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Operational management procedures for New Zealand rock lobster (*Jasus edwardsii*) in CRA 7 and CRA 8 for 2025–26

New Zealand Fisheries Assessment Report 2025/19

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PLAIN LANGUAGE SUMMARY

The red rock lobster supports the most valuable inshore commercial fishery in New Zealand. This fishery has been managed with catch quotas in nine Quota Management Areas (QMAs), which are usually treated as independent populations or stocks.

The catch quotas are calculated for some QMAs using management procedures (MPs). Given an input, such as catch per unit effort (CPUE), MPs return an output such as Total Allowable Commercial Catch (TACC).

This document describes the operation of the current MPs used to manage New Zealand red rock lobster (*Jasus edwardsii*) in CRA 7 and CRA 8 for the 2025–26 fishing year. The operation of the MPs for the upcoming 2025–26 fishing year indicated that there should be no change in TACC for CRA 8, but indicated an increase in TACC for CRA 7.

EXECUTIVE SUMMARY

Webber, D.N.[1]; Roberts, J.[2]; Pons, M.[3]; Rudd, M.B.[4]; Starr, P.J.[5] (2025). Operational management procedures for New Zealand rock lobster (*Jasus edwardsii*) in CRA 7 and CRA 8 for 2025–26.

***New Zealand Fisheries Assessment Report 2025/19*. 24 p.**

This document describes the operation of management procedures (MPs) in November 2024 to inform the management of New Zealand red rock lobster (*Jasus edwardsii*) in CRA 7 and CRA 8 for the 2025–26 fishing year.

Management procedures are simulation-tested decision rules. Given an input (e.g., standardised offset year catch per unit effort, CPUE), they return an output (e.g., Total Allowable Commercial Catch, TACC). MPs consist of a harvest control rule (HCR), which defines the relationship between CPUE and TACC, and other controls such as minimum change thresholds that modify the HCR output. The MPs are simulation-tested using an operating model, which is based on the most recent stock assessment model for each rock lobster QMA.

For the past few years, no rock lobster QMAs were managed using MPs. However, the CRA 7 MP, which was last operated in 2019, was reinstated in 2023 for operation over the next several years without repeating the management procedure evaluation step. In 2023, management procedure evaluation was done for CRA 8 which was used to set a new MP for that QMA.

When operated in 2024, the CRA 7 MP indicated that the TACC should be increased for the 2025–26 fishing year, but no change to the TACC was indicated by the CRA 8 MP.

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[2] Anemone Consulting Ltd, Wellington, New Zealand.
[3] Independent consultant.
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[5] Starrfish, New Zealand.

1. INTRODUCTION

The red rock lobster (*Jasus edwardsii*) supports the most valuable inshore commercial fishery in New Zealand, with exports worth NZD$329 million in 2021 (Seafood New Zealand 2022) and it is also valuable to customary Māori, recreational fishers, and non-extractive stakeholders. Commercial red rock lobster fisheries have been managed with Individual Transferable Quotas (ITQs) in nine Quota Management Areas (QMAs) since April 1990, which are treated as independent stocks for stock assessment (Breen et al. 2016a, Figure 1).

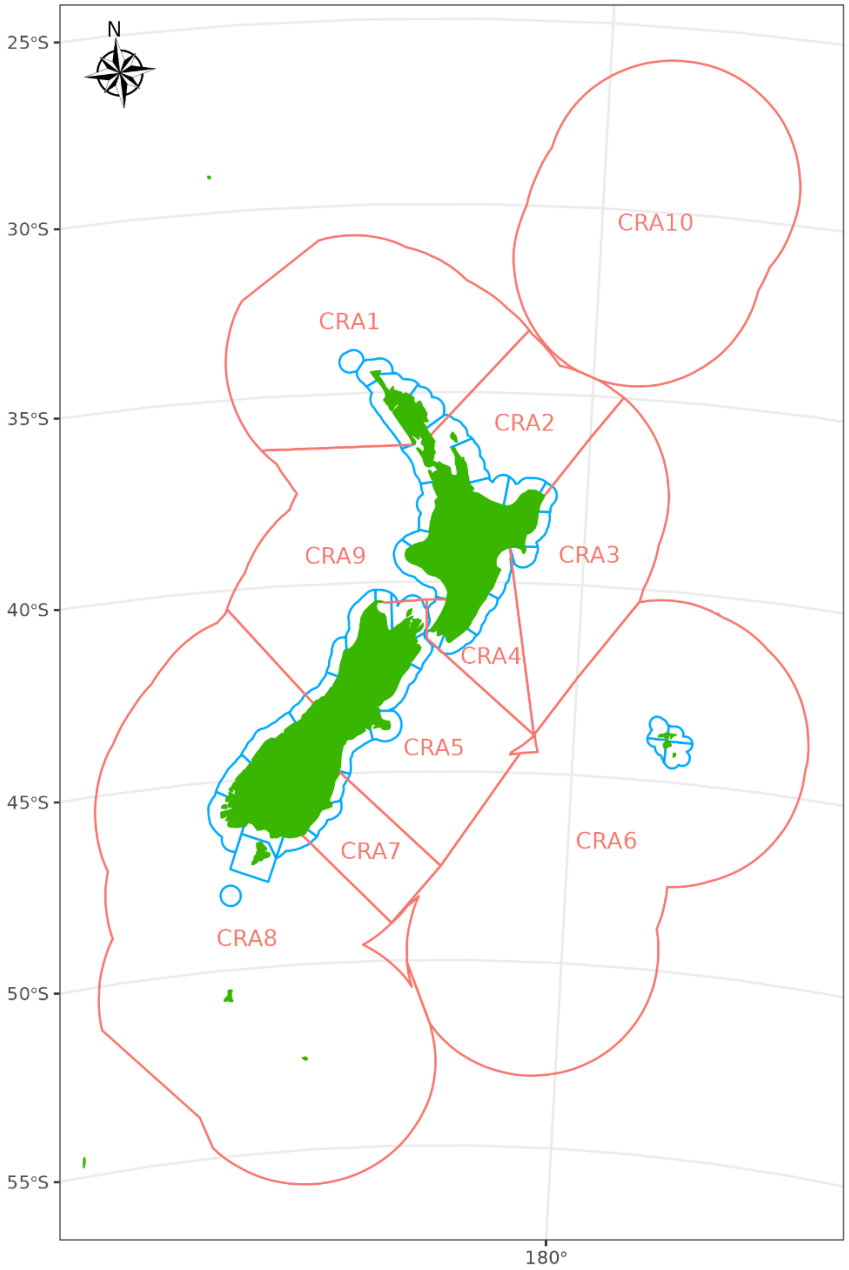

Figure 1: New Zealand red rock lobster (*Jasus edwardsii*) Quota Management Areas (QMAs) in red and statistical areas in blue. CRA 10 is not fished commercially.

This document presents the current (as of November 2024) operational management procedures (MPs) used to manage CRA 7 and CRA 8 red rock lobsters in New Zealand.

MPs are simulation-tested decision rules (Butterworth & Punt 1999), or functions, often referred to as harvest control rules (HCRs), that specify one of more inputs and return an output value. New

Zealand rock lobster MPs use standardised catch per unit effort (CPUE) as the input and a catch limit as the output [6]. Other controls, such as minimum or maximum change thresholds, may also be used to modify the output.

MPs are becoming an important management tool globally (Edwards & Dankel 2016). They are used to manage rock lobsters in South Africa (Johnston & Butterworth 2005; Johnston et al. 2014), South Australia (Punt et al. 2012), and Victoria (Punt et al. 2013). MPs were a major part of New Zealand rock lobster management (Bentley et al. 2003b; Breen et al. 2009a; Bentley & Stokes 2009; Breen et al. 2016a, 2016b), but a shift away from reporting on paper forms to electronic reporting of commercial catch and effort data halted their use because data collected using the new platforms were deemed to be of poor quality and inconsistent with the data collected using the previous paper forms.

