Ministry for Primary Industries
Manatū Ahu Matua

Operational management procedures for New Zealand rock lobster stocks (*Jasus edwardsii*) in 2017

New Zealand Government

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EXECUTIVE SUMMARY

Breen, P.A. (2017). Operational management procedures for New Zealand rock lobster stocks (*Jasus edwardsii*) in 2017.

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This document describes operational management procedures used for the 2017–18 fishing year to manage New Zealand stocks of red rock lobsters (*Jasus edwardsii*). Management procedures are extensively simulated-tested decision rules; they specify what data will be used as input (CPUE for all stocks managed in 2017) and for every valid value of the input they return an output value (Total Allowable Commercial Catch, TACC). They consist of a harvest control rule, which defines the relation between CPUE and TACC, and other rules such as minimum change thresholds that modify the output.

In 2016 a new stock assessment and management procedure evaluations were done for CRA 4, and for the 2017–18 fishing year a new management procedure was adopted for CRA 4. There are now seven rock lobster stocks with management procedures, with only CRA 6 and CRA 9 managed without them.

For CRA 2 the management procedure indicated no change to the TACC for the 2017–18 fishing year. As in the previous year, CRA 2 industry considered that a decrease was necessary and voluntarily shelved 25% of their quota. For CRA 1, CRA 5 and CRA 8 the management procedures indicated no change. For CRA 3 the management procedure resulted in a decrease and for CRA 7 an increase in TACC and TAC.

This document is intended as a central reference resource that contains all the equations and specifications for the current management procedures and their recent histories. The original material is scattered among FARs, consultation documents and other sources, so this document should be updated every year.

1. INTRODUCTION

The red rock lobster (*Jasus edwardsii*) supports the most valuable inshore commercial fishery in New Zealand, with exports worth NZ$268 million in 2015 (Seafood New Zealand 2016), and is also valuable to customary Maori and recreational fishers. The commercial trap or pot fisheries have been managed since 1991 with individual transferable quotas in nine arbitrary stocks (Breen et al. 2016a) (Figure 1).

This document describes the current – as of 1 April 2017 – operational management procedures (MPs) used to manage New Zealand stocks of red rock lobsters (Breen et al. 2016b). Management procedures (Butterworth & Punt 1999) are extensively simulated-tested decision rules: see Johnston & Butterworth (2005) and Johnston et al. (2014) for discussion of MPs used to manage rock lobsters in South Africa. The potential shift in management thinking that MPs can support is discussed by Bentley & Stokes (2009). MPs are now a major part of New Zealand rock lobster management (Bentley et al. 2003a; Breen et al. 2009a; Breen et al. 2016a; 2016b) and are becoming an important management tool globally (Edwards & Dankel 2016). They are used for rock lobsters in South Australia (Punt et al. 2012) and Victoria (Punt et al. 2013).

MPs specify what data will be used as input and for every valid value of the input they return an output value. For New Zealand rock lobster MPs, the input is standardised CPUE and the output is a catch limit: currently all New Zealand rock lobster MPs produce Total Allowable Commercial Catch (TACC) and allowances for other sectors are added to provide a Total Allowable Catch (TAC).

Some work has investigated the use of MPs with additional inputs (e.g. settlement indices, Bentley et al. 2005 and Bentley unpublished) but so far other inputs have not been used. Before 2007, the input CPUE was from the preceding fishing year, which runs from April through March and is named by the first year, thus "2011–12" is called "2011". This approach created a one-year lag between observed CPUE and the resulting catch limit: the fishing year ended on the 31st of March and any new catch limit from the MP was applied in April of the next year. To shorten the lag to six months, "offset-year" CPUE is calculated using the October through September year. Much exploratory work has been done on CPUE and its standardisation (e.g. Starr 2012).

MPs consist of a harvest control rule, which defines the relation between input CPUE and output TACC, and other rules such as minimum change thresholds that modify the output.

The first New Zealand MP and its successors were used to rebuild the depleted CRA 8 stock in New Zealand and to manage the volatile CRA 7 stock (Starr et al. 1997; Bentley et al. 2003b; Breen et al. 2008; Haist et al. 2013). In the CRA 4 fishery described below, industry adopted an MP, before any formal adoption by MPI, to reduce their catches voluntarily (quota "shelving"; Breen et al. 2009b) and a voluntary MP for CRA 5 was designed to maintain high abundance (Breen 2009).

There are now seven rock lobster stocks with MPs, all described below. Only CRA 6 and CRA 9 are managed without MPs. An MP for CRA 9 was abandoned for 2016, after two years of operation, because analysis indicated that the CRA 9 CPUE was not robust enough to support an MP.

Much of the evolution of MPs for rock lobsters has occurred as each stock has been assessed and MPEs have been made, but some generalised work has also been done (e.g. Breen et al. 2003). Advances were made by Nokome Bentley in the way that MPE results are interpreted (Bentley et al. 2003a). The industry-inspired "plateau" rules described below impart great stability if they are designed appropriately. However, because designing stability into rules reduces their responsiveness to changes in abundance there are tradeoffs between stability and safety. Recent experience (CRA 2, CRA 4) suggests a need for caution with respect to locating the lower edge of the plateau.

The impetus for adoption of MPs for rock lobsters in New Zealand originally came from the need to rebuild depleted stocks. This has been largely successful: Breen et al. (2016a) showed that fishing effort (potlifts) has been steady in stocks where MPs are only recent, but declined strongly since 2000 in stocks with established MPs. Catch and CPUE, also steady in stocks without MPs, has increased since 2008 in stocks with established MPs: in CRA 7 and CRA 8 the CPUE increase has been two- or three-fold.

Success of these MPs is partly in rebuilding depleted stocks and maintaining healthy stocks, but also in making stakeholders think about management goals. There has been a shift in thinking towards the strategic (Bentley & Stokes 2009). A series of Ministers, in whose hands the catch limit decisions always lie, have chosen to accept all recommendations from the National Rock Lobster Management Group (NRLMG) based on MP results throughout their short New Zealand history. In some instances, the NRLMG has rejected MP results:

- for CRA 5 for 2015–16, where the MP would have delivered a TACC reduction less than 5%
- for CRA 9 for 2015–16, where the industry requested a delay pending the results of an audit and other analyses
- for CRA 4 for 2016–17, where industry requested a larger decrease than was specified by the MP

And for both 2016–17 and 2017–18, CRA 2 industry voted to shelve 25% of their quota voluntarily, despite the MP result of no TACC change.

This document is intended as a central reference containing all the specifications for the current MPs. The original material is scattered among FARs, consultation documents, ministerial decision letters and other sources, so this document should be updated every year (the annual Report from the Mid-Year Plenary is not a suitable repository because changes made for April of the new fishing year are not captured there). The most definitive documents for each rule are the relevant FAR describing the stock assessment and MPEs, the NRLMG Final Advice Paper or consultation document containing the basis on which the Minister for Primary Industries (MPI)[1] signed off the MP, and the Minister's decision letter.

The document does not attempt to describe the historical MPs before the current MP for each stock (see Breen et al. (2009a) and previous incarnations of this document, e.g. Breen 2015).

Catch limits and allowances are all in tonnes; CPUE is in kg/potlift. The fishing year runs from April through March and is named by the first year; *viz.* 2016–17 is termed "2016".

