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EXECUTIVE SUMMARY

Breen, P.A.; Starr, P.J.; Haist, V.; Bentley, N. (2009). New Zealand decision rules and management procedures for rock lobsters (*Jasus edwardsii*).

***New Zealand Fisheries Assessment Report 2009/43*. 18 p.**

This document summarises work conducted on decision rules and operational management procedures used to manage rock lobster stocks in New Zealand. The document describes the decision rule or a management procedure for every stock that has such management, and the history of performance of these is described.

No new work is described, but this document brings together all the information into one document that will be useful for reference.

1. INTRODUCTION

This document summarises research on management procedures undertaken in New Zealand for managing red rock lobster (*Jasus edwardsii*) stocks, then lists the decision rules and management procedures that have been used and that are used now. One function of the document is to centralise the formal descriptions of the various rules and the specifications of their inputs.

1.1 Management procedures

The use of management procedures (MPs) in fisheries management was reviewed by Butterworth (2007). He contrasted the MP approach with the historical approach, which involves "developing a "best assessment" of the resource" and translating this into management advice such as a proposed TAC, either by using a harvest control rule based on a reference point or by considering alternative forward projections from the stock assessment, made with different catches.

The historical approach is the one most widely used in New Zealand. For at least the highest-profile stocks, including rock lobsters, stock assessments are done periodically, and a very few are done annually (e.g., hoki). The stock assessment delivers advice on whether the TAC is sustainable; if it is not, the Ministry of Fisheries (MFish) advises the Minister of Fisheries on a TAC change. TAC increases may also result from stock assessments, usually based on alternative forward projections from the stock assessment.

This traditional approach has obvious drawbacks. Stock assessment capacity is limited, and for rock lobsters only one or two assessments can be carried out each year. Stock assessments thus must be periodic, with several years between assessments. The process of recommending a TAC change involves a comprehensive Initial Advice Paper, statutory public consultation with interested parties, a summary of the comments, and a comprehensive Final Advice Paper. MFish capacity is limited, so only a few TAC changes can be accommodated each year. The possibility of litigation following a TAC change causes advice papers to be comprehensive and minutely written.

The delay caused by having infrequent stock assessments causes TAC levels to lag behind the abundance of stocks. TACs cannot be reduced quickly when stock abundance falls; there is reluctance to increase TACs when abundance increases. The *de facto* management strategy becomes "set it and forget it", with consequent loss of catch when stocks are abundant and loss of economic opportunity through the unnecessary depletion of stocks.

The MP approach can avoid these drawbacks. An MP specifies the input to a formula that provides a specific management recommendation such as a TAC specification. The formula in an MP has been extensively simulation-tested, using an appropriate operating model, to ensure that it will deliver on specified management goals with high probability. These goals might be maintaining abundance above a lower threshold (i.e., minimising risk), delivering high average annual catches (i.e., maximising yield), maintaining annual catches with little variability (i.e., maximising stability), or others; these goals are often in conflict (maximising catches and minimising risk are incompatible, for instance).

In New Zealand, the MP approach was used first for rock lobsters in CRA 7 and CRA 8, beginning in 1996 (Starr et al. 1997), and indeed these remained the only New Zealand stocks managed this way until 2006. An MP has been developed for managing the sea lion bycatch in the SQU 6T fishery (Breen et al. 2003, 2008, Breen & Kim 2006a), but the actual fisheries management has not treated this as a management procedure, and has instead been *ad hoc*. There is interest in using MPs for species in New Zealand other than rock lobsters, but so far only two lobster stocks are officially managed this way.

The CRA 7 and CRA 8 management procedure, which came to be known as the "NSS decision rule", illustrated some of the benefits of an MP approach over the historical approach. In 1996 the state of the southern stocks was poor (considered depleted) and controversy surrounded management proposals. However, after the MP was adopted amid much discussion by the National Rock Lobster Management Group (NRLMG), the amount of time spent discussing these two stocks was greatly reduced. Two TAC decreases were approved by the Minister without opposition from the industry and certainly without litigation. In contrast, a TAC decrease for CRA 6, made about the same time as the first lobster decrease, attracted litigation.

Thus the MP approach allows for much more rapid management responses than does the historical approach, with less discussion and (once the MP is adopted) much less argument and negotiation. MPs reduce the need for stock assessment, although they do introduce a need for extensive evaluation before an MP can be adopted.

