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EXECUTIVE SUMMARY

Breen, P.A.; Haist, V.; Smith, A.N.H.; Starr, P.J. (2008). Review of the NSS decision rule for stocks CRA 7 and CRA 8 and development of new operational management procedures.

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This document describes a review of the NSS decision rule that operated to manage TACs in CRA 7 and CRA 8 from 2002 through 2007. The review was a component of the management procedure that was agreed when the rule was adopted by the Minister of Fisheries.

The document describes conversion of the multi-stock length-based assessment model to an operating model for the two stocks, using 2006 assessment results. It describes work designed to measure the productivity characteristics of the operating model stocks, and four families of candidate harvest control rules. Preliminary, intermediate and final testing of the rules is described, and indicators are summarised from base case runs and sensitivity trials. Final rule choices are discussed.

Contents

1. INTRODUCTION

This document describes a scheduled review of the NSS decision rule. The work was conducted by the rock lobster stock assessment team contracted by the New Zealand Rock Lobster Industry Council (NZ RLIC Ltd) to conduct Objective 4 of Ministry of Fisheries (MFish) contract CRA2006-01, Rock Lobster Stock Assessment.

The NSS decision rule is an operational management procedure used to set catch limits for the CRA 7 and CRA 8 (Otago and Southern) stocks of red rock lobsters (*Jasus edwardsii*). The operational management procedure approach was developed in South Africa (Butterworth et al. 1997, Cochrane et al. 1998), was adopted by the International Whaling Commission (Kirkwood 1997), and is now reasonably widespread. Johnston & Butterworth (2005) described choosing management procedures to manage South African rock lobsters (*Jasus lalandii*).

Management procedures are also called "decision rules", but the latter term includes much simpler rules that have not been extensively evaluated with an operating model. Management procedures specify how management changes will be made in response to changes in specified fishery data. A management procedure is "a fully specified feedback control system applied as part of a fishery management system" (McAllister et al. 1999) and specifies what data will be collected, how they will be collected and processed, what estimates will be made from the data, and how those estimates will determine harvest controls. Good reviews were provided by Butterworth & Punt (1999) and McAllister et al. (1999).

The NSS decision rule, which is described in recent Reports from the Plenary, was proposed by the National Rock Lobster Management Group (NRLMG) and accepted by the Minister of Fisheries in 1996 (Starr et al. 1997). It resulted in TAC and TACC decreases in 1999 and 2001. A revised management procedure was proposed and accepted in 2002 after extensive evaluation of alternatives (Bentley et al. 2003). The evaluations considered a number of different stock and recruitment hypotheses across a series of management strategies and evaluated a family of "harvest control rules" operating within a generic procedure to set an annual TAC. Both the old and new management procedures are rebuilding rules designed to achieve a specific target CPUE within a specified number of years.

The decision rule evaluates how well observed CRA 8 CPUE tracks the rebuilding trajectory (through a "status" indicator) and how well the CPUE trend compares with the increasing target trajectory (through a "gradient" indicator). The harvest control rule represents a compromise between fishery harvest goals and stock risk goals while staying within the rebuilding time frame. The criteria used to select this specific harvest control rule were presented in Bentley et al. (2003), along with the rule's performance relative to other evaluated rules.

The NSS decision rule currently applies to the entire NSS substock (i.e., CRA 7 and CRA 8), but uses only data from CRA 8; this arrangement was agreed because CRA 7 quota holders wanted the option of adopting a different management procedure at some later date. In the interim, CRA 7 stakeholders agreed in 2002 to abide by the results from the NSS management procedure.

This review was scheduled when the current rule was adopted in 2002 by the NRLMG, who specified that the rule should be reviewed after five years. The NRLMG agreed that Objective 4 of the contract, which normally involves producing a stock assessment for a nominated stock or group of stocks, would be addressed in 2007 by conducting a review of the NSS decision rule (or operational management procedure).

For this work, we used the most recent stock assessments of CRA 7 and CRA 8 (Haist et al. unpublished data), which were made with the new multi-stock length-based lobster stock assessment model (MSLM) (Haist et al. unpublished data). We modified MSLM for use as an operating model under various alternative assumptions, and made other decisions that were necessary to run such an operating model. We defined a number of alternative harvest control rule families, and have conducted preliminary and intermediate testing of a large number of rules.

The rock lobster fishing year runs from April through March, and the convention used here is to use the first year as the short name; viz. the 2002–03 fishing year is referred to as '2002'.

2. BASE CASE OPERATING MODEL

2.1 General

The operating model used for the CRA 7 and CRA 8 decision rule evaluation has the same structure as the "base case" multi-stock assessment model used in 2006 (Haist et al. unpublished data) with the following exceptions:
the stock initialisation was changed from a matrix equilibrium method to an iterative loop method (this doesn't affect the "base case" run), and other minor changes were made in response to an external review of the model in March 2007 by Andre Punt;
the model parameter that describes the standard deviation of the normal prior on recruitment deviations in log space – *SigmaR* – was increased to 0.7 from the assessment value of 0.4, based on the observed standard deviation;
the relative weight for the size frequency data sets was decreased to 15 from the assessment value of 25;
parameters describing movement from CRA 7 to CRA 8, involving fish from 40–60 mm tail width (TW), were estimated from 1985 through 2005,
the fishing mortality dynamics were modelled as instantaneous (see below),
the natural mortality rate parameter M was fixed at four selected values: 0.06, 0.08, 0.10 and 0.12 and
the parameter describing shape of the relation between biomass and CPUE – *CPUEpow* – was fixed at 1.

The model's instantaneous dynamics gave a better fit to the data than the finite dynamics when fitted to the CRA 7 and CRA 8 data during the assessment (Table 1). As part of the Andre Punt review of the model in early 2007, we investigated the reason for this, and isolated the fit to the CRA 8 length frequency data as the source of the improved fit. The differences are illustrated in detail in Table 2.

We considered that the differences among alternative fits may be greater and more consequential than the uncertainties within a model fit, i.e., that variation among alternative MPD fits (MPD is the mode of the joint posterior distribution) is greater than variation within one Markov chain – Monte Carlo (McMC) simulation. Therefore, our operating model used a pseudo-posterior file instead of the joint posterior distribution of parameters obtained from McMC simulations from one model fit. The pseudo-.psv file comprised 150 copies of the MPD estimates from each of the four values of M, so each trial is based on 600 different stochastic runs. Table 3 shows, for reference, the model's 2005 *Bvuln* estimates from the four MPD fits that formed the base case pseudo-.psv file. The 2005 values for observed annual CPUE were 1.26 and 2.18 kg/pot for CRA 7 and CRA 8, respectively.

2.2 Projections

2.2.1 Annual deviations

In projections, the operating model simulates annual recruitment deviations for each stock whilst retaining the observed variance and autocorrelation structure within stocks (ρ_r) and correlation between stocks (Table 4). Similarly, the operating model simulates CPUE observation error whilst retaining the observed variance and autocorrelation structure within stocks and correlation between stocks (Table 4). If we ignore the CRA 7/CRA 8 correlation, then the CPUE error terms for region r in year y $(d_{y,r})$ are:

$$d_{y,r} = \rho_r d_{y-1,r} + \sqrt{1-\rho_r^2}\sigma_r \varepsilon_{y,r} \quad \text{where } \varepsilon_{y,r} \sim N[0,1]$$

The correlation between regions (ρ^{stock}) is applied to the random normal deviate component for stock 2:

$$\varepsilon_{y,2} = \rho^{stock}\varepsilon_{y,1} + \sqrt{1-\left(\rho_r^{stock}\right)^2}\varepsilon'_{y,2} \quad \text{where } \varepsilon'_{y,r} \sim N[0,1]$$

The operating model re-samples movement parameters from the estimated movements for 1985 to 2005 (Figure 1).

The projected commercial catch limits (total allowable commercial catches, TACCs) are equal to the TAC from a harvest control rule minus the non-commercial allowances (CRA 7 = 20 t; CRA 8 = 87 t). The projected actual non-commercial catches are the current estimates (Table 5). If the projected TAC is less than the non-commercial allowances, the TACC is set to zero.

Catches projected for 2006–07 and 2007–08 are based on the TACs obtained from current values: CRA 8 TAC is 842.2 t and TACC is 755.2 t; CRA 7 TAC is 140.2 t and TACC is 120.2 t. The model's harvest control rules set TACs beginning in the 2008–09 year.

The projected seasonal split between autumn-winter (AW; April through September) and spring-summer (SS) commercial catch was based on a relation between seasonal split and stock abundance estimated from annual CPUEs (Figure 2 and Figure 3). The model uses observed CPUE from the previous year, using the relationship described below, with a maximum AW proportion of SL catch set at 0.95.

$$C_{CRA7,t}^{AW} = TAC_{CRA7,t}\left(0.7143 + 0.0681 PCPUE_{CRA7,t-1}\right)$$
$$C_{CRA8,t}^{AW} = TAC_{CRA8,t}\left(0.156 + 0.2788 PCPUE_{CRA8,t-1}\right)$$

Seasonal splits of the non-commercial catch components are shown in Table 5.

2.2.2 Model-predicted CPUE

In population projections made using MSLM as the operating model, it was necessary to predict annual CPUE. For the assessment, MSLM makes seasonal CPUE predictions, because biomass is calculated seasonally. We considered three predictors of annual CPUE: 1) a simple mean of seasonal predicted CPUE, 2) a mean of predicted seasonal CPUE weighted by seasonal SL catch, and 3) a more complex combination of predicted seasonal CPUE. The trials related here were made before the input CPUE protocol was changed (Section 2.5, but this should not affect the conclusions.

The simple mean was calculated as:

$$\hat{I}_t^{annual} = \frac{\hat{I}_t^{AW} + \hat{I}_t^{SS}}{2}$$

The weighted mean predictor was calculated as:

$$\hat{I}_t^{annual} = \frac{\left(\hat{I}_t^{AW} C_t^{AW}\right) + \left(\hat{I}_t^{SS} C_t^{SS}\right)}{\left(C_t^{AW} + C_t^{SS}\right)}$$

and the third predictor was:

$$\hat{I}_t^{annual} = a + b1\hat{I}_t^{AW} + b2\hat{I}_t^{SS}$$

where t indexes year, $\hat{I}_t^{AW}$ is predicted AW CPUE, C_t^{AW} is the SL catch in AW, a is an intercept, and $b1$ and $b2$ are coefficients that can be estimated using a least squares estimator. We called these the simple mean, weighted mean and MLR predictors. The simple mean predictor is a special case of the third predictor in which $a = 0$ and $b1 = b2 = 0.5$. For the MLR predictor, coefficients estimated from the base case MPD are shown in Table 6.

Predicted vs. observed annual CPUE is shown in Figure 4 through Figure 6 for the three predictors respectively. There is not much difference in the fit between the simple mean and weighted mean predictors, but the MLR fits the observed CPUE much better for CRA 8, slightly better for CRA 7. This better fit is also seen in the residuals (Figure 7).

However, the coefficients for the MLR fit make little sense for CRA 8: $b1$ is negative for the AW, and $b2$ is greater than 1 for the SS. Over the period 1979–2005, 60% of CRA 8 SL catch has come from the SS, although the proportion is higher in recent years. The coefficients are dubious for CRA 7: 75% of the catch has come from the AW, but the predictor heavily favours the SS CPUE by making $b2$ twice as large as $b1$.

Table 7 shows some statistics from the three predictors: the simple mean fitted slightly better than the weighted mean. The autocorrelation in the annually-standardised CPUE was 0.86 and 0.61 for CRA 8 and CRA 7 respectively; the predicted values were higher than these for all predictors for each stock. CRA 8 showed a very high autocorrelation in residuals, probably reflecting the poor fit in CRA 8, but the autocorrelation was very low in CRA 7.

We did the same analysis using MPD sensitivity trial fits reported in the assessment. Results were not substantially different from the base case results. The simple mean of AW and SS predictions performed at least as well as, and usually better than, the catch-weighted mean of seasonal CPUE. Differences between these two predictors were small. Based on these results we chose the simple predictor to use in the operating model.

2.3 Sensitivity trials

Sensitivity trials were used to test rule behaviour when there was failure of base case operating model assumptions, and to identify rules that behaved differently under failure of the base case assumptions. These trials helped to select good rules that behaved well across a range of assumptions.

We selected the following sensitivity trial operating models:

S1: recruitment was arbitrarily reduced to 75% of the base case value, to test for rule behaviour when recruitment is lower than normal, as might happen by chance for an extended period, or as a result of climate change or an introduced species problem;
S2: observation error for CPUE was doubled, to test for rule behaviour if the inherent level of noise in the CPUE observations had been underestimated;
S3: catchability for CPUE was increased by 1% per year to test for rule behaviour when there is a trend of increasing catchability such as might occur if gear or other factors combined to make fishing more effective;
S4: no estimated movements from CRA 7 to CRA 8;
S5: using a domed selectivity curve instead of the fixed right-hand limb used by the base case, to test rule behaviour under the hypothesis that selectivity of lobsters diminishes as they become larger;
S6: Beverton-Holt stock-recruitment dynamics turned on with fixed steepness = 0.7 (the base case operating model assumes no relation between spawning stock biomass and subsequent recruitment);
S7: stock-recruitment dynamics turned on with estimated steepness (this trial was dropped because estimated steepness was so close to 1.0 (Table 8), so this trial provided little contrast with the base case operating model);
S8: using randomly chosen combinations of stock-specific *M*s for the two stocks. This trial was also dropped because it provided little contrast with the base case operating model);
S9: using estimated *CPUEpow* combined with the four fixed values of *M* (Table 9);
S10: high recruitment to CRA 8 for 2001 (or 2002 in one of the component fits) was arbitrarily reduced by 40% and 2007 biomass was consequently reduced.

After conducting intermediate runs, we added S10 for CRA 8 only: this uses reduced recruitment in 2001 or 2002. Most CRA 8 runs showed an early increase in biomass, caused by the assessment model's high estimate of recruitment in 2001 (or 2002 in one of the four components) (Figure 8, upper). In trial S10 we multiplied the 2001 (or 2002) recruitment deviations by 0.4 – this had only a small effect on the model's productivity (mean recruitment was reduced a bit), but it changed the average CRA 8 biomass at the start of the projections (Figure 8, lower).

2.4 Consultation with commercial stakeholders

Some of the assessment team met with CRA 7 and CRA 8 stakeholders in December 2006, explained the project, its timetable and its possible outcomes, and sought feedback on management objectives of the industry, especially on the major trades-off to be expected from a decision rule. The project outline and a description of the project for the industry were contained in a letter sent to stakeholders in January 2007 (see Appendix).

The assessment team had a meeting with NZ RLIC Ltd. and CRA 7 and CRA 8 industry representatives on 14 March 2007. Both meetings gave insight into the expectations of each CRA area. In particular, it appeared that CRA 7 was content to have a decision rule that changed TAC each year as abundance rose and fell, while CRA 8 tended to favour stability of catch and was willing to trade off some long-term catch for higher long-term abundance.

2.5 Harvest control rule input

The 2002 NSS decision rule was based on annual standardised CPUE indices. Other possible inputs were evaluated and discussed by Bentley et al. (2005). It was agreed for this project, after considering other data that might be used, to use only CPUE as a rule input.

However, we proposed that new rules should use data that are more recent by six months than those used by the 2002 rule. Whereas the 2002 rule used an annual index based on data from fishing year y, we proposed to use an annual index for year based on the AW CPUE in year y and the SS CPUE in year y-1, removing 6 months of the lag between data and implementation of a new catch limit. This is represented graphically in Figure 9.

Under this proposal we calculated the annual standardised CPUE series based on the offset October–September year instead of the April–March rock lobster fishing year for CRA 7 (Figure 10 left panel) and CRA 8 (Figure 10 right panel). These October–September series compared well with the equivalent April–March series and should give similar results in the management strategy evaluations.

The effect of this change on harvest control rule results is described below. Model outputs are unaffected by this change – all indicator references to CPUE are to fishing-year CPUE.

2.6 Harvest control rules

Six rule families were defined. The first two were defined only for establishing the productivity characteristics of the stock, and not proposed as candidates for actual use. They were:
constant TAC and
constant exploitation rate operating on actual CPUE (biomass times q).

The rule families defined as candidates for evaluation were
the Bentley rule family as described by Bentley et al. (2003),
"ERules" as described by Breen & Kim (2006),
constant exploitation rate, illustrated below (Figure 11) and
a "plateau" rule, illustrated below (Figure 11).

Figure 11 illustrates the idea of rule families. Using different multipliers for Rule 5 gives different TACs for a given level of CPUE. Rule 5 has just the single main parameter. Rule 6 has five parameters that determine the TAC at the plateau, the CPUE levels at the lower and upper ends of the plateau and the slope below and above the plateau. The figure shows rules resulting from two different plateau height parameters and two sets of plateau end parameters, combined with several values for slope. Through appropriate selection of parameters this rule can be a constant catch or constant exploitation rate rule.

Different harvest control rules were run simultaneously for CRA 7 and CRA 8. The effect of the CRA 7 rule on CRA 8 is measurable but not great. In final rule selection evaluations, the choice of rule used for the "other" stock were made carefully.

Initially, all rules except constant TAC use *min* and *max* change parameters as defined for the 2002 NSS decision rule. These define the level of TAC change below which a change will not be made (usually 5%) and the level at which large changes are truncated (25% in the 2002 rule). In the early testing, rules were tested with three latent year options: none, one year, as in the 2002 NSS decision rule, and two years.

After preliminary runs, the Bentley rule family (Rule 3) was excluded from further testing because of its poor performance in a wide variety of parameter combinations: some examples are illustrated below (Figure 12 and Figure 13). No examples from this rule family showed acceptable behaviour in 50-year runs. Thus, results are shown only for the Rules 5 and 6 families.

Intermediate and final testing were restricted to the Rules 5 and 6 families. The *min* change parameter was set at 5% for all rules. The *max* change parameter was used only for Rule 5 members; it was considered essential to have very responsive rules in the Rule 6 family when CPUE was below the lower end of the plateau, and that stability in this rule was given by the plateau, so that further buffering was not required.

Rule 5 members were specified by:

$$TAC_{y+1} = par2 I_y$$

where *par2* is a simple multiplier that acts on CPUE, *I*.

Rule 6 members were specified by:

$$TAC_{y+1} = \begin{cases} par2 - par6\left(par4 - C_y\right)\dfrac{par2}{par4}, & I_y < par4, \\ par2, & par4 \le I_y \le par5, \\ par2 + par7\left(I_y - par5\right)\dfrac{par2}{par4}, & I_y > par5. \end{cases}$$

and the *pars* were read in from a control file; *par1* was the rule type.

2.7 Performance indicators

A suite of performance measures was defined to evaluate alternative decision rules relative to sustainability and exploitation objectives. We relied on the current use in assessments of empirical proxies for Bmsy, and define Bref as the mean vulnerable biomass for 1979–81. This was the reference point accepted by the Rock Lobster Working group for the 2006 assessment of CRA 7 and CRA 8 (Haist et al. unpublished data).

In the operating model projections, annual CPUE was a catch-weighted combination of the predicted AW and SS CPUE. Observation error was added to this. Although the harvest control rules use the offset-annual CPUE, all model outputs use the standard annual fishing year CPUE.

For each year of each run, the model captured six key quantities:
Bvuln, vulnerable biomass: the simple mean of AW and SS for each year (this calculation was chosen from a set of alternatives that included a catch-weighted mean),
PCPUE, or actual CPUE: the catch-weighted mean of q times vulnerable biomass from the AW and SS seasons for each fishing year,
OCPUE, observed CPUE: modified from PCPUE by the appropriate stochastic deviation, taking into account the autocorrelation and cross-correlation,
TAC and **TACC**, where *TACC* = *TAC* minus the non-commercial allowances and
CommCatch: commercial catch, which was total catch minus the recreational catch estimates of 4.51 and 20.1 t for CRA 7 and CRA 8 respectively.

At the end of each run, the model calculated summary indicators for biomass, catch, CPUE, TACC variation, population productivity and rule performance against references:
minBio: the nadir of Bvuln, expressed as a proportion of Bref,
avBio: the mean of Bvuln, also expressed as a proportion of Bref,
rangeBio: the zenith of Bvuln minus the nadir,
minCatch: the nadir of CommCatch,
avCatch: the mean of CommCatch,
minCPUE: the nadir of OCPUE,
avCPUE: the mean of OCPUE,
minTACC: the nadir of TACC,
%Var: the mean of percentage annual variation in TACC, calculated as change in TACC divided by the mean of the old and new TACCs,
nlessBref: the number of years in the run in which Bvuln was less than Bref; Bref in turn is defined as the mean of vulnerable biomass for 1979–81,
nlessBmin: the number of years in the run in which Bvuln was less than 0.5Bref;
gnTarget: the number of years in the run in which OCPUE is "near or greater than the target", i.e. greater than 90% of the "target" defined in *par3* and
lowCatch: the number of years in the run in which CommCatch was less than 95% of the TACC.

The end-of-run indicators were calculated from 2008 (because the rules begin to affect the results only for 2008) through 2027 (i.e., 20-year runs).

Two screening criteria were calculated for each rule in each trial:
whether biomass was more than Bref at least 50% of the time and
whether biomass was more than Bmin (Bmin is not defined)at least 95% of the time.

2.8 Effect of changing the rule input structure

Section 2.5 above describes how the 2002 NSS decision rule uses CPUE from the previous fishing year to calculate TAC for the next year, and how the proposed rules use the most recent AW data combined with the previous year's SS CPUE.

We examined the effects of this change using Rule 5 with no latent year. The older procedure was embodied in a version of the operating model that we can call model 6, and the newer approach in a version that we can call model 7.

There was little difference between mean catch and mean CPUE from the two models (Figure 14). The AVV diverged at higher exploitation levels (Figure 15), with model 6 increasing steeply while model 7 remained moderate. The %<Bmin indicator was substantially different between the two models, rising much more steeply as a function of the rule multiplier for model 6 (Figure 16), especially for CRA 8. This translates to a different relation between safety and catch in both stocks (Figure 17).

These key indicators show the value of using the more recent CPUE data: for the same levels of yield and abundance, stability and safety are both greatly improved.

2.9 The "other" stock

Performance of a rule on a stock is to some extent dependent on the rule used for the other stock, because there is some interaction between the stocks: movement from CRA 7 to CRA 8. In preliminary runs, we tested similar rules simultaneously in both stocks. The rule type was always the same for both stocks, and rule parameters were varied in concert between the two stocks, i.e., lowest values in the same run for both stocks. In final runs, a single reasonable rule (one likely to be among the final candidates) was chosen for CRA 7 while evaluating a variety of rules for CRA 8 and vice versa.

2.10 Stock productivity

The assessment team made a set of preliminary runs to explore basic productivity of the two stocks. The team also made numerous exploratory runs to answer specific questions and to verify that model and rule operation were correct. Based on the preliminary runs, the team designed and ran a large set of intermediate runs.

In constant-catch explorations (Figure 18), the safety limit (5% of years less than Bmin) was reached at a TAC of about 125 t for CRA 7 (TACC of about 105 t) and 1300 t for CRA 8 (TACC of about 1210 t). These were associated with mean CPUE of 3.6 and 4.7 kg/pot respectively.

To explore whether these maximum safe catches were reasonable, we made an independent check of the assessment model by using the time series of catch and standardised CPUE data for CRA 7 and CRA 8. For each year we calculated

$$P_t = B_{t+1} - B_t + C_t$$

where P, B and C represent production, vulnerable biomass and catch (total catch) respectively. Biomass can be estimated from CPUE, represented by I:

$$B_t = I_t / q$$

The catchability, q, is unknown, but a range of assumed values can be explored – a main consequence is the exploitation rate (C/B), which cannot realistically be greater than one, but which we know must have been reasonably high at some point during the time series.

The effects of various assumed q values are shown for CRA 7 in Figure 19 through Figure 21 and for CRA 8 in Figure 22 through Figure 24. Biomass and exploitation rate are affected by changes in the assumed q; a quite narrow range of q gives the extremes of credible exploitation rate; production estimates vary little within this range.

When production is normalised to the mean value – 209 t for CRA 7 and 1249 t for CRA 8, the anomalies (Figure 25 and Figure 26) show a long below-average period of productivity in the 1990s, and some suggestion of above-average production in recent years. Mean production was slightly higher than mean catch – 177 t and 1180 t for these two areas.

When production was compared with biomass (Figure 27 and Figure 28), the CRA 7 pattern was almost linear, while CRA 8 showed a period of low productivity associated with low biomass and the highest productivity with intermediate biomass, although this relation is poorly determined.

We also examined the mean size-limited catches (for practical purposes these are the commercial plus recreational catches) for the period for which we have data (Table 10). These suggest that the estimates of safe constant TACs are in the ballpark, with that for CRA 7 on the low side.

3. PRELIMINARY RUNS

A comprehensive set of preliminary runs was made with Rules 1 through 5. We tested 20 members each of the Rule 1 and Rule 2 families, 192 members of Rule 3, 72 of Rule r and 40 of Rule 5, for a total of 344 different harvest control rules. At this stage, Rule 6 had not been defined. Each rule was evaluated for performance in each of nine operating model states: the base case plus sensitivity trials S1 through S8 (at this stage trials S9 and S10 had not been defined).

For each of the 344 rule/model combinations, the model was run 600 times, each run using a parameter vector from the pseudo-psv file; about 1.8 million runs altogether. The run length was 50 years for Rules 1 and 2 and 20 years for the rest. The rationale for this was that the first two "rules" are not candidates but rather exploratory rules. A special run of 100 years was made to explore stability of the 2002 NSS decision rule.