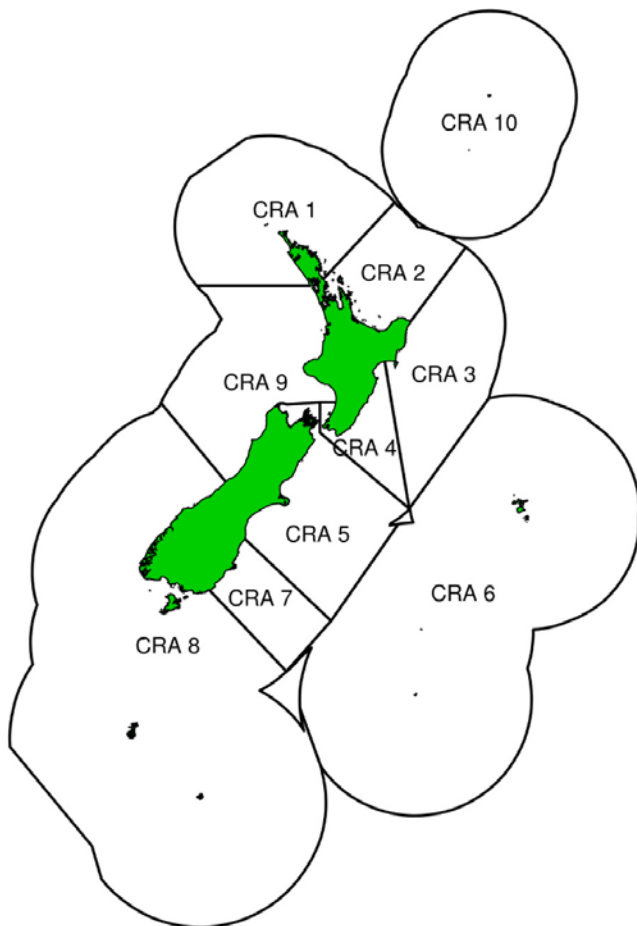[1] formerly the Minister of Fisheries

Figure 1: Rock lobster Quota Management Areas.

2. GENERALISED PLATEAU RULES

2.1 Step and slope harvest control rules

The seven current MPs have either a "plateau step" harvest control rule or a "plateau slope" rule, illustrated in Figure 2 and Figure 3. CRA 3 has a modified plateau slope rule that is described in the CRA 3 section below. With respect to output TACC vs. input CPUE these rules have:

- a straight-line segment from zero TACC at some value of CPUE (not necessarily zero CPUE) up to a plateau
- a plateau over which TACC stays the same as CPUE changes (the plateau could be of zero width but all current rules have an actual plateau)
- and either:
  - a series of steps to the right of the plateau (step rules) or
  - an ascending function at CPUE values to the right of the plateau (slope rules).

In the past, model coding of the rule parameters has been inconsistent. For a given stock, the parameters defined here may differ from those defined in the relevant MPE document or in previous descriptions; the descriptions here and the model code are now consistent.

Descriptions in this section assume that the MP determines the TACC, as do all current MPs. A TAC-determining MP was developed in 2010, at MPI's request, for CRA 5 (Haist et al. 2011). This had a TACC component plus components for non-commercial catch sectors; it was rejected by the Minister and a TACC-determining rule was developed and approved the following year. There is some concern that rules controlling only the commercial catch will pump catch away from the commercial sector into the non-commercial sectors, which can increase their catch share as stocks increase. This idea was confirmed by simulation modelling (Breen et al. 2003) and remains a concern for commercial stakeholders, who are increasingly unwilling to be the only sector affected by TAC changes.
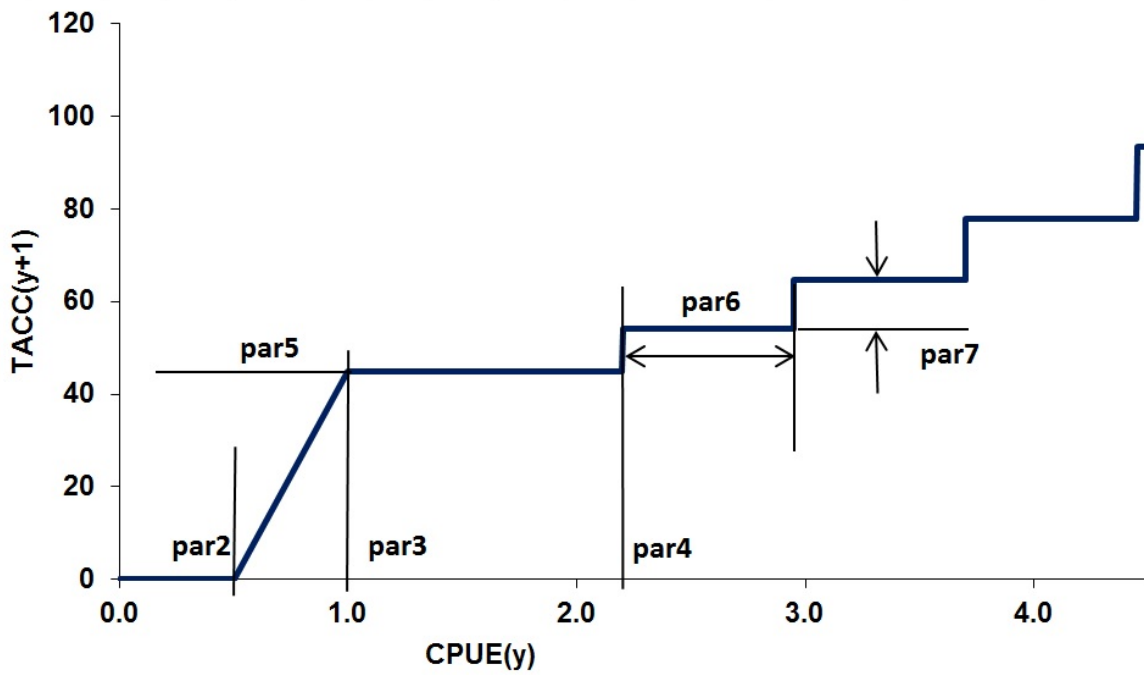
Figure 2: A generalised plateau step rule; see Table 1 for parameter definitions.
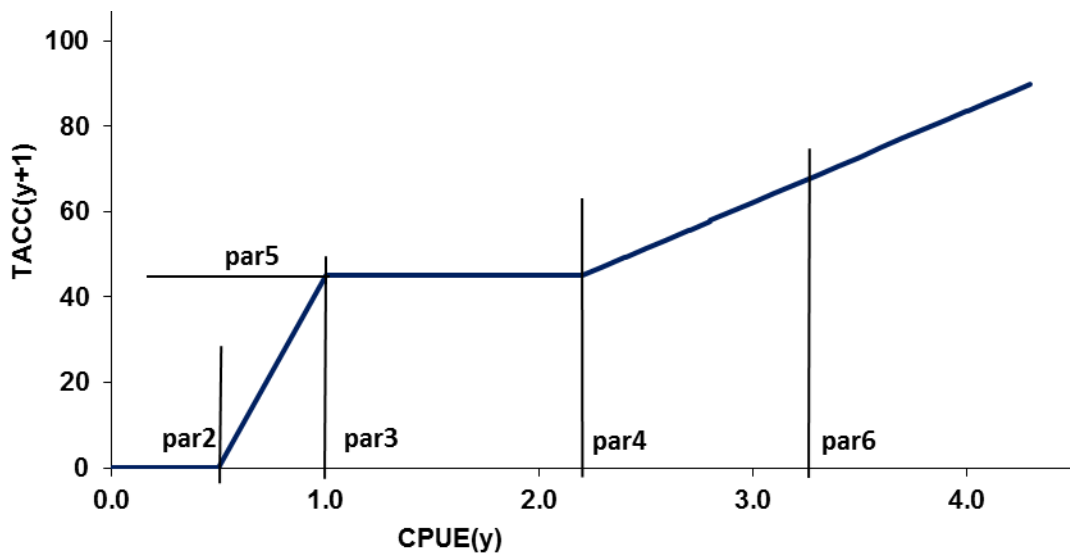

Figure 3: A generalised plateau slope rule; see Table 1 for parameter definitions.

2.2 Rule parameters

The generalised rule parameters are defined in Table 1.

Table 1: Parameters for the generalised plateau rules.

