	0.0	0.0
2005	5.1	23.2	71.7	0.0	0.0
2006	9.9	23.3	66.8	0.0	0.0
2007	10.8	19.3	69.9	0.0	0.0
2008	11.6	19.0	69.4	0.0	0.0
2009	11.4	18.6	70.0	0.0	0.0
2010	10.7	16.2	73.1	0.0	0.0
2011	9.9	14.5	75.6	0.0	0.0
2012	7.7	14.8	77.5	0.0	0.0
2013	5.6	14.1	80.3	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	17.8	48.2	34.0	0.0	0.0
2004	2.7	21.5	75.8	0.0	0.0
2005	9.3	27.3	63.4	0.0	0.0
2006	15.0	26.0	59.0	0.0	0.0
2007	15.8	23.4	60.8	0.0	0.0
2008	15.8	22.3	61.9	0.0	0.0
2009	15.6	21.3	63.1	0.0	0.0
2010	13.7	22.4	63.9	0.0	0.0
2011	12.6	18.7	68.7	0.0	0.0
2012	10.5	17.0	72.5	0.0	0.0
2013	8.2	17.6	74.2	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.5	0.3	7.4	2.2	2.6	16.7
2006	1.5	1.0	9.9	5.0	2.3	13.5
2007	2.6	2.9	11.9	4.1	2.3	9.4

2008	2.8	2.6	8.6	4.0	2.2	9.5
2009	3.2	2.5	9.7	4.2	1.3	10.3
2010	2.5	3.8	8.5	4.0	1.6	7.6
2011	3.1	2.2	9.3	2.6	1.9	7.1
2012	3.4	2.6	6.8	2.6	1.2	6.3
2013	2.8	2.3	7.8	2.5	0.5	6.8

Percent prob. of level 2,3 => level 1 at least once: 37.1
Percent prob. of level 3 => level 2 at least once: 65.3

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	1.2	0.7	7.6	4.8	3.4	17.3
2006	2.9	1.8	10.9	6.4	3.4	13.7
2007	4.0	4.3	10.5	5.6	3.0	10.0
2008	4.7	3.0	10.0	4.7	2.4	9.5
2009	4.4	3.1	9.0	5.3	1.3	9.6
2010	3.9	3.1	8.6	4.7	1.5	9.4
2011	4.5	3.0	11.1	3.8	1.4	7.9
2012	4.5	2.6	9.0	3.3	0.9	6.9
2013	3.8	2.6	7.5	2.9	0.9	7.5

Percent prob. of level 2,3 => level 1 at least once: 34.4
Percent prob. of level 3 => level 2 at least once: 68.6

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	21046.4	26574.3	31518.1	37506.2	47302.2
2004	26382.3	35324.4	43018.6	52952.0	72029.6
2005	22188.3	30491.5	39653.8	52035.8	82083.4

2006	19353.0	28671.2	38632.4	51309.0	76823.5
2007	19347.3	29249.4	39154.5	52893.9	78929.8
2008	18969.9	29305.6	40560.6	53498.6	79604.1
2009	18323.1	29465.3	40709.1	54125.9	83187.0
2010	18412.5	30727.0	41114.0	57008.6	85849.2
2011	19140.8	31782.8	43917.6	60211.5	89488.8
2012	20695.7	33477.5	45893.0	61116.9	93197.0
2013	21878.9	34534.4	47936.4	65353.9	94952.9

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2009

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	22140.7	51702.9	87468.6	145315.7	385527.4
2004	28627.2	55716.1	90201.1	162308.2	297343.4
2005	29026.4	58986.6	98417.6	163628.3	323161.0
2006	26989.7	53138.7	91224.8	157240.7	360260.5
2007	29860.9	54677.4	94146.6	158643.0	323653.2
2008	28407.9	56419.3	93902.3	155276.3	307112.7
2009	30881.0	60084.2	97912.6	167034.8	343509.1
2010	27904.8	57982.5	92861.5	154660.6	299722.9
2011	25449.0	55755.8	93858.6	165075.1	323618.2
2012	25769.6	59043.2	96212.7	160253.9	327819.2
2013	28848.9	56209.0	96129.5	158385.1	332667.4

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	13817.1	17226.9	20355.7	23999.1	30332.6
2004	14483.1	18997.1	23131.5	29098.7	41687.6
2005	12752.0	17585.7	21637.0	27581.9	42397.3
2006	11549.2	15967.7	20527.8	26415.7	38021.3
2007	10915.9	15761.2	20300.4	25977.5	36528.0
2008	10715.7	15749.4	19985.5	25311.0	36139.7
2009	10759.8	15196.6	19221.6	24788.5	35946.0
2010	10482.0	15251.2	19743.4	24892.8	33782.8
2011	10443.0	15062.0	19069.9	24319.1	34620.7
2012	10330.9	15250.8	19022.5	24368.3	32414.2
2013	10507.6	15033.1	18917.6	24041.5	33697.0

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%

2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	36.8	56.4	75.4	97.9	161.5
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	11.0	16.6	22.0	27.6	38.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	14029.9	17998.0	21811.4	26211.7	34985.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	12281.8	16725.6	19931.1	23746.4	30360.1
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.480	0.480	0.480	0.480	0.480
2004	0.390	0.456	0.503	0.562	0.658
2005	0.375	0.439	0.488	0.547	0.642
2006	0.356	0.422	0.473	0.532	0.638
2007	0.343	0.407	0.456	0.515	0.628
2008	0.324	0.390	0.440	0.502	0.619

2009	0.310	0.369	0.420	0.483	0.594
2010	0.297	0.356	0.405	0.471	0.587
2011	0.278	0.332	0.380	0.443	0.558
2012	0.264	0.313	0.366	0.430	0.526
2013	0.250	0.301	0.346	0.404	0.513

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.442	0.442	0.442	0.442	0.495
2005	0.406	0.406	0.406	0.477	0.477
2006	0.374	0.374	0.439	0.439	0.515
2007	0.344	0.371	0.404	0.438	0.477
2008	0.316	0.364	0.377	0.436	0.502
2009	0.296	0.342	0.371	0.401	0.471
2010	0.280	0.314	0.363	0.396	0.470
2011	0.267	0.303	0.339	0.387	0.464
2012	0.256	0.288	0.321	0.367	0.438
2013	0.245	0.279	0.308	0.350	0.423

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000

```
 2012     0.000     0.000     0.000     0.000     0.000
 2013     0.000     0.000     0.000     0.000     0.000
```

9.5 TRAJECTORY FROM FSQ TO LONG TERM F =0.3 IN 5 YEARS WITHOUT CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.2.9

```
Run id 20040617  160737.969
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sol.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

   1     0.0      0.050    0.000   100000.0 100000.0
   2 25000.0      0.300    0.000   100000.0 100000.0
   3 35000.0      0.300    0.000   100000.0 100000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.479999989
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=         21296.
Recr. level=  96762.000
Stochastic term x has normal distribution with sigma= 0.7797
truncated at:  1.80

 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
```

Assumed faulty assessment with factor: 1.100 +/- 0.050
Assumed overfishing of quotas with factor: 1.000 +/- 0.100
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	1.1	15.6	83.3	0.0	0.0
2005	4.6	22.6	72.8	0.0	0.0
2006	6.6	22.0	71.4	0.0	0.0
2007	5.4	17.1	77.5	0.0	0.0
2008	3.9	14.7	81.4	0.0	0.0
2009	2.0	12.1	85.9	0.0	0.0
2010	1.2	9.3	89.5	0.0	0.0
2011	0.5	7.9	91.6	0.0	0.0
2012	0.5	5.7	93.8	0.0	0.0
2013	0.3	4.4	95.3	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	17.8	48.2	34.0	0.0	0.0
2004	2.7	21.5	75.8	0.0	0.0
2005	8.3	27.1	64.6	0.0	0.0
2006	10.8	25.3	63.9	0.0	0.0
2007	9.0	20.5	70.5	0.0	0.0
2008	6.3	19.3	74.4	0.0	0.0
2009	3.7	16.9	79.4	0.0	0.0
2010	2.9	12.7	84.4	0.0	0.0
2011	1.3	11.6	87.1	0.0	0.0
2012	0.9	9.4	89.7	0.0	0.0
2013	0.7	7.6	91.7	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.6	0.3	7.4	2.1	2.3	15.9
2006	1.8	1.2	11.0	3.4	1.6	12.0
2007	2.9	2.1	12.5	2.9	0.9	7.6
2008	2.5	1.5	9.8	1.6	0.9	6.5