After these were run, the assessment team made a change to the base case operating model (dropping an early estimated *CPUEpow* component of the pseudo-psv file) and made other small changes, such as redefining the variability indicator. The change to the operating model's base case meant that most of this large set of runs, representing more than a month's work, became practically worthless.

Some of the flavour of this work is seen in Figure 29 and Figure 30, where the risk indicators are plotted against the slope parameter for Rule 2 for both stocks. Risk of biomass falling below Bmin or Bref, of commercial catch not being caught and CPUE being less than the target all increase as the slope parameter increases. Figure 31 and Figure 32 show the mean catch from the constant-catch Rule 1 plotted against mean CPUE: the highest possible constant catches can be taken from a narrow range of high biomass. The exploratory runs also confirmed that higher catches are possible from the constant-exploitation rate rules than from constant-catch rules.

It was this set of runs that showed poor performance of the Rule 3 family. Only a handful of rules (none for CRA 7) achieved less than 5% risk of B<Bmin. For the 2002 NSS decision rule, the population crashed in all runs and demonstrated huge induced fluctuations in most runs. It appears that the lag in TAC behind biomass caused these fluctuations. Because no parameter combination gave satisfactory performance, further evaluation of this rule family was suspended.

This set of trials also demonstrated that latent years altered the trades-off between mean catch and abundance, mean catch and risk. With a latent year, the average performance of rules showed higher risk, lower abundance and lower catch than the average performance of rules without a latent year.

For Rule 5, Figure 33 shows major trades-off against the mean of average catch for the preliminary trials.

4. INTERMEDIATE RUNS

In the intermediate runs series, 12 levels of the multiplier for Rule 5 were run for each stock (Table 11). Each level was run with *min* (par 8) of 5%, *max* (par 9) of 25%, 50% or 100%, and the latent year option set to none, one-year or two-year. For each stock, this made 108 runs. Runs for CRA 7 and CRA 8 were made simultaneously, that is, the level shown for CRA 7 was always associated with the level shown for CRA 8.

Rule 6 was also run with 108 runs for each stock. In all runs, the latent year option was none, and *min* and *max* were disabled. For CRA 7 (Table 12), the plateau was shortened to zero: the low-CPUE and high-CPUE points were equal, so these rules were all constant-exploitation rate rules with possibly changing slope at some point in the middle. For CRA 8, all plateaus had the same upper level of CPUE (Table 13). All combinations of the parameters were run, giving 108 runs.

After the 108 values of Rule 6 had been examined for CRA 8, 15 runs were added with a latent year of 1 or 2 years, with a TAC plateau of 987 or 1137 t and CPUE at the left edge of the plateau of 1.0 or 1.5 kg/pot.

The number of rules made, and the number that passed both screening criteria (at least 50% of years with biomass >Bref; at least 95% of years with biomass >Bmin) are shown in Table 14.

After the intermediate runs had been inspected, a smaller series of rules were selected to show the trades-off among rules in terms of rule parameters. In the figures that follow, these choices are been highlighted.

Figure 34 and Figure 35 show the most obvious trade-off – that between CPUE and catch. For both stocks, low CPUE was associated with high catch and vice versa; the range of CPUE across rules was greater than the range of mean catch.

For CRA 7, all the tested Rule 6 members fell on the high-catch/low-CPUE end of the spectrum, but on the same underlying relation (Figure 34). For CRA 8, the trade-off differed between the two rule families, with Rule 6 members having lower CPUE for the same average catch (Figure 35).

The trade-off between the percentage of years less than 50% Bref and average catch is shown in Figure 36 and Figure 37. Again, the CRA 7 Rule 6 members were at one end of the spectrum, but are consistent with Rule 5; for CRA 8 there was a dichotomy between the two rule families, with Rule 5 achieving higher mean catch for the same risk against this criterion. For the Bmin criterion, there was a great deal of variability among individual rules that tends to mask the variability between families (Figure 38 and Figure 39).

The trade-off between minimum TACC and average catch (Figure 40 and Figure 41) showed a very large difference between the Rule 5 and Rule 6 families in CRA 7: the minimum TACC was often zero for Rule 6, but never lower than 40 t for the Rule 5 members. The same difference was seen in CRA 8, although the TACC rarely reached zero.

Related to the trade-off between CPUE and catch is that between minimum biomass and catch (Figure 42 and Figure 43). These relations have the same form as those seen in Figure 34 and Figure 35.

For CRA 7, the trade-off between CPUE and catch was unaffected by the latent option or the choice of max parameter (Figure 44 and Figure 45). For CRA 8, the trade-off is also affected by rule family rather than by these buffering choices (main differences are also the result of rule family (Figure 46 and Figure 47).

For CRA 8, one member of Rule 5 did exceptionally well for CRA 8. In all trades-off examined, it showed high values that can be seen in Figure 35. However, when we examined trajectories of this rule, we saw a simple pattern of change: early increase in biomass followed by a decrease, with TAC lagging behind. An example is shown in Figure 50. The rule's slow response was caused by a double latent year and a small *max* (25%). Although this rule's performance statistics in 20-year runs was good, the rule would obviously not perform well in longer runs and the apparent good performance in 20-year runs is probably an artefact.

The trade-off between AAV and mean catch is seen in Figure 48 and Figure 49. In CRA 7, the Rule 6 members showed much AAV. In CRA 8, some members of Rule 6 show high AAV, while others are comparable with Rule 5 members giving the same mean catch.

5. FINAL RUN SET

After defining and running large numbers of harvest control rules in preliminary and intermediate trials (several million runs), and screening of these rules with the two safety criteria, a set of rules for each stock was defined and presented to the NRLMG meeting of 15 October 2007. These rules were selected to give indicators within the ranges of alternative options that were available.

A sub-set of these rules, combined with a few additional rules identified by the assessment team, was then considered the final set of rules, and these were subjected to the full range of robustness trials. The rule ID numbers and parameters that define rules are shown for CRA 7 in Table 15 and for CRA 8 in Table 16. All rules for both stocks used a *min* of either zero or 0.05. The set comprised 20 rules for CRA 7 and 29 for CRA 8. For CRA 7, there were 15 Rule 5 members and 5 Rule 6 members. Seven of the Rule 5 rules had a latent year. The choice of *max* for Rule 5 ranged from 0.25 to 1.00; no *max* was used for Rule 6 members.

For CRA 8 there were 7 Rule 5 members and 22 Rule 6 members. Four of the Rule 5 rules had a latent year and one had a double latent year; two of the Rule 6 rules had a latent year. The choice of *max* for Rule 5 ranged from 0.25 to 1.00; no *max* was used for Rule 6 members.

5.1 CRA 7

The base case results are shown in Table 17 and the results of the base case are compared with the sensitivity trials in Table 18.

These rules showed various levels of contrast in the base case performances for most indicators. The median of average catch varied from 121 to 151 t, and there was a strong negative relation between this and the biomass and abundance indicators. Runs with the highest average catch tended to have the highest percentage B<Bref, and lower percentage of years at or above target CPUE, but average catch was not strongly correlated with other indicators.

Mean biomass ranged from 1.3 to 2.1 times Bref. This showed strong positive correlations with the minimum TACC indicator and percentage of years near the target CPUE, and negative correlations with the risk indicators.

Risk was unacceptably high – %B<Bmin greater than 5% – for two rules. All rules satisfied the other risk criterion, and most had high rates of being near the CPUE target.

Performance in the sensitivity trials (Table 18) was better for some indicators in some trials and worse in other combinations. Variation in TACC was not very much affected in these trials. Trials S1 and S6 usually produced lower catch and higher risk indications than the base case, as result of lower biomass. In many instances, rules that passed the risk criteria in the base case trial failed the %<Bmin criterion in one of the sensitivity trials. However, failure of the %<Bref criterion was rare (two instances only).

5.2 CRA 8

The base case results are shown in Table 19 and the results of the base case are compared with the sensitivity trials in Table 20.

In contrast with CRA 7, these evaluations were all very optimistic: over all rule/trial combinations, the mean of minimum biomass was higher than Bref 90% of the time; mean biomass was 2.2 times Bref; mean catch was 1100 t; both risk criteria were met in 98% of combinations. Trials S1 and S2 caused the greatest degradation of performance.

6. CHOICE OF CANDIDATES

The rule candidates to be presented to industry were chosen by the assessment team from the list of final rules described above. The team was influenced by the preference of CRA 7 for a responsive rule that made changes quickly as abundance changed, thus favouring Rule 5, and the preference of CRA 8 for stability of catch, even at the expense of long-term catch, thus favouring a plateau rule. The team examined the performance of rules in the base cases and sensitivity trials, and chose a range of options that all satisfied basic criteria, at least in the base case.

The short list of rules comprised three candidates for CRA 7, all Rule 5 members, and composed of Rules 75049, 75062 and 75067. These rules differed in their slopes (see Table 15) and also in buffering: Rule 75062 had a latent year and *max* = 1.0, while the others had no latent year and *max* = 0.5.

From this short list, when it was presented to the NRLMG, Rule 75062 was removed, largely because of it failed to meet the 95%>Bmin criterion in several of the sensitivity trials (see Table 18). The remaining two rules were presented to the CRA 7 industry organisation, who expressed a unanimous preference for Rule 75049, the more conservative of the two rules presented to them. The NRLMG advocated this rule in its 2007 advice to the Minister.

The short list of rules for CRA 8 comprised two candidates from Rule 5 and four candidates from Rule 6. They comprised Rules 85029 and 85040, 86302, 86303, 86309 and 86312. The results from these six (see Table 20) were presented to the executive of the CRA 8 industry organisation, who expressed a preference for the plateau rule, Rule 6, and chose two examples for presentation to their membership. These two rules were 86303 and 86309. A majority of the membership chose Rule 86303, and the NRLMG advocated this rule in its 2007 advice to the Minister.

7. DISCUSSION

In New Zealand's Quota Management System, TACC and TAC changes are relatively rare but they are extremely time-consuming for all parties when assessment results suggest their necessity: many parties must be formally consulted through a comprehensive Initial Position Paper (IPP), their comments must be summarised and MFish must develop comments in a Final Advice Paper. With hundreds of stocks in the QMS, the frequency of change for any stock is severely restricted. The de facto default management strategy for most stocks is therefore maximum constant yield (MCY), although it is well known that MCY delivers substantially lower yields than would be available under other strategies.

Management procedures are a relatively new tool for fisheries management, with clearly demonstrated benefits. Johnston & Butterworth (2005) described the reduction of time spent discussing catch limit proposals each year for South African rock lobsters. The NSS management procedure produced two decreases and two increases in TACC since 1997: these were accompanied by very little of the debate and controversy that accompanies most other TAC changes (although much of the accompanying paperwork was required nevertheless).

We evaluated a variety of rule families, some of which were quite complex (Rule 3) and some quite simple (Rule 5). The Rule 3 family did poorly, probably because of its inherent lags between changed abundance and changed catch. This work showed again that "buffering" rules increases TACC stability but changes the balances among abundance, catch and safety: buffered rules must take less catch to provide the same levels of safety.

Some of the best performances came from simple Rule 5 members with no latent year, although stability of catch is low for these rules.

Cooke (1999) suggested that management procedures must be tested against a wide range of mis-specifications of, or uncertainties about, the underlying reality. Specifically, he suggested testing with a range of productivities, different starting conditions, misreported catches, regime shifts, incorrect stock structure, trends in bias of the abundance indices, alternative stock-recruitment hypotheses, linear or cyclic trends in productivity, and episodic events. Our sensitivity trials reflect only some of that range, because of time constraints: there is a trade-off between evaluating the size of the rule field to be evaluated and the number of alternative trials. How the sensitivity trials should be used in choosing a rule is an open question: the NRLMG considered that final rule candidates should show acceptable performance in the sensitivity trials as well as in the base case.

It might be possible to include the pre-recruit index derived from catch sampling as an index, as suggested by Bentley et al. (2005), but an assessment in CRA 4 (Breen et al. 2006) suggested that the pre-recruit index in CRA 4 may not contain much information.

This study explored only the medium-term performance of harvest control rule candidates. Management procedures are unlikely to remain in place for longer than about five years without a review, because in five years the operating model used to evaluate rules will be obsolete and performance should be re-evaluated. Such a review was written into the 2002 NSS management procedure (Bentley et al. 2003). It can be argued, therefore, that only the short-term behaviour of a rule is important. However, the evaluations must be long enough to elucidate the longer-term stability characteristics of each rule. One rule that showed very promising indicators proved to show a pattern of initial increase and then decrease over 20 years, and was not a good rule. We introduced the terminal biomass indicator as a guard against such behaviour, but examining rule behaviour visually is also essential.

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Table 1: Objective function values from the model fitted to size frequency data from CRA 7 and CRA 8 using instantaneous or finite dynamics, and the difference between the two options.

	Total	CRA 7	CRA 8
instantaneous	40665.9	375.7	1006.1
finite	40722.5	369.2	1068.0
difference	56.6	-6.6	62.0

Table 2: Investigation into the source of the difference in objective function values when fitting the instantaneous or finite dynamics to the CRA 8 size frequency data. Sex 1 is males, 2 is immature and 3 mature females; size bins are in mm TW. Values are the differences in function value (negative implies instantaneous is a better fit).

Sex	1	1	1	2	2	2	3	3	3	Total
Season	AW	SS	Total	AW	SS	Total	AW	SS	Total	
43	-0.77	-0.35	-1.12	-0.02	-0.44	-0.46				-1.58
45	-0.24	0.07	-0.16	0.22	-0.19	0.03				-0.14
47	-0.27	0.48	0.22	0.59	-0.22	0.37				0.59
49	-1.24	1.68	0.45	1.16	-0.17	0.99				1.44
51	-12.48	1.23	-11.25	1.49	-0.08	1.41	0.24	-1.09	-0.85	-10.69
53	-64.29	-26.04	-90.33	-1.38	-1.77	-3.15	0.69	-1.88	-1.19	-94.67
55	25.13	9.67	34.81	-15.81	-13.07	-28.88	1.49	-4.95	-3.46	2.47
57	16.74	6.88	23.62	-28.12	-21.32	-49.44	0.94	-10.45	-9.51	-35.34
59	7.76	3.65	11.41	21.99	3.78	25.77	2.28	7.59	9.87	47.05
61	3.96	1.93	5.89	7.03	-0.19	6.84	1.65	6.65	8.30	21.03
63	1.59	0.86	2.45	1.69	-0.79	0.91	0.60	4.66	5.26	8.61
65	0.69	0.35	1.04	0.31	-0.60	-0.29	-0.07	3.00	2.93	3.68
67	0.32	-0.02	0.30	0.01	-0.93	-0.92	-0.35	1.83	1.48	0.85
69	0.13	-0.18	-0.05				-0.55	1.10	0.55	0.50
71	0.05	-0.24	-0.19				-0.62	0.72	0.10	-0.09
73	0.00	-0.29	-0.29				-0.55	0.46	-0.09	-0.38
75	-0.31	-2.99	-3.30				-0.49	0.25	-0.24	-3.54
77							-0.38	0.18	-0.20	-0.20
79							-0.36	0.13	-0.23	-0.23
81							-0.27	0.03	-0.24	-0.24
83							-0.23	0.09	-0.14	-0.14
85							-0.82	-0.13	-0.96	-0.96
Total	-23.21	-3.31	-26.52	-10.83	-36.00	-46.83	3.18	8.20	11.38	-61.97

Table 3: MPD estimates of *Bvuln* (t) in the AW and SS seasons for 2005 for each stock from each of the four base case minimisations.

	AW	SS	AW	SS
M	CRA 7	CRA 7	CRA 8	CRA 8
0.06	482	418	2362	2724
0.08	553	442	2340	2729
0.10	543	525	2357	2774
0.12	537	526	2395	2841

Table 4: Empirical estimates of standard deviations, autocorrelations, and between-stock correlations for CRA 7 and CRA 8 CPUE and recruitment deviations for the base case sub-models with alternative *M* values.

		CRA 7		CRA 8		
	M	Std. dev.	Auto-correlation	Std. dev.	Auto-correlation	Cross-correlation
CPUE	0.06	0.21	0.17	0.19	0.40	0.27
deviations	0.08	0.21	0.13	0.20	0.45	0.24
	0.10	0.22	0.09	0.20	0.49	0.25
	0.12	0.22	0.07	0.20	0.52	0.26
Recruitment	0.06	0.86	0.29	0.52	0.49	0.27
deviations	0.08	0.82	0.29	0.53	0.45	0.20
	0.10	0.79	0.30	0.54	0.45	0.17
	0.12	0.78	0.30	0.53	0.47	0.17

Table 5: Simulated catches and seasonal splits, by fishery, assumed in stock projections for CRA 7 and CRA 8.

		Total		Split (proportions)	
Simulated catches	Fishery	CRA 7	CRA 8	AW	SS
Commercial	SL	same as TACC (see above)		use rule	
Recreational	SL	4.51	20.10	0.1	0.9
Customary	NSL	1.00	2.00	0.1	0.9
Illegal	NSL	1.00	18.00	use rule	

Table 6: Coefficients for the MLR predictor of annual CPUE, estimated with the Excel Solver.

	CRA 8	CRA 7
a	0.2508	0.0209
b1	-0.5183	0.2836
b2	1.1029	0.6183

Table 7: Statistics from the three CPUE predictors using the base case MPD fit.

	simple mean	weighted mean	MLR
CRA 8 sum of squares	3.342	3.630	0.715
CRA 7 sum of squares	0.553	0.609	0.491
CRA 8 std dev of residuals	0.340	0.357	0.166
CRA 7 std dev of residuals	0.143	0.152	0.137
CRA 8 autocorrelation in predicted CPUE	0.923	0.936	0.909
CRA 7 autocorrelation in predicted CPUE	0.780	0.749	0.794
CRA 8 autocorrelation in residuals	0.820	0.833	0.350
CRA 7 autocorrelation in residuals	0.021	0.021	0.031

Table 8: Estimated values of steepness from the model fits made for robustness trial R4.

M	steepness
$M = 0.06$	0.94
$M = 0.08$	0.91
$M = 0.10$	0.92
$M = 0.12$	0.91

Table 9: Estimated values of *CPUEpow* at four values of assumed M.

M	CPUEpow
$M = 0.06$	0.721
$M = 0.08$	0.710
$M = 0.10$	0.643
$M = 0.12$	0.624

Table 10: Mean catch, mean estimated production and maximum TACC from preliminary runs (all in t) for CRA 7 and CRA 8.

	CRA 7	CRA 8
mean catch, 1979-2006	177	1180
mean estimated production	209	1249
TACC from preliminary runs	125	1300

Table 11: Levels of the multiplier (*par2*) used for Rule 5 intermediate runs.

level	CRA 7	CRA 8
1	50	250
2	60	275
3	70	300
4	80	325
5	90	350
6	100	375
7	110	400
8	120	450
9	130	500
10	140	600
11	150	800
12	160	1000

Table 12: Parameters used for Rule 6 family members for CRA 7.

par2 TAC plateau	par4 CPUE at left	par5 CPUE at right	par6 lower slope	par7 higher slope
130	1.00	same	1.0	1.0
165	1.25	same	1.2	1.1
200	1.50	same	1.4	1.2
			1.6	1.3
			1.8	1.4
			2	1.5

Table 13: Parameters used for Rule 6 family members for CRA 8.

par2 TAC plateau	par4 CPUE at left	par5 CPUE at right	par6 lower slope	par7 higher slope
987	1.5	4.0	1.0	1.0
1137	2.0		1.5	1.5
1287	2.5		2.0	2.0
1437				

Table 14: Numbers of intermediate runs made and the number that passed the two screening criteria.

Stock	Family	No. runs	No. passed
CRA 7	Rule 5	108	57
CRA 7	Rule 6	108	76
CRA 8	Rule 5	108	78
CRA 8	Rule 6	123	123

Table 15: The final set of rules evaluated for CRA 7. Asterisks indicate a final candidate.

Stock	Rule	rule family par1	par2	par3	par4	par5	par6	par7	min par8	max par9	latent switch par10
CRA 7	75020	5	70	1	-	-	-	-	0.05	0.25	1
CRA 7	75038	5	90	1	-	-	-	-	0.05	0.25	1
CRA 7	*75049	5	100	1	-	-	-	-	0.05	0.50	0
CRA 7	75055	5	110	1	-	-	-	-	0.05	0.25	0
CRA 7	75058	5	110	1	-	-	-	-	0.05	0.50	0
CRA 7	75059	5	110	1	-	-	-	-	0.05	0.50	1
CRA 7	*75062	5	110	1	-	-	-	-	0.05	1.00	1
CRA 7	*75067	5	120	1	-	-	-	-	0.05	0.50	0
CRA 7	75070	5	120	1	-	-	-	-	0.05	1.00	0
CRA 7	75201	5	70	1	-	-	-	-	0.05	0.25	0
CRA 7	75202	5	70	1	-	-	-	-	0.05	0.50	0
CRA 7	75203	5	70	1	-	-	-	-	0.05	0.50	1
CRA 7	75204	5	120	1	-	-	-	-	0.05	0.50	1
CRA 7	75205	5	120	1	-	-	-	-	0.05	0.25	0
CRA 7	75206	5	120	1	-	-	-	-	0.05	0.25	1
CRA 7	76007	6	130	1	1.0	1.0	1.2	1.0	0.05	0.00	0
CRA 7	76043	6	165	1	1.3	1.3	1.2	1.0	0.05	0.00	0
CRA 7	76079	6	200	1	1.5	1.5	1.2	1.0	0.05	0.00	0
CRA 7	76094	6	200	1	1.5	1.5	1.6	1.3	0.05	0.00	0
CRA 7	76108	6	200	1	1.5	1.5	2.0	1.5	0.05	0.00	0

Table 16: The final set of rules evaluated for CRA 8. Asterisks indicate a final candidate.

Stock	Rule	rule family par1	par2	par3	par4	par5	par6	par7	min par8	max par9	latent switch par10
CRA 8	85011	5	275	1.9	-	-	-	-	0.05	0.25	1
CRA 8	*85029	5	325	1.9	-	-	-	-	0.05	0.25	1
CRA 8	85033	5	325	1.9	-	-	-	-	0.05	0.50	2
CRA 8	85037	5	350	1.9	-	-	-	-	0.05	0.25	0
CRA 8	*85040	5	350	1.9	-	-	-	-	0.05	0.50	0
CRA 8	85041	5	350	1.9	-	-	-	-	0.05	0.50	1
CRA 8	85089	5	600	1.9	-	-	-	-	0.05	1.00	1
CRA 8	86013	6	987	1.9	2.0	4.0	1.5	1.00	0.05	0	0
CRA 8	86038	6	1137	1.9	2.0	4.0	1.0	1.50	0.05	0	0
CRA 8	86113	6	987	1.9	2.0	4.0	1.5	1.00	0.05	0	1
CRA 8	86119	6	1137	1.9	2.0	4.0	1.0	1.50	0.05	0	1
CRA 8	86207	6	987	1.9	2.0	4.0	1.4	0.30	0.05	0	0
CRA 8	86208	6	1050	1.9	2.0	4.0	1.4	0.30	0.05	0	0
CRA 8	86209	6	987	1.9	2.0	4.0	1.4	0.60	0.05	0	0
CRA 8	86210	6	1050	1.9	2.0	4.0	1.4	0.60	0.05	0	0
CRA 8	86211	6	987	1.9	2.0	4.0	1.4	0.80	0.05	0	0
CRA 8	86212	6	1050	1.9	2.0	4.0	1.4	0.80	0.05	0	0
CRA 8	86301	6	987	1.9	1.9	3.2	1.2	0.22	0.05	0	0
CRA 8	*86302	6	987	1.9	1.9	4.0	1.2	0.30	0.05	0	0
CRA 8	*86303	6	1053	1.9	1.9	3.2	1.2	0.16	0.05	0	0
CRA 8	86304	6	1053	1.9	1.9	4.0	1.2	0.22	0.05	0	0
CRA 8	86305	6	987	1.9	1.9	3.2	1.2	0.28	0.05	0	0
CRA 8	86306	6	987	1.9	1.9	4.0	1.2	0.40	0.05	0	0
CRA 8	86307	6	1053	1.9	1.9	3.2	1.2	0.22	0.05	0	0
CRA 8	86308	6	1053	1.9	1.9	4.0	1.2	0.31	0.05	0	0
CRA 8	*86309	6	987	1.9	1.9	3.2	1.2	0.35	0.05	0	0
CRA 8	86310	6	987	1.9	1.9	4.0	1.2	0.50	0.05	0	0
CRA 8	86311	6	1053	1.9	1.9	3.2	1.2	0.29	0.05	0	0
CRA 8	*86312	6	1053	1.9	1.9	4.0	1.2	0.40	0.05	0	0

Table 17: Base case results for the final CRA 7 rules. Asterisks indicate a final candidate.