Parameter	Applies to	Function
*par*1	all	rule type
*par*2	all except CRA 3	CPUE at TACC = 0
*par*2	CRA 3 rule	CPUE at first inflection
*par*3	all	CPUE at plateau left
*par*4	all	CPUE at plateau right
*par*5	all	plateau height
*par*6	step rules	step width
*par*6	slope rules	slope
*par*6	CRA 3 rule	slope (defined differently)
*par*7	step rules	step height
*par*8	all	minimum change
*par*9	all	maximum change
*par*10	all	latent year switch

Rule type, *par*1, is 3 for plateau slope rules, 4 for plateau step rules and 6 for the modified CRA 3 rule form. The CRA 3 rule form is described in the CRA 3 section below; the description here is for rule types 3 and 4 only.

The point at which TACC becomes zero, *par*2, can be zero or non-zero but must be less than the left edge of the plateau, *par*3. *Par*3 must be less than or equal to the right edge, *par*4. In plateau slope rules, *par*6 must be greater than *par*4. Thus for an acceptable rule:

$$par2 < par3 \leq par4 < par6$$

Step height for step rules, *par*7, is defined as a proportion of the TACC on the previous step; thus 0.1 would indicate that TACC on the first step is 10% higher than TACC on the plateau and that each step increases by 10% of the previous step. The slope parameter for slope rules, *par*6, is defined as the CPUE at which TACC is 1.5 times the plateau height, *par*5.

The minimum change parameter, *par*8, defines the minimum proportional change in TACC. When CPUE changes only slightly and the rule specifies a new TACC differing from the existing TACC by an amount less than *par*8, there is no change to the TACC. If the minimum change parameter and the step height are the same, then technically the TACC cannot be reduced from the second step to the first because the step downwards would be less than the minimum change threshold. Either it must be agreed that minimum change does not apply in the area of the steps, or the minimum change parameter must be set at less than $par7 / (1+par7)$.

The maximum change parameter, *par*9, specifies the maximum allowable proportion of TACC change. When CPUE changes so much that the rule specifies a TACC change greater than *par*9, the TACC is changed only by the *par*9 proportion. A value of zero for *par*9 indicates that there is no maximum change threshold and that any TACC change is allowed.

A latent year component to the rule (not used in any current rule) means that TACC cannot be changed if it was changed in the previous year. An "asymmetric latent year" means that TACC can be decreased but not increased when it was changed in the previous year. The switch *par*10 operates as follows:

Par10   **Effect**

0	no latent year
1	latent year
2	asymmetric latent year

2.3 Rule operation

For both rule forms and for CPUE less than or equal to the right edge of the plateau *par*4, the provisional TACC (before operation of thresholds) is given by:

$$TACC_{y+1} = 0 \qquad\qquad\qquad\qquad \text{for } I_y \leq par2$$

$$TACC_{y+1} = par5\left(\frac{I_y - par2}{par3 - par2}\right) \qquad \text{for } par2 < I_y \leq par3$$

$$TACC_{y+1} = par5 \qquad\qquad\qquad\qquad \text{for } par3 < I_y \leq par4$$

where $TACC_{y+1}$ is the provisional TACC and I_y is the standardised offset-year CPUE in the preceding year. When CPUE is above the right edge of the plateau, TACC for the plateau step rules is given by:

$$TACC_{y+1} = par5\left((1 + par7)^{\text{floor}\left((I_y - par4)/par6\right)+1}\right) \quad \text{for } I_y > par4$$

and for the plateau slope rules by:

$$TACC_{y+1} = par5\left(1 + \frac{0.5(I_y - par4)}{par6 - par4}\right) \qquad \text{for } I_y > par4$$

The provisional TACC that results from these equations may be modified by the operation of the minimum and maximum change thresholds, or by a latent year, to give the rule's recommended TACC.

In the rule information given below for each stock, some definitions are:
- fishing years (April through the following March) are named by the April–December portion; *viz.* 2010–11 is labelled "2010"
- offset years (October through the following September) are named by the January–September portion; *viz.* 2010–11 is labelled "2011"
- "review scheduled" is usually the year five years after development of the current rule; whether the review occurs is a matter for the NRLMG and reviews are sometimes brought forward
- input CPUE is standardised offset year for all stocks; "F2-LFX" (now used for all stocks except CRA 8) defines the data extraction algorithm, which must be the same as that used in MPEs when the rule was developed (see Starr 2016)
- managers vary in the precision they use in recommending catch limits; the tables report at least the precision used by managers

3.   CRA 1 MANAGEMENT PROCEDURE

3.1   Summary

	CRA 1
First year with MP	2015
First year of current MP	2015
Review scheduled	2019
Input CPUE	offset year F2-LFX
Output	TACC
Type of rule	generalised plateau step rule
Latent year?	no
Minimum change	5%
Maximum change	none
2017–18 TAC	273.062
2017–18 customary allowance	20
2017–18 recreational allowance	50
2017–18 other mortality allowance	72
Total non-commercial allowance	142
2017–18 TACC	131.062

The rule is based on work conducted in 2014 by Webber & Starr (2015), using an operating model based on the CRA 1 stock assessment model.

Rules evaluated were generalised plateau step rules as described above. From the options recommended (NRLMG 2015), the Minister adopted rule 9d, for which the specific parameter values are shown in Table 2.

Table 2: Parameters for the CRA 1 generalised plateau step rule.

		CRA 1
Par	**Function**	**rule 9d value**
*par*1	rule type	4
*par*2	CPUE at TACC = 0	0.1
*par*3	CPUE at plateau left	1.1
*par*4	CPUE at plateau right	1.7
*par*5	plateau height	131.062
*par*6	step width	0.25
*par*7	step height	0.05
*par*8	minimum change	0.05
*par*9	maximum change	0
*par*10	latent year switch	0

A TAC was set for the first time for CRA 1 in 2015; before that there had been only a TACC and in 2015 the Minister had to set allowances for non-commercial catches.

The Final Advice Paper (NRLMG 2015) for the 2015–16 fishing year described the rule as follows:
> *Some important elements of the CRA 1 management procedures are:*
> *The output variable is TACC (tonnes);*
> *Offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April;*
> *CPUE is calculated using the 2012 F2_LFX procedure which uses landings to a licensed fisher receiver, along with recreational landings from a commercial vessel and the amount of rock lobsters returned to the water in accordance with Schedule 6 of the Act (i.e. highgraded rock lobsters), estimates, by vessel, of the ratio of annual landed catch divided by annual estimated catch to correct every landing record in a quota management area for the vessel;*
> *The management procedure is to be evaluated every year (no "latent year"), based on offset-year CPUE;*
> *The minimum change threshold for the TACC is 5%. There is no maximum change threshold for the TACC.*

For Rule 9d: between CPUEs of 0 to 0.1 kg/potlift the TACC is zero, the TACC then increases linearly with CPUE to 1.1 kg/potlift, and between CPUEs of 1.1 to 1.7 kg/potlift the TACC is 131.062 tonnes. As CPUE increases above 1.7 kg/potlift, the TACC increases in steps with a width of 0.25 kg/potlift and a height of 5% of the preceding TACC.

3.2 History

This is the first MP for this stock. In November 2014, standardised offset-year CPUE was 1.5803 kg/potlift, which gave a suggested TACC of 131.062 t. The Minister accepted this rule and assigned the current allowances of customary 20 t, recreational 50 t and other mortality 72 t.

In November 2015, standardised F2-LFX CPUE was 1.3154, which remained on the plateau so there was no change to the TACC. The Minister accepted this (Table 3 and Figure 4). In November 2016, standardised F2-LFX CPUE was 1.4289, which remained on the plateau so there was no change to the TACC. The Minister accepted this (Table 3 and Figure 4).

Table 3: History of the CRA 1 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds.