Some work has investigated the use of MPs with additional inputs (e.g., settlement indices, Bentley et al. 2005) but so far other inputs have not been used formally for management in New Zealand. Much exploratory work has been done on CPUE and its standardisation (e.g., Starr 2012).

Before 2007, the input CPUE was from the preceding fishing year [7]. This approach resulted in a one-year lag between observed CPUE and the resulting catch limit (i.e., the fishing year ends on 31 March and any new catch limit from the MP is applied to the year beginning in April the following year). To shorten the lag to six months, 'offset-year' CPUE was developed [8]. The 2024 offset year is from 1 October 2023 to 30 September 2024 (i.e., a twelve-month period spanning two fishing years). It is useful to note that the CPUE for the most recent offset-year index is partially determined by the CPUE in the active fishing year. For more information on CPUE, see Starr (2024).

The first New Zealand MP and its successors were used to rebuild the depleted CRA 8 stock and to concurrently manage the volatile CRA 7 stock (Starr et al. 1997; Bentley et al. 2003a; Breen et al. 2008; Haist et al. 2013). Initially, the CRA 4 fishing industry adopted an MP to reduce catches voluntarily (quota 'shelving', Breen 2009) prior to moving to a system whereby catch reductions were set by Fisheries New Zealand. A voluntary MP for CRA 5 was adopted with the intent to maintain existing high abundance (Breen et al. 2009b). An MP for CRA 9 was abandoned in 2016, after two years of operation, because analysis indicated that the CRA 9 CPUE was not sufficiently robust to support a stock assessment and a TACC-altering MP.

Much of the evolution of rock lobster MPs occurred as each stock was assessed and subsequent management procedure evaluations (MPEs) were done. Some generalised work has also been done (Bentley et al. 2003b; Breen et al. 2003). The industry-inspired 'plateau' rules, described below, can impart great stability. However, because stable rules are less responsive to changes in abundance, there are trade-offs between stability and safety. Recent experience (e.g., in CRA 2 and CRA 4) suggested a need for caution in locating the lower plateau edge.

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, particularly in Otago (CRA 7) and Fiordland (CRA 8). Both of these stocks are now considered rebuilt, with standardised CPUE several times greater than the minimum observed in the late 1990s (Starr 2024). The total arithmetic CPUE for all of New Zealand has nearly tripled since the lowest observations in the late 1990s (Starr, pers. comm.). Fishing effort has declined in all QMAs except CRA 6, including those with longstanding MPs (CRA 3, CRA 4, CRA 5, CRA 7, and CRA 8) (Starr 2024).

[6] 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). Catch limits and allowances are always specified in metric tonnes.
[7] The statutory rock lobster fishing year runs from 1 April through to 31 March of the following year and is named by the first year (i.e. 2016–17 is termed '2016').
[8] An offset-year runs from 1 October through to 30 September of the following year and is named by the second year (i.e. 2017–18 is termed '2018').

One measure of the success of these MPs is where they have rebuilt depleted stocks and then maintained healthy stocks (e.g., CRA 7 and CRA 8). MPs also involve stakeholders in setting management goals and participating in the rebuilding process. This has resulted in an emphasis on strategic planning for research and management of these fisheries, stepping beyond the usual tactical responses used to manage fisheries (Bentley & Stokes 2009). This shift is evidenced by the willingness of the New Zealand government to accept, in most instances, the recommendations made by the National Rock Lobster Management Group (NRLMG) since the implementation of the first MPs in the mid-1990s. These recommendations were usually based on MP results, when available. However, in some instances, the NRLMG or the Minister has rejected MP results:

- for CRA 5 in 2015–16, where the MP would have delivered a TACC reduction less than 5% (at the time a 5% minimum change threshold was not in place for CRA 5);
- for CRA 9 in 2015–16, where industry requested a delay pending the results of an audit and other analyses;
- for CRA 4 in 2016–17, where industry requested a larger decrease than was specified by the MP;
- for CRA 2 in 2016–17 and 2017–18, where industry voted to shelve 49 tonnes (25%) of their quota voluntarily, despite the MP result of no TACC change; and
- for CRA 4 in 2018–19, where the Minister decided not to follow the advice provided by the NRLMG and the MP that would have increased the TACC. Instead, the Minister retained the previous year's TACC.

In the rule information tables below, the 'review scheduled' year is usually five years after development of the current rule; however, the actual timing of the review is a matter for the NRLMG and Fisheries New Zealand, with reviews sometimes being brought forward. Input CPUE is standardised offset-year for all stocks where the standardisation includes year, month, and statistical area coefficients. The 'F0-LFX' defines the data extraction algorithm (defined in appendix D, Starr 2024), which must be the same as that used in MPEs when the rule was evaluated[9]. Fisheries management varies the precision used when recommending catch limits to the Minister; and the tables report at least the precision used by Fisheries New Zealand.

2. CRA 7 MANAGEMENT PROCEDURE

2.1. Summary and history

The current CRA 7 (Figure 2) MP was initially tested using the 2012 joint stock assessment for CRA 7 and CRA 8 as the operating model (Haist et al. 2013). This MP was re-evaluated in 2015 using a new single area CRA 7 stock assessment (Haist et al. 2016) and was retained. Rules evaluated in 2012 and again in 2015 were generalised slope rules (Table 1). From the options originally recommended (National Rock Lobster Management Group 2013), the Minister adopted the rule specified in Table 2. This rule replaced an earlier rule and is the latest in a series (Starr et al. 1997; Bentley et al. 2003a; Breen et al. 2008). The CRA 7 MP was operational in 2019, followed by a break from 2020–2022 when the data changed over from paper-based reporting to electronic reporting. The Minister reinstated this rule in 2023 for the 2024–25 fishing year.

[9] Note that the standardisation procedure weighted each CPUE observation using the associated vessel correction factor (see Appendix B.1 below). This has effectively converted the data to be equivalent to the F2-LFX data extract used in the 2019 (and earlier) CRA 7 MP.

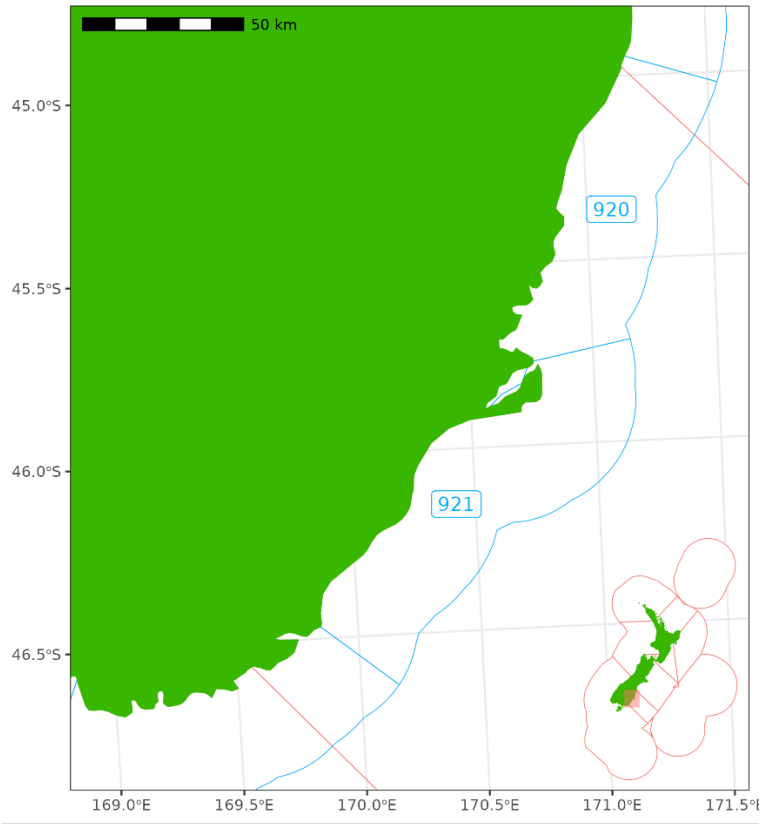

Figure 2: Statistical areas within CRA 7.