Rule	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
75020	1.11	2.09	66	121	0.89	2.16	66	13	11.9	2.08	9.4	1.1	90.3
75038	0.83	1.81	66	132	0.65	1.83	67	133	12.2	1.69	19.5	4.0	80.4
*75049	0.82	1.62	46	139	0.64	1.63	46	0	31.3	1.48	20.9	1.3	79.9
75055	0.68	1.58	50	140	0.52	1.57	50	40	23.2	1.43	26.1	4.1	74.1
75058	0.72	1.52	44	143	0.55	1.53	44	0	32.4	1.36	26.2	2.2	74.6
75059	0.66	1.58	49	139	0.49	1.57	49	45	19.9	1.44	27.1	4.6	73.3
*75062	0.65	1.49	41	143	0.49	1.48	41	5	24.6	1.37	28.9	4.1	71.8
*75067	0.64	1.44	43	146	0.49	1.43	43	2	33.4	1.27	31.1	3.9	70.0
75070	0.63	1.38	41	147	0.48	1.37	41	0	37.1	1.23	33.1	4.0	68.2
75201	1.17	2.11	56	123	0.94	2.16	56	0	21.6	2.04	6.2	0.2	93.5
75202	1.20	2.07	48	123	0.95	2.12	48	0	29.2	1.97	5.8	0.1	94.0
75203	1.15	2.09	54	123	0.90	2.12	54	0	17.5	2.04	7.4	0.3	92.5
75204	0.58	1.51	46	142	0.42	1.49	47	103	20.3	1.39	31.3	6.8	69.2
75205	0.59	1.50	49	143	0.45	1.48	49	85	23.8	1.32	30.8	6.2	69.4
75206	0.51	1.50	67	142	0.36	1.49	70	489	12.5	1.28	33.3	11.5	66.4
76007	0.58	1.29	25	151	0.44	1.28	25	0	45.5	1.15	37.7	4.6	63.4
76043	0.62	1.33	21	148	0.48	1.32	21	0	47.7	1.20	34.6	3.2	66.8
76079	0.60	1.30	17	149	0.46	1.30	17	1	52.5	1.19	36.1	3.5	65.4
76094	0.65	1.35	0	148	0.52	1.35	0	6	80.5	1.26	31.1	1.8	71.2
76108	0.66	1.38	0	146	0.55	1.38	0	10	91.0	1.32	28.5	1.8	74.1

Table 18: For each CRA 7 final rule, base case and sensitivity trial results.

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
75020	Base	1.11	2.09	66	121	0.89	2.16	66	13	11.9	2.08	9.4	1.1	90.3
75020	S01	0.92	1.72	51	100	0.72	1.77	51	21	12.5	1.58	18.2	2.6	82.9
75020	S02	1.10	2.15	66	120	0.67	2.36	66	58	12.5	2.10	11.2	2.1	85.5
75020	S03	0.99	2.01	69	126	0.89	2.30	69	23	11.9	1.85	12.6	1.7	90.8
75020	S04	1.84	3.29	99	181	1.40	3.51	101	61	11.3	3.16	1.6	0.1	97.7
75020	S05	1.02	2.02	63	117	0.87	2.12	63	3	12.0	1.87	11.6	1.2	90.0
75020	S06	0.93	1.76	49	94	0.72	1.74	49	15	12.7	1.84	17.8	2.1	82.0
75020	S09	1.89	3.03	69	107	1.03	1.89	69	0	11.1	3.20	1.7	0.1	95.5
75038	Base	0.83	1.81	66	132	0.65	1.83	67	133	12.2	1.69	19.5	4.0	80.4
75038	S01	0.64	1.45	49	111	0.48	1.48	50	205	12.9	1.26	31.6	8.4	68.9
75038	S02	0.77	1.81	68	131	0.45	1.96	70	224	12.8	1.64	20.5	5.6	76.8
75038	S03	0.72	1.71	68	137	0.62	1.92	70	243	12.3	1.46	23.3	5.5	80.9
75038	S04	1.41	2.82	105	193	0.98	2.88	111	313	11.4	2.52	5.1	1.2	92.3
75038	S05	0.72	1.70	64	128	0.61	1.77	65	99	12.2	1.53	23.2	4.6	79.6
75038	S06	0.67	1.47	49	105	0.49	1.44	49	86	12.9	1.47	30.9	7.6	69.4
75038	S09	1.58	2.65	81	126	0.89	1.72	82	2	11.1	2.55	4.3	0.4	91.3
*75049	Base	0.82	1.62	46	139	0.64	1.63	46	0	31.3	1.48	20.9	1.3	79.9
*75049	S01	0.67	1.34	34	115	0.52	1.34	34	0	32.5	1.16	33.3	3.4	68.6
*75049	S02	0.77	1.66	32	137	0.46	1.78	32	14	41.5	1.54	21.0	2.7	76.0
*75049	S03	0.72	1.53	46	144	0.63	1.70	46	0	32.0	1.29	26.0	2.4	80.7
*75049	S04	1.35	2.35	81	204	0.95	2.39	81	13	31.1	2.25	3.2	0.1	94.8
*75049	S05	0.73	1.52	45	134	0.62	1.59	45	0	31.0	1.36	24.8	1.7	79.4
*75049	S06	0.67	1.37	33	112	0.51	1.33	33	0	33.1	1.27	33.3	3.6	67.5
*75049	S09	1.45	2.39	65	137	0.83	1.59	65	0	27.1	2.23	5.1	0.3	89.3
75055	Base	0.68	1.58	50	140	0.52	1.57	50	40	23.2	1.43	26.1	4.1	74.1
75055	S01	0.54	1.29	37	117	0.42	1.28	37	53	24.3	1.10	39.4	8.5	61.9
75055	S02	0.62	1.59	47	141	0.36	1.69	47	178	25.5	1.43	27.1	6.5	70.4

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
75055	S03	0.58	1.49	51	145	0.50	1.64	51	93	23.8	1.22	30.9	6.4	74.6
75055	S04	1.15	2.29	84	203	0.76	2.35	86	344	22.2	2.08	8.2	1.2	87.8
75055	S05	0.61	1.49	50	135	0.52	1.53	50	23	23.4	1.31	30.4	5.0	73.6
75055	S06	0.56	1.32	38	112	0.42	1.27	38	26	24.4	1.22	38.7	8.1	62.1
75055	S09	1.30	2.28	78	142	0.77	1.52	78	1	19.9	2.06	7.8	0.6	86.1
75058	Base	0.72	1.52	44	143	0.55	1.53	44	0	32.4	1.36	26.2	2.2	74.6
75058	S01	0.59	1.26	32	118	0.45	1.25	32	0	33.4	1.06	39.5	5.7	62.7
75058	S02	0.67	1.56	31	140	0.40	1.66	31	31	41.6	1.43	25.7	4.1	71.6
75058	S03	0.63	1.44	45	148	0.54	1.59	45	2	33.1	1.20	31.6	4.1	75.7
75058	S04	1.20	2.19	77	208	0.83	2.22	77	37	31.8	2.06	5.7	0.1	91.4
75058	S05	0.65	1.42	43	138	0.55	1.49	43	0	31.9	1.24	30.6	3.1	74.0
75058	S06	0.60	1.28	31	115	0.45	1.24	31	0	34.3	1.15	39.3	5.8	62.1
75058	S09	1.30	2.23	67	144	0.78	1.50	67	0	27.1	2.02	7.8	0.6	86.0
75059	Base	0.66	1.58	49	139	0.49	1.57	49	45	19.9	1.44	27.1	4.6	73.3
75059	S01	0.53	1.30	34	116	0.40	1.28	34	51	20.9	1.12	40.0	8.8	61.7
75059	S02	0.60	1.59	42	136	0.36	1.72	42	201	22.8	1.52	27.6	7.2	70.2
75059	S03	0.56	1.50	48	144	0.47	1.67	48	110	20.2	1.30	31.8	7.0	74.0
75059	S04	1.11	2.28	79	200	0.73	2.35	80	336	18.9	2.19	9.0	1.2	87.6
75059	S05	0.59	1.49	47	135	0.49	1.55	47	37	20.2	1.34	31.1	6.0	73.0
75059	S06	0.53	1.31	35	111	0.39	1.27	35	41	21.4	1.28	39.5	9.1	61.1
75059	S09	1.26	2.24	75	143	0.75	1.52	75	1	15.9	2.06	8.8	0.9	85.3
*75062	Base	0.65	1.49	41	143	0.49	1.48	41	5	24.6	1.37	28.9	4.1	71.8
*75062	S01	0.53	1.21	30	118	0.40	1.22	30	5	25.3	1.05	42.6	8.4	59.5
*75062	S02	0.60	1.51	25	141	0.34	1.64	25	64	32.2	1.46	27.9	5.6	69.5
*75062	S03	0.56	1.41	39	148	0.46	1.58	39	16	26.0	1.19	33.7	6.4	73.0
*75062	S04	1.10	2.15	70	206	0.73	2.19	70	61	23.1	2.02	8.2	0.5	88.3
*75062	S05	0.57	1.41	42	137	0.48	1.46	42	3	24.6	1.24	33.1	5.1	71.2
*75062	S06	0.53	1.24	30	114	0.39	1.21	30	4	26.7	1.14	42.1	8.8	58.6
*75062	S09	1.21	2.18	71	145	0.75	1.49	71	0	17.6	1.98	9.2	0.9	84.3

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
*75067	Base	0.64	1.44	43	146	0.49	1.43	43	2	33.4	1.27	31.1	3.9	70.0
*75067	S01	0.52	1.18	31	120	0.40	1.17	31	2	34.7	0.99	45.0	8.3	56.9
*75067	S02	0.60	1.48	30	143	0.35	1.55	30	63	42.1	1.33	30.3	5.7	67.7
*75067	S03	0.55	1.36	43	151	0.47	1.49	43	8	34.2	1.12	36.4	6.2	70.9
*75067	S04	1.08	2.07	74	210	0.73	2.08	74	68	32.6	1.87	9.0	0.4	87.2
*75067	S05	0.58	1.35	41	142	0.49	1.40	41	0	32.9	1.16	35.4	4.9	69.2
*75067	S06	0.53	1.21	30	117	0.40	1.15	30	0	35.4	1.05	44.4	8.5	56.6
*75067	S09	1.15	2.09	68	150	0.71	1.42	68	0	27.4	1.82	11.0	1.0	82.1
75070	Base	0.63	1.38	41	147	0.48	1.37	41	0	37.1	1.23	33.1	4.0	68.2
75070	S01	0.51	1.14	29	122	0.39	1.12	29	0	38.5	0.95	47.5	8.9	54.6
75070	S02	0.58	1.37	22	147	0.34	1.46	22	13	55.3	1.24	33.5	5.9	64.7
75070	S03	0.54	1.30	40	152	0.46	1.42	40	1	38.3	1.06	38.6	6.5	69.1
75070	S04	1.04	1.95	69	213	0.72	1.96	69	14	37.4	1.79	9.9	0.4	86.4
75070	S05	0.57	1.30	39	144	0.48	1.34	39	0	36.4	1.11	37.7	5.2	67.5
75070	S06	0.52	1.16	28	119	0.39	1.12	28	0	39.6	1.01	46.8	9.1	54.2
75070	S09	1.12	2.04	65	151	0.70	1.40	65	0	30.0	1.79	11.6	1.1	81.3
75201	Base	1.17	2.11	56	123	0.94	2.16	56	0	21.6	2.04	6.2	0.2	93.5
75201	S01	0.98	1.74	42	102	0.79	1.78	42	0	22.3	1.58	13.6	0.4	87.1
75201	S02	1.13	2.14	50	122	0.68	2.34	50	7	24.7	2.04	8.6	0.7	87.6
75201	S03	1.06	1.99	58	129	0.96	2.27	58	2	21.7	1.81	9.5	0.3	94.0
75201	S04	1.89	3.10	91	186	1.44	3.27	91	0	20.8	3.16	0.4	0.0	99.3
75201	S05	1.10	1.98	55	119	0.92	2.08	55	0	21.3	1.83	8.3	0.3	93.2
75201	S06	1.00	1.79	42	99	0.78	1.77	42	0	22.7	1.76	13.8	0.6	85.9
75201	S09	1.91	3.02	60	107	1.03	1.89	60	0	20.2	3.16	1.1	0.0	96.0
75202	Base	1.20	2.07	48	123	0.95	2.12	48	0	29.2	1.97	5.8	0.1	94.0
75202	S01	1.01	1.73	38	103	0.81	1.77	38	0	30.0	1.53	12.3	0.3	88.2
75202	S02	1.16	2.09	35	122	0.69	2.31	35	0	40.3	2.03	7.2	0.3	88.6
75202	S03	1.09	1.94	50	130	0.97	2.22	50	0	29.5	1.74	8.7	0.2	94.7
75202	S04	1.88	3.01	82	189	1.45	3.18	82	0	29.1	3.12	0.4	0.0	99.5

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
75202	S05	1.11	1.95	48	121	0.93	2.05	48	0	29.1	1.80	7.7	0.1	93.7
75202	S06	1.04	1.77	37	101	0.79	1.74	37	0	30.7	1.72	12.7	0.3	86.9
75202	S09	1.91	3.00	53	108	1.03	1.89	53	0	27.4	3.10	1.0	0.0	96.1
75203	Base	1.15	2.09	54	123	0.90	2.12	54	0	17.5	2.04	7.4	0.3	92.5
75203	S01	0.96	1.72	42	101	0.75	1.76	42	0	18.1	1.60	14.6	0.6	86.2
75203	S02	1.12	2.13	45	121	0.66	2.30	45	20	21.8	2.12	9.3	1.2	86.9
75203	S03	1.03	1.98	56	129	0.92	2.24	56	3	17.8	1.79	10.5	0.6	93.0
75203	S04	1.84	3.10	88	184	1.42	3.27	88	7	16.8	3.17	0.7	0.0	99.0
75203	S05	1.05	1.96	52	117	0.91	2.07	52	0	17.5	1.84	9.5	0.4	92.4
75203	S06	0.98	1.75	40	98	0.75	1.75	40	0	18.7	1.79	14.9	0.9	85.0
75203	S09	1.89	3.02	58	108	1.03	1.89	58	0	15.7	3.12	1.2	0.0	95.8
75204	Base	0.58	1.51	46	142	0.42	1.49	47	103	20.3	1.39	31.3	6.8	69.2
75204	S01	0.46	1.22	33	117	0.34	1.22	33	112	22.0	1.08	44.6	12.3	56.7
75204	S02	0.52	1.53	40	138	0.30	1.61	40	322	23.3	1.43	31.5	9.4	66.6
75204	S03	0.49	1.43	47	147	0.40	1.57	47	186	21.0	1.20	36.2	9.5	70.0
75204	S04	0.96	2.15	71	200	0.63	2.23	74	525	19.7	2.05	13.0	2.0	83.1
75204	S05	0.50	1.42	46	136	0.41	1.48	46	57	20.8	1.25	35.5	8.4	68.6
75204	S06	0.46	1.23	33	113	0.33	1.19	33	86	21.9	1.20	44.1	12.4	56.7
75204	S09	1.10	2.08	75	148	0.70	1.43	75	1	16.0	1.86	12.2	1.5	81.2
75205	Base	0.59	1.50	49	143	0.45	1.48	49	85	23.8	1.32	30.8	6.2	69.4
75205	S01	0.46	1.22	35	119	0.35	1.20	35	126	25.0	1.04	44.4	11.9	57.0
75205	S02	0.54	1.52	47	143	0.31	1.60	47	258	25.5	1.36	31.3	8.7	66.5
75205	S03	0.49	1.42	50	148	0.42	1.55	51	184	23.9	1.14	36.0	9.0	70.1
75205	S04	1.00	2.15	79	204	0.65	2.19	82	572	22.6	1.91	12.0	2.2	83.4
75205	S05	0.53	1.40	48	137	0.44	1.45	48	63	24.0	1.22	35.3	7.6	68.9
75205	S06	0.48	1.25	36	114	0.35	1.20	36	61	25.1	1.14	43.7	11.2	57.2
75205	S09	1.16	2.14	79	148	0.71	1.45	79	4	20.0	1.85	10.8	1.1	82.4
75206	Base	0.51	1.50	67	142	0.36	1.49	70	489	12.5	1.28	33.3	11.5	66.4
75206	S01	0.36	1.19	46	120	0.25	1.19	49	725	13.3	0.96	47.3	20.0	53.9

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
75206	S02	0.49	1.51	67	141	0.28	1.61	72	590	12.8	1.26	32.9	12.8	65.6
75206	S03	0.42	1.42	67	146	0.33	1.57	72	696	12.5	1.11	37.4	14.4	67.1
75206	S04	0.89	2.35	92	200	0.52	2.40	115	1085	11.9	1.70	15.8	5.6	80.2
75206	S05	0.44	1.41	67	137	0.34	1.45	69	392	12.5	1.17	37.3	13.3	65.9
75206	S06	0.39	1.21	49	113	0.27	1.17	51	459	13.3	1.12	45.6	18.3	54.9
75206	S09	1.10	2.16	88	147	0.70	1.47	88	27	11.0	1.89	12.4	2.2	81.1
76007	Base	0.58	1.29	25	151	0.44	1.28	25	0	45.5	1.15	37.7	4.6	63.4
76007	S01	0.48	1.08	14	124	0.37	1.06	14	1	50.4	0.92	51.8	9.5	50.6
76007	S02	0.48	1.23	0	152	0.29	1.31	0	39	76.1	1.10	41.3	8.6	58.3
76007	S03	0.49	1.20	24	156	0.43	1.31	24	5	47.3	0.99	43.7	7.9	64.3
76007	S04	0.92	1.77	56	214	0.62	1.76	56	40	41.9	1.62	14.5	0.6	81.7
76007	S05	0.52	1.22	25	147	0.44	1.27	25	0	44.8	1.04	42.3	6.2	63.2
76007	S06	0.48	1.09	13	120	0.36	1.06	13	0	52.2	0.96	51.1	10.1	50.1
76007	S09	1.00	1.90	55	156	0.64	1.33	55	0	33.3	1.63	14.6	1.4	77.6
76043	Base	0.62	1.33	21	148	0.48	1.32	21	0	47.7	1.20	34.6	3.2	66.8
76043	S01	0.53	1.12	11	121	0.41	1.11	11	0	53.7	0.96	48.3	6.7	54.4
76043	S02	0.52	1.27	0	150	0.31	1.36	0	36	79.9	1.15	38.4	7.1	60.8
76043	S03	0.53	1.24	21	154	0.46	1.37	21	3	49.9	1.03	40.9	6.0	67.5
76043	S04	0.97	1.82	52	214	0.66	1.81	52	33	43.6	1.68	12.0	0.3	84.3
76043	S05	0.56	1.27	22	145	0.47	1.31	22	0	47.2	1.09	39.5	4.4	66.4
76043	S06	0.52	1.14	10	119	0.40	1.10	10	0	55.7	1.02	47.8	6.9	53.7
76043	S09	1.07	1.97	50	153	0.67	1.37	50	0	35.4	1.71	12.1	0.8	80.0
76079	Base	0.60	1.30	17	149	0.46	1.30	17	1	52.5	1.19	36.1	3.5	65.4
76079	S01	0.52	1.10	7	122	0.40	1.09	7	1	59.6	0.96	49.6	6.8	53.1
76079	S02	0.49	1.24	0	151	0.30	1.32	0	43	84.7	1.11	40.0	7.8	59.5
76079	S03	0.51	1.22	15	155	0.45	1.34	15	5	55.1	1.01	42.7	6.5	66.2
76079	S04	0.92	1.76	45	214	0.63	1.75	45	47	47.0	1.61	13.9	0.4	82.2
76079	S05	0.54	1.24	16	146	0.46	1.29	16	0	51.8	1.08	41.0	4.8	65.1
76079	S06	0.51	1.13	5	119	0.39	1.08	5	0	61.3	1.01	48.9	7.2	52.5

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
76079	S09	1.02	1.92	46	155	0.65	1.34	46	0	37.8	1.66	13.0	0.9	78.6
76094	Base	0.65	1.35	0	148	0.52	1.35	0	6	80.5	1.26	31.1	1.8	71.2
76094	S01	0.59	1.17	0	119	0.48	1.18	0	5	87.4	1.09	42.1	2.9	62.1
76094	S02	0.47	1.29	0	151	0.30	1.36	0	102	101.0	1.19	37.4	7.1	62.0
76094	S03	0.55	1.25	0	154	0.50	1.38	0	14	81.9	1.08	39.0	3.9	71.4
76094	S04	0.90	1.70	0	215	0.64	1.70	0	72	72.1	1.55	13.2	0.2	84.4
76094	S05	0.59	1.30	0	144	0.52	1.34	0	2	79.4	1.17	35.9	2.6	71.1
76094	S06	0.59	1.22	0	116	0.48	1.18	0	2	87.9	1.14	41.1	3.1	61.3
76094	S09	1.10	1.95	11	152	0.69	1.37	11	1	59.3	1.77	8.5	0.2	83.0
76108	Base	0.66	1.38	0	146	0.55	1.38	0	10	91.0	1.32	28.5	1.8	74.1
76108	S01	0.61	1.23	0	118	0.51	1.23	0	8	92.2	1.15	37.4	2.7	67.2
76108	S02	0.45	1.31	0	150	0.29	1.38	0	148	101.3	1.21	36.2	7.2	62.9
76108	S03	0.57	1.27	0	153	0.51	1.41	0	27	90.6	1.12	36.6	3.8	74.0
76108	S04	0.88	1.67	0	215	0.64	1.69	0	76	91.6	1.54	13.0	0.3	85.8
76108	S05	0.62	1.32	0	143	0.56	1.38	0	2	88.9	1.24	32.9	2.3	74.7
76108	S06	0.61	1.27	0	115	0.51	1.23	0	3	90.4	1.21	36.0	2.8	65.9
76108	S09	1.14	2.00	0	150	0.73	1.40	0	1	77.6	1.81	6.0	0.1	85.9

Table 19: Base case results for the final rules evaluated for CRA 8. Asterisks indicate a final candidate.

Rule	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
85011	1.94	2.55	773	1185	2.80	4.96	775	45	9.8	2.32	0.7	0.2	98.7
*85029	1.60	2.30	776	1223	2.17	4.32	783	185	10.3	1.98	2.7	1.0	94.8
85033	1.59	2.26	727	1216	2.19	4.18	727	82	10.4	2.06	2.0	0.4	96.0
85037	1.57	2.14	718	1233	2.12	3.93	718	7	17.4	1.92	0.7	0.0	97.5

Rule	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
*85040	1.57	2.08	683	1234	2.13	3.79	683	0	20.2	1.91	0.4	0.0	98.2
85041	1.50	2.12	678	1228	2.02	3.89	679	12	13.8	1.94	0.9	0.0	96.8
85089	0.77	1.41	445	1266	0.78	2.31	448	315	22.3	1.19	23.4	1.6	62.5
86013	1.80	2.30	900	1212	2.59	4.32	900	0	21.2	2.13	0.5	0.0	98.3
86038	1.35	1.92	913	1242	1.70	3.40	913	20	20.4	1.69	5.0	0.0	88.6
86113	1.71	2.27	900	1218	2.39	4.28	900	6	14.5	2.11	0.8	0.0	97.3
86119	1.17	1.84	796	1248	1.41	3.26	799	110	15.2	1.62	8.1	0.3	84.5
86207	2.19	2.83	900	1132	3.48	5.60	900	0	11.1	2.82	0.1	0.0	99.6
86208	2.13	2.67	963	1159	3.22	5.23	963	0	10.5	2.59	0.3	0.0	99.1
86209	2.02	2.52	900	1187	2.96	4.82	900	0	16.6	2.36	0.2	0.0	99.2
86210	1.90	2.39	963	1205	2.69	4.54	963	0	15.9	2.19	0.6	0.0	98.1
86211	1.90	2.39	900	1204	2.76	4.54	900	0	19.2	2.21	0.4	0.0	98.7
86212	1.77	2.28	963	1215	2.51	4.27	963	0	18.2	2.08	0.9	0.0	97.3
86301	2.16	2.75	902	1145	3.35	5.42	902	0	8.9	2.73	0.3	0.0	99.4
*86302	2.19	2.80	900	1137	3.44	5.55	900	0	11.5	2.79	0.2	0.0	99.5
*86303	2.14	2.72	966	1149	3.30	5.34	966	1	6.9	2.67	0.6	0.0	98.8
86304	2.17	2.77	966	1141	3.38	5.44	966	0	8.8	2.73	0.4	0.0	99.1
86305	2.09	2.62	900	1171	3.13	5.08	900	0	10.4	2.53	0.3	0.0	99.2
86306	2.13	2.68	900	1161	3.21	5.22	900	0	13.6	2.60	0.2	0.0	99.4
86307	2.06	2.57	966	1181	3.05	4.97	966	1	8.6	2.45	0.7	0.0	98.3
86308	2.10	2.63	966	1169	3.16	5.12	966	1	11.0	2.52	0.5	0.0	98.8
*86309	1.99	2.50	900	1190	2.89	4.81	900	0	11.9	2.38	0.4	0.0	98.9
86310	2.07	2.58	900	1176	3.06	4.96	900	0	15.5	2.44	0.3	0.0	99.2
86311	1.92	2.43	966	1202	2.74	4.65	966	0	10.3	2.26	1.0	0.0	97.8
*86312	2.03	2.53	966	1186	2.95	4.85	966	1	12.8	2.39	0.6	0.0	98.4