1.2 Management procedure research in New Zealand

For rock lobsters, the input to MPs has been CPUE. The assessment team believes that, despite some problems, CPUE is a valid index of abundance. Not many fisheries can rely on such a simply calculated index. The calculation (standardisation) involves using data collected on the CELR forms returned by the commercial fishery for each landing, a standard grooming procedure described by Bentley et al. (2005b), and fitting a generalised linear model. The indices show little departure from obvious trends that cover several years, suggesting that observation error is relatively low. Problems include possible non-linearity of the index and various kinds of reporting problems, including confusion about what should be reported and a disconnection between catch and the effort that generated the catch.

Other indices are available besides CPUE for rock lobsters, including puerulus settlement, pre-recruit indices, trends in CPUE and climate indices. These were explored by Bentley et al. (2005a) with a simple delay-difference model based on parameter estimates from recent assessments, who found that only pre-recruit indices appeared to have immediate potential for use in improving management procedures. Accordingly, most work on MPs for rock lobsters has used CPUE.

The earliest "decision rules" used in New Zealand were not management procedures; they were an attempt to bring objective criteria into a structure for rebuilding depleted stocks, in an environment without the Fisheries Act 1996. These are described below. The first management procedures were explicitly aimed at rebuilding depleted stocks. Later, rules were explored for CRA 3 (Breen et al. 2005) and CRA 4 (Breen & Kim 2006b) that were expected to manage the stock around abundance targets. Although the outputs of early rules were TACs, later work explored rules that could be implemented through voluntary ACE shelving, and such rules were later adopted in CRA 4 (Breen et al. 2009) and CRA 5 (Breen in press).

The design of MPs was explored by Breen et al. (2003), who explored the literature to see what kinds of harvest control rule formulae had at that time been evaluated worldwide. These authors studied the several ways that inputs (usually CPUE) have been used in the formulae; they identified more major approaches: for instance, CPUE can be compared with a target value, or rate of change in CPUE can be compared with a target value, or CPUE can be used (with assumed catchability) to estimate biomass, or CPUE can be used with catch to estimate production. They also listed the many ways in which the output could be buffered or otherwise modified for stability or other reasons: for instance, by having hybrid control rules, using a sensitivity parameter, combining the prescribed TAC with the previous TAC and taking an average, using minimum and maximum change components to rules, etc. In a simple but

generalised study of harvest control rule behaviour, they concluded that implementation of lags or "latent years" degraded rule performance. They showed empirically that, where MPs control only part of the catch, and the other catch is both substantial and uncontrolled, MPs act merely to transfer catch from the controlled to uncontrolled sectors. They confirmed the suggestion of Polacheck et al. (1999) that constant catch rate MPs perform best.

Evaluation of MPs involves substantial work (McAllister et al. 1999), at least as demanding as a stock assessment and perhaps more so. Most of the New Zealand MP evaluations (MPEs) have used modifications of the most recent stock assessment model for the stock involved. This began with the first MP for the NSS (Starr et al. 1997) and continued through the second and third southern MPs (Bentley et al. 2003a; Breen et al. 2008), and has also been done for CRA 3 (Breen et al. 2005) and CRA 4 (Breen & Kim 2006b). An MP commissioned by the CRA 5 industry (Breen in press) could not do this, because there was no recent stock assessment model and also no time to use this approach. Instead, a simpler surplus-production model, based on the CRA 5 fishery, was used. MPEs should involve different rule families and many members of each family in at least the first trials, and a suite of robustness or sensitivity trials in which major modifications of the operating model are made to test the MPs with a different base (Punt & Donovan 2007).

How to evaluate MPs is a major problem. First, the specific goals of management have rarely been explicitly stated. The MFish requirement to maintain stocks at or above *Bmsy* is enshrined in the Fisheries Act 2006, but how *Bmsy* is to be specified and how "at or above" is to be interpreted in a stochastic situation are not defined. The assessment team believes that stakeholders, not fishery scientists, should define the goals, choosing from among the major alternative groups: yield, abundance, risk and stability. Meeting with stakeholders is critically important to defining and producing rules that will deliver the stakeholder expectations. In the most recent set of MPEs for CRA 7 and CRA 8 (Breen et al. 2008), it became clear that CRA 7 placed yield above stability, while the converse was true in CRA 8.