Table 1: Summary of the current CRA 7 management procedure.

First year with MP	1996
First year of current MP	2013
Review scheduled	2026
Input	F0-LFX offset year CPUE[9]
Output	TACC
Type of rule	generalised plateau slope rule
Minimum change	10%
Maximum change	50%
Latent year	none
2024–25 customary allowance	10
2024–25 recreational allowance	5
2024–25 other mortality allowance	8
2024–25 total non-commercial allowance	23
2024–25 TACC	111.5
2024–25 TAC	134.5

Table 2*:* Parameters for the CRA 7 generalised plateau slope rule.

Parameter	Function	Value
par1	rule type	3
par2	CPUE at TACC = 0	0.17
par3	CPUE at plateau left	1
par4	CPUE at plateau right	1.75
par5	plateau height	80
par6	slope	3
par7	n.a.	0
par8	minimum change	0.1
par9	maximum change	0.5
par10	latent year switch	0

Some important elements of the CRA 7 MP are:

- The output variable is the TACC (tonnes) (non-commercial catch assumptions are made from the operating model).
- Offset-year standardised CPUE based on CELR/ERS statutory catch/effort data are used as an input to the rule to determine the TACC for the fishing year that begins in the following April (see Appendix B).
- The management procedure is to be evaluated every year (no 'latent year'), based on offset-year CPUE.
- The new CRA 7 MP is based on a generalised slope 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%.
- In November 2017, standardised F2-LFX offset-year CPUE decreased to 2.328 kg/potlift and the preliminary rule result was a TACC of 98.499 tonnes, a 12.5% decrease from the TACC of 112.52 tonnes. Because this is greater than the minimum change threshold of 10%, the result was a 12.5% decrease in the 2018–19 TACC to 98.499 tonnes. The Minister accepted this result and set the TACC at 97 tonnes.
- In November 2018, standardised F2-LFX offset-year CPUE decreased to 2.292 kg/potlift and the preliminary rule result was a TACC of 97.343 tonnes. This change in TACC was less than 1% and less than the minimum change threshold of 10%, resulting in no change to the TACC. The Minister accepted this result.
- In November 2019, standardised F2-LFX offset-year CPUE was 2.567 kg/potlift when the EDW data were excluded, which resulted in a TACC increase of 9.51% when applying the rule specified. This increase was less than the minimum change threshold of 10%, resulting in no change to the TACC. The 2019 CPUE index value which included the EDW data was 3.217 kg/potlift, which resulted in a TACC of 126.947 tonnes representing an increase of +30.9%. This was greater than the minimum change threshold of 10%.
- In November 2023, standardised F2-LFX offset-year CPUE was 2.503 kg/potlift and the preliminary rule result was a TACC of 111.5 tonnes. The Minister decided not to change the TACC.

2.2. Operation

Standardised offset-year CPUE for CRA 7 increased from 2.503 to 3.105 for the 2024 offset-year (Figure 3, see Appendix II for details). The MP was operated for the 2025–26 fishing year (i.e., to set the TACC from 1 April 2025), and indicated a potential 10.6% increase in the TACC from 111.5 to 123.35 tonnes (Table 3, Figure 4).

Table 3: **History of the previous and current CRA 7 management procedure and its operation in 2024. 'Rule result TACC' is the result of the management procedure. 'Applied TACC' and 'Applied TAC' are the catch limits decided by the Minister.**

Offset year	Offset year CPUE (kg/potlift)	Applied to fishing year	Rule result TACC (tonnes)	Applied TACC (tonnes)	Applied TAC (tonnes)
2012	0.625	2013–14	43.960	44.00	64.00
2013	1.356	2014–15	66.000	66.00	86.00
2014	2.304	2015–16	97.720	97.72	117.72
2015	2.212	2016–17	97.720	97.72	117.72
2016	2.766	2017–18	112.512	112.52	132.52
2017	2.328	2018–19	98.499	97.00	117.00
2018	2.292	2019–20	97.343	97.00	117.00
2019	2.570	2020–21	97.000	106.20	126.20
2020	–	2021–22	–	106.20	126.20
2021	–	2022–23	–	111.50	134.50
2022	–	2023–24	–	111.50	134.50
2023	2.503	2024–25	111.500	111.50	134.50
2024	3.105	2025–26	123.352	–	–