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
75206	S02	0.49	1.51	67	141	0.28	1.61	72	590	12.8	1.26	32.9	12.8	65.6
75206	S03	0.42	1.42	67	146	0.33	1.57	72	696	12.5	1.11	37.4	14.4	67.1
75206	S04	0.89	2.35	92	200	0.52	2.40	115	1085	11.9	1.70	15.8	5.6	80.2
75206	S05	0.44	1.41	67	137	0.34	1.45	69	392	12.5	1.17	37.3	13.3	65.9
75206	S06	0.39	1.21	49	113	0.27	1.17	51	459	13.3	1.12	45.6	18.3	54.9
75206	S09	1.10	2.16	88	147	0.70	1.47	88	27	11.0	1.89	12.4	2.2	81.1
76007	Base	0.58	1.29	25	151	0.44	1.28	25	0	45.5	1.15	37.7	4.6	63.4
76007	S01	0.48	1.08	14	124	0.37	1.06	14	1	50.4	0.92	51.8	9.5	50.6
76007	S02	0.48	1.23	0	152	0.29	1.31	0	39	76.1	1.10	41.3	8.6	58.3
76007	S03	0.49	1.20	24	156	0.43	1.31	24	5	47.3	0.99	43.7	7.9	64.3
76007	S04	0.92	1.77	56	214	0.62	1.76	56	40	41.9	1.62	14.5	0.6	81.7
76007	S05	0.52	1.22	25	147	0.44	1.27	25	0	44.8	1.04	42.3	6.2	63.2
76007	S06	0.48	1.09	13	120	0.36	1.06	13	0	52.2	0.96	51.1	10.1	50.1
76007	S09	1.00	1.90	55	156	0.64	1.33	55	0	33.3	1.63	14.6	1.4	77.6
76043	Base	0.62	1.33	21	148	0.48	1.32	21	0	47.7	1.20	34.6	3.2	66.8
76043	S01	0.53	1.12	11	121	0.41	1.11	11	0	53.7	0.96	48.3	6.7	54.4
76043	S02	0.52	1.27	0	150	0.31	1.36	0	36	79.9	1.15	38.4	7.1	60.8
76043	S03	0.53	1.24	21	154	0.46	1.37	21	3	49.9	1.03	40.9	6.0	67.5
76043	S04	0.97	1.82	52	214	0.66	1.81	52	33	43.6	1.68	12.0	0.3	84.3
76043	S05	0.56	1.27	22	145	0.47	1.31	22	0	47.2	1.09	39.5	4.4	66.4
76043	S06	0.52	1.14	10	119	0.40	1.10	10	0	55.7	1.02	47.8	6.9	53.7
76043	S09	1.07	1.97	50	153	0.67	1.37	50	0	35.4	1.71	12.1	0.8	80.0
76079	Base	0.60	1.30	17	149	0.46	1.30	17	1	52.5	1.19	36.1	3.5	65.4
76079	S01	0.52	1.10	7	122	0.40	1.09	7	1	59.6	0.96	49.6	6.8	53.1
76079	S02	0.49	1.24	0	151	0.30	1.32	0	43	84.7	1.11	40.0	7.8	59.5
76079	S03	0.51	1.22	15	155	0.45	1.34	15	5	55.1	1.01	42.7	6.5	66.2
76079	S04	0.92	1.76	45	214	0.63	1.75	45	47	47.0	1.61	13.9	0.4	82.2
76079	S05	0.54	1.24	16	146	0.46	1.29	16	0	51.8	1.08	41.0	4.8	65.1
76079	S06	0.51	1.13	5	119	0.39	1.08	5	0	61.3	1.01	48.9	7.2	52.5

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
76079	S09	1.02	1.92	46	155	0.65	1.34	46	0	37.8	1.66	13.0	0.9	78.6
76094	Base	0.65	1.35	0	148	0.52	1.35	0	6	80.5	1.26	31.1	1.8	71.2
76094	S01	0.59	1.17	0	119	0.48	1.18	0	5	87.4	1.09	42.1	2.9	62.1
76094	S02	0.47	1.29	0	151	0.30	1.36	0	102	101.0	1.19	37.4	7.1	62.0
76094	S03	0.55	1.25	0	154	0.50	1.38	0	14	81.9	1.08	39.0	3.9	71.4
76094	S04	0.90	1.70	0	215	0.64	1.70	0	72	72.1	1.55	13.2	0.2	84.4
76094	S05	0.59	1.30	0	144	0.52	1.34	0	2	79.4	1.17	35.9	2.6	71.1
76094	S06	0.59	1.22	0	116	0.48	1.18	0	2	87.9	1.14	41.1	3.1	61.3
76094	S09	1.10	1.95	11	152	0.69	1.37	11	1	59.3	1.77	8.5	0.2	83.0
76108	Base	0.66	1.38	0	146	0.55	1.38	0	10	91.0	1.32	28.5	1.8	74.1
76108	S01	0.61	1.23	0	118	0.51	1.23	0	8	92.2	1.15	37.4	2.7	67.2
76108	S02	0.45	1.31	0	150	0.29	1.38	0	148	101.3	1.21	36.2	7.2	62.9
76108	S03	0.57	1.27	0	153	0.51	1.41	0	27	90.6	1.12	36.6	3.8	74.0
76108	S04	0.88	1.67	0	215	0.64	1.69	0	76	91.6	1.54	13.0	0.3	85.8
76108	S05	0.62	1.32	0	143	0.56	1.38	0	2	88.9	1.24	32.9	2.3	74.7
76108	S06	0.61	1.27	0	115	0.51	1.23	0	3	90.4	1.21	36.0	2.8	65.9
76108	S09	1.14	2.00	0	150	0.73	1.40	0	1	77.6	1.81	6.0	0.1	85.9

Table 19: Base case results for the final rules evaluated for CRA 8. Asterisks indicate a final candidate.

Rule	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
85011	1.94	2.55	773	1185	2.80	4.96	775	45	9.8	2.32	0.7	0.2	98.7
*85029	1.60	2.30	776	1223	2.17	4.32	783	185	10.3	1.98	2.7	1.0	94.8
85033	1.59	2.26	727	1216	2.19	4.18	727	82	10.4	2.06	2.0	0.4	96.0
85037	1.57	2.14	718	1233	2.12	3.93	718	7	17.4	1.92	0.7	0.0	97.5
*85040	1.57	2.08	683	1234	2.13	3.79	683	0	20.2	1.91	0.4	0.0	98.2
85041	1.50	2.12	678	1228	2.02	3.89	679	12	13.8	1.94	0.9	0.0	96.8
85089	0.77	1.41	445	1266	0.78	2.31	448	315	22.3	1.19	23.4	1.6	62.5
86013	1.80	2.30	900	1212	2.59	4.32	900	0	21.2	2.13	0.5	0.0	98.3
86038	1.35	1.92	913	1242	1.70	3.40	913	20	20.4	1.69	5.0	0.0	88.6
86113	1.71	2.27	900	1218	2.39	4.28	900	6	14.5	2.11	0.8	0.0	97.3
86119	1.17	1.84	796	1248	1.41	3.26	799	110	15.2	1.62	8.1	0.3	84.5
86207	2.19	2.83	900	1132	3.48	5.60	900	0	11.1	2.82	0.1	0.0	99.6
86208	2.13	2.67	963	1159	3.22	5.23	963	0	10.5	2.59	0.3	0.0	99.1
86209	2.02	2.52	900	1187	2.96	4.82	900	0	16.6	2.36	0.2	0.0	99.2
86210	1.90	2.39	963	1205	2.69	4.54	963	0	15.9	2.19	0.6	0.0	98.1
86211	1.90	2.39	900	1204	2.76	4.54	900	0	19.2	2.21	0.4	0.0	98.7
86212	1.77	2.28	963	1215	2.51	4.27	963	0	18.2	2.08	0.9	0.0	97.3
86301	2.16	2.75	902	1145	3.35	5.42	902	0	8.9	2.73	0.3	0.0	99.4
*86302	2.19	2.80	900	1137	3.44	5.55	900	0	11.5	2.79	0.2	0.0	99.5
*86303	2.14	2.72	966	1149	3.30	5.34	966	1	6.9	2.67	0.6	0.0	98.8
86304	2.17	2.77	966	1141	3.38	5.44	966	0	8.8	2.73	0.4	0.0	99.1
86305	2.09	2.62	900	1171	3.13	5.08	900	0	10.4	2.53	0.3	0.0	99.2
86306	2.13	2.68	900	1161	3.21	5.22	900	0	13.6	2.60	0.2	0.0	99.4
86307	2.06	2.57	966	1181	3.05	4.97	966	1	8.6	2.45	0.7	0.0	98.3
86308	2.10	2.63	966	1169	3.16	5.12	966	1	11.0	2.52	0.5	0.0	98.8
*86309	1.99	2.50	900	1190	2.89	4.81	900	0	11.9	2.38	0.4	0.0	98.9

Rule	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
86310	2.07	2.58	900	1176	3.06	4.96	900	0	15.5	2.44	0.3	0.0	99.2
86311	1.92	2.43	966	1202	2.74	4.65	966	0	10.3	2.26	1.0	0.0	97.8
*86312	2.03	2.53	966	1186	2.95	4.85	966	1	12.8	2.39	0.6	0.0	98.4

Table 20: Results from the base case and sensitivity trials for the CRA 8 final runs. Asterisks indicate a final candidate.

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
85011	Base	1.94	2.55	773	1185	2.80	4.96	775	45	9.8	2.32	0.7	0.2	98.7
85011	S01	1.47	2.17	625	1036	2.12	4.17	628	112	10.2	1.72	2.8	0.7	95.2
85011	S02	1.90	2.70	690	1189	2.05	5.46	698	135	11.0	2.28	1.6	0.7	95.6
85011	S03	1.68	2.41	777	1236	2.79	5.13	789	135	10.0	1.97	1.6	0.7	97.7
85011	S04	1.89	2.44	752	1116	2.69	4.65	753	11	9.6	2.30	0.3	0.0	99.0
85011	S05	1.30	1.69	497	747	1.87	3.09	497	0	9.5	1.69	2.5	0.0	95.5
85011	S06	1.96	3.20	755	1323	3.09	6.10	755	0	9.6	4.41	0.0	0.0	100.0
85011	S09	1.83	2.92	597	898	2.52	3.71	597	0	8.3	3.09	0.0	0.0	99.8
85011	S10	1.58	2.23	620	1018	2.45	4.33	621	24	9.7	2.14	0.5	0.1	98.9
*85029	Base	1.60	2.30	776	1223	2.17	4.32	783	185	10.3	1.98	2.7	1.0	94.8
*85029	S01	1.21	1.93	580	1052	1.64	3.64	594	416	10.9	1.45	8.9	3.1	87.2
*85029	S02	1.50	2.40	693	1228	1.57	4.73	728	468	11.3	1.88	5.7	2.7	89.2
*85029	S03	1.38	2.16	776	1263	2.10	4.47	799	392	10.6	1.70	5.2	2.2	93.1
*85029	S04	1.64	2.18	755	1149	2.17	4.03	755	115	10.0	2.03	1.9	0.6	95.8
*85029	S05	1.19	1.60	537	825	1.68	2.86	537	1	9.6	1.57	5.1	0.0	91.6
*85029	S06	1.89	2.90	860	1377	2.78	5.43	860	0	9.5	3.84	0.0	0.0	99.8
*85029	S09	1.73	2.60	686	985	2.32	3.41	686	0	8.4	2.67	0.1	0.0	99.3
*85029	S10	1.46	1.96	664	1044	2.08	3.66	667	89	9.9	1.86	1.6	0.5	96.1

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
85033	Base	1.59	2.26	727	1216	2.19	4.18	727	82	10.4	2.06	2.0	0.4	96.0
85033	S01	1.22	1.90	545	1050	1.66	3.53	545	150	11.1	1.55	6.4	1.1	89.8
85033	S02	1.47	2.31	607	1195	1.59	4.48	618	443	12.9	2.00	6.2	3.1	89.5
85033	S03	1.36	2.13	719	1251	2.10	4.33	722	196	10.8	1.79	3.8	1.2	94.6
85033	S04	1.59	2.14	704	1139	2.13	3.95	704	38	10.3	2.06	1.2	0.1	96.7
85033	S05	1.19	1.59	515	828	1.65	2.85	515	0	9.5	1.57	5.0	0.0	91.7
85033	S06	1.82	2.86	814	1391	2.68	5.36	814	0	9.7	3.77	0.2	0.0	99.7
85033	S09	1.70	2.59	682	985	2.30	3.38	682	0	7.5	2.66	0.0	0.0	99.3
85033	S10	1.44	1.95	634	1041	2.04	3.65	636	47	10.2	1.87	1.6	0.3	96.2
85037	Base	1.57	2.14	718	1233	2.12	3.93	718	7	17.4	1.92	0.7	0.0	97.5
85037	S01	1.23	1.83	552	1064	1.66	3.35	552	26	17.9	1.46	4.4	0.1	91.1
85037	S02	1.39	2.16	593	1221	1.44	4.17	599	268	21.7	1.91	5.4	2.0	88.8
85037	S03	1.37	2.01	724	1265	2.09	4.03	725	33	17.8	1.67	2.1	0.1	96.9
85037	S04	1.57	2.04	698	1162	2.07	3.68	698	1	16.9	1.95	0.4	0.0	98.0
85037	S05	1.17	1.55	527	874	1.63	2.74	527	0	15.2	1.51	5.4	0.0	91.2
85037	S06	1.76	2.59	820	1450	2.57	4.73	820	0	16.5	3.35	0.1	0.0	99.7
85037	S09	1.69	2.46	694	1027	2.21	3.23	694	0	13.1	2.48	0.1	0.0	99.1
85037	S10	1.41	1.83	641	1056	1.98	3.36	641	1	16.5	1.78	0.9	0.0	96.9
*85040	Base	1.57	2.08	683	1234	2.13	3.79	683	0	20.2	1.91	0.4	0.0	98.2
*85040	S01	1.24	1.77	531	1060	1.67	3.23	531	0	20.7	1.46	3.5	0.0	92.5
*85040	S02	1.41	2.09	489	1232	1.49	4.00	489	49	32.0	1.93	2.4	0.2	91.8
*85040	S03	1.38	1.95	685	1264	2.11	3.88	685	1	20.7	1.65	1.4	0.0	97.9
*85040	S04	1.57	2.00	662	1161	2.08	3.57	662	0	19.9	1.93	0.3	0.0	98.5
*85040	S05	1.17	1.54	515	877	1.64	2.73	516	0	16.5	1.51	5.4	0.0	91.3
*85040	S06	1.70	2.53	774	1449	2.48	4.54	774	0	19.4	3.27	0.1	0.0	99.7
*85040	S09	1.69	2.44	681	1029	2.20	3.21	681	0	14.1	2.47	0.1	0.0	99.1
*85040	S10	1.41	1.81	616	1058	1.98	3.29	616	0	19.5	1.76	0.7	0.0	97.3
85041	Base	1.50	2.12	678	1228	2.02	3.89	679	12	13.8	1.94	0.9	0.0	96.8

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
85041	S01	1.19	1.80	520	1056	1.57	3.30	520	40	14.5	1.49	5.2	0.2	90.0
85041	S02	1.39	2.17	550	1205	1.46	4.20	556	224	18.5	2.00	4.9	1.5	89.5
85041	S03	1.31	1.98	676	1257	1.96	4.00	676	50	14.4	1.70	2.6	0.2	96.0
85041	S04	1.51	2.01	671	1157	2.02	3.64	671	7	13.4	1.94	0.8	0.0	97.1
85041	S05	1.16	1.55	524	871	1.62	2.75	524	0	12.0	1.52	6.0	0.0	90.4
85041	S06	1.72	2.61	806	1444	2.47	4.78	806	4	13.1	3.36	0.2	0.0	99.5
85041	S09	1.69	2.45	708	1029	2.19	3.22	708	0	9.8	2.47	0.1	0.0	98.8
85041	S10	1.37	1.82	620	1053	1.90	3.35	620	10	13.3	1.78	1.3	0.0	96.0
85089	Base	0.77	1.41	445	1266	0.78	2.31	448	315	22.3	1.19	23.4	1.6	62.5
85089	S01	0.59	1.18	323	1081	0.59	1.96	329	475	23.3	0.90	46.1	4.8	45.4
85089	S02	0.58	1.47	264	1255	0.39	2.58	268	673	30.2	1.26	25.2	5.1	63.1
85089	S03	0.64	1.31	403	1277	0.67	2.37	404	529	24.3	1.03	32.0	3.3	63.2
85089	S04	0.81	1.37	472	1197	0.82	2.16	473	192	20.9	1.23	21.7	0.9	60.6
85089	S05	0.79	1.19	531	1090	0.95	1.92	532	26	16.0	1.08	33.3	0.4	53.3
85089	S06	0.90	1.72	610	1511	1.03	2.84	610	150	20.1	1.97	10.6	0.6	79.9
85089	S09	1.02	1.52	694	1206	1.21	2.13	695	34	11.8	1.35	14.0	0.3	69.5
85089	S10	0.75	1.21	454	1085	0.82	1.96	455	197	18.9	1.13	30.3	1.3	57.1
86013	Base	1.80	2.30	900	1212	2.59	4.32	900	0	21.2	2.13	0.5	0.0	98.3
86013	S01	1.31	1.94	810	1060	1.77	3.61	810	1	18.4	1.49	5.0	0.0	91.3
86013	S02	1.39	2.07	556	1229	1.45	3.96	556	40	35.4	1.87	3.4	0.1	90.7
86013	S03	1.60	2.13	900	1249	2.59	4.40	900	1	22.7	1.85	1.3	0.0	98.1
86013	S04	1.80	2.23	900	1142	2.53	4.15	900	0	18.8	2.14	0.4	0.0	98.6
86013	S05	1.13	1.53	585	881	1.51	2.73	585	0	10.2	1.45	8.4	0.0	86.3
86013	S06	1.88	2.74	900	1443	2.90	5.06	900	0	21.7	3.47	0.0	0.0	99.9
86013	S09	1.73	2.67	900	946	2.39	3.49	900	0	8.0	2.81	0.3	0.0	98.1
86013	S10	1.53	1.99	900	1039	2.21	3.75	900	0	15.0	1.93	1.3	0.0	96.8
86038	Base	1.35	1.92	913	1242	1.70	3.40	913	20	20.4	1.69	5.0	0.0	88.6
86038	S01	0.88	1.54	560	1092	1.04	2.70	563	114	19.7	1.06	20.3	0.5	71.6

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
86038	S02	0.97	1.66	467	1255	0.90	2.98	467	212	36.2	1.47	14.2	1.2	74.5
86038	S03	1.16	1.78	872	1267	1.61	3.43	876	90	22.1	1.44	8.7	0.1	88.3
86038	S04	1.35	1.85	896	1179	1.63	3.26	896	7	16.6	1.66	4.8	0.0	88.8
86038	S05	0.96	1.39	651	988	1.23	2.37	651	3	10.4	1.26	17.9	0.1	72.0
86038	S06	1.62	2.34	1050	1491	2.33	4.15	1050	2	22.6	2.84	0.5	0.0	98.4
86038	S09	1.60	2.28	1050	1063	2.03	3.06	1050	0	7.1	2.20	2.1	0.0	93.9
86038	S10	1.14	1.63	767	1079	1.43	2.87	769	15	13.2	1.46	8.8	0.0	83.5
86113	Base	1.71	2.27	900	1218	2.39	4.28	900	6	14.5	2.11	0.8	0.0	97.3
86113	S01	1.23	1.91	732	1068	1.62	3.54	732	15	13.3	1.46	5.9	0.0	89.7
86113	S02	1.19	2.03	417	1229	1.20	3.90	420	183	25.2	1.83	6.7	0.9	87.6
86113	S03	1.48	2.11	900	1249	2.34	4.37	900	21	15.5	1.80	2.2	0.0	96.7
86113	S04	1.71	2.20	900	1145	2.38	4.09	900	3	12.6	2.07	0.6	0.0	97.6
86113	S05	1.13	1.54	617	879	1.51	2.75	617	0	7.2	1.46	8.5	0.0	86.3
86113	S06	1.87	2.75	900	1453	2.82	5.08	900	3	15.2	3.40	0.1	0.0	99.6
86113	S09	1.72	2.67	900	954	2.36	3.46	900	0	5.4	2.77	0.3	0.0	98.1
86113	S10	1.49	1.97	900	1043	2.09	3.69	900	4	9.9	1.90	1.5	0.0	95.9
86119	Base	1.17	1.84	796	1248	1.41	3.26	799	110	15.2	1.62	8.1	0.3	84.5
86119	S01	0.80	1.49	505	1090	0.93	2.60	505	216	15.1	1.07	24.5	1.5	67.8
86119	S02	0.72	1.63	349	1241	0.58	2.95	354	536	27.1	1.44	19.7	4.7	71.4
86119	S03	0.98	1.69	719	1271	1.28	3.29	729	226	16.7	1.37	13.2	0.8	83.4
86119	S04	1.22	1.80	792	1184	1.45	3.10	793	57	12.1	1.60	7.0	0.2	85.0
86119	S05	0.96	1.38	655	985	1.20	2.39	656	8	7.5	1.26	17.9	0.1	72.2
86119	S06	1.50	2.31	1050	1492	2.06	4.08	1050	69	16.5	2.74	1.5	0.2	96.1
86119	S09	1.61	2.26	1050	1067	1.99	3.02	1050	0	4.8	2.15	2.3	0.0	93.3
86119	S10	1.06	1.60	739	1075	1.32	2.82	740	72	9.6	1.45	10.2	0.2	81.7
86207	Base	2.19	2.83	900	1132	3.48	5.60	900	0	11.1	2.82	0.1	0.0	99.6
86207	S01	1.73	2.34	900	1026	2.60	4.58	900	1	9.8	1.85	2.4	0.0	96.5
86207	S02	2.10	2.70	900	1155	2.34	5.52	900	0	19.4	2.59	0.3	0.0	98.2

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86207	S03	2.11	2.69	900	1177	3.63	5.92	900	0	11.8	2.52	0.3	0.0	99.7
86207	S04	2.02	2.66	900	1070	3.27	5.14	900	0	10.0	2.67	0.2	0.0	99.4
86207	S05	1.13	1.55	612	876	1.51	2.76	612	0	6.7	1.46	8.5	0.0	86.2
86207	S06	1.96	3.36	900	1239	3.13	6.58	900	0	10.3	5.05	0.0	0.0	100.0
86207	S09	1.74	2.74	900	916	2.45	3.57	900	0	4.1	2.95	0.3	0.0	98.1
86207	S10	1.59	2.22	900	987	2.59	4.35	900	0	7.7	2.37	1.0	0.0	97.9
86208	Base	2.13	2.67	963	1159	3.22	5.23	963	0	10.5	2.59	0.3	0.0	99.1
86208	S01	1.49	2.19	963	1058	2.15	4.20	963	1	9.8	1.58	4.3	0.0	93.3
86208	S02	1.97	2.54	963	1183	2.14	5.12	963	0	19.0	2.36	0.8	0.0	96.6
86208	S03	2.01	2.54	963	1202	3.35	5.51	963	1	11.2	2.31	0.7	0.0	99.2
86208	S04	1.96	2.51	963	1100	3.01	4.78	963	0	9.4	2.46	0.7	0.0	98.7
86208	S05	1.07	1.49	590	918	1.42	2.62	590	0	8.2	1.39	10.8	0.0	82.6
86208	S06	1.92	3.19	963	1272	3.00	6.13	963	0	9.7	4.76	0.0	0.0	99.9
86208	S09	1.72	2.58	963	972	2.34	3.43	963	0	4.1	2.71	0.7	0.0	97.2
86208	S10	1.53	2.06	963	1016	2.33	3.92	963	0	7.5	2.12	2.2	0.0	95.5
86209	Base	2.02	2.52	900	1187	2.96	4.82	900	0	16.6	2.36	0.2	0.0	99.2
86209	S01	1.48	2.10	900	1054	2.10	4.01	900	1	14.4	1.60	3.5	0.0	93.9
86209	S02	1.70	2.33	808	1207	1.83	4.59	808	12	27.7	2.11	1.3	0.0	94.8
86209	S03	1.82	2.36	900	1231	3.03	4.99	900	1	17.6	2.05	0.7	0.0	99.2
86209	S04	1.94	2.41	900	1116	2.83	4.56	900	0	15.1	2.35	0.3	0.0	99.2
86209	S05	1.13	1.54	610	880	1.51	2.75	610	0	8.2	1.45	8.6	0.0	86.0
86209	S06	1.93	3.00	900	1372	3.05	5.68	900	0	15.9	4.06	0.0	0.0	100.0
86209	S09	1.74	2.70	900	930	2.42	3.54	900	0	6.2	2.90	0.3	0.0	98.1
86209	S10	1.55	2.10	900	1019	2.42	4.03	900	0	11.5	2.10	1.1	0.0	97.5
86210	Base	1.90	2.39	963	1205	2.69	4.54	963	0	15.9	2.19	0.6	0.0	98.1
86210	S01	1.28	1.98	837	1075	1.67	3.70	838	7	14.5	1.41	6.2	0.0	89.8
86210	S02	1.57	2.20	721	1222	1.62	4.25	721	18	27.1	1.96	2.4	0.1	92.7
86210	S03	1.68	2.24	963	1245	2.78	4.69	963	4	16.7	1.90	1.6	0.0	98.0