Yield is not generally ranked highly as a management goal. In a set of workshops (Bentley et al. 2003b), commercial fishermen tended to rank abundance highest. When abundance is high, the TACC can be taken cost-efficiently and fishermen have the option of fishing where and when they want. A point made by fishermen in these workshops was that higher abundance is associated with higher diversity of fish sizes: higher abundance means that seasonal size-based market differentials can be exploited most effectively and profitably.

Once goals are defined, it is still a daunting task to compare the performance of the many rules evaluated. Some techniques to apply in this were elucidated and discussed by Bentley et al. (2003b); they include "screening" by discarding rules that fail to deliver specified minimum performance, and exploring "choice frontiers" where the many rules can be compared in the context of trades-off between goals in a 2- or 3-dimensional phase space to find the best compromises.

Management procedures are already a success story in New Zealand; they complement the qualified success of the quota management system. Development of MPs for the remaining rock lobster stocks should be a research priority.

2. ROCK LOBSTER DECISION RULES AND MANAGEMENT PROCEDURES

2.1 NSN and NSC decision rules (1994)

These two decision rules were agreed by the NRLMG in 1993 (Breen et al. 1994). These are not management procedures, in that 1) they do not specify a firm management recommendation for a given input and 2) they have not been simulation-tested. At the time these were introduced, the Fisheries Act 1996 had not been passed, and there was no clear direction to maintain stocks at or above any specific level. The concern at that time for some lobster stocks was to rebuild them from a depleted condition, and these decision rules were intended to give some objective guidance to that process.

The wording of the rules is as follows (taken from MFish 1997).

1. The decision rule will be based on standardised CPUE (Vignaux, 1992) analysis of rock lobster potting data from the CELR data base, stratified by the current substock definitions for the NSI stock.

2. The decision rule analysis will be based on a calculated abundance index, using all available CPUE data from 1 September 1979 through 31 August [in the current year]*, and using as a base year that year beginning on 1 September with the lowest variance, excluding the two years being compared (defined in the following paragraph). The standardisastion procedure will use at least month, year and statistical area as explanatory variables, but may also include other variables examined and recommended by the Rock Lobster Stock Assessment Working Group.*

3. The decision rule will be based on the standardised CPUE for 1 December [of the preceding year] *through 31 August* [of the current year] *relative to the same estimate for 1 September 1992 through 31 August 1993, using one standard error as the measure of difference between the two estimates.*

4. The nature of the decision rule will be as follows:

a) A 'significant' change in the context of the estimated abundance is defined as a change in which the defined error bars do not overlap;

b) if there is a 'significant' increase in the abundance index, there will be no change in the permissible total removals for that substock;

c) if there is a 'significant' decrease in the abundance index, then a 'trigger point' will be considered invoked.

5. If the 'trigger point' is invoked, then the appropriate analysis will be begun through the Rock Lobster Stock Assessment Working Group which will determine the amount of reduction required in total removals in order to allow for a 50% probability of the sub-stock increasing in recruited biomass in the subsequent fishing year.

The substock definitions referred to are simply these:

- the NSN substock comprises CRA 1 and CRA 2,
- the NSC substock comprises CRA 3, CRA 4 and CRA 5,
- the NSS substock comprises CRA 7 and CRA 8,
- these stocks along with CRA 9 were collectively considered to be the NSI stock and
- CRA 6 comprised the CHI stock (Booth & Breen 1994).

Some changes have been made since the rule was adopted. First, the NRLMG agreed to remove clause 4(b) so that TAC or TACC increases were not precluded following increased abundance and a stock assessment.

Second, the year on which the standardised CPUE was calculated changed at some stage: it reverted to the fishing year, 1 April through 31 March.

In recent years the CPUE in both stocks has been significantly above the 1992–93 values. The 'trigger point' in these rules has never been invoked.

The results of these rules are reported each year in the Report from the Mid-Year Stock Assessment Plenary. Note that the 1992–93 CPUE is not constant, because the whole dataset is used each year to calculate the standardised indices (year effects).

2.2 NSS decision rule (1996)

Although referred to as a "decision rule" in all the years of its existence, this was a management procedure that operated for the NSS stock (CRA 7 and CRA 8). It was proposed by the National Rock Lobster Management Group (NRLMG) and accepted by the Minister of Fisheries (John Luxton) in early 1997 (NRLMG 1996, Starr et al. 1997). The generalised harvest control rule (taken from Starr et al. 1997) was:

(1) Obtain a target CPUE trajectory from deterministic forward simulation as described [by Starr et al. 1997].