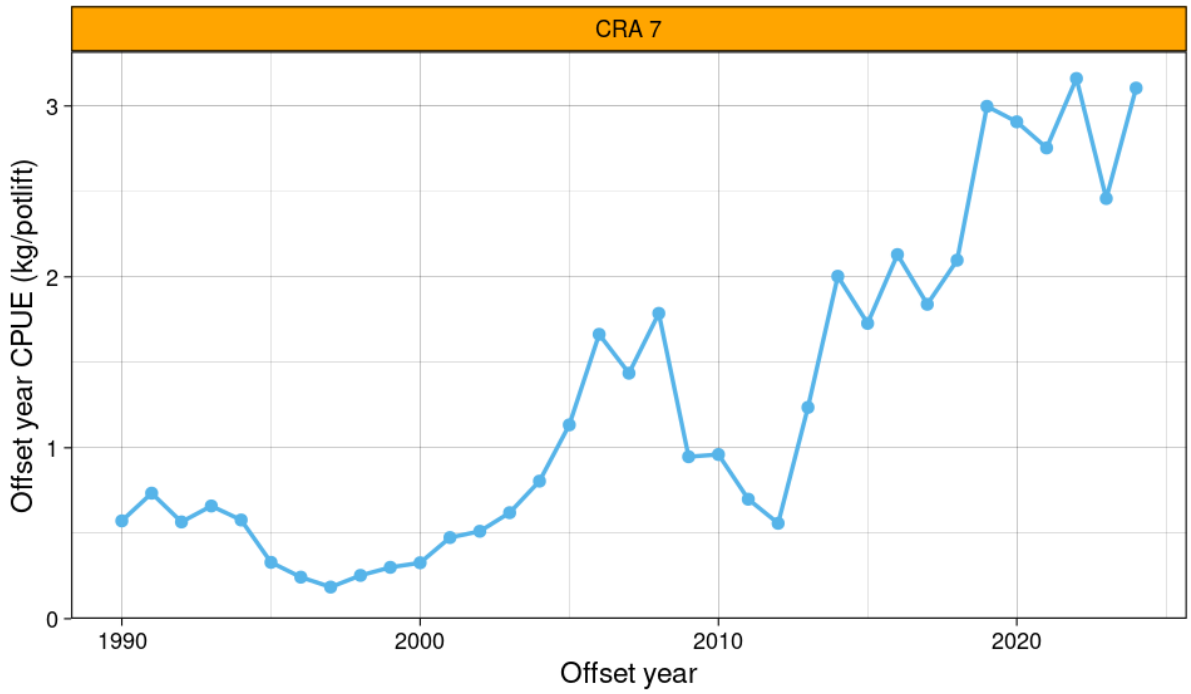

Figure 3: **Offset-year CPUE (kg/potlift) for CRA 7 from 1990 to 2024.**

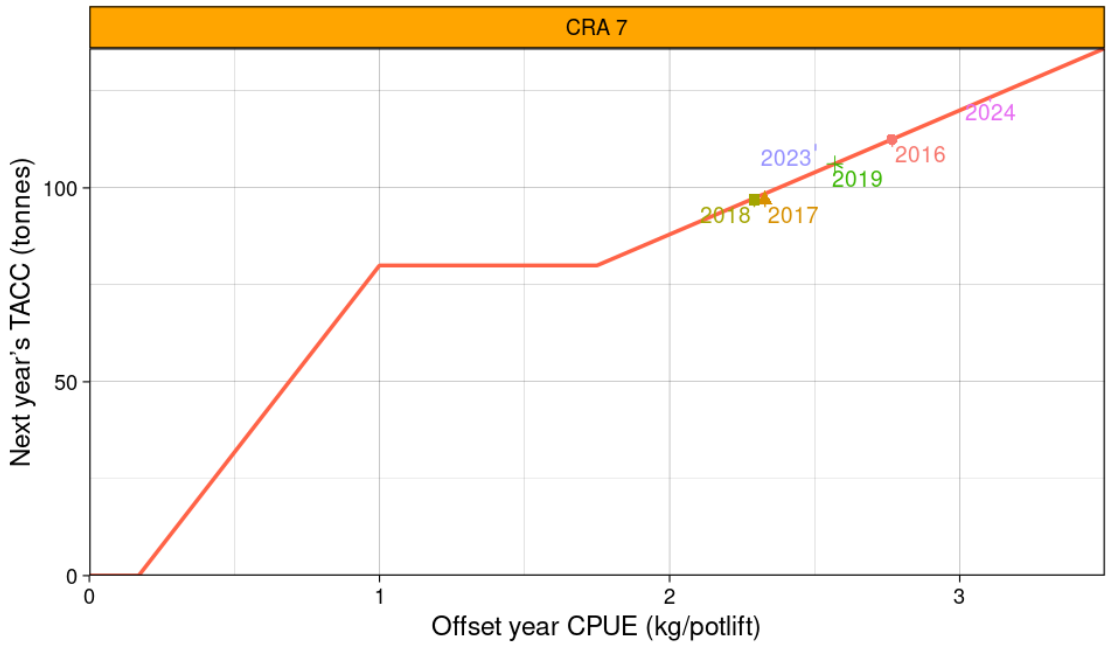

Figure 4*:* **History of the current CRA 7 management procedure. The coloured symbols show the 2016 to 2024 offset-year CPUE and the resulting TACCs.**

3. CRA 8 MANAGEMENT PROCEDURE

3.1. Summary and history

A summary of the CRA 8 (Figure 5) MP is provided in Table 4. The CRA 8 MP is based on MPEs done in 2023, using an operating model based on the combined CRA 7 and CRA 8 2021 stock assessment (Webber et al. 2022). This stock assessment assumed a two-region model that combined the two CRA 7 statistical areas with the four Southland CRA 8 statistical areas (including Stewart Island and Snares Islands) as one region and a second region consisting of the three Fiordland CRA 8 statistical areas. The input CPUE was derived from voluntary logbook data rescaled to match the mean of the CELR CPUE series (Figure 6). The MPE was done using region 2 of the assessment model only, because this region accounted for approximately 80% of the CRA 8 catch over the past 10 years and the CRA 8 MP is not applicable to CRA 7 which is part of region 1.

From the options recommended, the NRLMG chose, and the Minister adopted, the rule (rule 23) specified in Table 5. This rule replaced a similar rule developed previously and is the sixth in a series that began in 1996 (Starr et al. 1997; Bentley et al. 2003a; Breen et al. 2008; Haist et al. 2013). Except for an extended plateau and the altered input CPUE series, the adopted rule is very similar to the previous CRA 8 MP. The 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 1251 tonnes at a CPUE of 3.4 kg/potlift. The TACC remains at 1251 tonnes until CPUE reaches 7.0 kg/potlift and then increases by 5.5% for each CPUE step of 1.0 kg/potlift.

Some important elements of the CRA 8 management procedure include:

- The output variable is TACC (tonnes);
- Standardised offset-year CPUE is used as an input to the rule to determine the TACC for the fishing year that begins in the following April (see Appendix B).

- The evaluation of the MP was based on the CRA 8 region 2 stock assessment, consequently a portion of the resulting TACC was assigned to CRA 8 region 1[10];
- 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 previous CRA 8 MP was operated for five years, followed by a hiatus of three years, while the 2024 evaluation is the second year for operating the current CRA 8 MP (Table 6).

- In November 2023, standardised offset-year logbook CPUE was 8.455463 kg/potlift, which gave a suggested TACC of 1392.394 tonnes. This TACC change was +5.5%, above the minimum change threshold of 5%, so the MP result was an increase in the TACC.

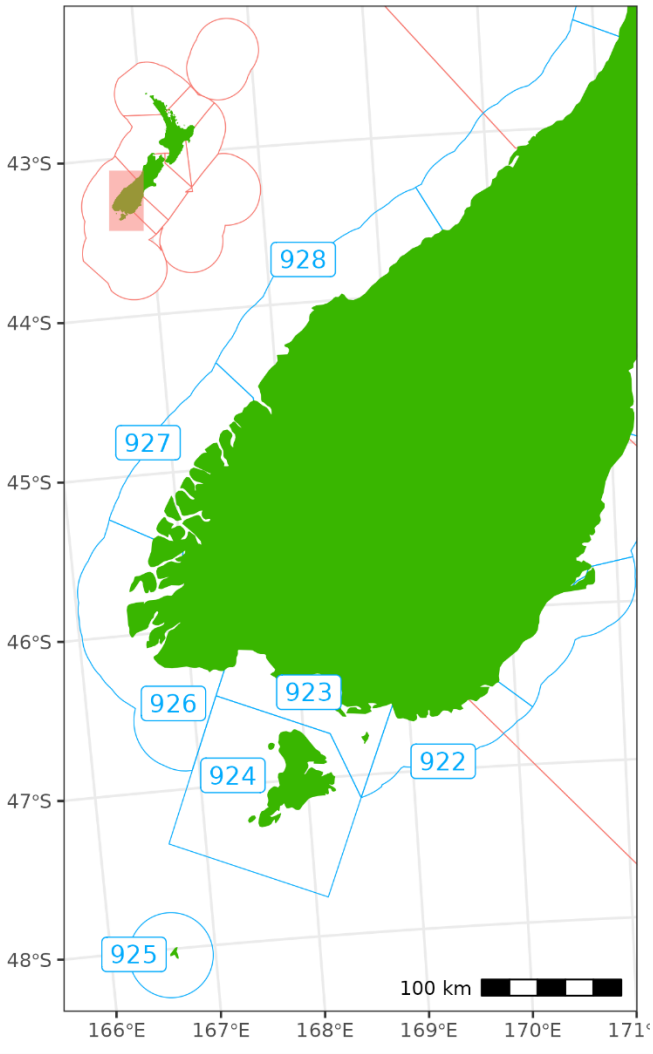

Figure 5: Statistical areas within CRA 8.

[10] 17.4% of the resulting TACC will be assigned to CRA 8 region 1, based on the average of the five years from 2019–20 to 2023–24.

Table 4: Summary of CRA 8 management procedures.

First year with MP	1996
First year of current MP	2023
Review scheduled	2026
Input	Logbook offset year CPUE
Output	TACC
Type of rule	generalised plateau step rule
Minimum change	5%
Maximum change	none
Latent year	none
2024–25 customary allowance	30
2024–25 recreational allowance	39
2024–25 other mortality allowance	140
2024–25 total non-commercial allowance	209
2024–25 TACC	1392
2024–25 TAC	1601

Table 5: Parameters for the CRA 8 generalised plateau step rule.

Parameter	Function	Value
par1	rule type	4
par2	CPUE at TACC = 0	0.6
par3	CPUE at plateau left	3.4
par4	CPUE at plateau right	7
par5	plateau height	1251
par6	step width	1
par7	step height	0.055
par8	minimum change	0.05
par9	maximum change	0
par10	latent year switch	0

Table 6: History of the previous and current CRA 8 management procedure and its operation in 2024. 'Rule result TACC' is the result of the management procedure. 'Applied TACC' and 'Applied TAC' are the catch limits decided by the Minister. Note that from 2015 to 2019 the offset year CPUE was based on the black line in Figure 6, while the 2023 and 2024 offset-year CPUE was based on the blue line in Figure 6.