2009	1.8	1.3	9.0	1.0	0.2	5.6
2010	0.9	0.8	8.7	0.6	0.3	5.6
2011	0.6	0.5	6.2	0.3	0.1	4.5
2012	0.0	0.5	5.6	0.3	0.2	3.7
2013	0.2	0.3	4.9	0.2	0.1	3.6

Percent prob. of level 2,3 => level 1 at least once: 16.3
Percent prob. of level 3 => level 2 at least once: 50.3

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	1.3	0.8	7.9	4.3	3.0	16.9
2006	3.2	1.7	12.8	5.1	2.0	13.2
2007	4.6	3.4	13.4	3.5	1.7	8.5
2008	4.1	2.4	11.4	2.4	1.0	8.9
2009	3.0	1.3	11.9	1.7	0.4	7.8
2010	1.1	1.6	11.0	1.1	0.8	6.8
2011	1.3	1.0	7.7	0.7	0.4	5.6
2012	0.3	0.8	7.8	0.7	0.1	5.9
2013	0.3	0.5	7.0	0.3	0.2	5.3

Percent prob. of level 2,3 => level 1 at least once: 17.1
Percent prob. of level 3 => level 2 at least once: 59.0

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	21046.4	26574.3	31518.1	37506.2	47302.2
2004	26382.3	35324.4	43018.6	52952.0	72029.6
2005	22893.0	30972.9	39981.8	52351.5	83029.0
2006	21359.6	30551.2	40964.6	52679.1	79135.4
2007	22616.2	33178.9	42889.7	57037.3	84250.0

2008	23933.1	34809.3	46092.9	60008.8	87505.5
2009	26328.1	36931.6	48777.2	63803.1	94958.3
2010	27289.5	40102.4	51648.2	66627.7	94779.6
2011	30112.0	41658.6	54237.1	70185.4	100712.7
2012	30696.3	43583.0	55262.9	71906.9	100843.1
2013	32104.6	44532.8	56160.5	72404.9	100626.4

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2008

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	22140.7	51702.9	87468.6	145315.7	385527.4
2004	28627.2	55716.1	90201.1	162308.2	297343.4
2005	29026.4	58986.6	98417.6	163628.3	323161.0
2006	26989.7	53138.7	91224.8	157240.7	360260.5
2007	30269.8	55324.7	94373.0	158931.8	335029.1
2008	28407.9	56811.6	94202.8	156297.9	312373.4
2009	31374.3	61568.5	99563.9	167938.5	343509.1
2010	28275.1	58092.8	94424.7	155774.5	302635.1
2011	26197.4	57148.2	95352.8	166939.5	329087.1
2012	26001.1	59451.6	96998.3	162294.0	327819.2
2013	29547.7	57708.4	96267.4	160084.6	338338.8

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	13817.1	17226.9	20355.7	23999.1	30332.6
2004	13897.6	18505.2	22799.3	28837.3	41328.1
2005	11642.1	16260.0	20462.6	26325.9	41209.5
2006	10235.0	14306.0	18795.2	24662.6	35759.7
2007	9447.7	14184.1	18598.8	24182.5	33566.0
2008	9417.2	14027.4	18135.5	22921.3	32917.5
2009	9480.3	14450.7	18539.4	24517.8	34994.4
2010	9674.1	15627.1	20074.5	25539.6	35001.4
2011	10723.1	15638.6	19946.9	25988.7	36112.7
2012	11192.4	16450.5	20596.4	26474.9	36402.5
2013	11304.9	16451.5	20820.5	26776.3	37117.6

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0

2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	39.9	61.9	80.0	103.6	160.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	12.2	18.8	24.8	31.2	42.3
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	12950.6	16808.1	20418.2	24680.8	33297.8
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	12626.9	17202.9	20414.9	24525.6	31694.2
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.480	0.480	0.480	0.480	0.480
2004	0.382	0.449	0.493	0.547	0.637
2005	0.349	0.408	0.447	0.497	0.568
2006	0.323	0.369	0.408	0.447	0.511
2007	0.295	0.340	0.372	0.405	0.471
2008	0.268	0.308	0.337	0.370	0.425
2009	0.264	0.303	0.334	0.366	0.419
2010	0.267	0.304	0.335	0.370	0.428

2011	0.260	0.299	0.331	0.364	0.416
2012	0.264	0.304	0.333	0.368	0.419
2013	0.265	0.306	0.333	0.364	0.421

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.437	0.437	0.437	0.437	0.437
2005	0.397	0.397	0.397	0.397	0.397
2006	0.362	0.362	0.362	0.362	0.362
2007	0.329	0.329	0.329	0.329	0.329
2008	0.300	0.300	0.300	0.300	0.300
2009	0.273	0.300	0.300	0.300	0.300
2010	0.273	0.300	0.300	0.300	0.300
2011	0.270	0.300	0.300	0.300	0.300
2012	0.273	0.300	0.300	0.300	0.300
2013	0.273	0.300	0.300	0.300	0.300

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

9.6 TRAJECTORY FROM FSQ TO LONG TERM F =0.4 IN 5 YEARS WITHOUT CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in Figure 4.2.10

```
Run id 20040617  161002.026
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sol.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.050    0.000   100000.0 100000.0
  2 25000.0      0.400    0.000   100000.0 100000.0
  3 35000.0      0.400    0.000   100000.0 100000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.479999989
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=         21296.
Recr. level=  96762.000
Stochastic term x has normal distribution with sigma= 0.7797
truncated at:  1.80

 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.100 +/- 0.050
```

Assumed overfishing of quotas with factor: 1.000 +/- 0.100
Stochastic initial stock numbers - lognormal distribution

****

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2004	1.1	15.6	83.3	0.0	0.0
2005	5.8	24.0	70.2	0.0	0.0
2006	9.4	25.6	65.0	0.0	0.0
2007	9.8	22.0	68.2	0.0	0.0
2008	9.4	21.2	69.4	0.0	0.0
2009	9.4	21.0	69.6	0.0	0.0
2010	8.4	20.3	71.3	0.0	0.0
2011	7.2	20.0	72.8	0.0	0.0
2012	5.9	19.3	74.8	0.0	0.0
2013	5.2	19.5	75.3	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2003	17.8	48.2	34.0	0.0	0.0
2004	2.7	21.5	75.8	0.0	0.0
2005	9.4	28.5	62.1	0.0	0.0
2006	15.3	27.5	57.2	0.0	0.0
2007	14.5	26.1	59.4	0.0	0.0
2008	14.2	23.9	61.9	0.0	0.0
2009	13.8	25.5	60.7	0.0	0.0
2010	11.8	24.7	63.5	0.0	0.0
2011	11.4	24.3	64.3	0.0	0.0
2012	9.1	24.4	66.5	0.0	0.0
2013	8.4	24.0	67.6	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.4	0.3	7.1	2.3	3.1	17.4
2006	2.1	1.1	10.9	4.3	2.5	14.7
2007	3.5	2.5	13.4	4.0	2.4	10.3
2008	3.2	2.4	11.5	3.3	1.9	10.8

2009	3.3	1.9	11.5	3.2	2.0	11.2
2010	2.8	3.4	11.3	3.3	1.9	11.1
2011	3.6	2.1	11.9	2.6	1.9	10.6
2012	2.6	2.7	10.3	2.8	1.2	9.8
2013	2.5	2.6	10.4	2.1	2.3	10.2

Percent prob. of level 2,3 => level 1 at least once: 37.0
Percent prob. of level 3 => level 2 at least once: 74.0