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86210	S04	1.85	2.27	963	1137	2.59	4.27	963	0	13.7	2.14	0.9	0.0	98.0
86210	S05	1.07	1.48	585	921	1.41	2.61	585	0	9.4	1.39	10.9	0.0	82.4
86210	S06	1.88	2.86	963	1392	2.90	5.37	963	0	15.0	3.86	0.0	0.0	99.8
86210	S09	1.71	2.55	963	981	2.32	3.39	963	0	5.9	2.67	0.7	0.0	97.2
86210	S10	1.49	1.95	963	1037	2.13	3.68	963	0	11.0	1.91	2.4	0.0	94.7
86211	Base	1.90	2.39	900	1204	2.76	4.54	900	0	19.2	2.21	0.4	0.0	98.7
86211	S01	1.38	2.01	900	1059	1.87	3.81	900	1	16.3	1.53	4.2	0.0	92.4
86211	S02	1.52	2.18	676	1219	1.60	4.21	676	24	31.4	1.95	2.4	0.1	92.6
86211	S03	1.69	2.23	900	1243	2.79	4.66	900	0	20.2	1.93	1.0	0.0	98.7
86211	S04	1.88	2.30	900	1133	2.65	4.33	900	0	17.1	2.22	0.4	0.0	98.9
86211	S05	1.13	1.53	608	881	1.50	2.74	609	0	9.0	1.45	8.7	0.0	86.0
86211	S06	1.91	2.85	900	1417	2.99	5.32	900	0	18.9	3.73	0.0	0.0	99.9
86211	S09	1.74	2.68	900	939	2.41	3.51	900	0	7.0	2.86	0.3	0.0	98.1
86211	S10	1.54	2.04	900	1031	2.30	3.88	900	0	13.4	2.00	1.3	0.0	97.1
86212	Base	1.77	2.28	963	1215	2.51	4.27	963	0	18.2	2.08	0.9	0.0	97.3
86212	S01	1.20	1.88	722	1075	1.54	3.48	722	8	16.8	1.35	7.5	0.0	88.1
86212	S02	1.41	2.06	604	1231	1.43	3.94	604	36	30.9	1.81	3.6	0.1	90.0
86212	S03	1.56	2.12	963	1257	2.52	4.36	963	6	19.2	1.79	2.1	0.0	97.2
86212	S04	1.76	2.18	963	1151	2.43	4.05	963	0	15.7	2.03	1.0	0.0	97.5
86212	S05	1.07	1.48	582	922	1.41	2.61	583	0	10.1	1.38	10.9	0.0	82.2
86212	S06	1.86	2.73	963	1430	2.82	5.05	963	0	17.9	3.56	0.1	0.0	99.7
86212	S09	1.70	2.54	963	986	2.30	3.34	963	0	6.8	2.65	0.7	0.0	97.2
86212	S10	1.48	1.90	963	1049	2.02	3.57	963	0	12.5	1.82	2.6	0.0	94.1
86301	Base	2.16	2.75	902	1145	3.35	5.42	902	0	8.9	2.73	0.3	0.0	99.4
86301	S01	1.61	2.24	900	1049	2.36	4.34	900	3	8.3	1.71	3.6	0.0	94.8
86301	S02	2.09	2.66	900	1163	2.29	5.43	900	0	16.5	2.59	0.5	0.0	97.6
86301	S03	2.08	2.63	919	1184	3.53	5.76	919	3	9.3	2.46	0.5	0.0	99.5
86301	S04	2.00	2.55	900	1087	3.09	4.90	900	0	8.2	2.57	0.5	0.0	99.1

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
86301	S05	1.11	1.52	662	894	1.46	2.70	662	0	6.1	1.42	10.3	0.0	83.5
86301	S06	1.93	3.30	900	1224	3.05	6.41	900	0	8.9	5.11	0.0	0.0	100.0
86301	S09	1.74	2.68	900	945	2.41	3.49	900	0	4.5	2.85	0.4	0.0	97.9
86301	S10	1.56	2.13	900	1007	2.47	4.11	900	0	7.2	2.24	1.6	0.0	96.9
*86302	Base	2.19	2.80	900	1137	3.44	5.55	900	0	11.5	2.79	0.2	0.0	99.5
*86302	S01	1.71	2.32	900	1029	2.57	4.54	900	1	9.9	1.83	2.9	0.0	95.9
*86302	S02	2.08	2.66	900	1161	2.31	5.44	900	0	19.6	2.53	0.5	0.0	97.8
*86302	S03	2.10	2.66	900	1181	3.59	5.85	900	1	12.1	2.48	0.3	0.0	99.6
*86302	S04	2.02	2.64	900	1073	3.24	5.10	900	0	10.2	2.65	0.3	0.0	99.3
*86302	S05	1.12	1.53	676	886	1.48	2.74	676	0	5.4	1.43	9.9	0.0	83.9
*86302	S06	1.96	3.34	900	1250	3.12	6.51	900	0	10.6	4.96	0.0	0.0	100.0
*86302	S09	1.74	2.74	900	918	2.45	3.57	900	0	3.8	2.95	0.4	0.0	97.9
*86302	S10	1.58	2.22	900	989	2.58	4.33	900	0	7.7	2.35	1.4	0.0	97.5
*86303	Base	2.14	2.72	966	1149	3.30	5.34	966	1	6.9	2.67	0.6	0.0	98.8
*86303	S01	1.47	2.16	966	1068	2.13	4.20	966	5	6.8	1.57	5.5	0.0	92.0
*86303	S02	2.08	2.65	966	1165	2.29	5.41	966	2	13.2	2.57	0.9	0.0	97.0
*86303	S03	2.08	2.63	976	1184	3.51	5.74	976	2	7.3	2.46	0.9	0.0	99.1
*86303	S04	1.96	2.49	966	1098	2.96	4.75	966	0	6.4	2.47	1.0	0.0	98.2
*86303	S05	1.04	1.46	649	937	1.36	2.56	650	0	6.7	1.35	13.2	0.0	79.1
*86303	S06	1.91	3.25	966	1207	2.96	6.28	966	0	6.8	5.20	0.0	0.0	99.8
*86303	S09	1.70	2.54	966	993	2.32	3.38	966	0	3.5	2.63	1.0	0.0	96.7
*86303	S10	1.52	2.01	966	1027	2.27	3.81	966	0	5.6	2.07	3.2	0.0	93.8
86304	Base	2.17	2.77	966	1141	3.38	5.44	966	0	8.8	2.73	0.4	0.0	99.1
86304	S01	1.56	2.24	966	1051	2.28	4.35	966	5	8.1	1.64	4.8	0.0	93.1
86304	S02	2.09	2.64	966	1165	2.28	5.40	966	1	15.8	2.54	0.8	0.0	97.1
86304	S03	2.09	2.65	966	1182	3.54	5.81	966	2	9.4	2.47	0.7	0.0	99.3
86304	S04	1.99	2.56	966	1085	3.10	4.93	966	0	7.7	2.56	0.9	0.0	98.5
86304	S05	1.04	1.48	653	932	1.37	2.57	653	0	6.2	1.35	12.9	0.0	79.6

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
86304	S06	1.92	3.30	966	1229	3.03	6.38	966	0	8.0	5.08	0.0	0.0	99.8
86304	S09	1.72	2.58	966	973	2.33	3.42	966	0	3.0	2.71	1.0	0.0	96.7
86304	S10	1.54	2.08	966	1011	2.36	4.01	966	2	6.1	2.18	3.0	0.0	94.5
86305	Base	2.09	2.62	900	1171	3.13	5.08	900	0	10.4	2.53	0.3	0.0	99.2
86305	S01	1.48	2.14	900	1062	2.16	4.09	900	3	9.8	1.60	4.4	0.0	93.5
86305	S02	1.95	2.52	900	1186	2.15	5.10	900	0	19.2	2.36	0.7	0.0	96.7
86305	S03	1.95	2.49	900	1209	3.26	5.38	900	2	10.9	2.27	0.7	0.0	99.3
86305	S04	1.94	2.44	900	1106	2.93	4.67	900	0	9.6	2.40	0.5	0.0	98.9
86305	S05	1.11	1.51	661	899	1.45	2.69	661	0	6.9	1.42	10.4	0.0	83.3
86305	S06	1.92	3.16	900	1273	3.00	6.11	900	0	10.4	4.75	0.0	0.0	99.9
86305	S09	1.74	2.65	900	956	2.39	3.47	900	0	5.3	2.81	0.4	0.0	97.8
86305	S10	1.54	2.07	900	1021	2.38	3.96	900	0	8.4	2.11	1.7	0.0	96.6
86306	Base	2.13	2.68	900	1161	3.21	5.22	900	0	13.6	2.60	0.2	0.0	99.4
86306	S01	1.59	2.22	900	1043	2.35	4.32	900	3	11.5	1.71	3.4	0.0	94.8
86306	S02	1.92	2.53	900	1185	2.10	5.07	900	1	22.6	2.31	0.8	0.0	96.5
86306	S03	1.98	2.53	900	1207	3.32	5.45	900	2	14.4	2.26	0.5	0.0	99.5
86306	S04	1.99	2.54	900	1093	3.06	4.86	900	0	12.3	2.49	0.3	0.0	99.2
86306	S05	1.12	1.53	675	886	1.48	2.73	675	0	6.1	1.43	10.0	0.0	83.9
86306	S06	1.95	3.18	900	1307	3.09	6.14	900	0	12.7	4.57	0.0	0.0	100.0
86306	S09	1.74	2.73	900	923	2.45	3.55	900	0	4.4	2.92	0.4	0.0	97.9
86306	S10	1.57	2.17	900	1004	2.51	4.19	900	0	9.2	2.23	1.5	0.0	97.3
86307	Base	2.06	2.57	966	1181	3.05	4.97	966	1	8.6	2.45	0.7	0.0	98.3
86307	S01	1.34	2.06	966	1081	1.85	3.91	966	10	8.6	1.43	6.5	0.0	90.2
86307	S02	1.92	2.47	966	1193	2.06	5.00	966	2	16.2	2.32	1.3	0.0	95.6
86307	S03	1.89	2.46	966	1215	3.20	5.29	966	4	9.0	2.21	1.4	0.0	98.6
86307	S04	1.90	2.37	966	1122	2.78	4.48	966	0	7.9	2.30	1.1	0.0	97.8
86307	S05	1.04	1.46	647	938	1.35	2.55	647	0	7.1	1.35	13.2	0.0	78.9
86307	S06	1.88	3.10	966	1264	2.89	5.93	966	0	8.5	4.76	0.0	0.0	99.7

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
86307	S09	1.70	2.52	966	1002	2.29	3.34	966	0	4.4	2.58	1.0	0.0	96.6
86307	S10	1.49	1.94	966	1039	2.17	3.68	966	0	7.0	1.96	3.4	0.0	93.4
86308	Base	2.10	2.63	966	1169	3.16	5.12	966	1	11.0	2.52	0.5	0.0	98.8
86308	S01	1.43	2.15	966	1063	2.08	4.12	966	7	9.8	1.52	5.5	0.0	91.7
86308	S02	1.90	2.49	966	1190	2.09	5.00	966	2	19.1	2.27	1.2	0.0	95.7
86308	S03	1.96	2.50	966	1210	3.26	5.40	966	3	11.7	2.24	0.9	0.0	99.0
86308	S04	1.94	2.48	966	1107	2.94	4.70	966	0	9.6	2.40	0.9	0.0	98.3
86308	S05	1.04	1.47	652	933	1.37	2.57	652	0	6.7	1.35	13.0	0.0	79.5
86308	S06	1.92	3.15	966	1289	2.98	6.04	966	0	10.1	4.65	0.0	0.0	99.8
86308	S09	1.71	2.57	966	976	2.33	3.41	966	0	3.7	2.70	1.0	0.0	96.7
86308	S10	1.53	2.04	966	1020	2.28	3.87	966	2	7.6	2.08	3.0	0.0	94.3
*86309	Base	1.99	2.50	900	1190	2.89	4.81	900	0	11.9	2.38	0.4	0.0	98.9
*86309	S01	1.38	2.06	900	1068	1.94	3.89	900	2	11.3	1.52	5.0	0.0	92.0
*86309	S02	1.79	2.39	900	1203	1.96	4.75	900	1	21.8	2.16	1.2	0.0	95.3
*86309	S03	1.80	2.36	900	1228	2.97	5.01	900	1	12.4	2.08	0.9	0.0	98.8
*86309	S04	1.90	2.36	900	1125	2.76	4.42	900	0	11.1	2.27	0.6	0.0	98.6
*86309	S05	1.10	1.51	657	903	1.45	2.68	658	0	7.6	1.41	10.5	0.0	83.2
*86309	S06	1.89	3.03	900	1319	2.95	5.76	900	0	12.0	4.39	0.0	0.0	99.9
*86309	S09	1.73	2.62	900	967	2.37	3.43	900	0	6.1	2.76	0.4	0.0	97.8
*86309	S10	1.53	2.02	900	1031	2.29	3.83	900	0	9.7	2.02	1.8	0.0	96.0
86310	Base	2.07	2.58	900	1176	3.06	4.96	900	0	15.5	2.44	0.3	0.0	99.2
86310	S01	1.52	2.16	900	1051	2.21	4.10	900	3	12.9	1.63	3.9	0.0	93.8
86310	S02	1.77	2.40	900	1199	1.93	4.76	900	8	25.0	2.16	1.2	0.0	95.2
86310	S03	1.88	2.42	900	1226	3.13	5.15	900	2	16.4	2.12	0.6	0.0	99.2
86310	S04	1.96	2.46	900	1108	2.91	4.68	900	0	13.9	2.39	0.4	0.0	99.1
86310	S05	1.12	1.53	672	888	1.47	2.73	672	0	6.6	1.43	10.1	0.0	83.8
86310	S06	1.94	3.07	900	1346	3.07	5.85	900	0	14.6	4.23	0.0	0.0	100.0
86310	S09	1.74	2.72	900	928	2.44	3.54	900	0	5.0	2.90	0.4	0.0	97.9

Rule	Scenario	(%Bref) min Bio med	(%Bref) av Bio med	(t) min Catch med	(t) av Catch med	(kg/pot) min CPUE med	(kg/pot) av CPUE med	(t) min TACC med	n low catch	% Var med	(t) term Bio med	% <Bref	% <Bmin	% gnTarg
86310	S10	1.55	2.13	900	1013	2.46	4.08	900	0	10.4	2.13	1.5	0.0	97.1
86311	Base	1.92	2.43	966	1202	2.74	4.65	966	0	10.3	2.26	1.0	0.0	97.8
86311	S01	1.24	1.96	893	1086	1.64	3.67	893	16	10.4	1.36	7.8	0.1	88.3
86311	S02	1.73	2.34	963	1213	1.86	4.60	964	5	19.1	2.08	1.7	0.0	94.0
86311	S03	1.73	2.31	966	1237	2.83	4.86	966	6	10.7	1.99	1.9	0.0	97.9
86311	S04	1.83	2.27	966	1140	2.57	4.24	966	0	9.4	2.15	1.3	0.0	97.3
86311	S05	1.03	1.45	643	944	1.34	2.54	644	0	7.9	1.34	13.4	0.0	78.6
86311	S06	1.85	2.96	966	1316	2.82	5.62	966	0	10.2	4.39	0.1	0.0	99.7
86311	S09	1.69	2.49	966	1011	2.26	3.31	966	0	5.3	2.53	1.1	0.0	96.6
86311	S10	1.46	1.90	966	1049	2.03	3.55	966	1	8.4	1.85	3.6	0.0	92.9
*86312	Base	2.03	2.53	966	1186	2.95	4.85	966	1	12.8	2.39	0.6	0.0	98.4
*86312	S01	1.35	2.06	966	1071	1.87	3.95	966	15	11.4	1.45	6.3	0.0	90.4
*86312	S02	1.74	2.36	966	1205	1.88	4.67	966	7	21.7	2.11	1.7	0.0	94.3
*86312	S03	1.83	2.38	966	1228	3.03	5.07	966	5	13.7	2.08	1.2	0.0	98.6
*86312	S04	1.91	2.40	966	1122	2.78	4.51	966	0	11.1	2.29	1.0	0.0	98.0
*86312	S05	1.04	1.47	650	934	1.37	2.57	650	0	7.2	1.35	13.0	0.0	79.5
*86312	S06	1.90	3.04	966	1333	2.96	5.75	966	0	12.0	4.31	0.0	0.0	99.8
*86312	S09	1.71	2.56	966	979	2.33	3.41	966	0	4.3	2.68	1.0	0.0	96.7
*86312	S10	1.52	2.00	966	1028	2.21	3.78	966	2	8.7	1.99	3.1	0.0	94.0

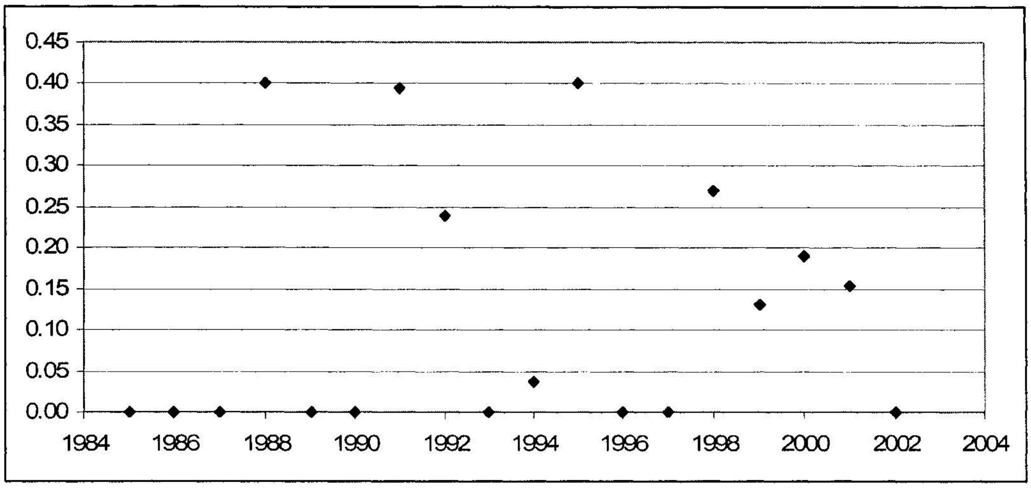

Figure 1: Estimated base case movement parameters (MPD fit from the assessment).

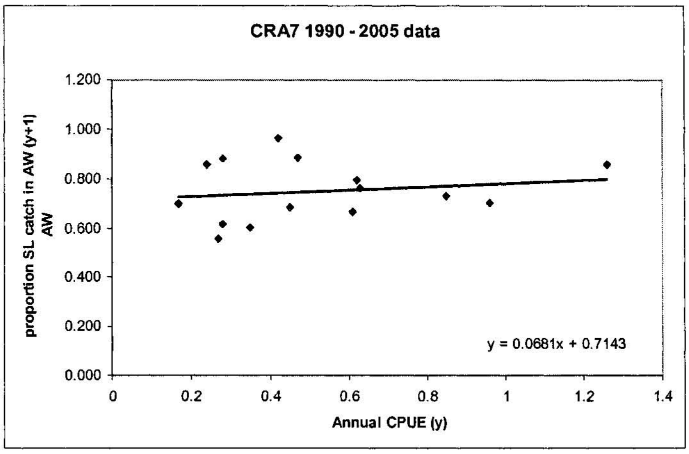

Figure 2: Proportion of SL catch taken in AW versus the annul CPUE in the previous year for CRA 7, 1990–2005.

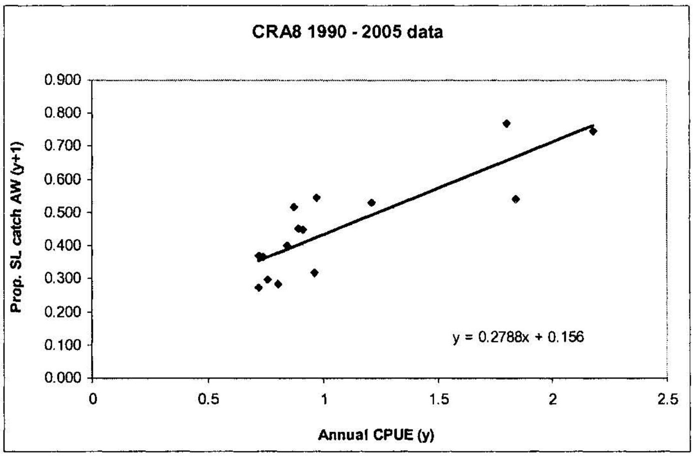

Figure 3: Proportion of SL catch taken in AW versus the annul CPUE in the previous year for CRA 8, 1990–2005.

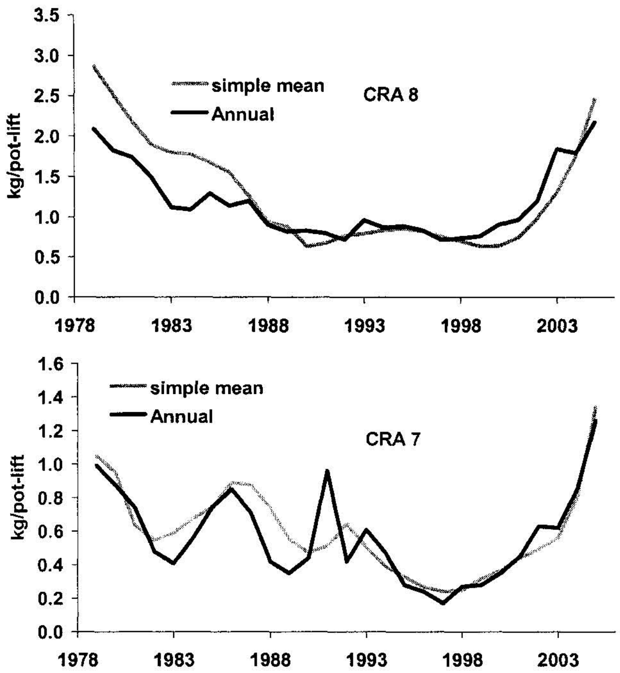

Figure 4: Comparing the simple mean predictor with the annually-standardised CPUE for each stock.

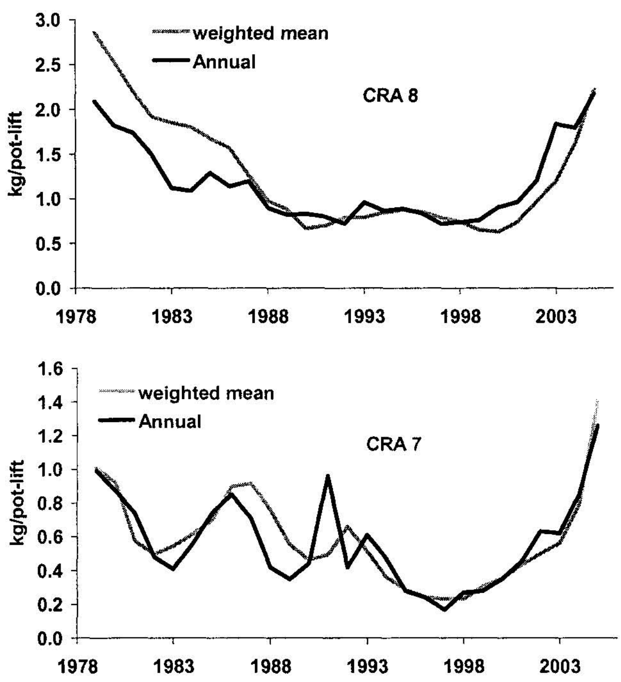

Figure 5: Comparing the weighted mean predictor with the annually-standardised CPUE for each stock.

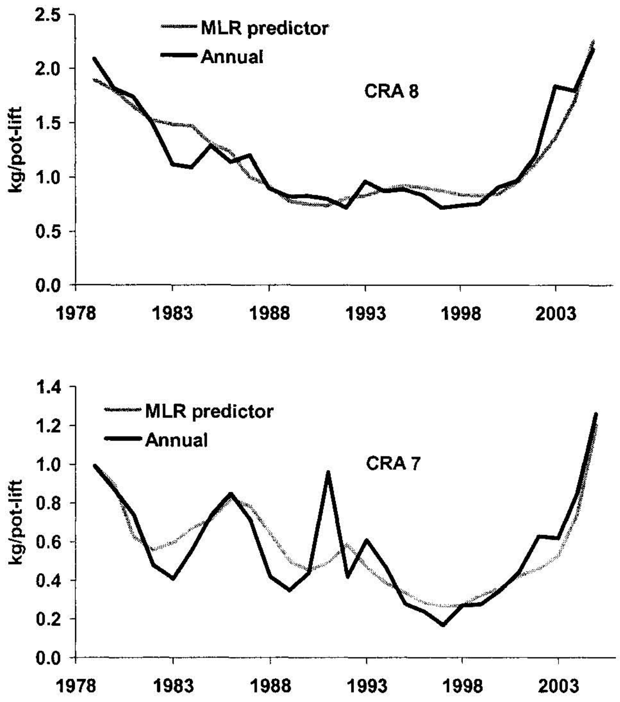

Figure 6: Comparing the MLR predictor with the annually-standardised CPUE for each stock.