(2) In each year for which a decision is required, compare the observed and target CPUEs for the previous N years; i.e., calculate the 'average ratio': A = {Σ[(C_{obs}/C_{targ})-1)]}/N, where A is the average ratio, C_{obj} is the observed CPUE, C_{targ} is the target CPUE, and N is the number of years over which the ratio is averaged.

(3) If A (multiplied by 100) is greater than X (a threshold), raise the quota by Y (an adjustment to the catch).

(4) If A (multiplied by 100) is less than -X, lower the quota by Y.

(5) If the quota was changed in the previous year, do nothing.

The input CPUE was standardised annual fishing year CPUE for CRA 8. CRA 7 industry accepted that their TACC would be governed in this way.

The rule output ("quota") was the TACC. Values adopted for the parameters were $N = 3$, $X = 25\%$ and $Y = 20\%$. The target CPUE trajectory was determined by deterministic assessment model projections, terminating at 3.61 kg/pot in 2014, which was the CPUE that would be realised at *Bmsy* (9802 t) determined from the stock assessment (Breen & Kendrick 1997).

Operation of this MP for the 1999–2000 fishing year in CRA 7 and CRA 8 produced a 20% TACC decrease and the creation of a TAC (Table 1). In the 2001–02 fishing year, the operation of the rule reduced the TACC by 20% and the TAC by about 16–17% as the allowances for other stakeholders were not affected by the rule. In both years, the TACC were reduced by 20%. These decreases were relatively

smoothly accomplished, with little or no argument or dissent, particularly for the second decrease. The environmental member on the NRLMG argued that both TAC decreases should have been larger, a view supported by some of the CRA 8 industry for the first decrease – they argued that a larger decrease would lead to a faster rebuild – but the NRLMG, MFish and the Ministers (John Luxton and Pete Hodgson) agreed to follow the MP.

2.3 NSS decision rule (2002)

A revised management procedure was proposed and accepted in 2002 after extensive evaluation of alternatives (Bentley et al. 2003a). The input to this rule was also defined as annual standardised CPUE. This was compared with a target CPUE trajectory in two ways: the relation between observed CPUE and the target trajectory CPUE was calculated and averaged over three years, and the rate of change in CPUE was compared with the target trajectory's rate of change and averaged over three years. These two measured were combined and a new TAC was the output.

The formal description of the rule (from the 2007 Report from the Mid-Year Stock Assessment Plenary) is as follows:

The new rule acts by calculating a multiplier that determines the new catch from the existing catch:

$$TAC_{t+2} = Z_t \, TAC_{t+1}$$

The Z_t is calculated from observed and target values for CPUE in any year and from the three parameters of the rule:
N, the number of years used for averaging CPUE in the rule;
W, relative weight given to the distance between observed and target CPUE, relative to the difference between target and observed gradients; and
S, a scaling or sensitivity parameter used to determine the rule's response.

These three parameters thus define a large family of candidate harvest control rules and the rule selected by the NRLMG is one specific member of this family. In this family of rules, the difference between target and observed CPUE is calculated in a "status indicator" for each year of data:

$$A_t^s = I_t^{obs} \big/ I_t^{pred} - 1$$

where I_t^{obs} and I_t^{pred} are the observed and predicted (target) CPUE observations.

Similarly, the difference between the target and observed gradient is calculated in a "gradient indicator:

$$A_t^g = \left(\left(I_t^{obs} - I_{t-1}^{obs} \right) \big/ I_{t-1}^{obs} \right) - \left(\left(I_t^{pred} - I_{t-1}^{pred} \right) \big/ I_{t-1}^{pred} \right)$$

Each is averaged for N years:

$$\overline{A}_t^s = \frac{1}{N} \sum_{d=t-N+1}^{d=t} A_d^s$$

and similarly for A_t^g *to obtain* $\overline{A}_t^g$ *. The mean gradient and status indicators are combined, using the relative weight W:*

$$A_t^* = W\overline{A}_t^s + (1-W)\overline{A}_t^g$$

Now the combined mean indicator is used with the scalar S to determine a response:

$$R_t = SA_t^*$$

Then this response is used to determine the multiplier Z_t *, taking into account the sign of* R_t *and limiting the magnitude with minimum and maximum thresholds*