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	1.1	0.8	7.6	4.8	3.6	18.5
2006	3.4	1.9	11.1	6.5	4.0	13.9
2007	4.7	4.2	11.1	5.0	2.8	10.3
2008	4.5	3.8	11.5	5.0	2.3	10.5
2009	4.7	2.8	10.5	4.7	2.2	12.3
2010	4.4	3.5	11.7	4.8	2.0	10.5
2011	4.6	3.0	11.7	4.1	2.9	11.0
2012	4.3	3.0	11.9	4.5	0.9	11.8
2013	3.9	2.7	11.7	3.8	2.3	11.0

Percent prob. of level 2,3 => level 1 at least once: 35.1
Percent prob. of level 3 => level 2 at least once: 77.0

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	21046.4	26574.3	31518.1	37506.2	47302.2
2004	26382.3	35324.4	43018.6	52952.0	72029.6
2005	22197.9	30118.8	38807.8	51291.5	81448.2
2006	19780.6	28312.7	38264.5	49611.8	74638.7
2007	19860.6	29404.3	38623.6	51540.3	76161.3

2008	19842.3	29252.6	39130.9	51041.0	76568.2
2009	20543.0	29361.3	39018.1	51439.1	79001.7
2010	20611.7	30502.4	39920.3	52364.4	76624.1
2011	21263.6	30853.3	41103.7	54066.7	80739.2
2012	21967.0	31289.0	41072.5	53892.7	77571.1
2013	22552.3	32038.6	41497.1	53775.5	78472.7

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2009

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	22140.7	51702.9	87468.6	145315.7	385527.4
2004	28627.2	55716.1	90201.1	162308.2	297343.4
2005	29026.4	58986.6	98417.6	163628.3	323161.0
2006	26989.7	53138.7	91224.8	156464.2	360260.5
2007	30108.0	55147.4	94146.6	158643.0	330253.5
2008	28407.9	56631.0	94181.6	155533.0	307432.1
2009	31212.6	61149.5	99035.0	167727.8	343509.1
2010	28129.5	58092.8	93969.8	155272.1	299722.9
2011	26172.7	56077.4	95003.7	166890.3	324764.3
2012	26001.1	58888.8	96560.6	160899.3	324644.4
2013	29454.0	56599.1	96129.5	159526.3	335484.7

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	13817.1	17226.9	20355.7	23999.1	30332.6
2004	14508.0	19300.7	23781.0	30089.8	43108.3
2005	12374.7	17335.0	21886.0	28222.4	44171.3
2006	10914.4	15464.0	20190.8	26764.9	39034.3
2007	10138.2	15429.2	20397.9	26496.6	37673.4
2008	10146.6	15401.5	20228.4	25771.4	37745.6
2009	10224.1	15396.9	19748.5	26198.6	39137.1
2010	10121.1	15611.9	20842.7	26640.2	37241.6
2011	10341.0	15304.3	20310.9	26583.5	38702.4
2012	10562.4	15828.8	20586.2	26920.2	37371.8
2013	10610.3	15863.3	20522.9	26721.9	38698.7

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0

2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	42.7	65.8	86.5	109.5	168.0
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	12.5	19.3	25.2	31.8	43.2
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	13891.5	18071.3	22154.7	26642.3	35594.8
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	12923.9	17694.8	21194.8	25601.1	32931.1
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.480	0.480	0.480	0.480	0.480
2004	0.402	0.473	0.521	0.579	0.676
2005	0.387	0.454	0.499	0.557	0.640
2006	0.378	0.433	0.481	0.529	0.609
2007	0.364	0.421	0.464	0.506	0.592
2008	0.355	0.408	0.451	0.497	0.573
2009	0.351	0.403	0.446	0.491	0.567
2010	0.355	0.404	0.446	0.495	0.579

2011	0.342	0.395	0.440	0.485	0.560
2012	0.339	0.395	0.439	0.485	0.567
2013	0.341	0.399	0.436	0.483	0.564

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.461	0.461	0.461	0.461	0.461
2005	0.442	0.442	0.442	0.442	0.442
2006	0.425	0.425	0.425	0.425	0.425
2007	0.408	0.408	0.408	0.408	0.408
2008	0.391	0.391	0.400	0.400	0.400
2009	0.376	0.384	0.400	0.400	0.400
2010	0.361	0.384	0.400	0.400	0.400
2011	0.346	0.384	0.400	0.400	0.400
2012	0.354	0.384	0.400	0.400	0.400
2013	0.346	0.383	0.400	0.400	0.400

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

APPENDIX 10 RESULTS OF CALCULATIONS FOR NORTH SEA AND WEST OF SCOTLAND SAITHE

10.1 TRANSITORY EFFECTS OF THE BASE CASE HCR (LONG TERM F=0.25, YEAR ON YEAR VARIATION IN CATCH +/-10%).

This run is shown graphically in Figure 0.2

```
Run id 20040616  115033.056
 **************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 **************************************************

 Options from file sei.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.100    0.000    10000.0  10000.0
  2   106.0      0.250    0.000    10000.0  10000.0
  3   200.0      0.250    0.000    10000.0  10000.0
 In level 2, F increases gradually with SSB from F1 to F3


 For the intermediate year  2003
 the following assumptions were made:
 For fleet 1: F- constraint =  0.259999990
 For fleet 2: F- constraint =  0.00000000E+00

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 0.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.500 for Fleet 1
 0.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=           250.
Recr. level=    251.000
Stochastic term x has normal distribution with sigma= 0.4400
truncated at:  1.00
```

```
 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.000 +/- 0.250
Assumed overfishing of quotas with factor:  1.000 +/- 0.000
 Stochastic initial stock numbers - lognormal distribution

 **************************************************


 Probabilities of APPLIED levels and limits:

 Year  %Level 1  %Level 2  %Level 3  %Max c1  %Max c2
 2004      0.0       1.1      98.9      0.0      0.0
 2005      0.0       0.9      99.1      0.0      0.0
 2006      0.0       1.7      98.3      0.0      0.0
 2007      0.2       2.0      97.8      0.0      0.0
 2008      0.1       2.6      97.3      0.0      0.0
 2009      0.6       1.9      97.5      0.0      0.0
 2010      0.8       3.2      96.0      0.0      0.0
 2011      1.1       4.3      94.6      0.0      0.0
 2012      2.4       3.6      94.0      0.0      0.0
 2013      2.2       3.9      93.9      0.0      0.0


 Probabilities of TRUE levels and limits:

 Year  %Level 1  %Level 2  %Level 3  %>Max c1 %>Max c2
 2003      0.0       1.1      98.9      0.0      0.0
 2004      0.0       0.3      99.7      0.0      0.0
 2005      0.0       0.3      99.7      0.0      0.0
 2006      0.0       0.3      99.7      0.0      0.0
 2007      0.1       0.7      99.2      0.0      0.0
 2008      0.0       1.5      98.5      0.0      0.0
 2009      0.4       1.7      97.9      0.0      0.0
 2010      0.7       2.0      97.3      0.0      0.0
 2011      0.9       3.8      95.3      0.0      0.0
 2012      2.0       3.3      94.7      0.0      0.0
 2013      2.2       3.4      94.4      0.0      0.0


 Probabilities of shifts of APPLIED level:
 (from previous year to present year)

 Year   %L 1=>2   %L 1=>3   %L 2=>3   %L 2=>1   %L 3=>1
%L3=>2
 2005       0.0       0.0       1.0       0.0       0.0
0.8
 2006       0.0       0.0       0.8       0.0       0.0
1.6
```

2007	0.0	0.0	1.4	0.0	0.2	1.7
2008	0.1	0.1	1.5	0.0	0.1	2.0
2009	0.0	0.0	1.6	0.3	0.2	1.2
2010	0.2	0.0	1.0	0.2	0.2	2.3
2011	0.2	0.0	1.9	0.3	0.2	3.1
2012	0.1	0.0	1.7	1.3	0.1	2.2
2013	0.7	0.2	1.3	0.6	0.1	1.5

Percent prob. of level 2,3 => level 1 at least once: 3.6
Percent prob. of level 3 => level 2 at least once: 15.3