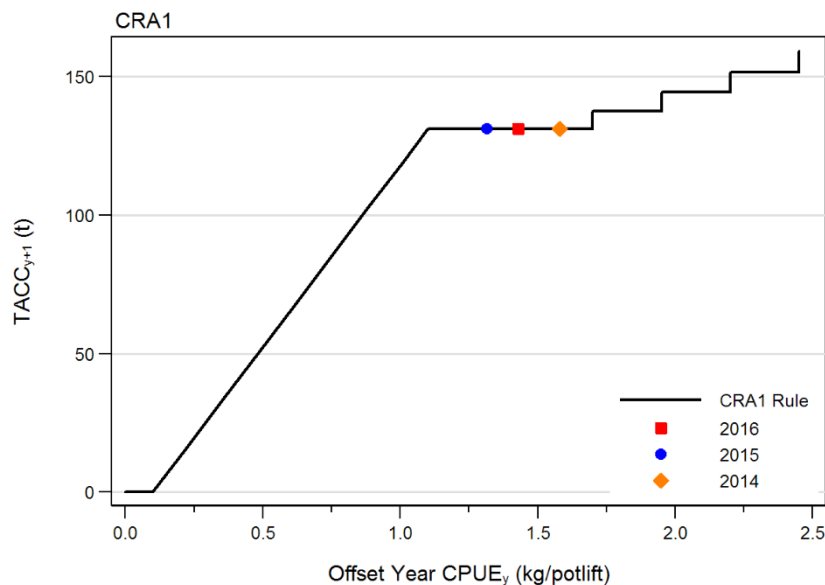| Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2014	2015–16	1.5803	131.062	131.062	273.062
2015	2016–17	1.3154	131.062	131.062	273.062
2016	2017–18	1.4289	131.062	131.062	273.062

Figure 4: The current CRA 1 harvest control rule. The coloured symbols show the 2014, 2015 and 2016 offset-year CPUE and the resulting TACCs.

4. CRA 2 MANAGEMENT PROCEDURE

4.1 Summary:

	CRA 2
First year with MP	2014
First year of current MP	2014
Review scheduled	2017
Input CPUE	offset year F2-LFX
Output	TACC
Type of rule	generalised plateau step rule
Latent year?	no
Minimum change	5%
Maximum change	none
2017–18 TAC	416.5
2017–18 customary allowance	16.5
2017–18 recreational allowance	140
2017–18 other mortality allowance	60
Total non-commercial allowance	216.5
2017–18 TACC	200

The rule is based on work conducted in 2013 by Starr et al. (2014), using an operating model based on the CRA 2 stock assessment model.

Rules evaluated were generalised plateau step rules as described above. From the options recommended (NRLMG 2014), the Minister adopted rule 4, with the specific parameter values shown in Table 4.

Table 4: Parameters for the CRA 2 generalised plateau step rule.

Par	Function	CRA 2 rule 4 value
$par1$	rule type	4
$par2$	CPUE at TACC = 0	0
$par3$	CPUE at plateau left	0.3
$par4$	CPUE at plateau right	0.5
$par5$	plateau height	200
$par6$	step width	0.1
$par7$	step height	0.1
$par8$	minimum change	0.05
$par9$	maximum change	0
$par10$	latent year switch	0

The 2014 decision was the first time that a TAC was set for CRA 2; before 2014 there had been only a TACC and in 2014 the Minister had to set allowances for non-commercial catches.

The Final Advice Paper (NRLMG 2014) for the 2014–15 fishing year described the rule as follows:

> *Some important elements of the CRA 2 management procedures are:*
> *a) The output variable is TACC (tonnes);*
> *b) Offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April;*
> *c) CPUE is calculated using the 2012 F2_LFX procedure which uses landings to a licensed fisher receiver, along with recreational landings from a commercial vessel and the amount of rock lobsters returned to the water in accordance with Schedule 6 of the Act (i.e. highgraded rock lobsters) and*
> *estimates, by vessel, of the ratio of annual landed catch divided by annual estimated catch to correct every landing record in a quota management area for the vessel;*
> *d) The management procedure is to be evaluated every year (no "latent year"), based on offset-year CPUE;*
> *e) The minimum change threshold for the TACC is 5%.*

The CRA 2 management procedures are based on a generalised 'step' rule.
For Rule 4: between a CPUE of zero and 0.3 kg/potlift, the TACC increases linearly with CPUE to a plateau of 200 tonnes, which extends to a CPUE of 0.5 kg/potlift. As CPUE increases above 0.5 kg/potlift, the TACC increases in steps with a width of 0.1 kg/potlift and a height of 10% of the preceding TACC.

4.2   History

First used for the 2014–15 fishing year, this was the first MP for this stock. In November 2013, standardised offset-year CPUE was 0.367 kg/potlift, which gave a suggested TACC of 200 t. The Minister accepted this rule and assigned the current allowances (customary 16.5 t, recreational 140 t and other mortality 60 t) to give the results in Table 5 and Figure 5.

In November 2014, CPUE was 0.3361, which gave a TACC that remained on the plateau.

In November 2015, standardised F2-LFX offset-year CPUE again decreased and was just below the plateau: the preliminary rule result was a TACC of 199.397 t. Because this would be a change of only 0.3%, below the minimum change threshold of 5%, the MP result was no change to the TACC. The Minister accepted this result and retained the current allowances to give the results in Table 5. However, more than 95% of the quota held by CRA 2 industry voted in favour of a 25% quota shelving, so the functional TACC for 2016 was 150 t.

In November 2016, standardised F2-LFX offset-year CPUE again decreased slightly and was just below the plateau: the preliminary rule result was a TACC of 196.884 t. Because this would be a TACC change of only 2%, which is below the minimum change threshold of 5%, the MP result was no change to the TACC. The Minister accepted this result and retained the current allowances to give the results in Table 5. However, as they had done in 2016, CRA 2 industry voted in favour of a 25% quota shelving, so the functional TACC for 2017 was 150 t.

Table 5: History of the CRA 2 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds; * indicates that the TACC was functionally 150 t after voluntary shelving.

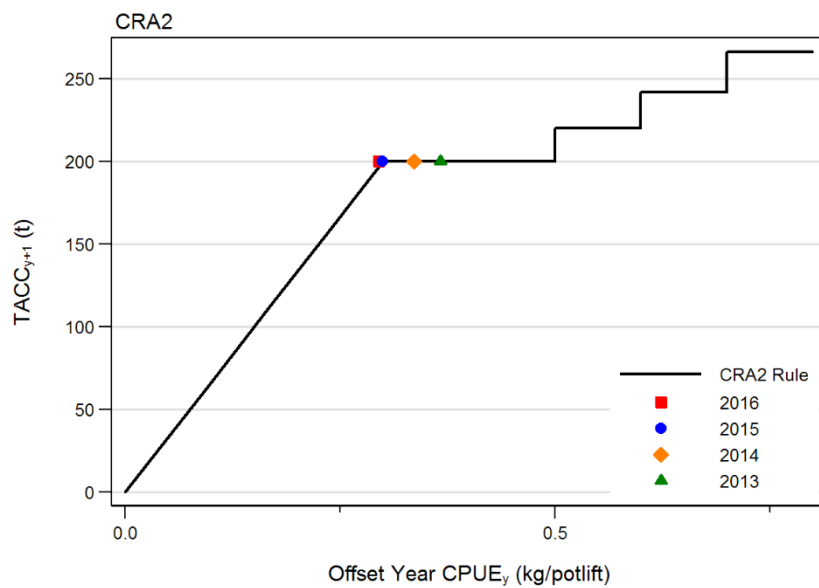| Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2013	2014–15	0.3668	200.0	200.0	416.5
2014	2015–16	0.3361	200.0	200.0	416.5
2015	2016–17	0.2991	200.0	200.0*	416.5
2016	2017–18	0.2953	200.0	200.0*	416.5

Figure 5: History of the current CRA 2 management procedure. The coloured points show the 2013, 2014, 2015 and 2016 offset-year CPUE and resulting TACCs. Note that the functional TACCs for 2016 and 2017 were 150 t after voluntary shelving.