Offset year	Offset year CPUE (kg/potlift)	Applied to fishing year	Rule result TACC (tonnes)	Applied TACC (tonnes)	Applied TAC (tonnes)
2015	3.0620	2016–17	962.0	962.0	1053.0
2016	3.0254	2017–18	962.0	962.0	1053.0
2017	3.7113	2018–19	1070.7	1070.7	1161.7
2018	4.2481	2019–20	1129.6	1129.6	1220.6
2019	4.8302	2020–21	1191.7	1191.7	1282.7
2020	–	2021–22	–	1251.0	1453.0
2021	–	2022–23	–	1251.0	1453.0
2022	–	2023–24	–	1251.0	1453.0
2023	8.4555	2024–25	1392.4	1392.0	1601.0
2024	8.1385	2025–26	1392.0	–	–

3.2. Operation

In November 2024, standardised offset-year logbook CPUE was 8.1385 kg/potlift, which gave a suggested TACC of 1392 tonnes. This TACC change was 0%, resulting in no change to the TACC for 2025–26.

Standardised offset-year CPUE was derived for CRA 8 up to the 2024 offset year (Figure 6). The CRA 8 offset year CPUE was based on logbook data. To make this year offset standardised CPUE comparable with the previous operational MP, it was rescaled by the geometric mean of the previous series (Figure 6). Logbook CPUE was in terms of numbers caught per pot whereas the previous CPUE series was in terms of catch weight and the rescaling converts the numbers to weight units. Also, the previous series did not include the X-discards. This procedure resulted in a decrease in CPUE from 8.4555 kg/potlift in 2023 to 8.1385 kg/potlift in 2024. The MP was operated for the 2025–26 fishing year (i.e., to set the TACC from 1 April 2025), producing no change to the 2025–26 TACC (Table 6, Figure 7).

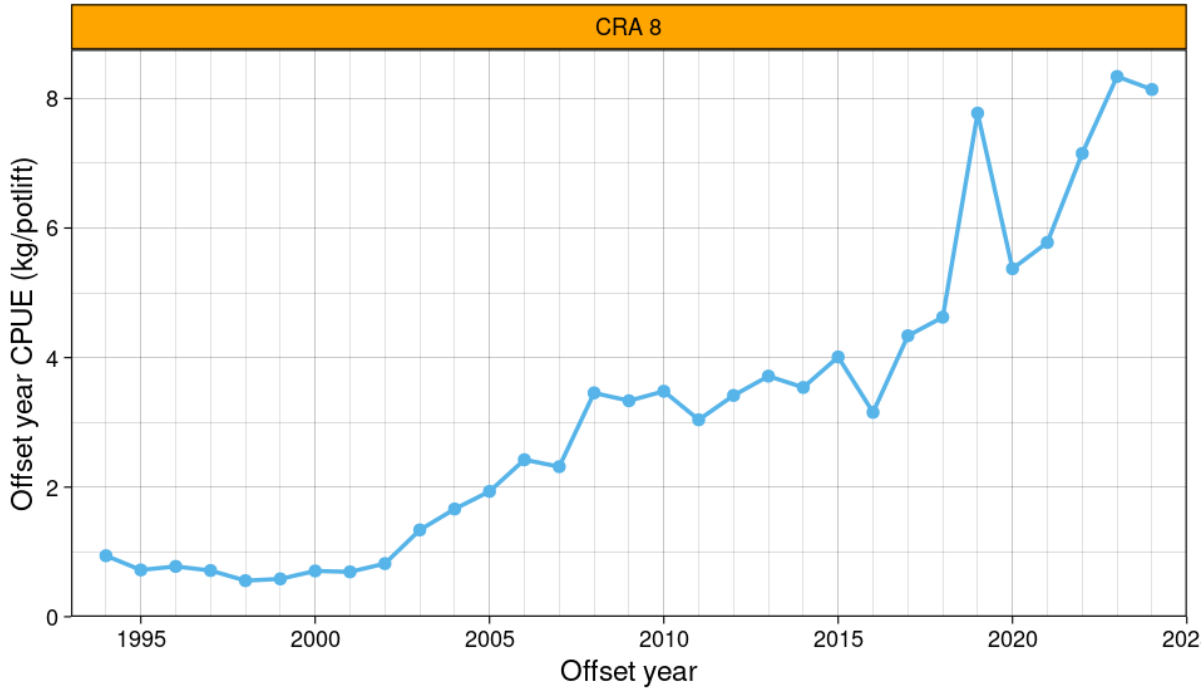

Figure 6: Offset-year CPUE (kg/potlift) for CRA 8 from 1994 to 2024. Numbers/potlift indices were rescaled to the geometric mean of the previous kg/pot indices calculated for the period 1994 to 2020.

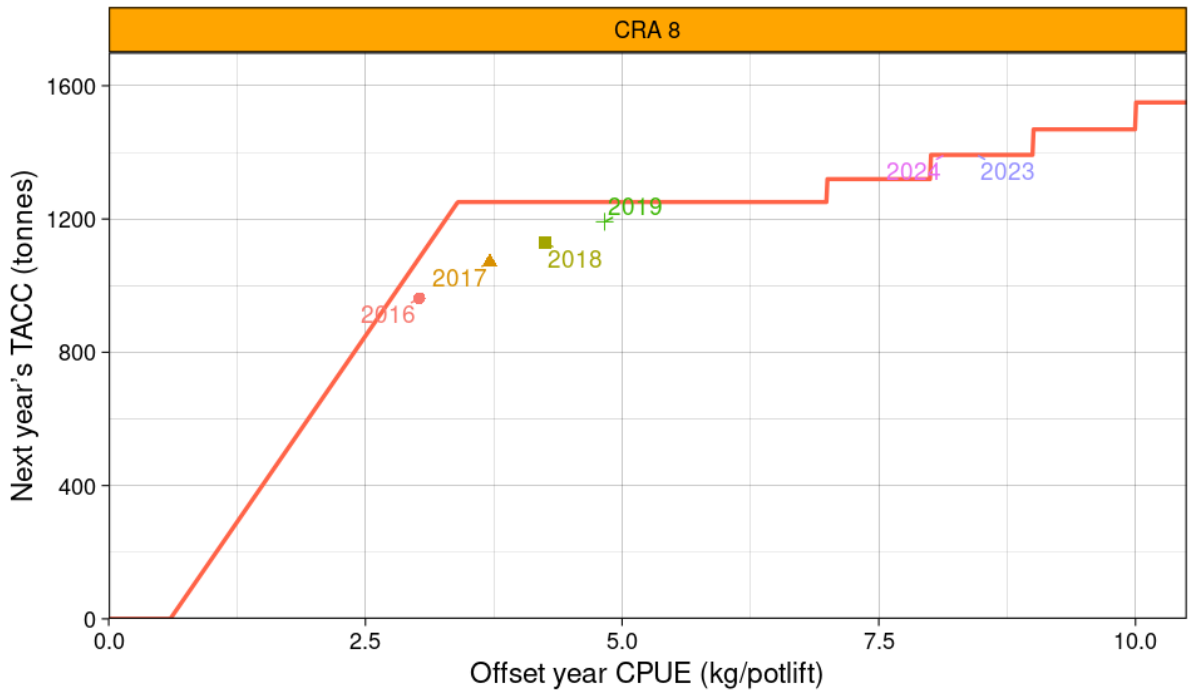

Figure 7: History of the current CRA 8 management procedure. The coloured symbols show the 2016 to 2024 offset-year CPUE and the resulting TACCs.

5. SUMMARY

Offset year CPUEs for CRA 7 and CRA 8 are summarised in Figure 8 and the associated MPs are summarised in Figure 9. The operation of the management procedures suggested in no change in TACC for CRA 8, and an increase in TACC for CRA 7.