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2005	0.0	0.0	0.2	0.0	0.0	0.2
2006	0.0	0.0	0.2	0.0	0.0	0.2
2007	0.0	0.0	0.1	0.1	0.0	0.6
2008	0.1	0.0	0.3	0.0	0.0	1.0
2009	0.0	0.0	0.7	0.2	0.2	1.1
2010	0.0	0.0	0.7	0.2	0.1	1.2
2011	0.2	0.0	0.3	0.3	0.0	2.3
2012	0.0	0.0	0.9	1.2	0.0	1.5
2013	0.4	0.0	0.9	0.5	0.0	1.2

Percent prob. of level 2,3 => level 1 at least once: 2.5
Percent prob. of level 3 => level 2 at least once: 8.7

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2003	241.1	345.0	442.9	575.2	778.1

2004	293.9	408.9	530.5	675.4	956.6
2005	300.2	425.6	539.8	697.5	1014.0
2006	290.3	424.1	550.3	696.2	990.1
2007	266.0	413.8	532.7	685.8	982.2
2008	273.5	409.4	525.9	676.6	979.7
2009	260.6	409.9	527.2	679.5	971.6
2010	244.7	401.6	516.8	666.1	912.2
2011	213.1	386.8	517.9	653.9	908.4
2012	195.7	389.3	528.7	665.2	937.9
2013	187.9	390.4	516.8	678.4	942.4

Fractiles for first year Bpa is reached:
(year 2014 means not earler than that year)

5%	25%	50%	75%	95%
2004	2004	2004	2004	2004

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2003	66.8	140.2	215.8	334.7	656.6
2004	122.6	181.3	245.2	335.1	481.9
2005	128.3	186.0	253.6	343.7	523.5
2006	128.4	185.5	248.0	329.0	475.0
2007	127.9	187.7	256.1	346.4	497.4
2008	131.3	191.1	249.6	334.0	507.6
2009	122.4	191.9	253.9	335.4	486.8
2010	123.7	186.5	241.6	329.9	485.9
2011	117.2	178.6	241.9	322.4	503.5
2012	114.2	182.5	250.1	328.0	505.9
2013	116.6	175.2	241.6	322.5	518.6

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	106.9	151.3	194.4	247.3	342.2
2004	107.7	148.2	189.9	247.2	347.9
2005	104.7	148.3	188.4	240.0	332.4
2006	108.1	147.1	186.9	238.2	328.0
2007	107.4	149.3	187.4	232.1	316.2
2008	111.8	152.3	191.5	230.2	314.3
2009	117.8	155.0	188.6	225.1	296.3
2010	120.9	157.7	186.3	222.3	280.9
2011	122.1	157.3	184.4	219.3	266.2
2012	124.5	155.9	182.6	215.2	265.3
2013	124.7	155.7	183.6	211.6	259.8

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.0	0.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	0.0
2005	0.0	0.0	0.0	0.0	0.0
2006	0.0	0.0	0.0	0.0	0.0
2007	0.0	0.0	0.0	0.0	0.0
2008	0.0	0.0	0.0	0.0	0.0
2009	0.0	0.0	0.0	0.0	0.0
2010	0.0	0.0	0.0	0.0	0.0
2011	0.0	0.0	0.0	0.0	0.0
2012	0.0	0.0	0.0	0.0	0.0
2013	0.0	0.0	0.0	0.0	0.0

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	19.1	28.7	39.9	52.4	87.5
2	0.0	0.0	0.0	0.0	0.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	6.6	8.2	9.1	9.9	10.6
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	109.3	151.7	190.7	237.7	318.9
2	0.0	0.0	0.0	0.0	0.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	126.7	160.1	186.4	217.4	270.0
2	0.0	0.0	0.0	0.0	0.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.260	0.260	0.260	0.260	0.260
2004	0.191	0.222	0.254	0.287	0.341
2005	0.181	0.223	0.257	0.299	0.382
2006	0.176	0.219	0.258	0.305	0.406

2007	0.160	0.211	0.254	0.308	0.412
2008	0.150	0.203	0.249	0.308	0.436
2009	0.149	0.200	0.249	0.310	0.445
2010	0.148	0.204	0.254	0.317	0.506
2011	0.150	0.206	0.256	0.322	0.535
2012	0.144	0.205	0.250	0.315	0.562
2013	0.148	0.201	0.253	0.313	0.570

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000
2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.158	0.222	0.250	0.290	0.418
2005	0.152	0.226	0.250	0.306	0.458
2006	0.146	0.220	0.250	0.309	0.470
2007	0.138	0.206	0.250	0.318	0.513
2008	0.129	0.197	0.250	0.291	0.516
2009	0.130	0.197	0.250	0.302	0.548
2010	0.124	0.203	0.250	0.313	0.567
2011	0.131	0.205	0.250	0.331	0.615
2012	0.131	0.207	0.250	0.327	0.655
2013	0.126	0.204	0.250	0.311	0.618

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2003	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.000	0.000	0.000	0.000
2007	0.000	0.000	0.000	0.000	0.000
2008	0.000	0.000	0.000	0.000	0.000
2009	0.000	0.000	0.000	0.000	0.000

2010	0.000	0.000	0.000	0.000	0.000
2011	0.000	0.000	0.000	0.000	0.000
2012	0.000	0.000	0.000	0.000	0.000
2013	0.000	0.000	0.000	0.000	0.000

APPENDIX 11 RESULTS OF CALCULATIONS FOR NORTH SEA HERRING

11.1 TRAJECTORY FOR 10 YEARS WITH CURRENT EU NORWAY HARVEST CONTROL RULE WITHOUT CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND IMPLEMENTATION BIAS OF 20%.

This run is shown graphically in Figure 0.10

```
Run id 20040618  074004.944
 *************************************************
 *  Results of stochastic medium term simulation  *
 *                                                *
 *************************************************

 Options from file nsh.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.200    0.050    10000.0  10000.0
  2   800.0      0.200    0.050    10000.0  10000.0
  3  1300.0      0.250    0.120    10000.0  10000.0


 For the intermediate year  2004
 the following assumptions were made:
 For fleet 1: F- constraint =  0.232600003
 For fleet 2: F- constraint =  3.68999988E-02

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.000 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=          537.
Recr. level=  49342.000
Stochastic term x has normal distribution with sigma= 0.5780
truncated at:  1.00
```

```
 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.100 +/- 0.200
Assumed overfishing of quotas with factor:  1.200 +/- 0.100
 Stochastic initial stock numbers - lognormal distribution

 **************************************************
```

Probabilities of APPLIED levels and limits:

Year	%Level 1	%Level 2	%Level 3	%Max c1	%Max c2
2005	0.0	2.8	97.2	0.0	0.0
2006	1.3	20.1	78.6	0.0	0.0
2007	1.7	26.3	72.0	0.0	0.0
2008	2.2	28.7	69.1	0.0	0.0
2009	1.4	26.8	71.8	0.0	0.0
2010	1.1	23.7	75.2	0.0	0.0
2011	0.8	22.7	76.5	0.0	0.0
2012	0.8	24.3	74.9	0.0	0.0
2013	0.4	23.7	75.9	0.0	0.0
2014	1.2	21.8	77.0	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2004	0.0	0.6	99.4	0.0	0.0
2005	0.2	5.5	94.3	0.0	0.0
2006	2.3	30.2	67.5	0.0	0.0
2007	3.6	47.1	49.3	0.0	0.0
2008	2.8	45.3	51.9	0.0	0.0
2009	1.7	41.8	56.5	0.0	0.0
2010	1.6	40.1	58.3	0.0	0.0
2011	2.2	37.4	60.4	0.0	0.0
2012	1.1	37.2	61.7	0.0	0.0
2013	2.0	37.5	60.5	0.0	0.0
2014	1.7	39.2	59.1	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2006	0.0	0.0	2.1	0.0	1.3	19.4
2007	0.7	0.5	14.2	0.0	1.6	19.7

2008	1.0	0.7	17.2	0.6	1.6	19.2
2009	0.9	1.1	21.4	0.2	1.0	18.8
2010	0.6	0.7	18.8	0.1	0.9	15.2
2011	0.6	0.5	17.0	0.3	0.5	15.7
2012	0.4	0.2	16.5	0.1	0.5	17.8
2013	0.5	0.3	16.8	0.0	0.4	15.7
2014	0.0	0.4	17.0	0.3	0.9	15.4