5. CRA 3 MANAGEMENT PROCEDURE

5.1 Summary:

	CRA 3
First year with MP	2010
First year of current MP	2015
Review scheduled	2019
Input CPUE	offset year F2-LFX
Output	TACC
Type of rule	modified plateau slope rule
Latent year?	no
Minimum change	5%
Maximum change	none
2017–18 TAC	366.86
2017–18 customary allowance	20
2017–18 recreational allowance	20
2017–18 other mortality allowance	89
Total non-commercial allowance	129
2017–18 TACC	237.86

The rule is based on work conducted in 2014 by Haist et al. (2015), using an operating model based on the 2014 CRA 3 stock assessment model.

The harvest control rule is a modified plateau slope rule. The modification involves a) fixing the intercept to zero, b) having two straight-line segments (instead of one) between zero and the left of the plateau (Figure 6) and c) having an inexplicably different slope equation from the generalised rule. Rule parameters (Table 6) are defined differently from those in the other rules.

The equations below define this harvest control rule. The Minister adopted rule 4, for which the specific parameter values are shown in Table 6.

Table 6: Parameters for the CRA 3 plateau slope rule evaluated in 2014 and their values for the rule agreed by the Minister in 2015.

Par	Function	CRA 3 rule 4 value
$par1$	rule type	6
fixed	CPUE at TACC = 0	0.0
$par2$	CPUE at first inflection	1.0
$par3$	left plateau	2.0
$par4$	right plateau	3.0
$par5$	plateau height	260
$par6$	slope	50
$par7$	TACC at first inflection	180
$par8$	minimum change	0.05
$par9$	maximum change	0
$par10$	latent year	0

The 2015 CRA 3 rule is described by:

$$TAC_{y+1} = par7\left(\frac{I_y}{par2}\right) \qquad\qquad \text{for } I_y \leq par2$$

$$TAC_{y+1} = par7 + \left(par5 - par7\right)\left(\frac{I_y - par2}{par3 - par2}\right) \qquad \text{for } par2 < I_y \leq par3$$

$$TAC_{y+1} = par5 \qquad\qquad \text{for } par3 < I_y \leq par4$$

$$TAC_{y+1} = par5 + par6\left(\frac{\left(I_y - par4\right)}{0.5}\right) \qquad\qquad \text{for } I_y > par4$$

where TAC_{y+1} is the provisional TAC (before thresholds operate) and I_y is the CPUE (kg/potlift) in the preceding year.

The Final Advice Paper (NRLMG 2015) for the 2015–16 fishing year described the rule as follows:

> *Some important elements of the proposed CRA 3 management procedures are:*
> *The output variable is TACC (tonnes);*
> *Offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April;*
> *CPUE is calculated using the 2012 F2_LFX procedure which uses landings to a licensed fisher receiver, along with recreational landings from a commercial vessel and the amount of rock lobsters returned to the water in accordance with Schedule 6 of the Act (i.e. highgraded rock lobsters), estimates, by vessel, of the ratio of annual landed catch divided by annual estimated catch to correct every landing record in a quota management area for the vessel;*
> *The management procedure is to be evaluated every year (no "latent year"), based on offset-year CPUE;*
> *The minimum change threshold for the TACC is 5%. There is no maximum change threshold for the TACC.*
>
> *The proposed new Rule 4 CRA 3 management procedure is a non-standard rule, illustrated in [Figure 6]. For Rule 4: the TACC is zero at a CPUE of zero, the TACC increases linearly with CPUE, reaching 180 tonnes at a CPUE of 1.0 kg/potlift. The TACC then increases linearly to reach 260 tonnes at a CPUE of 2.0 kg/potlift. The TACC remains at 260 tonnes until CPUE reaches 3.0 kg/potlift, after which the TACC increases linearly again with a slope of 100 tonnes per 1 kg/potlift.*

5.2   History

The current rule is the second MP for this stock. Of the rules recommended (NRLMG 2015), the Minister chose rule 4 for the 2015–16 fishing year.

In November 2014, standardised offset-year CPUE was 2.2139 kg/potlift, which gave a TACC on the main plateau (Table 7). The Minister accepted this result and retained the previous non-commercial allowances (customary 20 t, recreational 20 t and illegal 89 t).

In November 2015, standardised F2-LFX offset-year CPUE decreased to 1.8842 kg/potlift and was no longer on the plateau; the preliminary rule result was a TACC of 250.736 t. Because this would have been a TACC change of 3.9%, which was below the minimum change threshold of 5%, the MP result was no change in the TACC. This result was accepted by the Minister.

In November 2016, standardised F2-LFX offset-year CPUE decreased again to 1.7232 kg/potlift; the preliminary rule result was a TACC of 237.856 t. This TACC change was 8.95%, well above the minimum change threshold of 5%, so the MP result was a decrease in the TACC. This result was accepted by the Minister.

Table 7: History of the current CRA 3 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds.

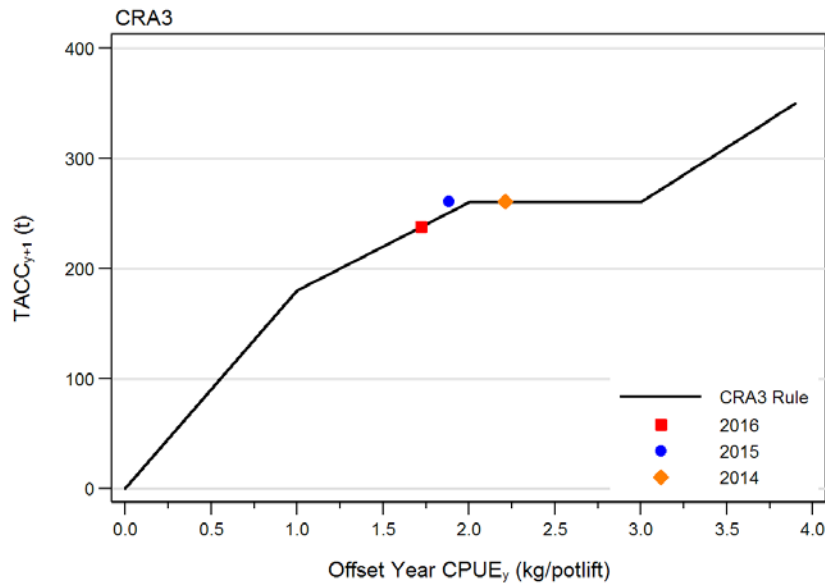| Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2014	2015–16	2.2139	260.00	260.95	389.95
2015	2016–17	1.8842	260.00	260.95	389.95
2016	2017–18	1.7232	237.857	237.86	366.86

Figure 6: The current CRA 3 harvest control rule; the coloured symbols show the 2014, 2015 and 2016 CPUE and resulting TACCs.

6. CRA 4 MANAGEMENT PROCEDURE

6.1 Summary:

	CRA 4
First year with MP	2007
First year of current MP	2017
Review scheduled	2021
Input CPUE	offset year F2-LFX
Output	TACC
Type of rule	generalised plateau step rule
Latent year?	no
Minimum change	5%
Maximum change	none
2017–18 TAC	484
2017–18 customary allowance	35
2017–18 recreational allowance	85
2017–18 other mortality allowance	75
Total non-commercial allowance	195
2017–18 TACC	289

The CRA 4 MP is based on work conducted in 2016 (Breen et al. 2017), using an operating model based on the CRA 4 stock assessment done in that year. Rules evaluated were generalised plateau step rules as described above. From the options recommended (NRLMG 2017), the Minister adopted rule 6, for which the specific parameter values are shown in Table 8.