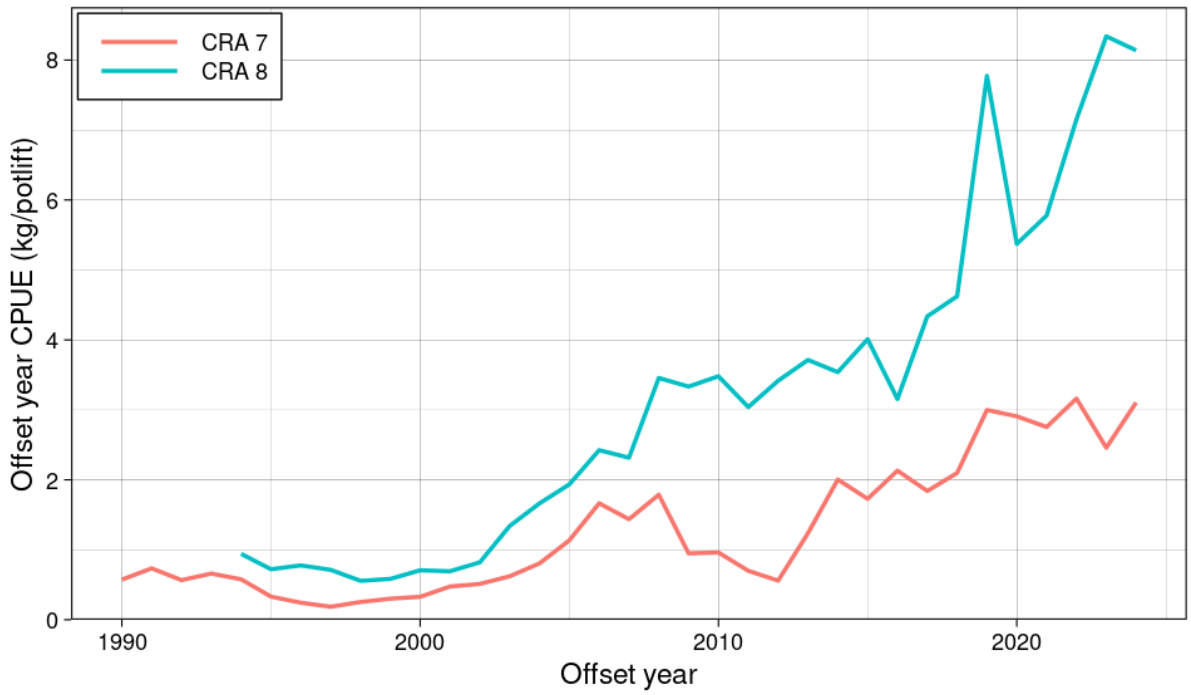

Figure 8: Offset-year CPUE (kg/potlift) for CRA 7 and CRA 8 using in the management procedure.

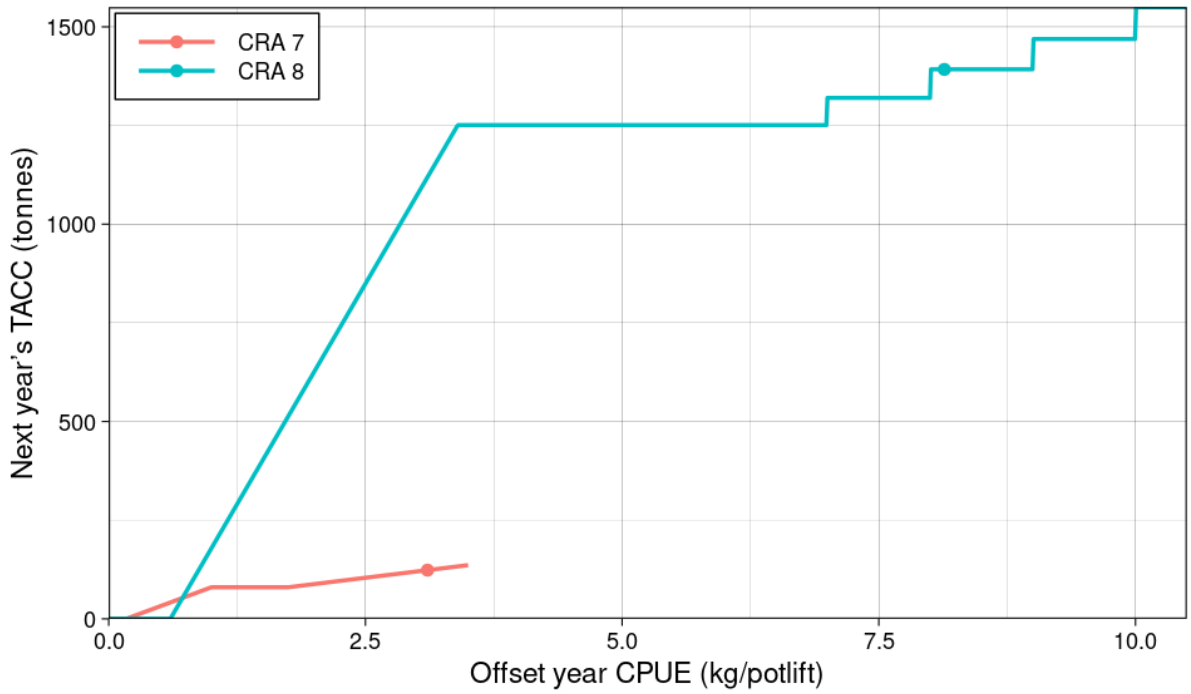

Figure 9: CRA 7 and CRA 8 current management procedures (lines) and the proposed TACC (points).

6. FULFILLMENT OF BROADER OUTCOMES

As required under Government Procurement rules[11], Fisheries New Zealand considered broader outcomes (secondary benefits such as environmental, social, economic or cultural benefits) that would be generated by this project.

Whakapapa links all people back to the land, sea, and sky, and our obligations to respect the physical world. This research aims to ensure the long-term sustainability of red rock lobster stocks, for the good of the wider community (including stakeholders and the public) and the marine ecosystems that lobsters inhabit. This project supports both Māori and regional businesses, and our research is inextricably linked to the moana from the work it carries out and the tangata whenua it supports.

To support the wider fisheries science community and enable more value to be extracted from the limited resources (time and money) available for fisheries research, we make as much code as possible open source (i.e., publicly available). Furthermore, this project has built capacity and capability in fisheries science and stock assessment by employing researchers with a range of experience so that those with a long history of working in fisheries science can pass on their knowledge. This approach has meant that rock lobster stock assessments have consisted of a team with some members that have been involved for many years and some newer team members. This approach further mitigates risk associated with team members not being able to participate any longer.

[11] https://www.procurement.govt.nz/procurement/principles-charter-and-rules/government-procurement-rules/planning-your-procurement/broader-outcomes/

7. ACKNOWLEDGEMENTS

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APPENDIX A. GENERALISED PLATEAU RULES

A.1 Step and slope harvest control rules

The current MPs have either a 'plateau slope' HCR (e.g., Figure A.1) or a 'plateau step' HCR (e.g., Figure A.2). Both step and slope rules use CPUE as the input, TACC as the output, and also 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).

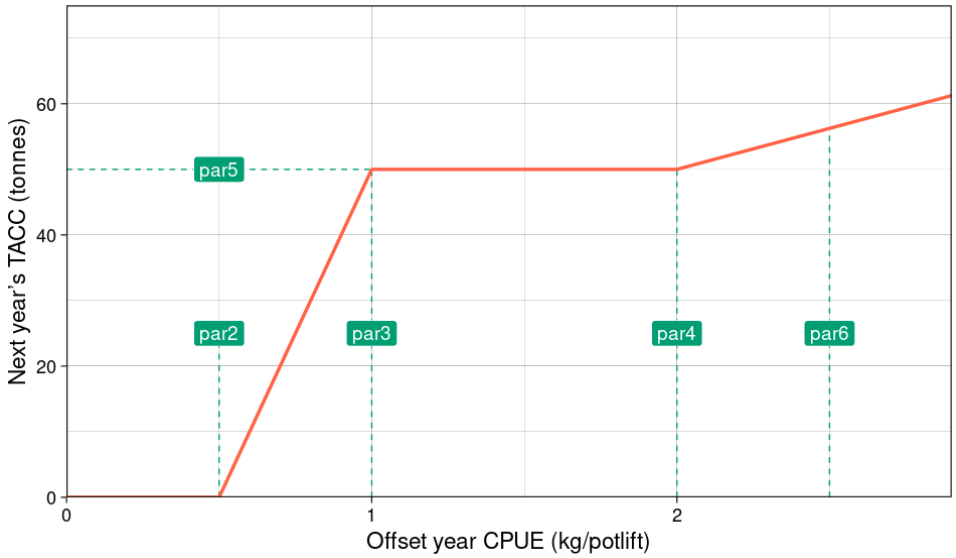

Figure A.1: An example of a generalised plateau slope rule. See Table A.1 for parameter definitions.