Percent prob. of level 2,3 => level 1 at least once: 10.2
Percent prob. of level 3 => level 2 at least once: 89.7

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2006	0.0	0.0	0.0	1.3	0.8	26.0
2007	1.5	0.0	5.1	2.1	0.0	23.3
2008	2.0	0.3	14.2	1.4	0.0	11.9
2009	2.0	0.0	14.9	1.3	0.1	10.3
2010	0.8	0.0	12.3	1.1	0.1	10.4
2011	1.0	0.0	13.4	1.5	0.0	11.3
2012	1.5	0.1	13.1	0.5	0.2	11.8
2013	0.7	0.0	11.6	1.5	0.0	12.8
2014	1.1	0.0	11.2	1.2	0.1	12.6

Percent prob. of level 2,3 => level 1 at least once: 11.2
Percent prob. of level 3 => level 2 at least once: 87.5

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2004	1555.2	1942.7	2252.6	2638.0	3263.7

2005	1280.3	1650.4	1907.6	2245.3	2810.4
2006	931.3	1224.5	1429.6	1670.0	2148.8
2007	832.5	1100.8	1296.0	1523.8	1894.5
2008	863.2	1104.8	1314.2	1532.2	1924.7
2009	892.7	1137.6	1357.7	1582.9	1968.3
2010	892.0	1182.1	1363.4	1613.3	2018.5
2011	903.3	1173.5	1399.2	1618.6	1976.7
2012	923.8	1184.2	1383.0	1608.9	2018.2
2013	912.8	1178.2	1374.9	1599.0	2018.4
2014	912.8	1174.8	1387.1	1623.4	2029.7

Fractiles for first year Bpa is reached:
(year 2015 means not earler than that year)

5%	25%	50%	75%	95%
2005	2005	2005	2005	2008

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2004	10449.6	13457.2	15984.2	18857.5	24387.5
2005	22317.7	33047.2	47711.0	69769.2	110723.3
2006	22593.0	33588.5	48947.2	69399.0	106516.1
2007	22877.0	35161.2	49332.5	72964.3	110816.1
2008	22501.1	34569.1	48205.4	69049.5	106286.3
2009	21705.6	32893.6	48045.3	68466.8	105256.0
2010	22731.6	33748.3	48278.9	70352.5	108447.0
2011	22053.5	34355.8	48384.8	69471.2	107330.8
2012	23021.0	36308.4	49650.4	70126.5	108323.5
2013	23912.3	35144.9	50313.4	70858.0	107995.2
2014	22867.4	34452.6	50177.6	69093.5	106651.7

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	356.5	437.2	501.2	582.9	718.0
2005	420.0	571.7	705.8	865.0	1145.2
2006	257.6	408.1	540.3	683.8	967.9
2007	215.6	330.2	465.9	576.4	775.0
2008	206.5	311.7	442.2	554.5	739.1
2009	213.2	319.4	455.8	567.6	780.3
2010	219.6	346.6	465.9	588.2	786.3
2011	226.7	353.7	467.0	577.3	809.1
2012	223.0	343.0	477.2	583.9	794.9
2013	235.4	346.0	477.4	598.2	800.8
2014	221.8	360.9	476.1	586.7	780.1

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	26.4	33.0	38.5	45.1	55.1
2005	80.3	116.7	146.4	181.7	245.2
2006	44.8	111.6	166.8	227.2	349.9
2007	51.8	101.6	203.7	267.8	385.7
2008	52.5	99.5	194.2	269.5	396.5
2009	53.1	104.8	204.9	281.4	428.5
2010	52.5	121.4	200.9	272.2	414.8
2011	53.0	131.7	207.9	273.4	417.4
2012	51.6	123.9	209.9	273.7	412.1
2013	53.2	132.3	215.9	284.4	417.8
2014	56.0	134.5	211.4	283.6	411.3

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	54.8	87.9	110.7	140.9	216.7
2	69.7	119.8	150.6	186.9	260.4

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	16.9	28.1	38.8	50.6	68.6
2	27.9	43.1	57.5	69.9	96.4

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	380.5	466.5	530.9	597.6	706.4
2	103.6	151.4	183.8	222.2	277.9

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	356.2	423.8	476.7	530.6	621.5
2	58.6	85.3	103.6	125.0	160.1

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	0.233	0.233	0.233	0.233	0.233
2005	0.218	0.289	0.348	0.425	0.565
2006	0.182	0.274	0.338	0.415	0.576
2007	0.191	0.264	0.338	0.414	0.564

2008	0.180	0.256	0.331	0.413	0.549
2009	0.186	0.256	0.329	0.409	0.560
2010	0.186	0.268	0.333	0.411	0.552
2011	0.187	0.266	0.335	0.406	0.570
2012	0.187	0.263	0.337	0.402	0.561
2013	0.193	0.266	0.339	0.423	0.564
2014	0.185	0.270	0.336	0.417	0.569

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	0.037	0.037	0.037	0.037	0.037
2005	0.103	0.137	0.163	0.196	0.251
2006	0.046	0.117	0.157	0.190	0.253
2007	0.048	0.072	0.157	0.190	0.250
2008	0.045	0.068	0.154	0.191	0.248
2009	0.047	0.073	0.153	0.190	0.250
2010	0.047	0.098	0.156	0.190	0.247
2011	0.047	0.109	0.157	0.188	0.254
2012	0.047	0.091	0.158	0.187	0.250
2013	0.049	0.104	0.158	0.193	0.252
2014	0.047	0.117	0.157	0.192	0.255

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	0.000	0.000	0.000	0.000	0.000
2005	0.250	0.250	0.250	0.250	0.250
2006	0.200	0.250	0.250	0.250	0.250
2007	0.200	0.200	0.250	0.250	0.250
2008	0.200	0.200	0.250	0.250	0.250
2009	0.200	0.200	0.250	0.250	0.250
2010	0.200	0.250	0.250	0.250	0.250
2011	0.200	0.250	0.250	0.250	0.250
2012	0.200	0.200	0.250	0.250	0.250
2013	0.200	0.250	0.250	0.250	0.250
2014	0.200	0.250	0.250	0.250	0.250

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	0.000	0.000	0.000	0.000	0.000
2005	0.120	0.120	0.120	0.120	0.120
2006	0.050	0.120	0.120	0.120	0.120
2007	0.050	0.050	0.120	0.120	0.120
2008	0.050	0.050	0.120	0.120	0.120
2009	0.050	0.050	0.120	0.120	0.120
2010	0.050	0.120	0.120	0.120	0.120

2011	0.050	0.120	0.120	0.120	0.120
2012	0.050	0.050	0.120	0.120	0.120
2013	0.050	0.120	0.120	0.120	0.120
2014	0.050	0.120	0.120	0.120	0.120

11.2 TRAJECTORY FOR 10 YEARS WITH CURRENT EU NORWAY HARVEST CONTROL RULE WITHOUT CONSTRAINT ON CHANGE IN TAC, WITH AN ASSESSMENT BIAS OF 10% AND NO IMPLEMENTATION BIAS.