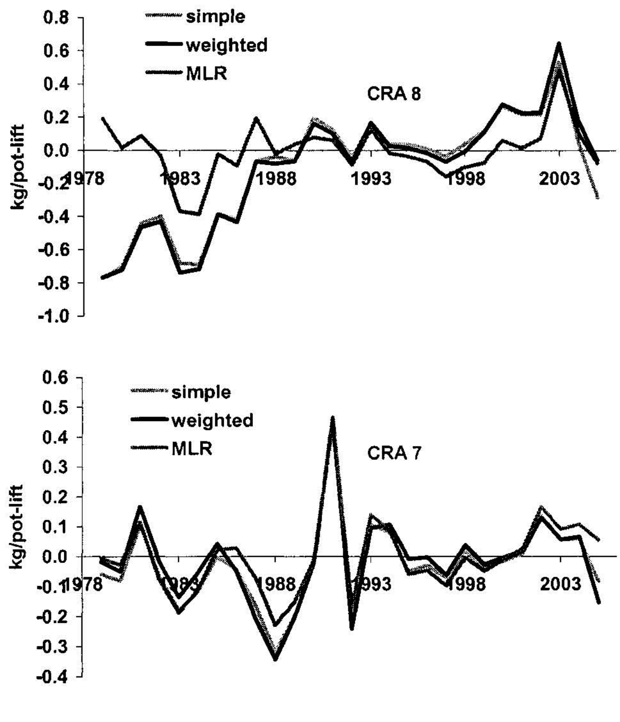

Figure 7: Residuals from the three predictors of annual CPUE shown above.

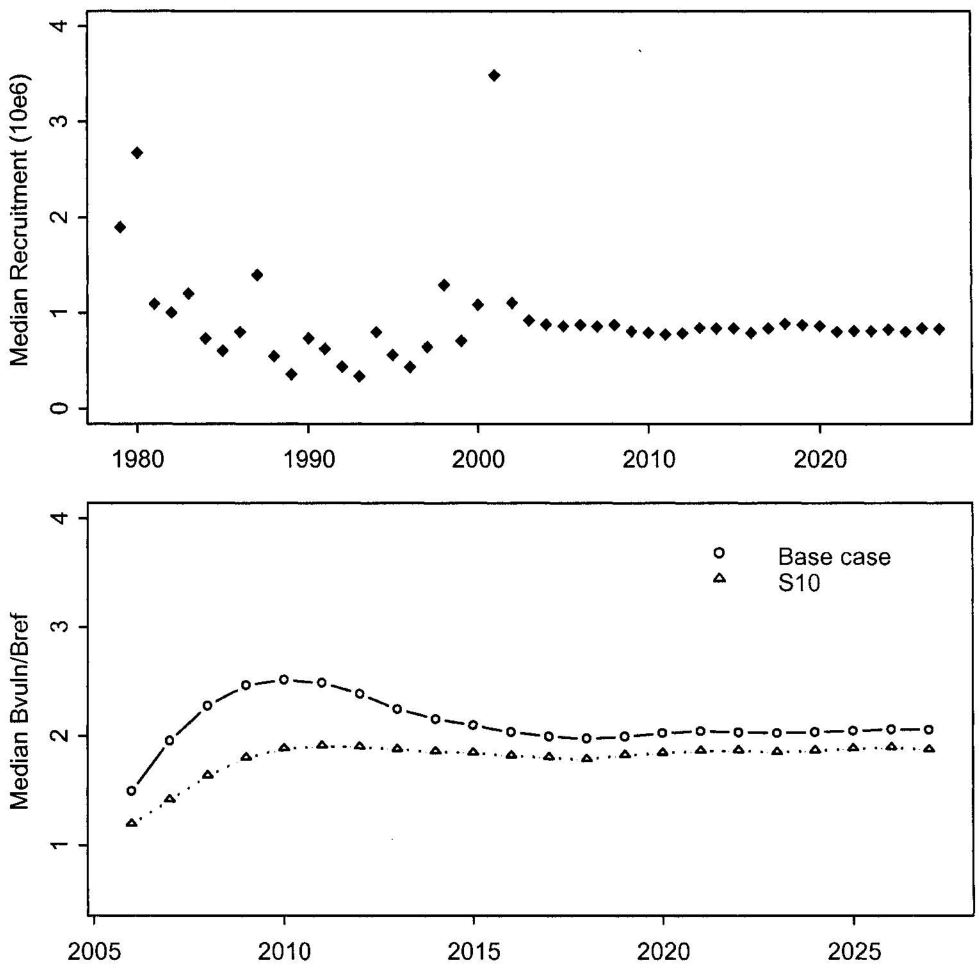

Figure 8: Median CRA 8 recruitment (1979–2027) for the base case operating model (upper panel) and the median CRA 8 ratio of vulnerable biomass to reference biomass for the base case and S10 operating models.

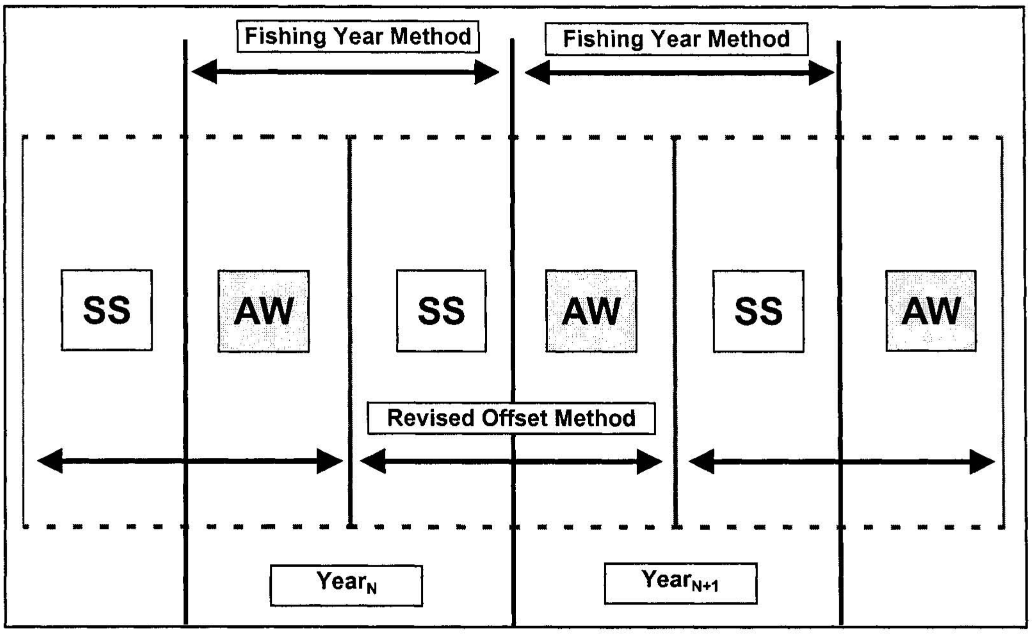

Figure 9: A schematic representation that compares the data input for the 2002 decision rule with the proposed new data input (revised offset method).

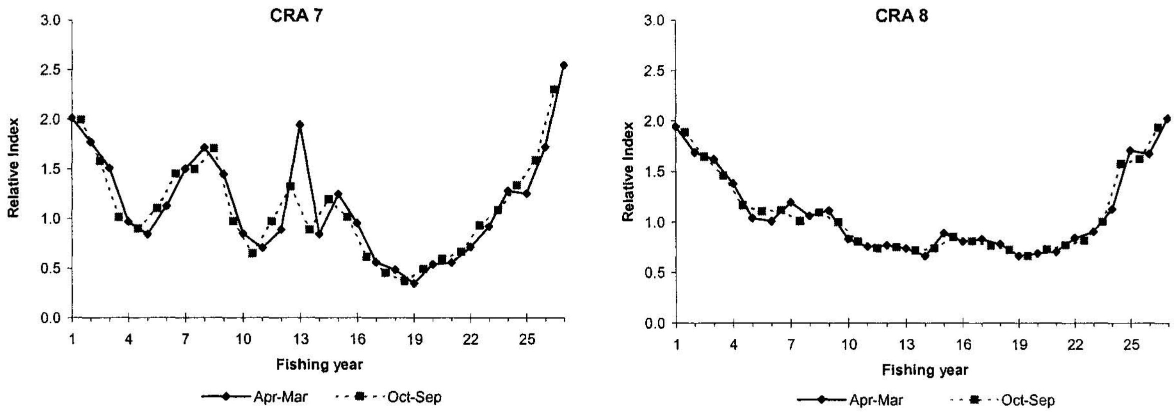

Figure 10: Comparison of two annual CPUE series, based on an April–March fishing year or an October–September fishing year, offset for plotting by half a year relative to the April–May series. Each series is scaled relative to the geometric mean 1979–80 (year=1) to 2004–05 (year=26).

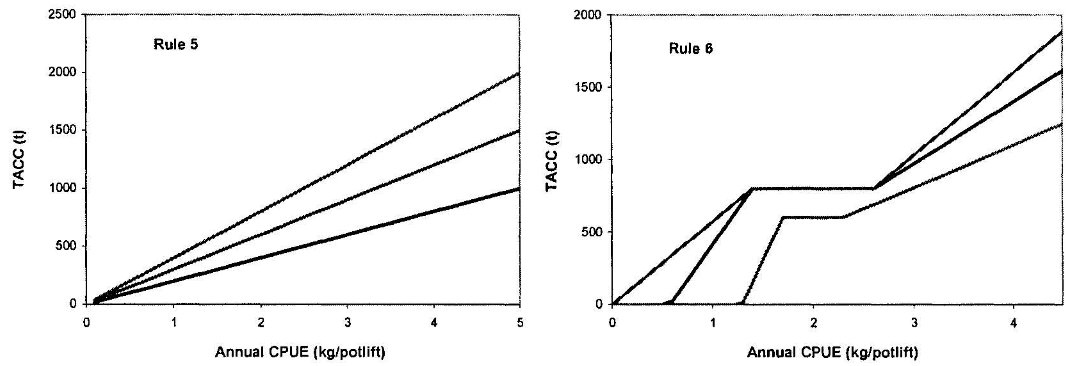

Figure 11: The TAC versus CPUE relationship for example decision rules in rule families 5 (left) and 6.

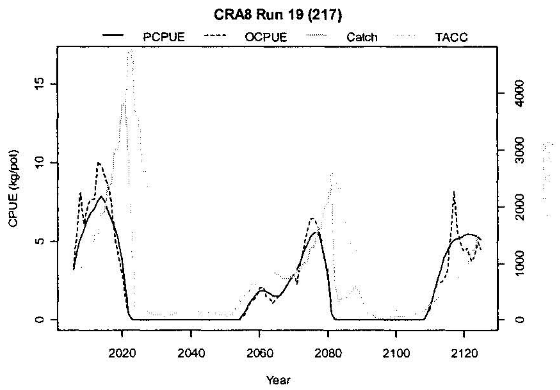

Figure 12: Trajectories of true and observed CPUE, TACC and catch, from run 217 (out of 600) of the current NSS decision rule (one of the Bentley rule family) using the base case model.

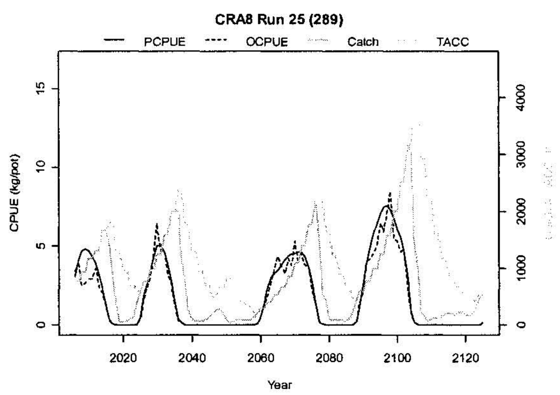

Figure 13: Trajectories of true and observed CPUE, TACC and catch, from run 289 of the current NSS decision rule (one of the Bentley rule family) using the base case model.

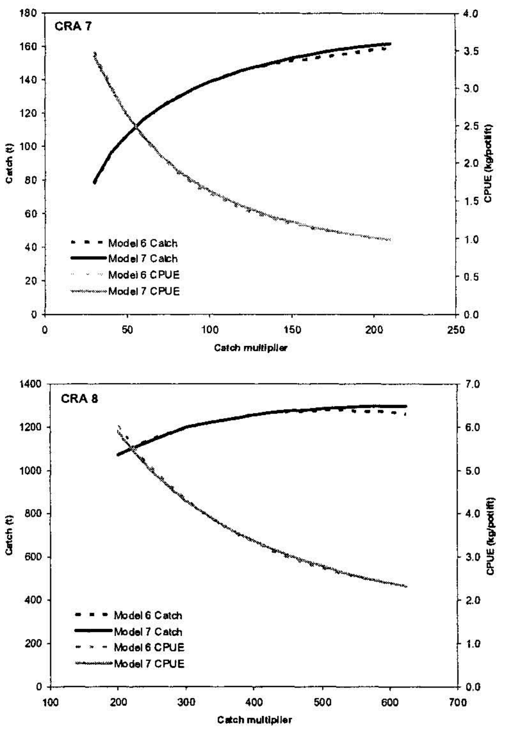

Figure 14: Comparison of median avCatch and median avCPUE for models 6 and 7 in CRA 7 and CRA 8, with Rule 5 and no latent year.

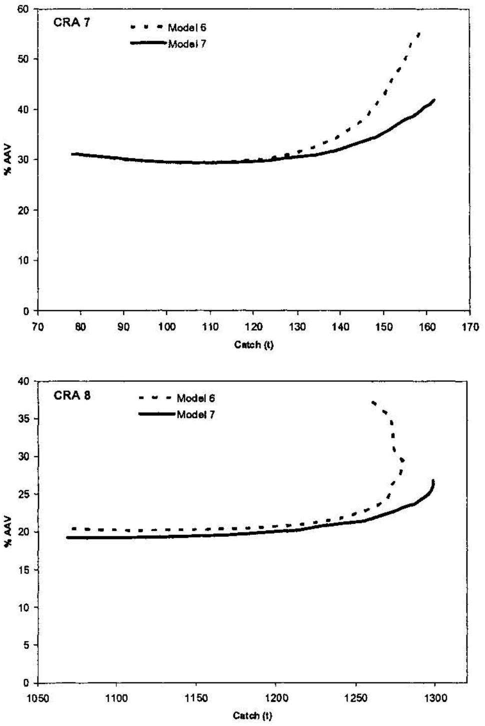

Figure 15: Comparison of %AAV for models 6 and 7 in CRA 7 and CRA 8, with Rule 5 and no latent year.

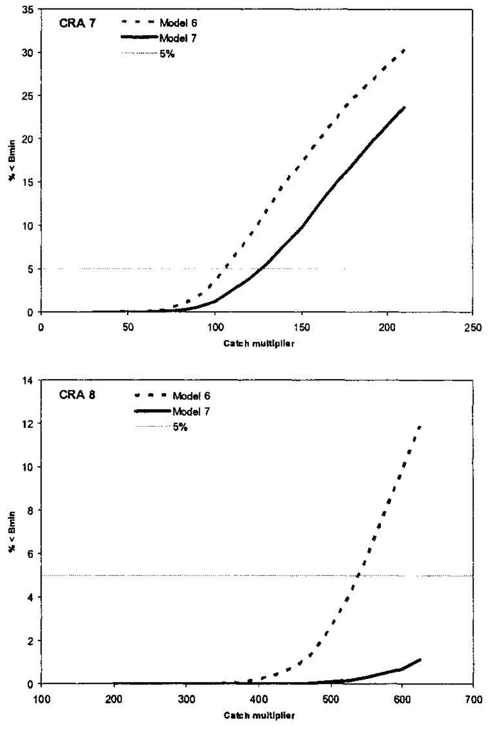

Figure 16: Comparison of % < Bmin for model 6 and 7 in CRA 7 and CRA 8, plotted across catch multiplier, with Rule 5 and no latent year.

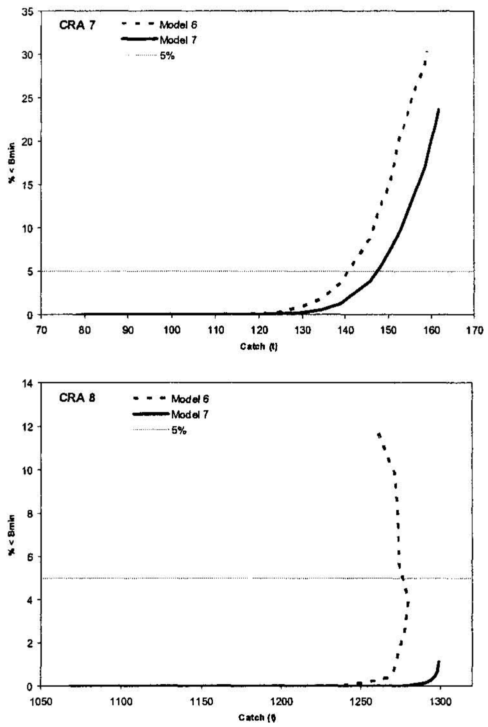

Figure 17: Comparison of %<Bmin for model 6 and 7 in CRA 7 and CRA 8, plotted across average catch, with Rule 5 and no latent year.

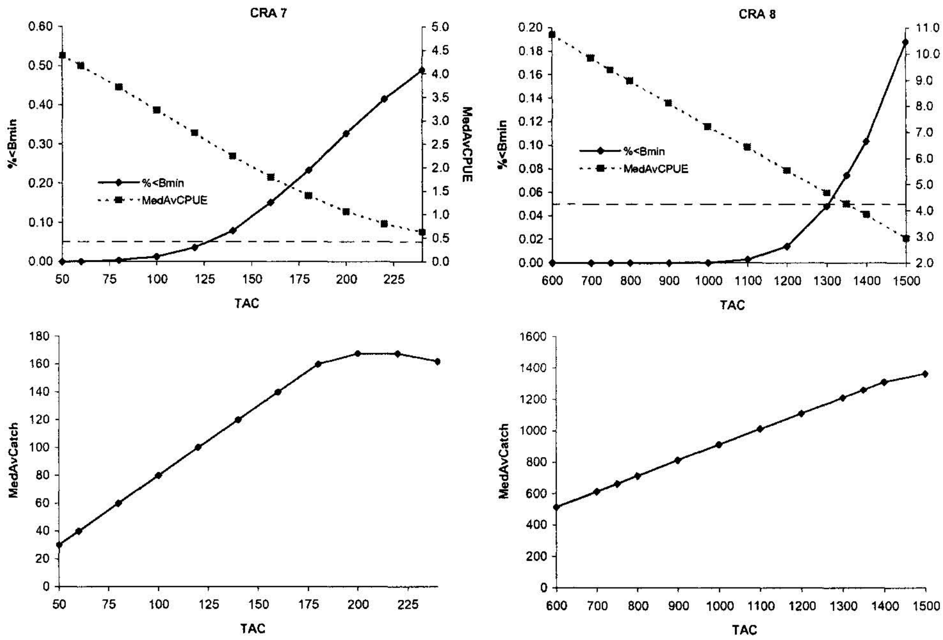

Figure 18: Performance indicators resulting from constant-TAC rules applied to CRA 7 (left column) and CRA 8.

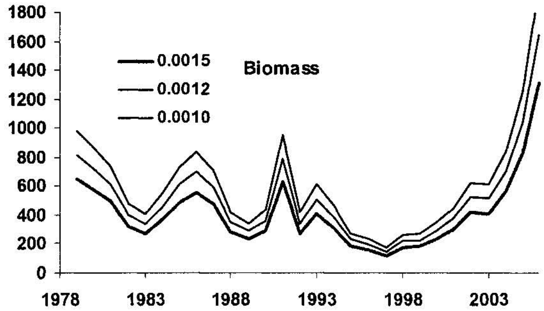

Figure 19: Biomass estimated for CRA 7 under three values of assumed *q* (highest value on bottom, lowest on top).

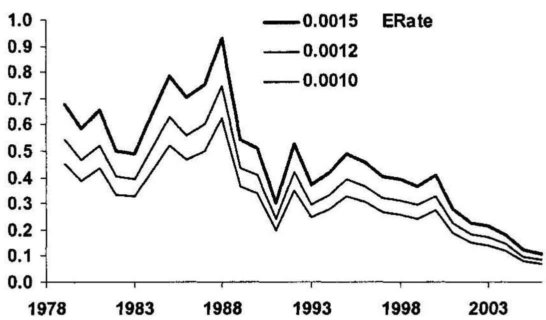

Figure 20: Exploitation rate estimated for CRA 7 under three values of assumed *q* (highest value on top, lowest on bottom).

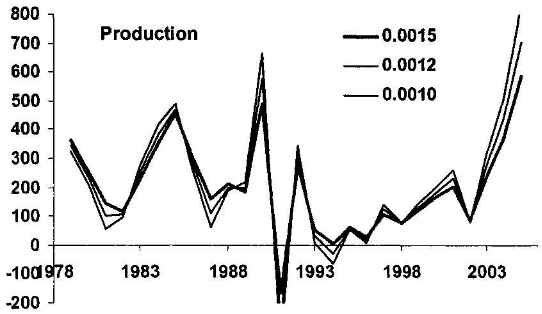

Figure 21: Production estimated for CRA 7 under three values of assumed *q* (highest value on top, lowest on bottom).

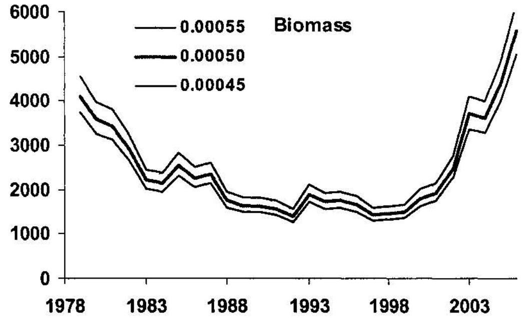

Figure 22: Biomass estimated for CRA 8 under three values of assumed *q* (highest value on bottom, lowest on top).

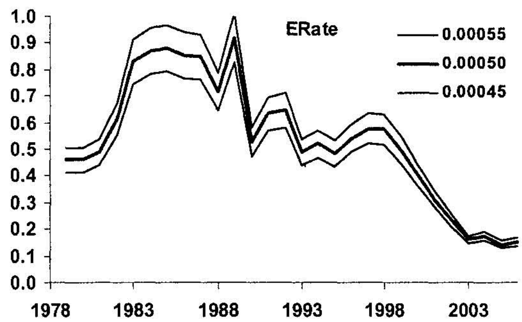

Figure 23: Exploitation rate estimated for CRA 8 under three values of assumed *q* (highest value on top, lowest on bottom).

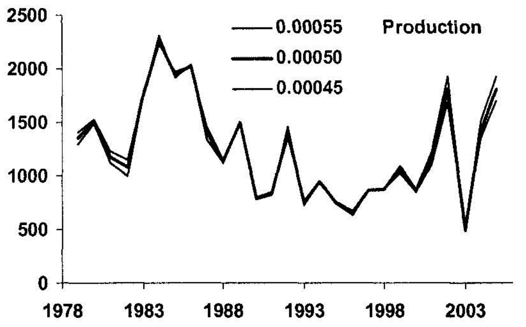

Figure 24: Production estimated for CRA 8 under three values of assumed *q* (highest value on top, lowest on bottom).

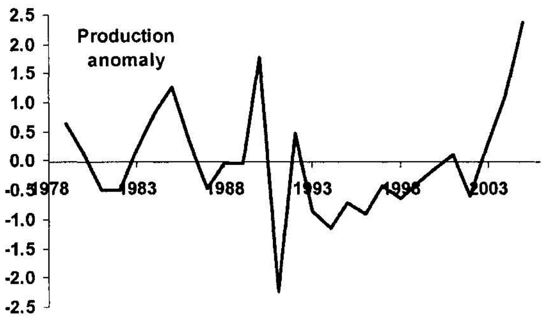

Figure 25: Production anomaly for CRA 7.

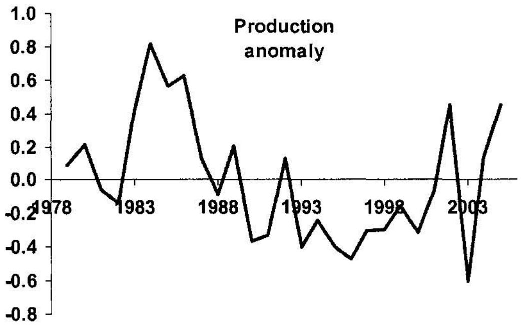

Figure 26: Production anomaly for CRA 8.

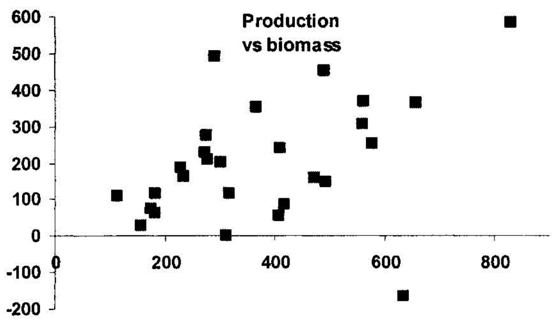

Figure 27: Production plotted against estimated biomass for CRA 7.

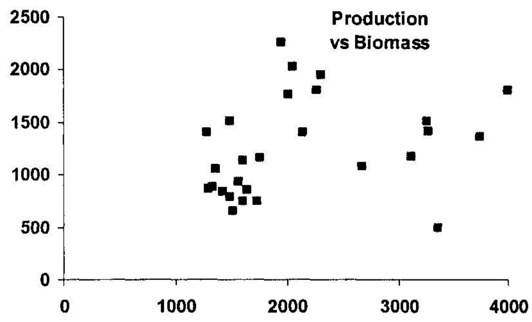

Figure 28: Production plotted against estimated biomass for CRA 8.

prelimruns go here

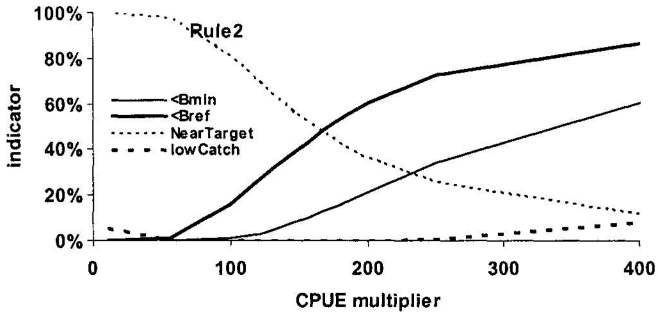

Figure 29: Risk indicators for Rule 2 for CRA 7, plotted against the multiplier.