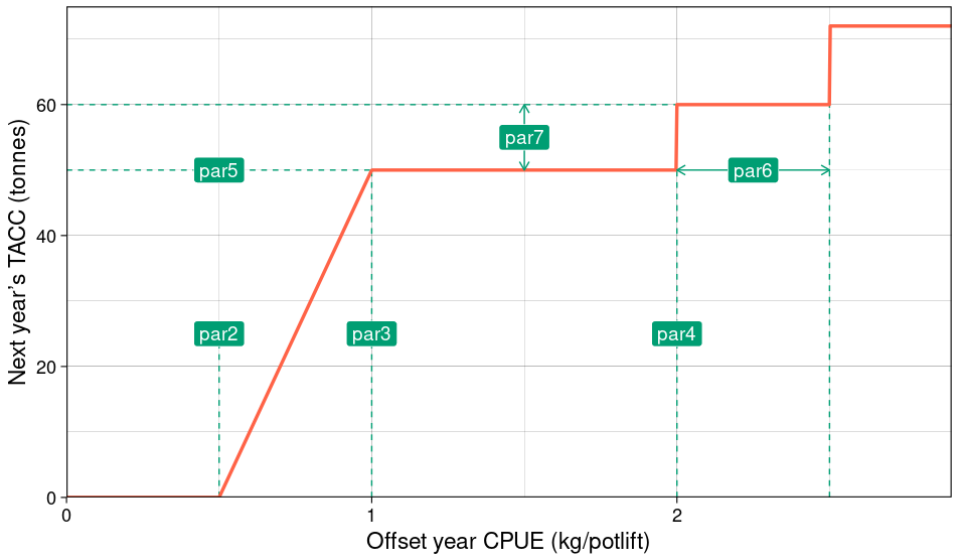

Figure A.2: An example of a generalised plateau step rule. See Table A.1 for parameter definitions.

Descriptions in this section assume that the MP determines the TACC, as do the current MPs for rock lobster in New Zealand. A TAC-determining MP was developed for CRA 5 in 2010, at the request of the Ministry of Fisheries (the name of the managing government agency in 2010, Haist et al. 2011). This had a TACC component plus components for non-commercial catch sectors. This approach was rejected by the Minister and a TACC-determining rule was developed and approved in the following year. There is concern that rules controlling only the commercial catch will divert catch away from the commercial sector into the non-commercial sectors, which can increase their relative catch share as stocks increase. This outcome has been 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.

A.2 Rule parameters

The generalised rule parameters are defined in Table A.1.

Table A.1: Parameters for the generalised step and slope harvest rules.

Parameter	Applies to	Function
par1	both	rule type
par2	both	CPUE at TACC = 0
par3	both	CPUE at plateau left
par4	both	CPUE at plateau right
par5	both	plateau height
par6	step rules	step width
par6	slope rules	slope
par7	step rules	step height
par8	both	minimum change
par9	both	maximum change
par10	both	latent year switch

The rule type parameter ($par1$) is set to 3 for plateau slope rules and 4 for plateau step rules. The point at which TACC becomes zero ($par2$) can be zero or non-zero but must be less than the left edge of the plateau ($par3$). $par3$ must be less than or equal to the right edge ($par4$). In plateau slope rules ($par6$) must be greater than $par4$. Thus, for an acceptable rule:

$$par2 < par3 \leq par4,$$
$$par4 < par6 \quad \text{if} \quad par1 = 3.$$

Step height for step rules ($par7$) 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 ($par6$) is defined as the CPUE at which TACC is 1.5 times the plateau height ($par5$).

The minimum change parameter ($par8$) 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 $par8$, 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 ($par9$) specifies the maximum allowable proportional TACC change. When CPUE changes so much that the rule specifies a TACC change greater than $par9$, the TACC is changed only by the $par9$ proportion. A value of zero for $par9$ indicates that there is no maximum change threshold and that any TACC change is allowed.

A latent year component to the rule means that TACC cannot be changed if it was changed in the previous year ($par10 = 1$). An 'asymmetric latent year' means that TACC can be decreased but not increased when it was changed in the previous year ($par10 = 2$). If $par10 = 0$ then no latent year is used.

A.3 Rule operation

For both rule forms, and for CPUE less than or equal to the right edge of the plateau ($par4$), the provisional TACC (before operation of thresholds $par8$, $par9$, and $par10$) is given by:

$$TACC_{y+1} = \begin{cases} 0 & \text{if} \quad I_y \leq par2 \\ par5\left(\dfrac{I_y - par2}{par3 - par2}\right) & \text{if} \quad par2 < I_y \leq par3, \\ par5 & \text{if} \quad par3 < I_y \leq par4 \end{cases}$$

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, the TACC for plateau step rules is given by:

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

and for plateau slope rules by:

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

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. The change in TACC is defined as:

$$\Delta = \frac{TACC_{y+1} - TACC_y}{TACC_y}.$$

The minimum change threshold is applied as:

$$TACC'_{y+1} = \begin{cases} TACC_y & \text{if} \quad par8 > 0, |\Delta| < par8 \\ TACC_{y+1} & \text{if} \quad par8 > 0, |\Delta| \geq par8' \end{cases}$$

and the maximum change threshold is applied as:

$$TACC'_{y+1} = \begin{cases} (1 - par9)TACC_{y+1} & \text{if} \quad par9 > 0, |\Delta| > par9, \Delta < 0 \\ (1 + par9)TACC_{y+1} & \text{if} \quad par9 > 0, |\Delta| > par9, \Delta > 0 \end{cases}.$$

APPENDIX B. CATCH PER UNIT EFFORT

B.1 CRA 7

Standardised offset-year CPUE based on CELR/ERS statutory catch/effort data was developed using a generalised linear mixed effects model (GLMM) for CRA 7 up to the 2024 offset year. A lognormal distribution was assumed. The dependent variable for this model was the weight (kilograms) of legal state lobsters caught divided by the number of pots lifted and the data were aggregated by offset year, month, statistical area, and vessel. At this level of aggregation, there were no zero catch records. This data set was derived using the 'F0-LFX' procedure which uses/retains all vessels in the analysis. However, for every year/vessel, the ratio of annual landed catch (including legal discards and retained catch for personal use), divided by the total annual estimated catch was calculated. This ratio is called the vessel correction factor (VCF, see Starr 2024). The VCF was transformed using:

$$1 - |1 - VCF|$$

The transformed VCF was then used to weight the likelihood for every observation in the model. For example:

- if in a particular year a vessel landed 10 tonnes, but estimated their catch to be 8 tonnes, then their VCF would be 1.25, and the data set weight for this vessel/year would be 0.75;
- if in a particular year a vessel landed 10 tonnes, but estimated their catch to be 12.5 tonnes, then their VCF would be 0.8, and the data set weight for this vessel/year would be 0.8; and
- if their landed catch was the same as their estimated catch then the data set weight would be 1.

This weighting procedure effectively makes the data equivalent to the F2-LFX data extract used in the 2019 (and earlier) CRA 7 MP. Note that this transformation results in a data set weight of zero being applied with the VCF ≥ 2 so these observations were dropped.

The explanatory variables in this model included offset year (oyear), month, statistical area, vessel, and an offset year × statistical area interaction term. The vessel and offset year × statistical area terms were treated as random effects. The model was coded using *brms* using the formula:

cpue | weights(wt) ~ oyear + month + (1 | vessel) + area + (1 | oyear:area)

Markov chain Monte Carlo (MCMC) mixing was visually acceptable (not shown), with no divergent transitions, the potential scale reduction $\hat{R}$ was <1.01 for all parameters, effective sample sizes were >400 for all parameters, and the lognormal assumption was reasonable (Figure B.1).