This run is shown graphically in

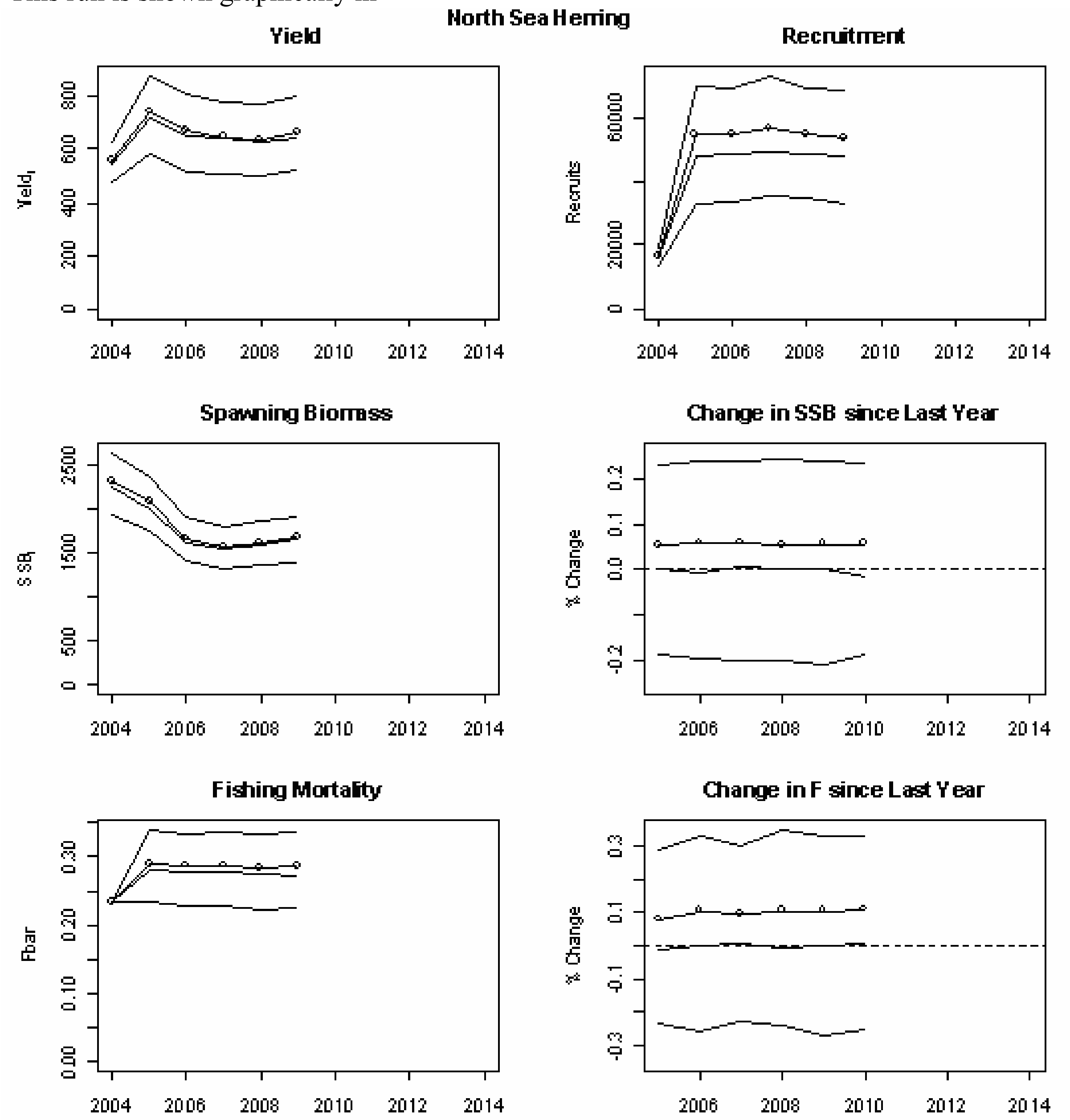

Figure 0.11

```
Run id 20040618  072819.230
 ************************************************
 *  Results of stochastic medium term simulation  *
 *                                              *
```

```
 **************************************************

 Options from file nsh.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.200    0.050    10000.0  10000.0
  2   800.0      0.200    0.050    10000.0  10000.0
  3  1300.0      0.250    0.120    10000.0  10000.0


 For the intermediate year  2004
 the following assumptions were made:
 For fleet 1: F- constraint =  0.232600003
 For fleet 2: F- constraint =  3.68999988E-02

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.000 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=          537.
Recr. level=  49342.000
Stochastic term x has normal distribution with sigma= 0.5780
truncated at:  1.00

 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.100 +/- 0.200
Assumed overfishing of quotas with factor:  1.000 +/- 0.100
 Stochastic initial stock numbers - lognormal distribution

 **************************************************


 Probabilities of APPLIED levels and limits:

 Year  %Level 1  %Level 2  %Level 3  %Max c1  %Max c2
 2005      0.0       2.8      97.2      0.0      0.0
 2006      0.5      11.5      88.0      0.0      0.0
 2007      0.3      15.4      84.3      0.0      0.0
```

2008	0.3	17.1	82.6	0.0	0.0
2009	0.4	12.6	87.0	0.0	0.0
2010	0.1	11.5	88.4	0.0	0.0
2011	0.2	10.2	89.6	0.0	0.0
2012	0.2	9.7	90.1	0.0	0.0
2013	0.0	10.0	90.0	0.0	0.0
2014	0.3	10.4	89.3	0.0	0.0

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2004	0.0	0.6	99.4	0.0	0.0
2005	0.1	2.7	97.2	0.0	0.0
2006	0.7	16.4	82.9	0.0	0.0
2007	0.6	22.2	77.2	0.0	0.0
2008	0.1	20.3	79.6	0.0	0.0
2009	0.0	16.4	83.6	0.0	0.0
2010	0.1	12.9	87.0	0.0	0.0
2011	0.1	12.3	87.6	0.0	0.0
2012	0.1	11.0	88.9	0.0	0.0
2013	0.1	11.9	88.0	0.0	0.0
2014	0.0	11.7	88.3	0.0	0.0

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2006	0.0	0.0	2.4	0.0	0.5	11.1
2007	0.2	0.2	9.3	0.0	0.2	13.0
2008	0.0	0.3	11.2	0.1	0.2	13.0
2009	0.0	0.3	14.8	0.2	0.2	10.5
2010	0.1	0.3	10.4	0.0	0.1	9.2
2011	0.0	0.1	9.2	0.0	0.2	7.9
2012	0.1	0.0	8.7	0.0	0.1	8.1
2013	0.1	0.1	8.5	0.0	0.0	8.7
2014	0.0	0.0	8.8	0.1	0.2	9.3

Percent prob. of level 2,3 => level 1 at least once: 2.1
Percent prob. of level 3 => level 2 at least once: 63.2

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2006	0.0	0.0	0.0	0.6	0.0	14.3
2007	0.5	0.0	4.8	0.5	0.0	10.5
2008	0.3	0.1	9.4	0.0	0.0	7.1
2009	0.1	0.0	10.5	0.0	0.0	6.5
2010	0.0	0.0	8.4	0.0	0.1	4.9
2011	0.0	0.0	5.6	0.0	0.0	5.0
2012	0.0	0.0	5.7	0.0	0.1	4.3
2013	0.1	0.0	5.0	0.1	0.0	5.9
2014	0.1	0.0	5.3	0.0	0.0	5.0

Percent prob. of level 2,3 => level 1 at least once: 1.2
Percent prob. of level 3 => level 2 at least once: 50.6

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2004	1555.2	1942.7	2252.6	2638.0	3263.7
2005	1362.5	1747.1	2010.1	2357.2	2947.6
2006	1072.5	1400.6	1618.9	1899.9	2416.9
2007	1034.8	1326.1	1537.2	1799.8	2238.1
2008	1068.8	1357.6	1578.1	1861.7	2289.6
2009	1128.7	1398.5	1646.2	1908.5	2384.0
2010	1139.5	1436.0	1666.7	1969.5	2439.1
2011	1131.4	1452.6	1714.4	1985.2	2407.4
2012	1182.7	1475.5	1727.6	1983.5	2429.4
2013	1137.4	1480.1	1726.9	1978.2	2462.0
2014	1171.0	1474.9	1727.0	2005.4	2494.1

Fractiles for first year Bpa is reached:
(year 2015 means not earler than that year)

5%	25%	50%	75%	95%
2005	2005	2005	2005	2005

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2004	10449.6	13457.2	15984.2	18857.5	24387.5
2005	22317.7	33047.2	47711.0	69769.2	110723.3
2006	22593.0	33588.5	48947.2	69399.0	106516.1
2007	22877.0	35162.0	49332.5	72964.3	110816.1
2008	22501.1	34569.1	48205.4	69178.9	106286.3
2009	21705.6	32893.6	48045.3	68466.8	105256.0
2010	22731.6	33748.3	48278.9	70352.5	108447.0
2011	22053.5	34355.8	48384.8	69471.2	107330.8
2012	23021.0	36308.4	49650.4	70126.5	108323.5
2013	23912.3	35144.9	50313.4	70858.0	107995.2
2014	22867.4	34452.6	50177.6	69093.5	106651.7