Table 8: Parameters for the CRA 4 generalised plateau step rule.

Par	Function	CRA 4 rule 6 value
*par*1	rule type	4
*par*2	CPUE at TACC = 0	0.0
*par*3	left plateau	0.9
*par*4	right plateau	1.3
*par*5	plateau height	380
*par*6	step width	0.1
*par*7	step height	0.053
*par*8	minimum change	0.05
*par*9	maximum change	0
*par*10	latent year switch	0

The Final Advice Paper (NRLMG 2017) for the 2017–18 fishing year described the rule as follows:

a) The output variable is TACC (tonnes);

b) Offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April;

c) CPUE is calculated using the 2012 F2_LFX procedure...

d) The management procedure is to be evaluated every year (no "latent year"), based on offset-year CPUE; and

e) The minimum change threshold for the TACC is 5%. There is no maximum change threshold for the TACC.

The proposed new CRA 4 management procedures are both generalised plateau step rules...

For Rule 6: at a CPUE value of zero the TACC is zero; the TACC then increases linearly to 0.9 kg/potlift; between CPUEs of 0.9 and 1.3 kg/potlift the TACC is 380 tonnes; as CPUE increases above 1.3 kg/potlift, the TACC increases in steps with a width of 0.1 kg/potlift and a height of 5.3% of the preceding TACC.

6.2   History

The first MP for CRA 4 was voluntary (Breen et al. 2009b), based on the work of Breen & Kim (2006), and was used to guide ACE (Annual Catch Entitlement, related to quota) shelving for 2007 and 2008. The Minister adopted the current MP in March 2017 for the 2017–18 fishing year.   The input standardised offset-year CPUE for 2016 was 0.6851 kg/potlift, giving a TACC of 289.264 t (Figure 7). The Minister retained the existing non-commercial allowances (Table 9): these were customary 35 t, recreational 85 t and other mortality 75 t.

Table 9: History of the current CRA 4 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds.

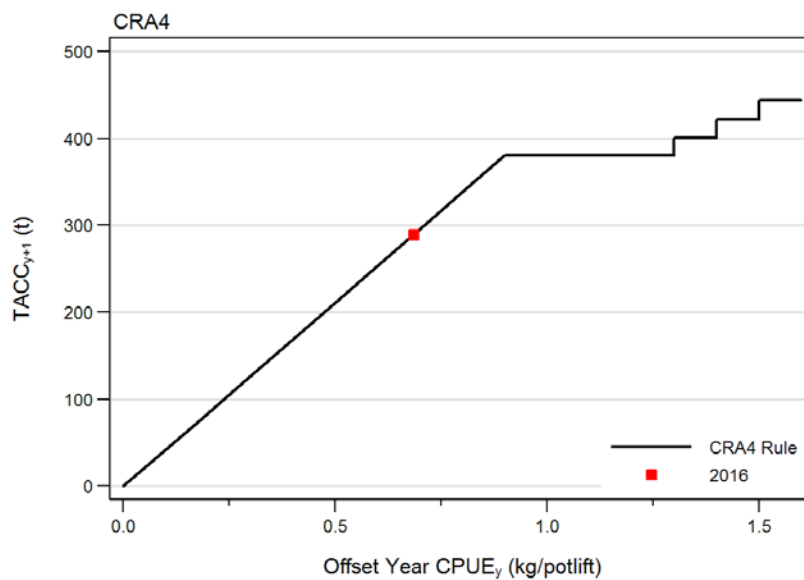| Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2016	2017–18	0.6851	289.264	289	484

Figure 7: History of the current CRA 4 management procedure; the coloured symbol shows the 2016 offset-year CPUE and the 2017 TACC.

7. CRA 5 MANAGEMENT PROCEDURE

7.1 Summary:

	CRA 5
First year with MP	2009
First year of current MP	2016
Review scheduled	2020
Input CPUE	offset year F2-LFX
Output	TACC
Type of rule	generalised plateau step rule
Latent year?	no
Minimum change	5%
Maximum change	none
2017–18 TAC	514
2017–18 customary allowance	40
2017–18 recreational allowance	87
2017–18 other mortality allowance	37
Total non-commercial allowance	164
2017–18 TACC	350

The CRA 5 MP is based on MPEs made in 2015 (Starr & Webber 2016), using an operating model based on a stock assessment in that year. Rules evaluated were generalised plateau step rules. From the options recommended to them, the NRLMG (2016) chose, and the Minister accepted, rule 45, for which the specific parameter values are shown in Table 10. The Minister increased the recreational allowance from 40 to 87 t to conform with best available information.

Table 10: Parameters for the CRA 5 generalised plateau step rule.

Par	Function	CRA 5 2015–45 rule value
$par1$	rule type	4
$par2$	CPUE at TACC = 0	0.3
$par3$	left plateau	1.2
$par4$	right plateau	2.2
$par5$	plateau height	350
$par6$	step width	0.2
$par7$	step height	0.055
$par8$	minimum change	0.05
$par9$	maximum change	0
$r10$	latent year switch	0

The Final Advice Paper (NRLMG 2016) for the 2016–17 fishing year described the new harvest control rule as follows:

> a) *The output variable is TACC (tonnes);*
> b) *Offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April;*
> c) *CPUE is calculated using the 2012 F2_LFX procedure which uses:*
> - *landings to a licensed fisher receiver, along with recreational landings from a commercial vessel and the amount of rock lobsters returned to the water in accordance with Schedule 6 of the Act (i.e. highgraded rock lobsters),*
> - *estimates, by vessel, of the ratio of annual landed catch divided by annual estimated catch to correct every landing record in a quota management area for the vessel;*
> d) *The management procedure is to be operated every year (no "latent year"), based on offset-year CPUE;*
> e) *The minimum change threshold for the TACC is 5%. There is no maximum change threshold for the TACC.*

The proposed new CRA 5 management procedure is based on a generalised plateau step rule... Between CPUEs of zero and 0.3 kg/potlift the TACC is zero, the TACC then increases linearly with CPUE to 350 tonnes at a CPUE of 1.2 kg/potlift. The TACC remains at 350 tonnes until CPUE reaches 2.2 kg/potlift and then increases by 5.5% in CPUE steps of 0.2 kg/potlift.

7.2   History

The current rule was adopted by the Minister for the 2016–17 fishing year. In November 2015, standardised F2-LFX offset-year CPUE was 1.789, which specified a TACC of 350 t, on the plateau. The Minister retained the customary allowance of 40 t and the illegal allowance of 37 t, but increased the recreational allowance from 40 to 87 t, giving a TAC of 514 t (Table 11 and Figure 8).

In November 2016, standardised F2-LFX offset-year CPUE was 1.5902, which specified a TACC of 350 t, on the plateau. The Minister retained the allowances set in 2016, giving a TAC of 514 t (Table 11 and Figure 8).

Table 11: History of the current CRA 5 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds.