$Z_t = 1$ *for –Minimum* $\leq (R_t) \leq$ *Minimum*

$Z_t = 1 + R_t$ *for –Maximum* $\leq (R_t) <$ *-Minimum and*

for Minimum $< (R_t) \leq$ *Maximum*

$Z_t = 1 - Maximum$ *for* $(R_t) <$ *- Maximum*

$Z_t = 1 + Maximum$ *for* $(R_t) >$ *Maximum*

Parameter values of the generalised harvest control rule chosen by the NRLMG were $N = 3$, $W = 0.4$, $S = 0.75$, *minimum* = 0.05, *maximum* = 0.25. The trajectory was changed from that used by the previous rule: it terminated at the mean of CPUE observed in 1979–81 (near 1.9 kg/potlift). In 2003 the procedure used for calculating CPUE was altered to address a database problem caused by holding pots, and the target CPUE trajectory was adjusted to end in 2014 at the target CPUE. Like the earlier rule, this rule had a "latent year" provision that precluded two consecutive TAC changes.

The effect of this MP is seen in Table 1. The 2002 MP resulted in about a 5.4% TAC increase in 2004 (the Minister was David Benson-Pope) and a 25% increase in 2006 (the Minister was Jim Anderton). Had the MP still been in operation to decide the 2008–09 TAC, it would have delivered another 25% TAC increase.

All the decreases and increases were implemented by changing the TAC according to the rule, then subtracting the constant allowances of 20 t for CRA 7 and 87 t for CRA 8 to obtain the TACCs. In other words, the commercial fishery took all the pain and received all the gain.

Table 1. The sequence of TACC and TAC changes for CRA 7 and CRA 8, 1997–2009.

Fishing year	CRA 7 TACC	CRA 7 TAC	CRA 8 TACC	CRA 8 TAC
1997–98	138.7	–	888.1	–
1998–99	138.7	–	888.1	–
1999–00	111.0	131.0	711.0	798.0
2000–01	111.0	131.0	711.0	798.0
2001−02	89.0	109.0	568.0	655.0
2002−03	89.0	109.0	568.0	655.0
2003–04	89.0	109.0	568.0	655.0
2004–05	94.9	114.9	603.4	690.4
2005–06	94.9	114.9	603.4	690.4
2006–07	120.2	140.2	755.2	842.2
2007–08	120.2	140.2	755.2	842.2
2008–09	123.9	143.9	966.0	1053.0
2009–10	189.0	209.0	1110.0	1019.0

2.4 CRA 7 management procedure (2007)

It was agreed for both versions of the NSS decision rule that they should be reviewed and revised if necessary after five years. The 2002 review led to the second rule; the 2007 review led to two new management procedures (Breen et al. 2008), based on the 2006 stock assessment of the these two stocks with a new multi-stock model (Haist et al. 2009). The CRA 7 industry, believing that they fished a volatile stock, wanted a rule that allowed them to fish harder when fish were abundant, and that reduced catches quickly when abundance decreased.

The input to the 2007 rule was standardised CPUE, but calculated in a different way. Whereas previous rules had used the fishing year CPUE, this rule used a year comprising 1 October through 30 September, i.e., the sping-summer of one fishing year combined with the autmun-winter season of the next year. This change allowed the rule, which is evaluated in November of each year, to be as responsive as possible to the most recent CPUE data.

CRA 7 fishermen voted between two final candidate rules, and chose Rule 7549, which is specified as follows (NRLMG 2007):

1. *Both the CRA 7 and CRA 8 proposed management procedures specify that:*
   a) the output variable is TAC (tonnes) and that standardised CPUE (kg/pot) is to be used as the input variable

   b) standardised CPUE is to be based on the autumn–winter (AW: April–September) season of the current fishing year and the spring–summer (SS: October–March) season of the previous fishing year, and

   c) CPUE is to be standardised according to the recent usage described in annual Fishery Assessment Reports (FARs), using a data extract obtained in November to ensure that sufficient data from the most recent AW season have been entered.

2. *For CRA 7, the proposed management procedure is specified as follows:*

   a) The TAC is to be set at 100 times the standardised CPUE;

b) The management procedure is to be evaluated every year (no "latent year");

c) If the procedure results in a TAC that changes by less than 5%, no change will be made; and

d) If the procedure results in a TAC that changes by more than 50%, the TAC will be changed by 50% only.

5. *Management procedures should not remain in place for longer than about five years without a review, because in five years the operating model used to evaluate management procedures will be obsolete, and fishery performance should be re-evaluated. Such a review was written into the 2002 NSS Management Procedure (Bentley et al. 2003a). The NRLMG recommends that a review of these management procedures take place in 2012.*

This rule (Figure 1) specified a CRA 7 TAC of 143.9 t (Table 1) for the 2008–09 fishing year. It was accepted by the Minister of Fisheries (Jim Anderton) in April 2008, and the TACC was again the TAC minus the 20 t allowances.