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	356.5	437.2	501.2	582.9	718.0
2005	350.0	476.5	588.2	720.8	954.4
2006	233.2	389.2	488.7	615.7	875.5
2007	212.0	353.9	444.0	545.7	732.9
2008	206.0	347.6	434.6	534.5	721.3
2009	219.3	362.0	448.0	555.1	772.8
2010	230.0	377.3	459.3	576.3	787.1
2011	232.6	382.5	468.3	578.7	797.1
2012	233.9	379.4	481.1	581.2	772.1
2013	242.9	390.2	476.9	591.4	804.7
2014	228.9	392.3	488.2	588.7	792.0

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	26.4	33.0	38.5	45.1	55.1
2005	66.9	97.2	122.0	151.4	204.3
2006	44.7	107.0	148.0	197.1	304.4
2007	46.8	128.8	182.3	232.5	338.5
2008	48.3	126.9	181.6	234.4	335.1
2009	50.0	136.5	185.7	245.0	367.3
2010	49.7	137.4	179.2	235.8	357.0
2011	52.7	138.1	185.5	237.3	356.8
2012	53.3	139.3	187.1	238.9	356.8
2013	55.2	143.2	192.7	246.0	360.8
2014	53.1	141.9	186.2	243.4	350.4

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	44.4	68.9	90.5	116.5	171.8
2	57.4	89.5	125.4	158.0	226.5

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	12.7	22.5	32.0	43.0	59.0
2	24.6	34.8	47.0	61.9	83.7

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	348.6	431.9	494.7	557.3	662.4
2	100.2	139.9	166.3	196.2	245.9

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	357.6	428.4	484.6	542.2	632.3
2	58.7	81.5	95.6	112.8	142.0

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	0.233	0.233	0.233	0.233	0.233
2005	0.178	0.234	0.279	0.338	0.443
2006	0.155	0.228	0.278	0.332	0.450
2007	0.160	0.228	0.278	0.335	0.447
2008	0.153	0.223	0.276	0.333	0.436
2009	0.159	0.225	0.273	0.334	0.444
2010	0.157	0.226	0.277	0.331	0.435
2011	0.162	0.230	0.276	0.330	0.450
2012	0.164	0.227	0.278	0.325	0.442
2013	0.166	0.232	0.279	0.340	0.447
2014	0.157	0.230	0.276	0.335	0.449

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	0.037	0.037	0.037	0.037	0.037
2005	0.084	0.112	0.133	0.159	0.203
2006	0.040	0.109	0.132	0.156	0.204
2007	0.041	0.108	0.132	0.157	0.206
2008	0.039	0.104	0.131	0.157	0.200

2009	0.040	0.107	0.130	0.158	0.203
2010	0.040	0.108	0.132	0.156	0.200
2011	0.043	0.110	0.132	0.155	0.207
2012	0.044	0.109	0.132	0.154	0.203
2013	0.044	0.111	0.133	0.160	0.205
2014	0.040	0.110	0.132	0.158	0.206

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	0.000	0.000	0.000	0.000	0.000
2005	0.250	0.250	0.250	0.250	0.250
2006	0.200	0.250	0.250	0.250	0.250
2007	0.200	0.250	0.250	0.250	0.250
2008	0.200	0.250	0.250	0.250	0.250
2009	0.200	0.250	0.250	0.250	0.250
2010	0.200	0.250	0.250	0.250	0.250
2011	0.200	0.250	0.250	0.250	0.250
2012	0.200	0.250	0.250	0.250	0.250
2013	0.200	0.250	0.250	0.250	0.250
2014	0.200	0.250	0.250	0.250	0.250

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	0.000	0.000	0.000	0.000	0.000
2005	0.120	0.120	0.120	0.120	0.120
2006	0.050	0.120	0.120	0.120	0.120
2007	0.050	0.120	0.120	0.120	0.120
2008	0.050	0.120	0.120	0.120	0.120
2009	0.050	0.120	0.120	0.120	0.120
2010	0.050	0.120	0.120	0.120	0.120
2011	0.050	0.120	0.120	0.120	0.120
2012	0.050	0.120	0.120	0.120	0.120
2013	0.050	0.120	0.120	0.120	0.120
2014	0.050	0.120	0.120	0.120	0.120

11.3 TRAJECTORY FOR 10 YEARS WITH CURRENT EU NORWAY HARVEST CONTROL RULE MAXIMUM CONSTRAINT ON TAC OF 460,000 T FLEET 1 AND 100,000 T FLEET 2, WITH AN ASSESSMENT BIAS OF 10% AND IMPLEMENTATION BIAS OF 20%.

This run is shown graphically in Figure 0.12

```
Run id 20040618  152801.774
 ***************************************************
 *  Results of stochastic medium term simulation   *
 *                                                 *
 ***************************************************
```

```
 Options from file nsh.opt:
 ****************************
 For each of the SSB-levels below, the catch
 corresponding to the f-value is taken, unless
 this catch is larger than the maximum permitted catch

        Lower   Standard F level       Max. catch
 Level   SSB    Fleet 1  Fleet 2    Fleet 1  Fleet 2

  1     0.0      0.200    0.050    10000.0  10000.0
  2   800.0      0.200    0.050    10000.0  10000.0
  3  1300.0      0.250    0.120      460.0    100.0


 For the intermediate year  2004
 the following assumptions were made:
 For fleet 1: F- constraint =  0.232600003
 For fleet 2: F- constraint =  3.68999988E-02

 Maximum possible fishing mortality is assumed to be:
 1.500 for Fleet 1
 1.000 for Fleet 2

 Maximum permitted fishing mortality is assumed to be:
 1.000 for Fleet 1
 1.000 for Fleet 2

 Ockhams razor recruitment, with parameters:
Min SSB=           537.
Recr. level=  49342.000
Stochastic term x has normal distribution with sigma= 0.5780
truncated at:  1.00

 Stock-recruit function not applied in year 0
 Weights at age and maturity ogive were drawn from historical
values
Assumed faulty assessment with factor:  1.100 +/- 0.200
Assumed overfishing of quotas with factor:  1.200 +/- 0.100
 Stochastic initial stock numbers - lognormal distribution

 **************************************************


 Probabilities of APPLIED levels and limits:

 Year  %Level 1  %Level 2  %Level 3  %Max c1  %Max c2
 2005      0.0        2.8      97.2     90.1     85.1
 2006      1.0       12.9      86.1     76.5     81.7
 2007      0.6       14.7      84.7     71.3     82.0
 2008      0.4       14.2      85.4     70.4     83.4
 2009      0.7       11.3      88.0     72.7     85.9
```

2010	0.2	10.2	89.6	78.7	87.3
2011	0.0	7.7	92.3	80.5	89.9
2012	0.0	7.1	92.9	82.4	90.5
2013	0.0	6.3	93.7	84.4	91.2
2014	0.3	6.1	93.6	85.1	91.2

Probabilities of TRUE levels and limits:

Year	%Level 1	%Level 2	%Level 3	%>Max c1	%>Max c2
2004	0.0	0.6	99.4	68.0	0.0
2005	0.2	4.0	95.8	86.9	81.8
2006	1.1	16.7	82.2	68.2	71.8
2007	1.2	24.5	74.3	60.6	67.3
2008	0.7	21.3	78.0	61.6	70.8
2009	0.2	15.8	84.0	66.4	77.5
2010	0.2	12.1	87.7	73.3	80.7
2011	0.5	10.6	88.9	75.8	83.1
2012	0.4	8.6	91.0	78.8	85.1
2013	0.4	9.4	90.2	80.0	85.1
2014	0.1	7.5	92.4	82.7	87.8

Probabilities of shifts of APPLIED level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2006	0.0	0.0	2.1	0.0	1.0	12.2
2007	0.5	0.4	9.5	0.0	0.5	10.8
2008	0.3	0.3	10.1	0.2	0.2	9.5
2009	0.1	0.2	10.9	0.2	0.4	8.1
2010	0.4	0.3	8.8	0.1	0.1	7.4
2011	0.1	0.1	8.3	0.0	0.0	5.7
2012	0.0	0.0	5.9	0.0	0.0	5.3
2013	0.0	0.0	5.5	0.0	0.0	4.7
2014	0.0	0.0	5.0	0.1	0.2	4.9