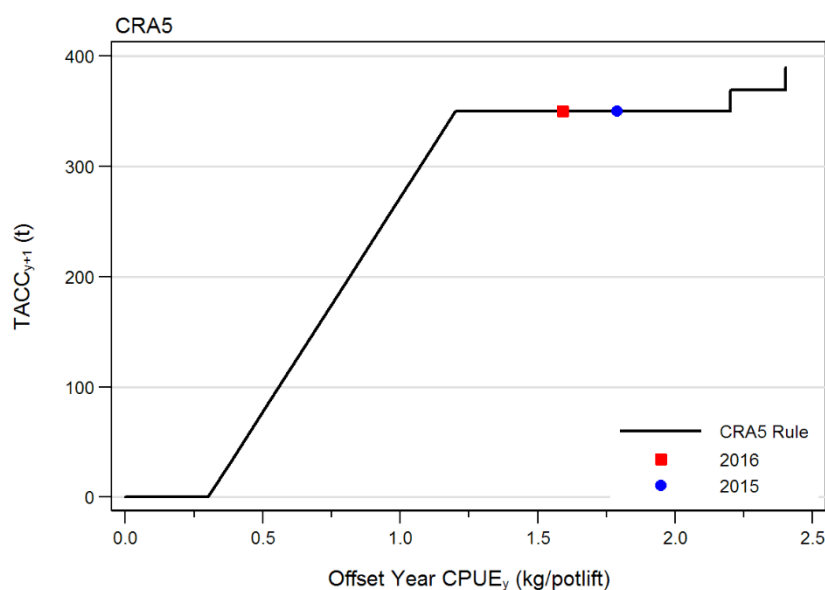| Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2015	2016–17	1.789	350	350	514
2016	2017–18	1.5902	350	350	514

Figure 8: History of the current CRA 5 management procedure; the coloured symbols show the 2015 and 2016 offset-year CPUE and resulting TACCs.

8. CRA 6

8.1 Summary:

	CRA 6
2017–18 TAC	370
2017–18 customary allowance	4
2017–18 recreational allowance	6
2017–18 other mortality allowance	0
Total non-commercial allowance	10
2017–18 TACC	360

There is no management procedure for CRA 6 and there has been no recent stock assessment.

9. CRA 7 MANAGEMENT PROCEDURE

9.1 Summary

	CRA 7
First year with MP	1996
First year of current MP	2013
Review scheduled	2020
Input CPUE	offset year F2-LFX
Output	TACC
Type of rule	generalised plateau slope rule
Latent year?	no
Minimum change	10%
Maximum change	50%
2017–18 TAC	132.52
2017–18 customary allowance	10.0
2017–18 recreational allowance	5.0
2017–18 other mortality	5.0
Total non-commercial allowance	20.0
2017–18 TACC	112.52

The CRA 7 MP is based on MPEs made in 2012, which used an operating model based on the 2012 joint stock assessment for CRA 7 and CRA 8 (Haist et al. 2013). This MP was evaluated in 2015 after a new stock assessment (Haist et al. 2016) and was retained.

Rules evaluated in 2012 and again in 2015 were generalised slope rules. From the options originally recommended (NRLMG 2013) the Minister adopted rule 39, for which specific parameter values are shown in Table 12. This rule replaced an earlier rule and is the latest in a series (Starr et al. 1997; Bentley et al. 2003b; Breen et al. 2008).

Table 12: Parameters for the CRA 7 generalised plateau slope rule.

Par	Function	CRA 7 rule 39 value
par1	rule type	3
par2	CPUE at TACC = 0	0.17
par3	left plateau	1.00
par4	right plateau	1.75
par5	plateau height	80
par6	slope	3.0
par7	step height	n.a.
par8	minimum change	0.1
par9	maximum change	0.5
par10	latent year switch	0

The Final Advice Paper (NRLMG 2013) for the 2013–14 fishing year described the rule as follows:
> *Some important elements of the new Rule 39 CRA 7 Management Procedure are:*
> - *the output variable is TACC (tonnes) (non-commercial catch assumptions are made from the operating model).*
> - *offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April.*
> - *CPUE is calculated using the new "F2-LFX" procedure which uses:*
>   - *landings to a licensed fisher receiver, along with recreational landings from a commercial vessel and the amount of rock lobsters returned to the water in accordance with Schedule 6 of the Act (i.e. highgraded rock lobsters),*

- o *estimates, by vessel, of the ratio of annual landed catch divided by annual estimated catch to correct every landing record in a quota management area for the vessel.*
- *the management procedure is to be evaluated every year (no "latent year"), based on offset-year CPUE.*
- *the new CRA 7 Management Procedure is based on a generalised plateau rule. Below a CPUE of 0.17 kg/potlift, the TACC is zero; between a CPUE of [0.17] and 1.0 kg/potlift, the TACC increases linearly with CPUE to a plateau of 80 tonnes, which extends to a CPUE of 1.75 kg/potlift. As CPUE increases above 1.75 kg/potlift, TACC increases linearly. The minimum change threshold for the TACC is 10% and the maximum change threshold is 50%.*

9.2   History

The Minister adopted this rule in 2013 for the 2013–14 fishing year. The standardised offset-year CPUE in November 2012 was 0.625, giving a TACC of 44.96 t. The Minister accepted this result and used the same allowances as for previous years (customary 10 t, recreational 5 t, other mortality 5 t) to set a TAC of 64 t (Table 13, Figure 9).

In November 2013 the offset-year CPUE had more than doubled to 1.356, which suggested a TACC of 80 t. The increase was greater than the maximum allowed increase of 50%, so the TACC was increased by 50% to 66 t. The Minister accepted this result and used the same allowances to set a TAC of 86 t.

In November 2014 the offset-year CPUE had increased to 2.3036, giving a TACC of 97.72 t. The Minister accepted this result and retained the same allowances as before, giving a TAC of 117.72 t.

In November 2015, standardised F2-LFX offset-year CPUE had decreased slightly to 2.2124 and the preliminary rule result was a TACC of 94.797 t. Because this would be a change of only 2.9%, less than minimum change threshold of 10%, the MP result was no change to the TACC.

In November 2016, standardised F2-LFX offset-year CPUE had increased to 2.7661 kg/potlift and the preliminary rule result was a TACC of 112.515 t. The TACC change of 10% was well above the minimum change threshold of 10%, so the MP result was an increased TACC. The Minister accepted this and retained the existing allowances.

Table 13: History of the CRA 7 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds.

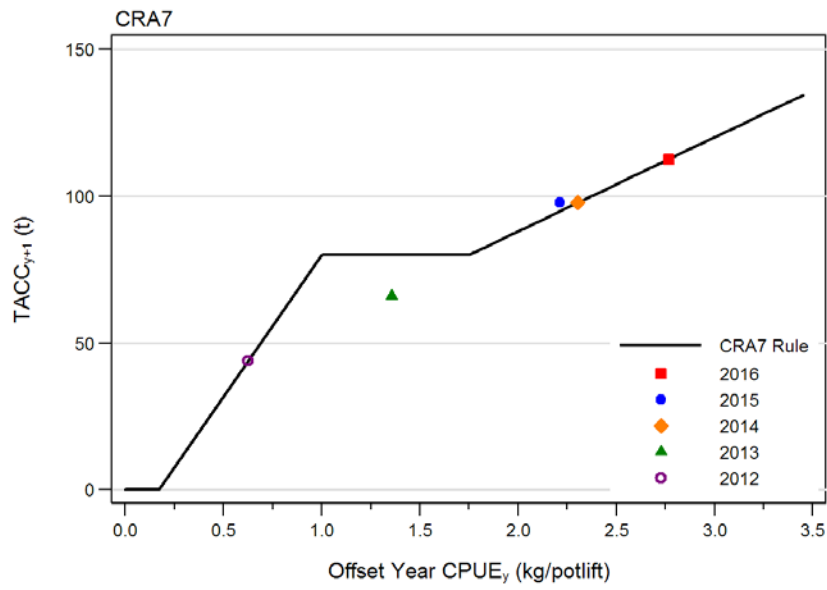| Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2012	2013–14	0.625	43.96	44.0	64.0
2013	2014–15	1.356	66.0	66.0	86.0
2014	2015–16	2.304	97.72	97.72	117.72
2015	2016–17	2.212	97.72	97.72	117.72
2016	2017–18	2.766	112.512	112.52	132.52

Figure 9: History of the current CRA 7 management procedure the coloured symbols show the 2012–16 offset-year CPUE and resulting TACCs.