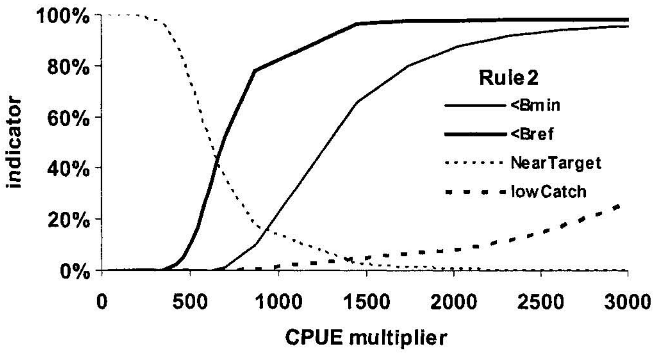

Figure 30: Risk indicators for Rule 2 for CRA 8, plotted against the multiplier.

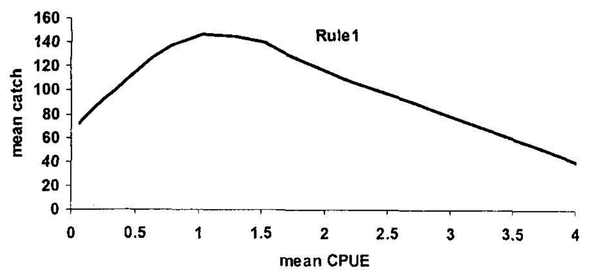

Figure 31: The median of avCatch under base case Rule 1 plotted against the median of avCPUE for CRA 7.

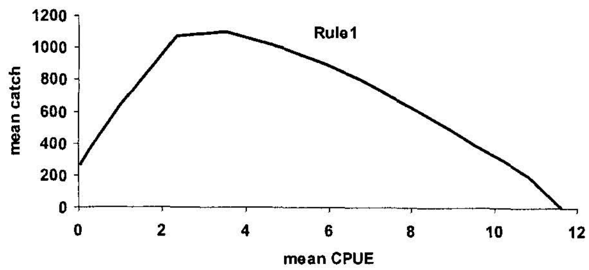

Figure 32: The median of avCatch under base case Rule 1 plotted against the median of avCPUE for CRA 8.

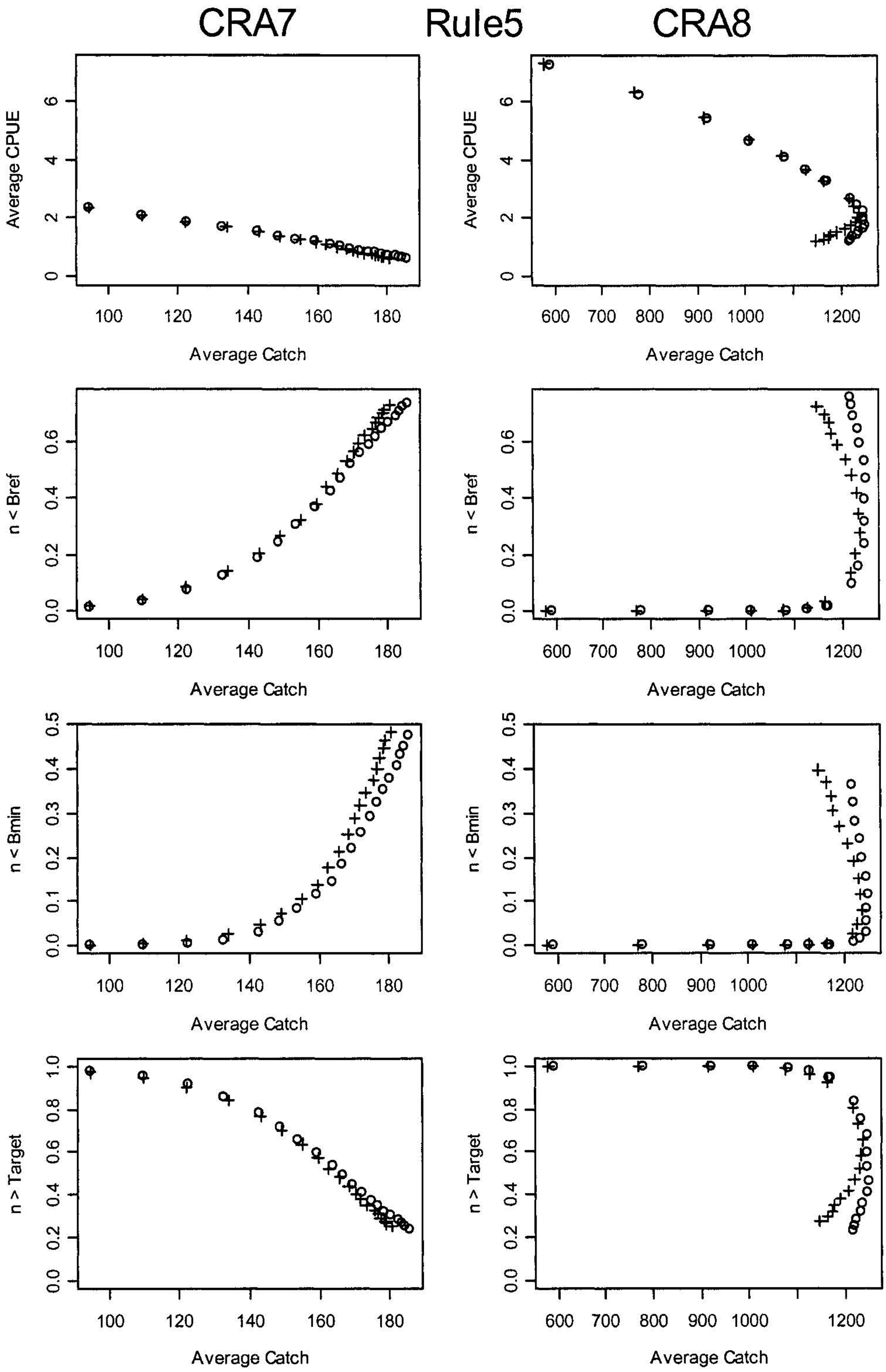

Figure 33: Plots of average CPUE and risk indicators for Rule 5 against average catch for the two stocks. Rules with and without the latent year are represented by crosses and circles respectively.

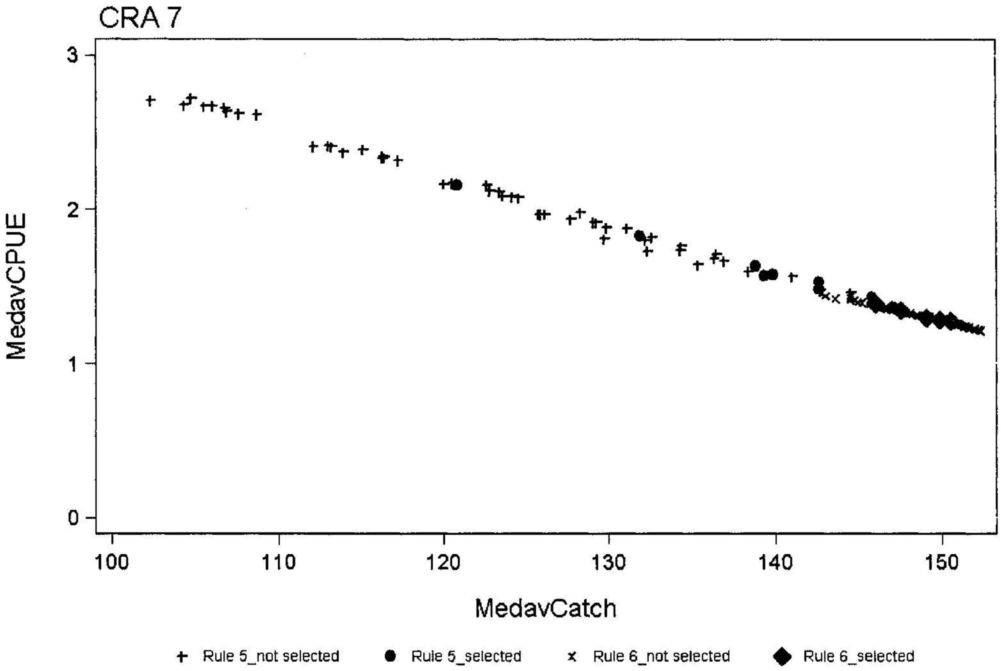

Figure 34. Median average CPUE plotted against median average catch for all CRA 7 intermediate runs that passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule family.

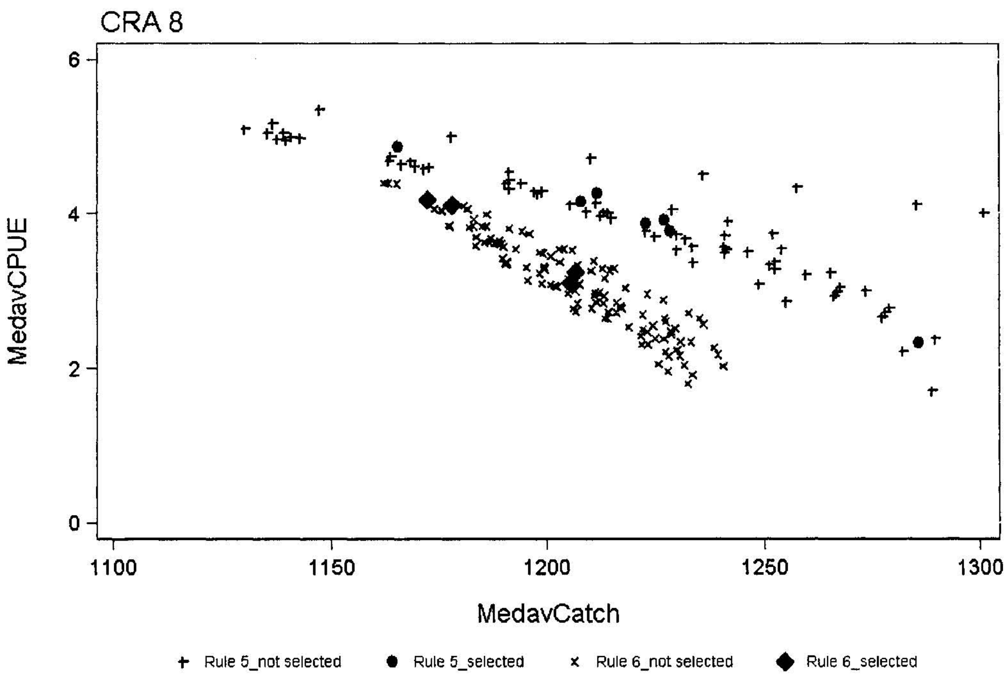

Figure 35. Median average CPUE plotted against median average catch for all CRA 8 intermediate runs that passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule family.

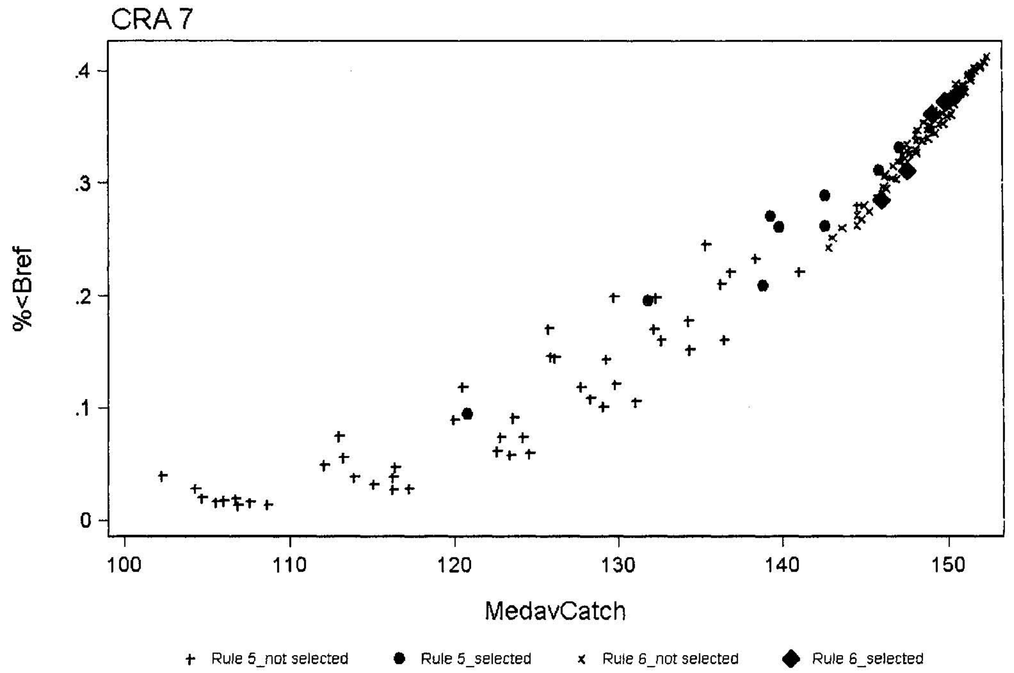

Figure 36. Percent of runs below 50% Bref plotted against median average catch for all CRA 7 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

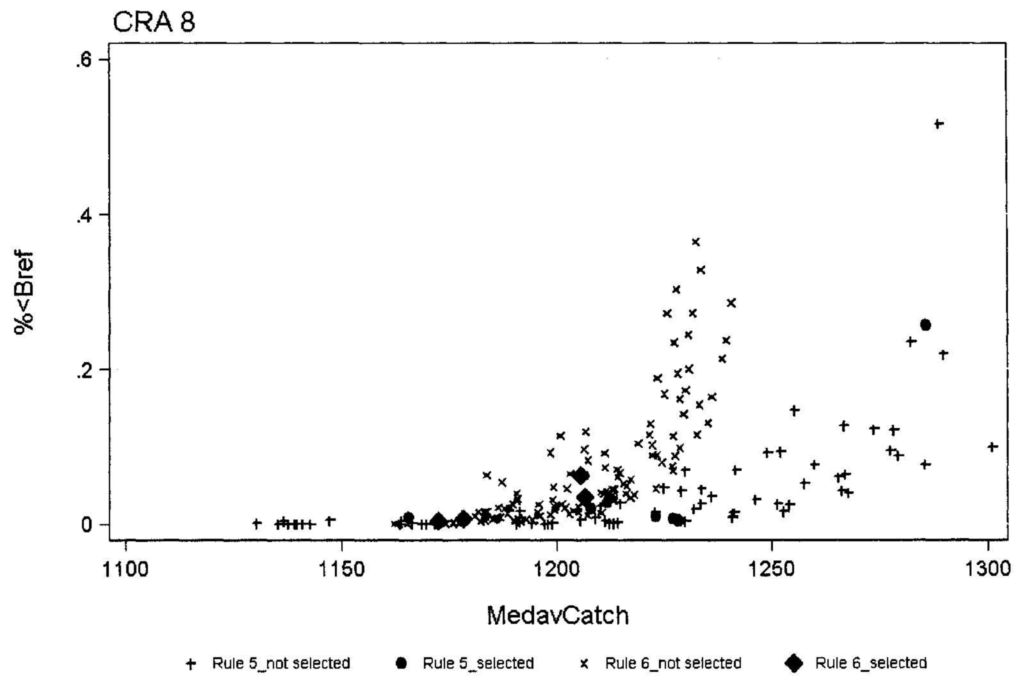

Figure 37. Percent of runs below 50% Bref plotted against median average catch for all CRA 8 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

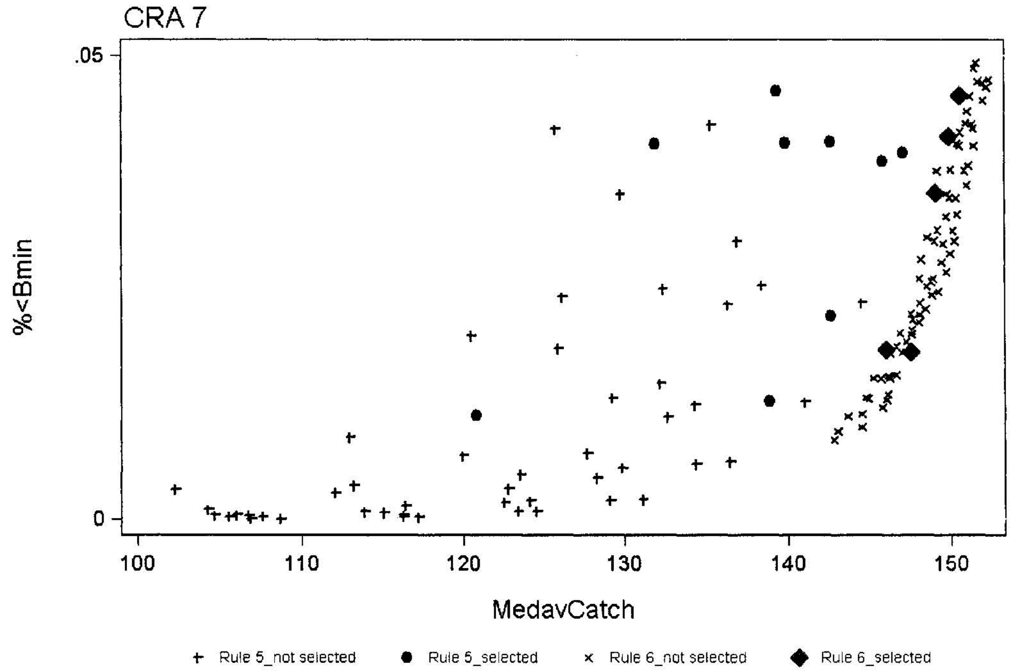

Figure 38. Percent of runs below 5% Bmin plotted against median average catch for all CRA 7 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

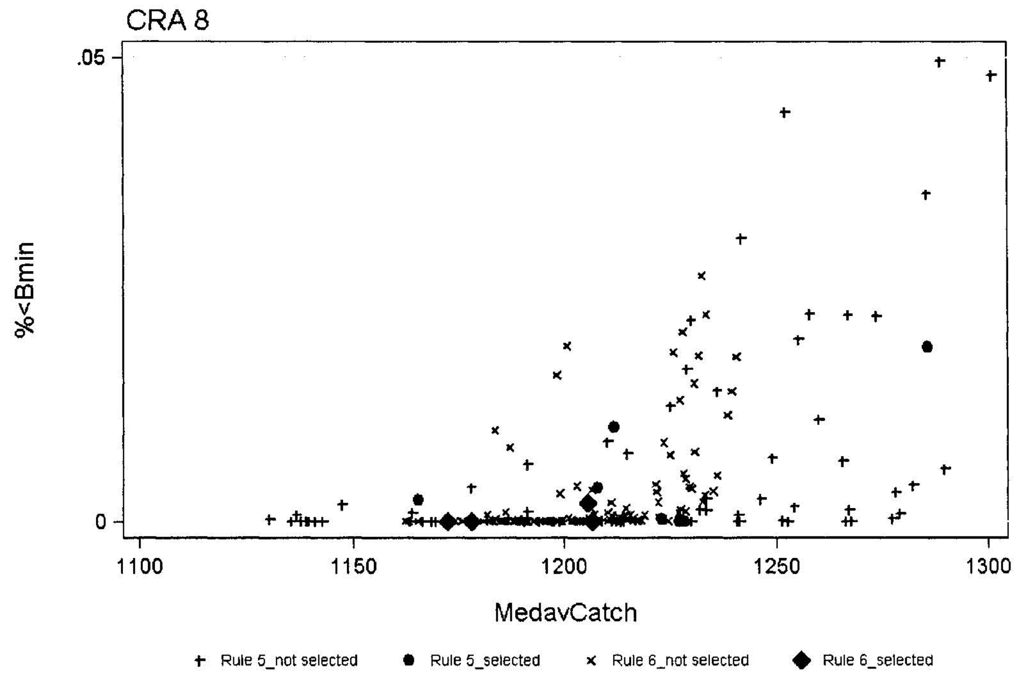

Figure 39. Percent of runs below 5% Bmin plotted against median average catch for all CRA 8 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

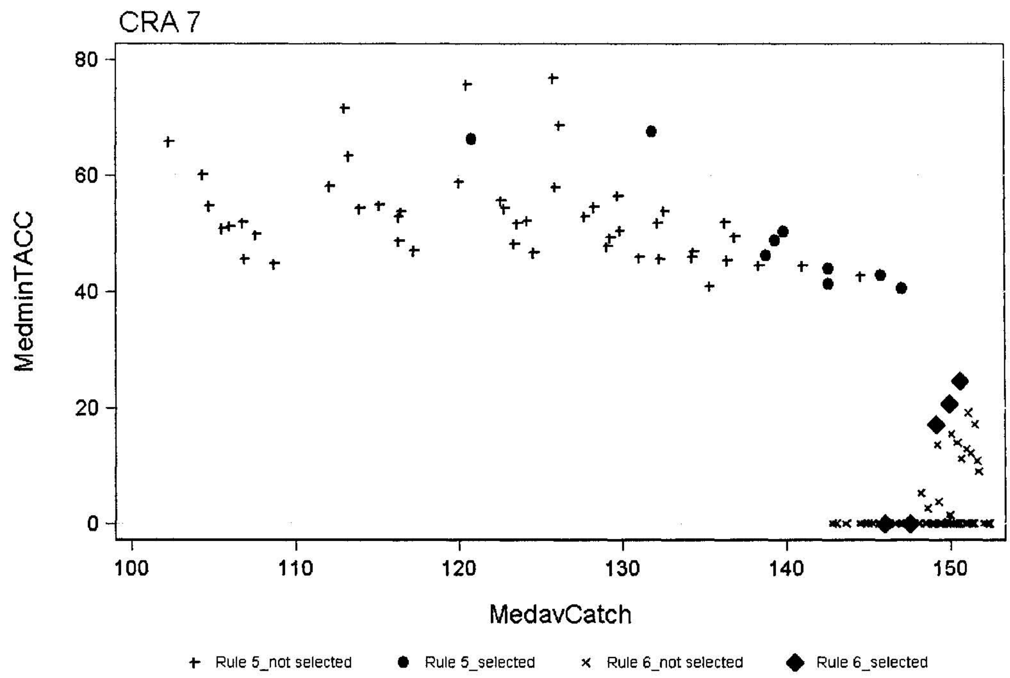

Figure 40. Median minimum TACC plotted against median average catch for all CRA 7 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

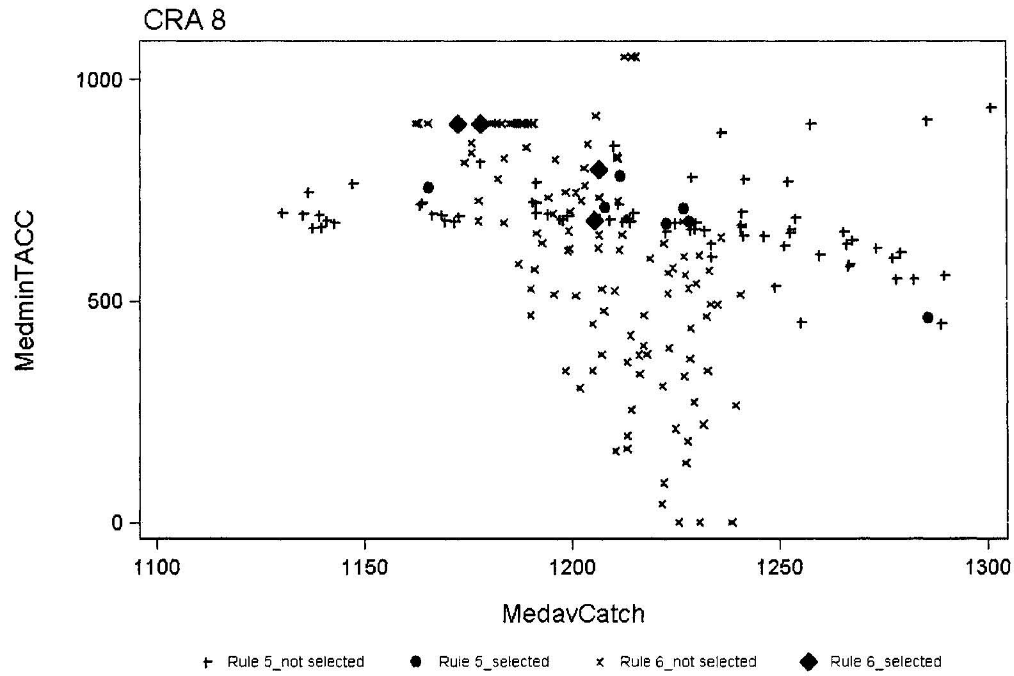

Figure 41. Median minimum TACC plotted against median average catch for all CRA 8 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