Percent prob. of level 2,3 => level 1 at least once: 3.0
Percent prob. of level   3 => level 2 at least once: 49.7

Probabilities of shifts of TRUE level:
(from previous year to present year)

Year	%L 1=>2	%L 1=>3	%L 2=>3	%L 2=>1	%L 3=>1	%L3=>2
2006	0.0	0.0	0.0	0.9	0.0	13.6
2007	0.9	0.1	4.7	0.6	0.0	12.7
2008	0.8	0.2	9.9	0.5	0.0	6.4
2009	0.5	0.0	10.0	0.1	0.0	4.0
2010	0.1	0.0	8.0	0.2	0.0	4.3
2011	0.2	0.0	5.0	0.5	0.0	3.8
2012	0.4	0.0	5.4	0.1	0.0	3.4
2013	0.4	0.0	3.0	0.2	0.0	3.8
2014	0.2	0.1	3.5	0.1	0.0	1.4

Percent prob. of level 2,3 => level 1 at least once: 3.1
Percent prob. of level 3 => level 2 at least once: 42.0

Fractiles for SSB:

Year	5%	25%	50%	75%	95%
2004	1555.2	1942.7	2252.6	2638.0	3263.7
2005	1334.8	1765.7	2067.8	2478.8	3136.1
2006	1030.9	1392.6	1666.8	2074.9	2783.0
2007	971.4	1292.4	1602.3	2007.3	2804.4
2008	1013.9	1345.4	1678.9	2113.1	2939.7
2009	1069.4	1414.6	1792.9	2269.0	3091.6
2010	1110.2	1493.3	1913.1	2473.5	3347.1
2011	1119.3	1550.0	1987.6	2579.2	3537.4
2012	1171.3	1621.7	2080.5	2666.3	3733.4
2013	1138.8	1682.2	2144.4	2772.7	3868.3
2014	1191.9	1722.8	2218.0	2969.3	4090.0

Fractiles for first year Bpa is reached:
(year 2015 means not earler than that year)

5%	25%	50%	75%	95%
2005	2005	2005	2005	2005

Fractiles for Recruitment:

Year	5%	25%	50%	75%	95%
2004	10449.6	13457.2	15984.2	18857.5	24387.5
2005	22317.7	33047.2	47711.0	69769.2	110723.3
2006	22593.0	33588.5	48947.2	69399.0	106516.1
2007	22877.0	35162.0	49332.5	72964.3	110816.1
2008	22501.1	34569.1	48205.4	69178.9	106286.3
2009	21705.6	32893.6	48045.3	68466.8	105256.0
2010	22731.6	33748.3	48278.9	70352.5	108447.0
2011	22053.5	34355.8	48384.8	69471.2	107330.8
2012	23021.0	36308.4	49755.9	70126.5	108323.5
2013	23912.3	35144.9	50313.4	70858.0	107995.2
2014	22867.4	34452.6	50177.6	69093.5	106651.7

Fractiles for Catches, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	356.5	437.2	501.2	582.9	718.0
2005	409.1	499.7	545.8	584.0	652.9
2006	277.4	460.2	526.5	575.4	634.8
2007	249.6	434.3	514.6	565.9	636.1
2008	244.8	430.2	511.1	567.9	629.2
2009	254.5	445.6	518.3	564.6	633.3
2010	274.8	471.6	525.2	573.1	641.1
2011	290.7	476.1	530.8	576.6	643.6
2012	293.5	481.4	528.9	575.1	646.4
2013	319.2	488.2	535.0	579.2	643.7
2014	304.1	496.0	540.3	581.7	638.1

Fractiles for Catches, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	26.4	33.0	38.5	45.1	55.1
2005	80.3	106.9	117.8	126.5	141.0
2006	52.0	106.2	117.9	127.5	139.6
2007	59.7	106.8	118.6	128.0	141.4
2008	60.9	109.2	118.7	127.6	141.1
2009	63.9	108.6	118.0	126.2	139.3
2010	63.9	109.2	118.9	127.4	140.8
2011	81.1	110.2	119.2	128.2	142.2
2012	78.0	110.1	118.8	127.1	141.5
2013	92.8	110.6	119.4	127.9	141.1
2014	85.5	110.3	119.3	127.9	140.1

Fractiles for catch variation (range yr 5-10)/mean in %:

Fleet	5%	25%	50%	75%	95%
1	17.4	26.5	38.8	65.7	95.3

2	16.7	24.9	34.1	54.5	107.0

Fractiles for year-to-year catch variation
Years 1-5: Mean yearly change / mean yearly catch in %

Fleet	5%	25%	50%	75%	95%
1	6.7	12.0	18.1	28.9	44.2
2	16.2	20.0	24.8	36.4	54.7

Fractiles for mean catch (year 1-5)

Fleet	5%	25%	50%	75%	95%
1	385.2	468.8	512.7	546.2	579.0
2	89.8	108.1	116.4	121.7	129.0

Fractiles for mean catch (year 5-10)

Fleet	5%	25%	50%	75%	95%
1	404.0	481.0	528.1	552.1	579.7
2	49.1	56.6	59.5	61.4	64.6

Fractiles for realised fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	0.233	0.233	0.233	0.233	0.233
2005	0.163	0.213	0.248	0.294	0.384
2006	0.168	0.223	0.272	0.329	0.421
2007	0.176	0.236	0.289	0.348	0.462
2008	0.170	0.234	0.288	0.346	0.455
2009	0.167	0.222	0.273	0.331	0.446
2010	0.156	0.213	0.265	0.321	0.419
2011	0.150	0.207	0.256	0.319	0.419
2012	0.141	0.200	0.251	0.306	0.406
2013	0.142	0.193	0.247	0.300	0.414
2014	0.132	0.185	0.237	0.292	0.396

Fractiles for realised fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	0.037	0.037	0.037	0.037	0.037
2005	0.075	0.105	0.125	0.147	0.187
2006	0.046	0.070	0.096	0.122	0.160
2007	0.044	0.059	0.076	0.100	0.139
2008	0.043	0.057	0.074	0.096	0.134
2009	0.042	0.058	0.071	0.091	0.129
2010	0.044	0.059	0.073	0.093	0.128

2011	0.043	0.059	0.074	0.093	0.126
2012	0.044	0.059	0.072	0.093	0.128
2013	0.045	0.058	0.073	0.091	0.122
2014	0.043	0.058	0.072	0.090	0.127

Fractiles for percieved fishing mortalities, FLEET 1:

Year	5%	25%	50%	75%	95%
2004	0.000	0.000	0.000	0.000	0.000
2005	0.113	0.152	0.191	0.232	0.250
2006	0.121	0.171	0.200	0.250	0.250
2007	0.129	0.188	0.211	0.250	0.250
2008	0.131	0.191	0.216	0.250	0.250
2009	0.117	0.178	0.207	0.250	0.250
2010	0.111	0.163	0.200	0.250	0.250
2011	0.103	0.159	0.200	0.250	0.250
2012	0.102	0.148	0.200	0.243	0.250
2013	0.096	0.139	0.190	0.234	0.250
2014	0.091	0.137	0.184	0.224	0.250

Fractiles for percieved fishing mortalities, FLEET 2:

Year	5%	25%	50%	75%	95%
2004	0.000	0.000	0.000	0.000	0.000
2005	0.051	0.076	0.095	0.117	0.120
2006	0.039	0.050	0.068	0.091	0.120
2007	0.033	0.048	0.053	0.070	0.098
2008	0.032	0.047	0.053	0.068	0.099
2009	0.030	0.044	0.052	0.069	0.095
2010	0.031	0.046	0.054	0.070	0.097
2011	0.030	0.045	0.054	0.070	0.098
2012	0.031	0.044	0.054	0.069	0.100
2013	0.031	0.043	0.052	0.067	0.098
2014	0.031	0.043	0.053	0.069	0.093