In March 2009 it was used again by the Minister of Fisheries, Phil Heatley, to vary the CRA 7 TAC to 209 t, and the TACC was again the TAC minus the 20 t allowances.

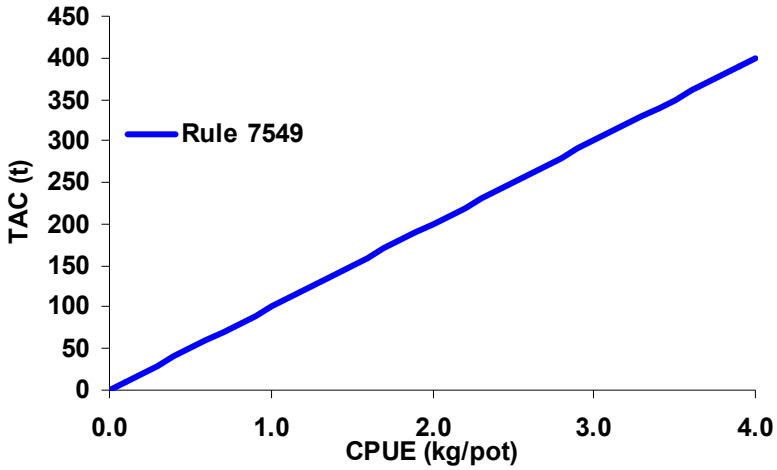

Figure 1: The 2007 CRA 7 management procedure.

2.5 CRA 8 management procedure (2007)

The 2007 review also led to a new management procedure specific to CRA 8. In meetings between the assessment team and stakeholders, the CRA 8 commercial industry indicated a preference for an MP that maintained high abundance and that changed the TAC as little as possible. To meet these objectives, the assessment team designed a "plateau" rule (Figure 2), which returns the same TAC over a range of CPUE values, but decreases TAC below a threshold and increases it above a threshold.

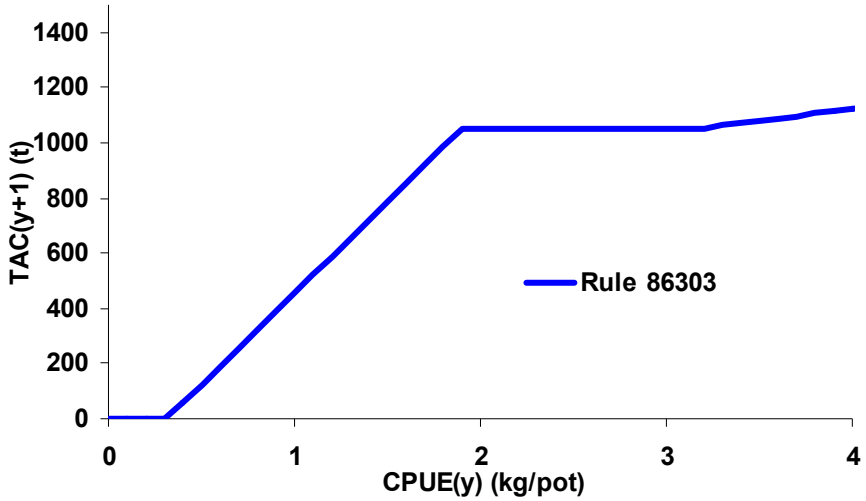

Figure 2: The 2007 CRA 8 management procedure.

The CRA 8 industry was shown a shortlist of four rules, and then a vote was held between the final two candidates. They chose (and the NRLMG ratified their decision) Rule 86303, which is formally specified as follows (NRLMG 2007):

1. *Both the CRA 7 and CRA 8 proposed management procedures specify that:*
   a) the output variable is TAC (tonnes) and that standardised CPUE (kg/pot) is to be used as the input variable

   b) standardised CPUE is to be based on the autumn–winter (AW: April–September) season of the current fishing year and the spring–summer (SS: October–March) season of the previous fishing year, and

   c) CPUE is to be standardised according to the recent usage described in annual Fishery Assessment Reports (FARs), using a data extract obtained in November to ensure that sufficient data from the most recent AW season have been entered.