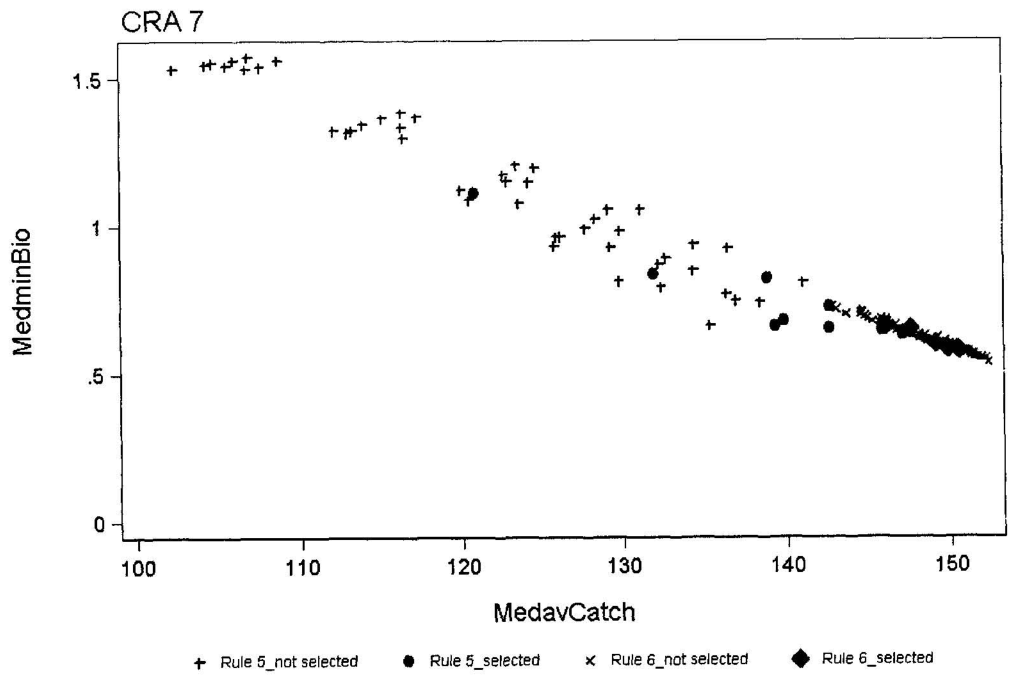

Figure 42. Median minimum biomass expressed relative to Bref plotted against median average catch for all CRA 7 runs from both rules which passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

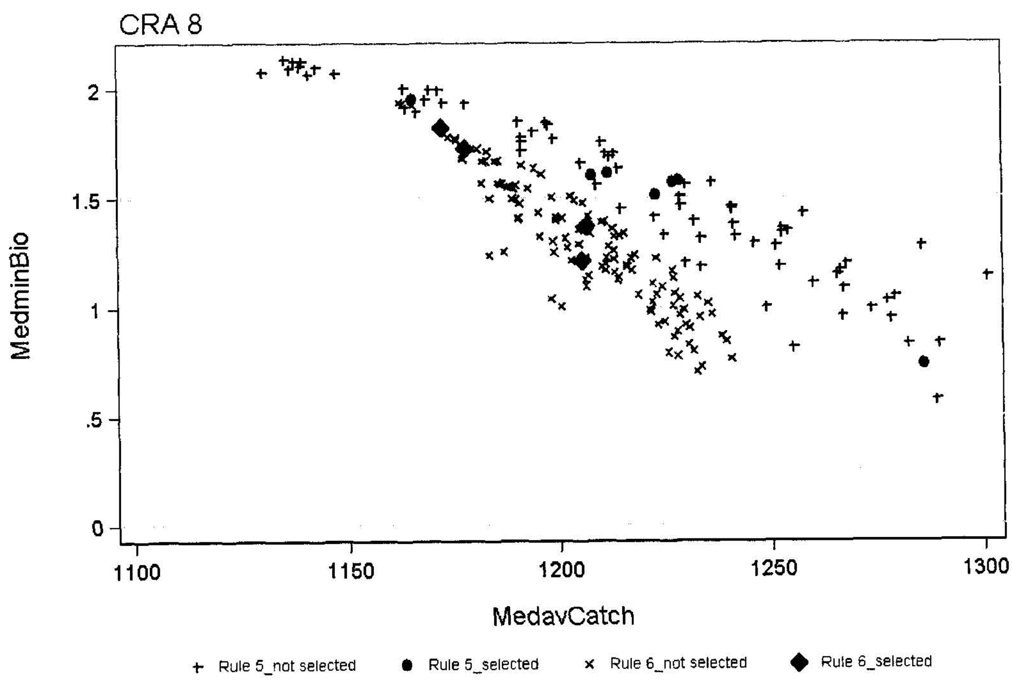

Figure 43. Median minimum biomass expressed relative to Bref plotted against median average catch for all CRA 8 runs from both rules that passed the 95%>Bmin criterion. Selected runs have been plotted separately for each rule.

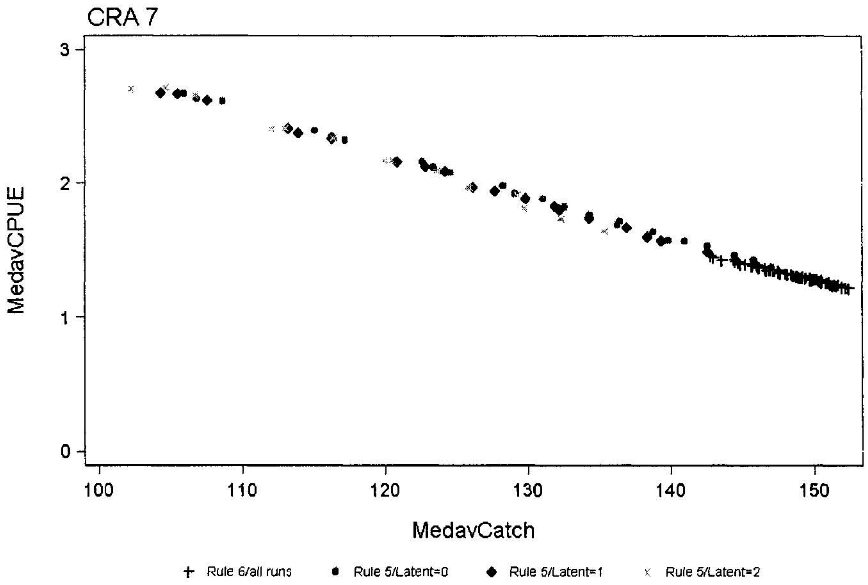

Figure 44. Median average CPUE plotted against median average catch for all CRA 7 runs from both rules which passed the 95%>Bmin criterion. Rule 5 has been further subdivided to show the effect of varying number of latent years.

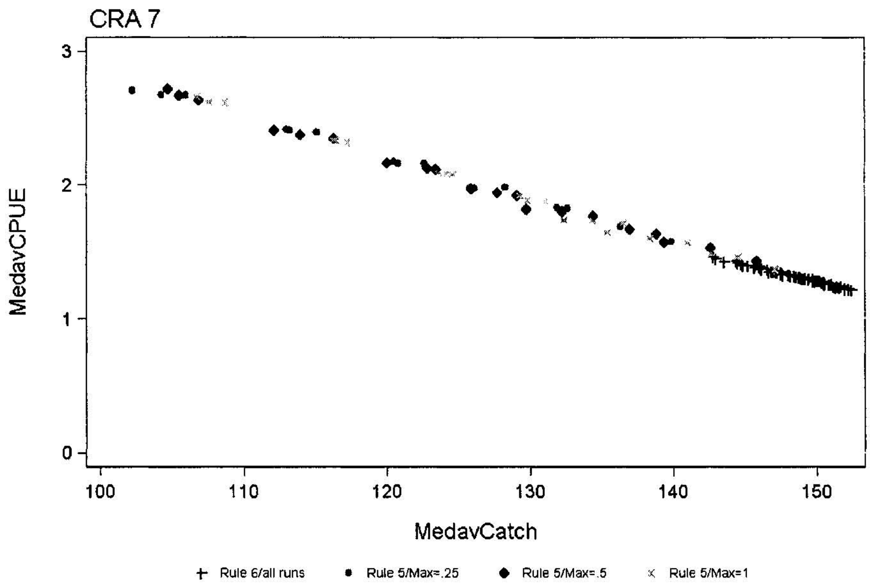

Figure 45. Median average CPUE plotted against median average catch for all CRA 7 runs from both rules which passed the 95%>Bmin criterion. Rule 5 has been further subdivided to show the effect of varying the maximum TAC change for any year.

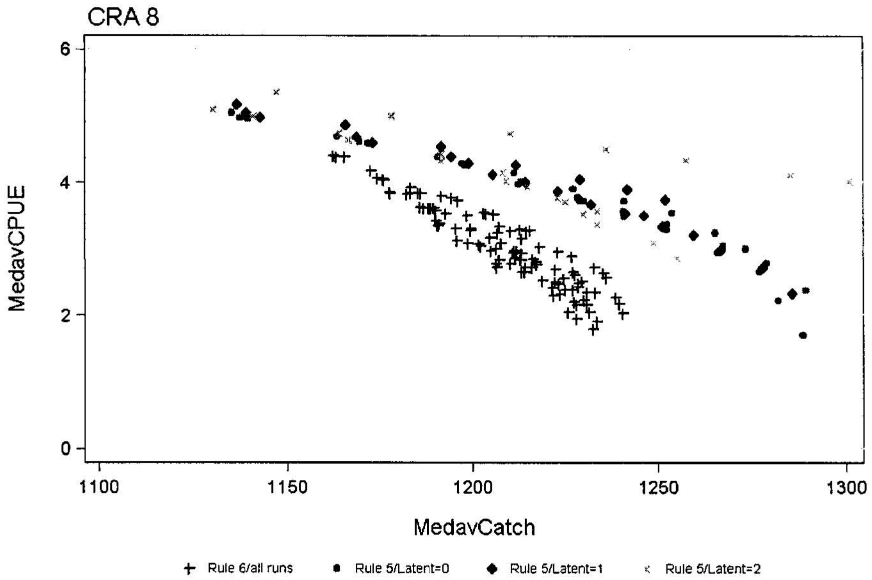

Figure 46. Median average CPUE plotted against median average catch for all CRA 8 runs from both rules which passed the 95%>Bmin criterion. Rule 5 has been further subdivided to show the effect of varying number of latent years.

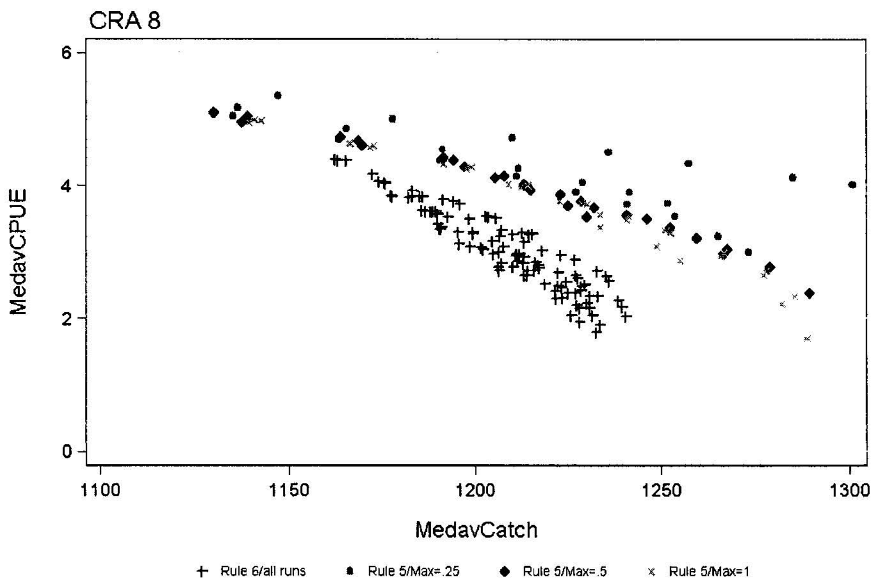

Figure 47. Median average CPUE plotted against median average catch for all CRA 8 runs from both rules which passed the 95%>Bmin criterion. Rule 5 has been further subdivided to show the effect of varying the maximum TAC change for any year.

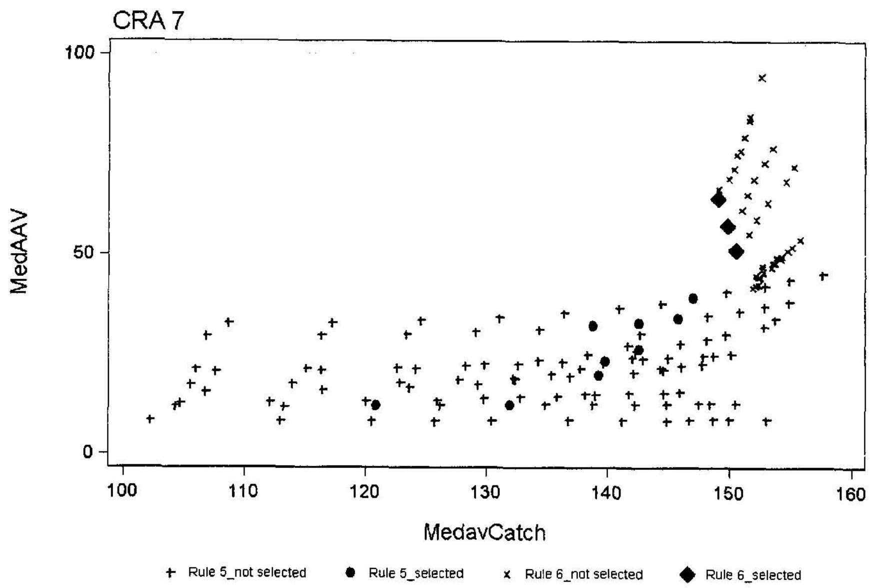

Figure 48. Median annual average variation (AAV) in TACC (as %) plotted against median average catch for all CRA 7 runs from both rules which had AAVs less than 100. Selected runs have been plotted separately for each rule.

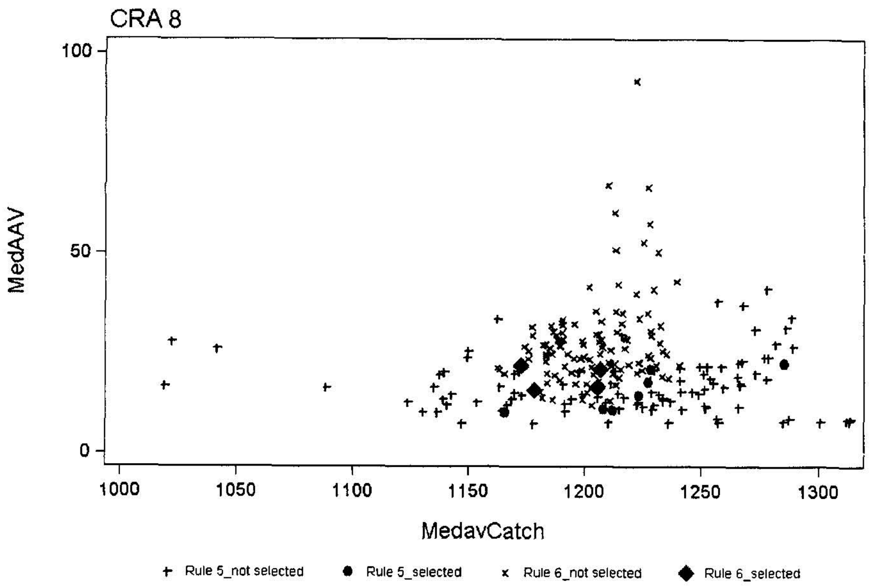

Figure 49. Median annual average variation (AAV) in TACC (as %) plotted against median average catch for all CRA 8 runs from both rules which had AAVs less than 100. Selected runs have been plotted separately for each rule.

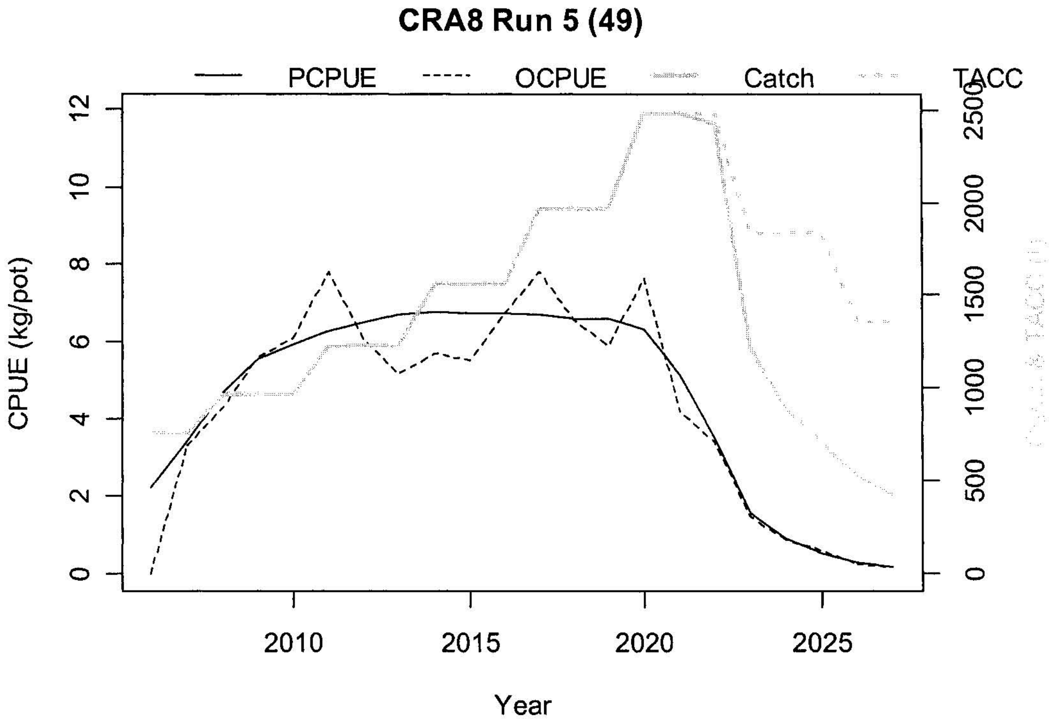

Figure 50. Example trajectory for CRA 8 from a rule 6 member with latent year=2 and maximum TAC change of 25%, showing the extreme lag from this parameter combination which causes a stock crash, in this example, by the end of the simulation.

10. Appendix – letter to stakeholders, January 2007

NEW ZEALAND ROCK LOBSTER INDUSTRY COUNCIL

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10 January 2007

Review of CRA 7 and CRA 8 decision rule

This document summarises the decision rule review, the review timetable and the options that industry must address in 2007.

Decision rule

Since 1996, the total allowable catches (TACs and TACCs) for CRA 7 and CRA 8 have been determined by a decision rule. This has been called the "NSS decision rule" where NSS means the southern substock of rock lobsters; sometimes it has been called the "NSS management procedure". The current NSS decision rule, which began in 2002, applies to both CRA 7 and CRA 8 but is based on CRA 8 data only.

The rule was put into place to rebuild the CRA 7 and CRA 8 stocks from their badly depleted state in the mid-1990s. The rebuilding target for the NSS stock is the average CRA 8 legal catch per pot-lift [catch-per-unit-effort or CPUE] for the period 1979/80 to 1981/82. This is about 1.9 kg/potlift. This level was selected in 2002 because it was the highest level observed up to that time and it was more than double the low levels observed in the late 1990s. This rebuilding target was considered achievable.

Each year, The rule operates by analysing CPUE and feeding the result into the set of arithmetic formulae that represent the rule. The rule then produces a new TAC, depending on whether CPUE for the year is above the target track or below it, and on whether the CPUE trend is increasing or decreasing.

Additional components to the current rule include:

a "latent year" provision prevents TAC changes in two consecutive years;
changes more than 25%up or down are limited to 25% and
changes less than 5% are not made.
The decision rule has produced four changes since 1996: two increases and two decreases. Each change was discussed by the National Rock Lobster Management Group (NRLMG) and recommended to the Minister of Fisheries. The Minister changed only the total allowable commercial catch (TACC) and did not change the allowances for non-commercial catches.

Thus the percentage change to the TACC is different (a bit greater than) the change made to the TAC. Table 1 shows the changes: decreases for the 1999 and 2001 fishing years, increases for the 2004 and 2006 years.

Table 1: TAC and TACC histories in CRA 7 and CRA 8 (there were no TACs for CRA 7 and CRA 8 before 2000).

	CRA 7				CRA 8			
Fishing year	TAC	%change to TAC	TACC	%change to TACC	TAC	%change to TAC	TACC	%change to TACC
1998–99	N/A		138.7		N/A		888.1	
1999–00	131.0		111.0	-20%	798.0		711.0	-20%
2000–01	131.0	0%	111.0	0%	798.0	0%	711.0	0%
2001-02	109.0	-17%	89.0	-20%	655.0	-18%	568.0	-20%
2002-03	109.0	0%	89.0	0%	655.0	0%	568.0	0%
2003–04	109.0	0%	89.0	0%	655.0	0%	568.0	0%
2004–05	114.9	+5%	94.9	+7%	690.4	+5%	603.4	+6%
2005–06	114.9	0%	94.9	0%	690.4	0%	603.4	0%
2006–07	140.2	+22%	120.2	+27%	842.2	+22%	755.2	+25%

Figure 1 shows the history of CPUE, in kg of legal fish per potlift, for the two stocks. CPUE in both stocks reached a minimum in the mid-1990s, and both stocks now show CPUE well above the average levels from 1979/80 to 1981/82. This means that recovery has taken place in both areas.

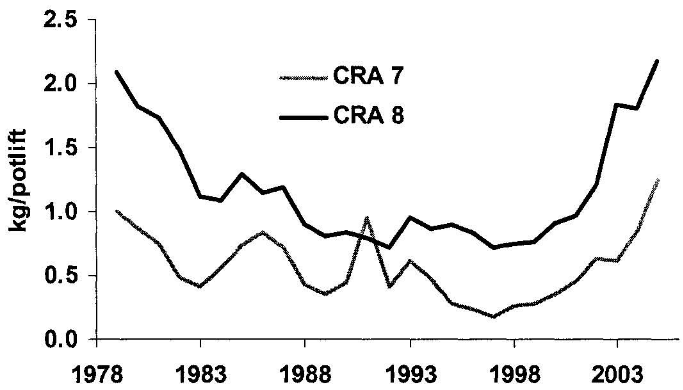

Figure 1: History of standardised CPUE in CRA 7 and CRA 8.

Review of decision rule

The first version of the NSS decision rule was reviewed and revised in 2002. A review at the end of five years (i.e., in 2007) was part of the rule package agreed to by then-Minister Pete Hodgson. That review will be conducted by the stock assessment team contracted to the New Zealand Rock Lobster Industry Council (NZ RLIC) in 2007 as a major part of the rock lobster research contract to the Ministry of Fisheries.

The review will explore the current rule and will also explore other possible decision rules. This work involves converting the assessment model into a model that can be used to test decision rules, and making many thousands of model runs with tens or hundreds of possible decision rules. Runs will be compared on the basis of agreed performance indicators that may include catch, average CPUE, risk of falling below reference levels, etc.

The timetable for this review is as follows:

When	Action
Dec 2006	first stakeholder meeting to explain review process and options
Dec 2006 - Feb 2007	assessment teams sorts out data and model, model review
Mar or Apr 2007	second stakeholder meeting
mid-May 2007	model ready, decision rule candidates agreed, indicators agreed
May - Jun 2007	preliminary model runs presented to Working Group
Sep - Oct 2007	final model runs
Sep - Nov 2007	stakeholder meetings to agree on final decision rule
Apr 2008	new rule adopted (or old rule reconfirmed)

Options to be considered

MFish requirements

First, we must consider what MFish requires of any scheme to manage a fishery. This is in a state of change, but we can report what MFish thinking has been up to now.

MFish has a statutory responsibility to try to maintain stocks near ("at or above") a sustainability target level. For CRA 8, they have accepted that this target level is the stock size that produced the autumn-winter CPUE that was seen in the 1979/80 to 1981/82 period - 1.9 kg per potlift. Such an average would also be an acceptable level for CRA 7 - that would be 0.953 kg per potlift. We can call this Bref.

They also have accepted, for lobster stock assessments, the idea of a "limit" reference level, which is a level that the stock must not ever be allowed to fall below. In all recent assessments, we have used the lowest point seen in the history of autumn-winter CPUE for the stock. This would be 0.564 kg per potlift for CRA 8, seen in 1998, and 0.143 kg per potlift in CRA 7, seen in 1997. We refer to this as Bmin.

MFish need to be assured (and we can do this assurance based on the review we undertake) that the stock is very unlikely to fall below Bmin, and likely to remain near Bref.

Any decision rule chosen by industry should ensure that these two criteria are met. However, provided that those two criteria are met, to satisfy MFish, the target of a decision rule is a choice for industry.

Stock structure

The current decision rule applies to both CRA 7 and CRA 8. The rule is based on CRA 8 data only, but any change made to the CRA 8 TAC is mirrored for CRA 7. This arrangement was used so that, if CRA 7 wished, it could opt out of the decision rule in favour of a CRA 7 specific decision rule between 2002 and 2007. This did not happen.

In theory, there are four options for the stock structure of a revised NSS decision rule:

as at present, a combined rule, affecting both CRA 7 and CRA 8, that is based on CRA 8 data;
a combined rule, affecting both CRA 7 and CRA 8, based on combined CRA 7 and CRA 8 data;
separate rules, each based on data from that stock; i.e. a CRA 7 rule based on CRA 7 data and a CRA 8 rule based on CRA 8 data;
a single rule applying to an amalgamated stock.