10. CRA 8 MANAGEMENT PROCEDURE

10.1 Summary

	CRA 8
First year with MP	1996
First year of current MP	2016
Review scheduled	2020
Input CPUE	offset year F2-LF
Output	TACC
Type of rule	generalised plateau step rule
Latent year?	no
Minimum change	5%
Maximum change	no
2017–18 TAC	1053
2017–18 customary allowance	30
2017–18 recreational allowance	33
2017–18 other mortality allowance	28
Total non-commercial allowance	91
2017–18 TACC	962

The CRA 8 MP is based on MPEs made in 2015, using an operating model based on the combined CRA 7 / CRA 8 stock assessment (Haist et al. 2016). The input CPUE is based only on the sizes of fish that are landed, not on all sizes including the larger ones that are not economic. This was called $CPUE or money-fish CPUE in the MPEs and is calculated using the F2-LF algorithm (see Starr 2016). The more usual F2-LFX procedure also considers destination X, legal lobsters returned to the sea.

From the options recommended, the NRLMG (2016) chose and the Minister adopted rule 43, for which the parameters are shown in Table 14. This rule replaced a similar rule and is the fourth in a series that began in 1996 (Starr et al. 1997; Bentley et al. 2003b; Breen et al. 2008). Except for an extended plateau and the altered input, the adopted rule is very similar to the previous CRA 8 MP when the allowances are the same (the previous rule generated a TAC; this rule generates a TACC).

Table 14: Parameters for the CRA 8 generalised plateau slope rule.

Par	Function	CRA 8 rule 13 value
*par*1	rule type	4
*par*2	CPUE at TACC = 0	0.5
*par*3	left plateau	1.9
*par*4	right plateau	3.2
*par*5	plateau height	962
*par*6	step width	0.5
*par*7	step height	0.055
*par*8	minimum change	0.05
*par*9	maximum change	0
*par*10	latent year switch	0

The Final Advice Paper (NRLMG 2016) for the 2016–17 fishing year described the rule as follows:

> *Some important elements of the proposed new CRA 8 management procedure are:*
> *a) The output variable is TACC (tonnes);*
> *b) Offset-year standardised CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April;*
> *c) CPUE is calculated using the new "F2_LF" procedure, which gives the "money-fish" CPUE, or $CPUE. This procedure uses:*
> > • *landings to a licensed fisher receiver, along with recreational landings from a commercial vessel (it does not include the amount of rock lobsters returned to the*

water in accordance with Schedule 6 of the Act (i.e. highgraded rock lobsters) as does the F2_LFX procedure),

- *estimates, by vessel, of the ratio of annual landed catch divided by annual estimated catch to correct every landing record in a quota management area for the vessel;*

d) The management procedure is to be evaluated every year (no "latent year"), based on offset-year CPUE;

e) The minimum change threshold for the TACC is 5%. There is no maximum change threshold for the TACC.

The proposed new CRA 8 management procedure is based on a generalised plateau step rule ... Between CPUEs of zero and 0.5 kg/potlift the TACC is zero, the TACC then increases linearly with CPUE to 962 tonnes at a CPUE of 1.9 kg/potlift. The TACC remains at 962 tonnes until CPUE reaches 3.2 kg/potlift and then increases by 5.5% in CPUE steps of 0.5 kg/potlift.

10.2 History

History of the CRA 8 MP is shown in Table 15. In November 2015, the standardised offset-year F2-LF CPUE was 3.062 kg/potlift, which gave a TACC on the plateau (Table 15 and Figure 10).

In November 2016, standardised offset-year F2-LF CPUE was 3.0254 kg/potlift, which gave a TACC on the plateau (Table 15 and Figure 10).

Table 15: History of the current CRA 8 management procedure. "Rule result" is the result of the management procedure after operation of all its components including thresholds.

Year	Applied to fishing year	Offset CPUE (kg/potlift)	Rule result: TACC (t)	Applied TACC (t)	Applied TAC (t)
2015	2016–17	3.062	962	962	1053
2016	2017–18	3.0254	962	962	1053

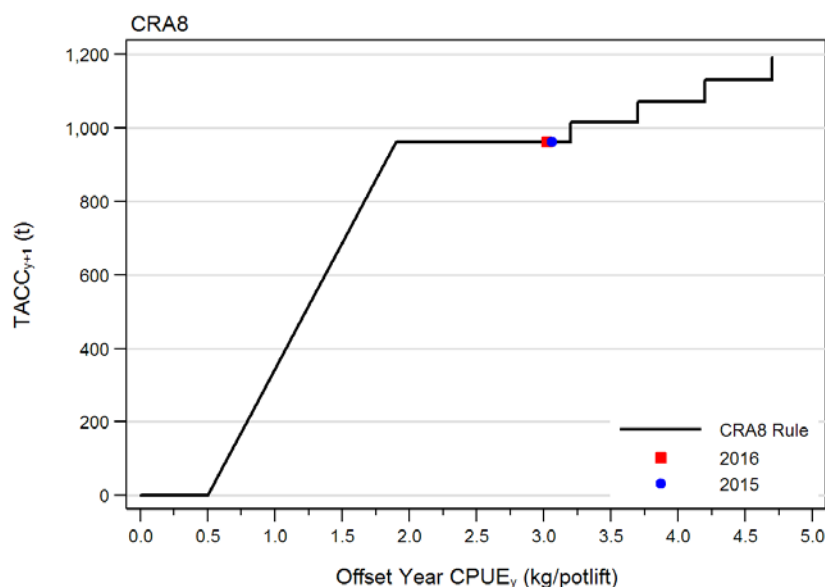**Figure 10: History of the current CRA 8 management procedure; coloured symbols show CPUE and resulting TACCs in 2015 and 2016.**

11. CRA 9

11.1 Summary

	CRA 9
First year with MP	2014
First year of current MP	n.a.
Review scheduled	n.a.
Input CPUE	n.a.
Output	n.a.
Type of rule	n.a.
Latent year?	n.a.
Minimum change	n.a.
Maximum change	n.a.
2017–18 TAC	115.8
2017–18 customary allowance	20
2017–18 recreational allowance	30
2017–18 other mortality allowance	5
Total non-commercial allowance	55
2017–18 TACC	60.8

A CRA 9 MP was based on MPEs made in 2013 (Breen 2014), using an operating model based on a simple surplus-production model. From the options recommended (NRLMG 2014) the Minister adopted rule 4041. When first used for 2014–15, it was the first MP for this stock, and for the first time in 2014 the Minister set TAC and non-commercial allowances.

When CPUE declined in November 2014, industry complained vigorously that this did not reflect a decline in the stock and instead was a mistake or an artefact of the small number of fishing vessels. The NRLMG advised the Minister not to change the TACC or TAC in 2015 and promised a CPUE review for this stock in 2015. The Minister made no changes.

In 2015, an audit of the CRA 9 catch and effort reporting identified some problems, concluded that the decline in CPUE was real and questioned whether CRA 9 CPUE is an index of abundance for the whole stock (Webber, unpublished data). This analysis and those performed by Starr (unpublished data) suggested that, because of the very large area and very small fleet, the small volume of information available and the sensitivity of standardised CPUE to standardisation options, CPUE is not a reliable index for CRA 9 stock abundance.

The NRLMG recommended that the MP not be followed for 2016–17, marking the end of the CRA 9 MP. The Minister accepted this suggestion (Nathan Guy, Minister for Primary Industries, unpublished document):

> I am comfortable with not using the current CRA 9 management procedure as long as the NRLMG explores alternative management approaches for the fishery during 2016. I recommend that the NRLMG and the CRA 9 industry starts to discuss feasible options for the future management of the CRA 9 as soon as possible, and in conjunction with the Rock Lobster Fisheries Assessment Working Group.
>
> Making no change to the CRA 9 catch limit in the short-term is unlikely to pose a sustainability risk; the size frequency distribution of commercial catches does not suggest a rock lobster stock under high fishing pressure.

For 2017 no changes were made to the TAC, TACC or allowances.

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