3. *For CRA 8, the proposed management procedure is specified as follows:*

4. *The relation between CPUE, indicated by Cy , and TAC, indicated by Ty +1 , is given in Figure* 2 *and in the equations below:*

a)
$$TAC_{y+1} = \begin{cases} \max\left(0, \left(1053 - 1.2\left(1.9 - I_y\right)\frac{1053}{1.9}\right)\right), & I_y < 1.9, \\ 1053, & 1.9 \le I_y \le 3.2, \\ 1053 + 0.16\left(I_y - 3.2\right)\frac{1053}{1.9}, & I_y > 3.2. \end{cases}$$

c) The management procedure is to be evaluated every year (no "latent year");

d) If the procedure results in a TAC which changes by less than 5%, no change will be made;

e) There is no limit to the amount by which a TAC may change.

5. Management procedures should not remain in place for longer than about five years without a review, because in five years the operating model used to evaluate management procedures will be obsolete, and fishery performance should be re-evaluated. Such a review was written into the 2002 NSS Management Procedure (Bentley et al. 2003a). The NRLMG recommends that a review of these management procedures take place in 2012.

The rule has several thresholds. If CPUE is between 1.9 and 3.2 kg/potlift, then the specified TAC is 1053 t. If CPUE exceeds 3.3 kg/potlift, then the TAC increases with a shallow slope. If CPUE is less than 1.9 kg/potlift, the TAC decreases with a steep slope, and becomes zero if CPUE reaches the low value of 0.316 kg/potlift.

This rule (86303) specified a CRA 8 TAC of 1053.0 t (Table 1) for the 2008–09 fishing year. It was accepted by the Minister of Fisheries (Jim Anderton) in April 2008, and the TACC was again the TAC minus the 87 t allowances.

In March 2009 it was used again by the Minister of Fisheries, Phil Heatley, to increase the CRA 8 TAC to 1110 t. At the request of CRA 8 industry, he varied the recreational allowance upward, and the TACC was set under the rule at the TAC minus the 91 t allowances, 1019 t.

2.6 CRA 4 management procedure (2006)

After a stock assessment for CRA 4 (Breen et al. 2006), a large set of management procedure evaluations were done, using an operating model based on the CRA 4 assessment model (Breen & Kim 2006b).

The 2005–06 catch in CRA 4 was 504 t; this was less than the TACC of 577 t. In the latter part of 2006 it was obvious that the catch for 2006–07 would be even further below the TACC In the event it turned out to be 445 t). A series of industry meetings discussed options that included adoption of a management procedure or decision rule that would specify annually how much annual catch entitlement (ACE) should be voluntarily shelved.

The Breen & Kim (2006b) study was used as the basis for choosing a management procedure. One of the obvious requirements, not considered by Breen & Kim, was that the 2007–08 catch limit should be set low enough that it actually constrained the catch. A rule was chosen that specified a low catch limit (321 t) when using the most recent CPUE estimate. This rule, E170 (Figure 3), is specified as follows:

$$SCC_{y+1} = 500\left(\frac{I_y}{0.9}\right)^{1.4}$$

where *SCC* is the specified catch limit and *I* is standardised CPUE from the most recent AW season. There is no latent year[1]; the maximum allowable change is 75% and the minimum change is 5%.

[1] The original MPEs described by Breen & Kim (2006b) used an asymmetric latent year, under a decrease could be made, but not an increase, in a year following a change. The latent year was dropped before a rule was adopted, at the request of NZ RLIC Ltd., after examination of the performance of the rule without a latent year.

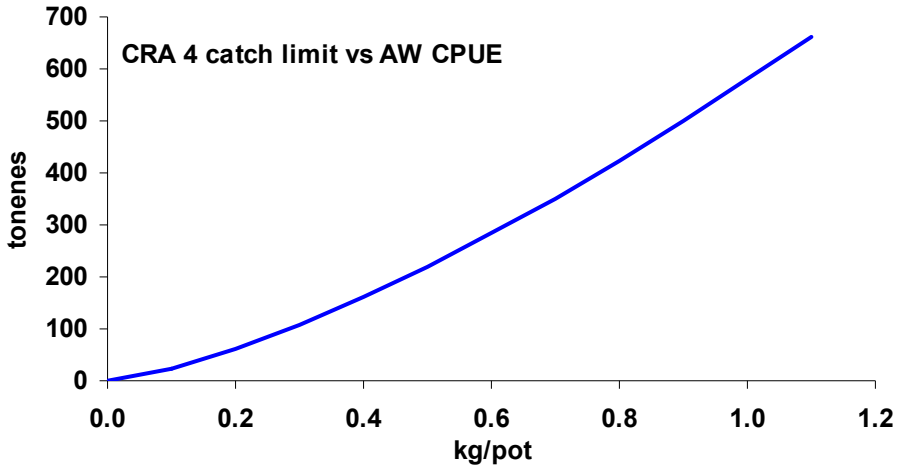

Figure 3: The CRA 4 management procedure.

Table 2 shows the history of the rule. In late 2006, the rule delivered a specified catch limit of 321 t. Not all quota owners shelved the requisite ACE, resulting in an operational limit of 339 t, a 41% reduction from the TACC.

In late 2007, the rule delivered a specified catch limit of 229 t. Not all quota owners shelved the requisite ACE, resulting in an operational limit of 245 t, a 57% reduction from the TACC.

In March 2009 this rule was adopted by the Minister of Fisheries, Phil Heatley, and the CRA 4 TACC was set at 266 t under the rule, with the allowances being added to this for a TAC of 461 t.

Table 2: History of the CRA 4 management procedure.

Year	Applied to fishing year	AW CPUE	Rule result	Operational limit
2006	2007-08	0.656	321.1	339
2007	2008-09	0.515	228.9	240
2008	2009-10	0.573	265.9	266

2.7 CRA 5 management procedure (2007)

In 2007, CRAMAC5 commissioned a management procedure for CRA 5, to be operated as a voluntary ACE shelving rule such as CRA 4 had adopted. The motivation was a recent decline in CPUE in CRA 5, although this decline was much less than in CRA 3 and CRA 4, and a concern that the stock might follow the CRA 3 and CRA 4 pattern of steep sudden reduction.

The design and evaluation of the management procedure were carried out by Breen (2009) in a short project. The evaluation was done with a surplus-production model.

After discussion centred on a short list of harvest control rules, the CRA 5 industry accepted a rule called Rule 6 from among three options presented to them. The rule is specified formally as follows:

$$SCC_{y+1} = \begin{cases} \max\left(0, \left(388.89\left(I_y - 0.3\right)\right)\right), & I_y < 1.2, \\ 305, & I_y \geq 1.2. \end{cases}$$

where *SCC* is the specified catch limit and *I* is standardised CPUE, calculated as an annual value for the offset year 1 October through 30 September. There is no maximum allowable change, no minimum value and no latent year. The rule gives a catch limit equal to the TACC when CPUE is above 1.2 kg/potlift, and a decreasing catch limit at CPUE values below 1.2. If CPUE reach 0.3 kg/potlift, the catch limit would be zero (Figure 4).

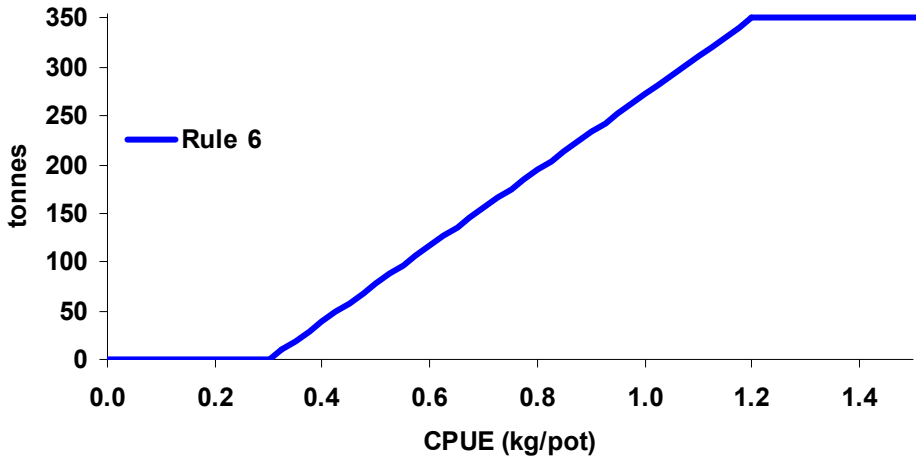

Figure 4: The CRA 5 management procedure.

This rule was accepted by CRA 5 industry in mid 2008. It was first used in late 2008 to examine whether a reduced catch limit was required. The standardised CPUE for the preceding offset year was 1.418 kg/potlift, giving a catch limit equal to the TACC of 350 t.

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