Finally, to make this standardised offset year CPUE comparable with the standardised offset year CPUE series that was used previously to drive the operational MP, it was rescaled by the geometric mean of the previous series (Figure B.2).

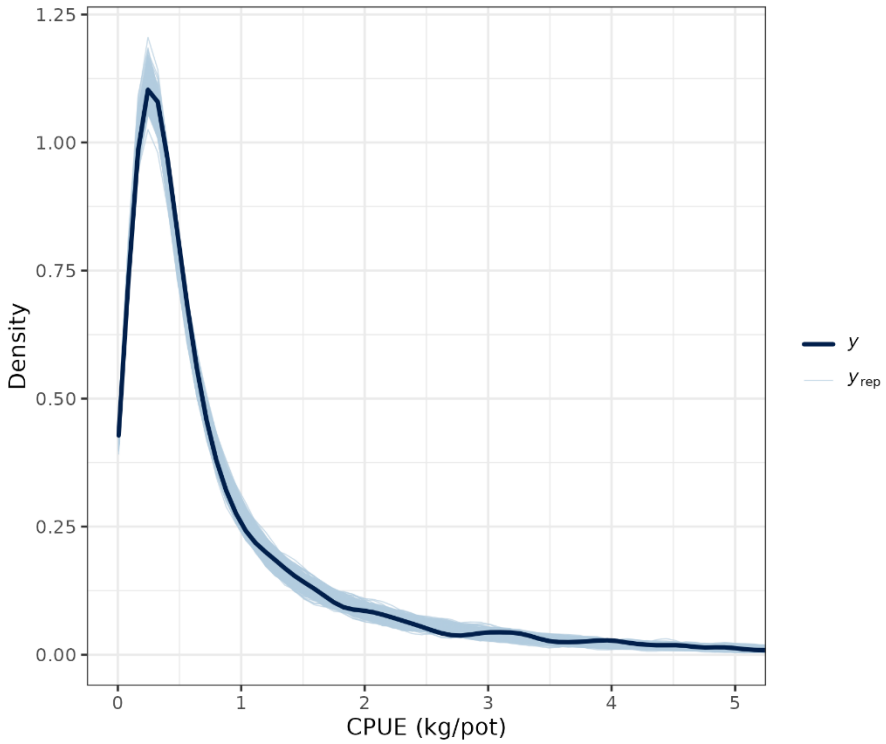

Figure B.1: Posterior predictive check plot showing the distribution of the data (y) and the model prediction (y_{rep}).

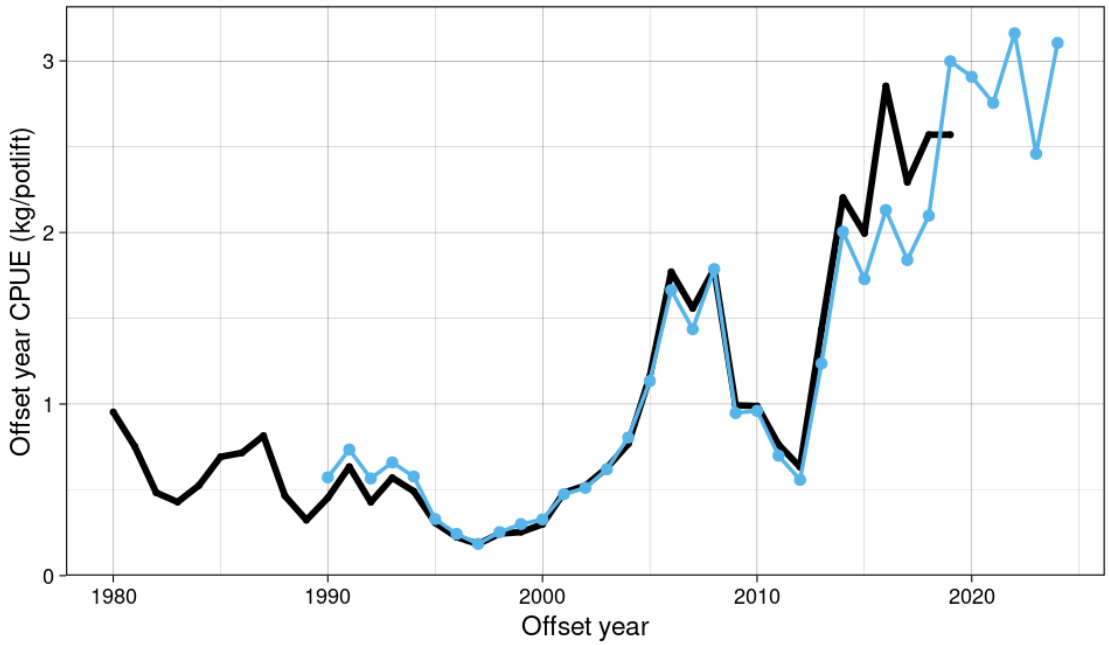

Figure B.2: Offset-year CPUE (kg/potlift) for CRA 7. The black solid line is the offset year CPUE from the previous operational MP. The blue solid line is the standardised CPUE from the CELR/ERS data using offset year, month, and area terms, and rescaled by the geometric mean of the previous series.

Table B.1: Number of records by statistical area and offset year in the CELR/ERS data set used to calculate the CRA 7 offset year CPUE time series. The median of the standardised offset year CPUE index series is also shown.

Offset	Number of records			
year	920	921	Total	Index
1990	268	69	337	0.572
1991	247	93	340	0.734
1992	146	44	190	0.566
1993	211	57	268	0.660
1994	144	43	187	0.578
1995	165	65	230	0.330
1996	139	51	190	0.243
1997	118	47	165	0.185
1998	94	56	150	0.253
1999	100	36	136	0.300
2000	108	55	163	0.327
2001	95	56	151	0.475
2002	107	35	142	0.512
2003	82	16	98	0.620
2004	70	17	87	0.805
2005	41	20	61	1.134
2006	36	27	63	1.664
2007	56	22	78	1.436
2008	55	32	87	1.787
2009	59	30	89	0.948
2010	69	42	111	0.961
2011	55	39	94	0.699
2012	53	29	82	0.558
2013	45	16	61	1.236
2014	40	14	54	2.004
2015	66	24	90	1.728
2016	68	28	96	2.131
2017	59	31	90	1.840
2018	65	28	93	2.098
2019	60	13	73	2.998
2020	72	14	86	2.907
2021	79	16	95	2.755
2022	59	19	78	3.161
2023	65	34	99	2.459
2024	54	30	84	3.105

B.2 CRA 8

Standardised offset-year CPUE based on voluntary logbook data was developed using a GLMM for CRA 8 up to the 2024 offset year. The dependent variable for this model was the number of lobsters above the MLS caught per pot lifted (including berried females) and the data were not aggregated (i.e., pot by pot data). All vessels were retained in the analysis and the model included all statistical areas within CRA 8. A negative binomial distribution was assumed. The explanatory variables in this model included offset year (oyear), month, statistical area, vessel, and an offset year × statistical area interaction term. The vessel and offset year × statistical area terms were treated as random effects. The model was coded using brms using the formula:

lobsters ~ oyear + month + (1 | vessel) + area + (1 | oyear:area)

Markov chain Monte Carlo (MCMC) mixing was visually acceptable (not shown), with no divergent transitions, the potential scale reduction $\hat{R}$ was <1.01 for all parameters, and effective sample sizes were >400 for all parameters. The negative binomial model underestimated the CPUE at low levels (i.e., for 0–4 lobsters caught per pot) which could be explored further in the future (Figure B.3).

Finally, to make this standardised offset year CPUE comparable with the standardised offset year CPUE series that was used previously to drive the operational MP, the logbook numbers caught per potlift CPUE series was rescaled by the geometric mean of the previous weight caught per potlift CELR series so that the geometric mean was the same for overlapping years (Figure B.4).

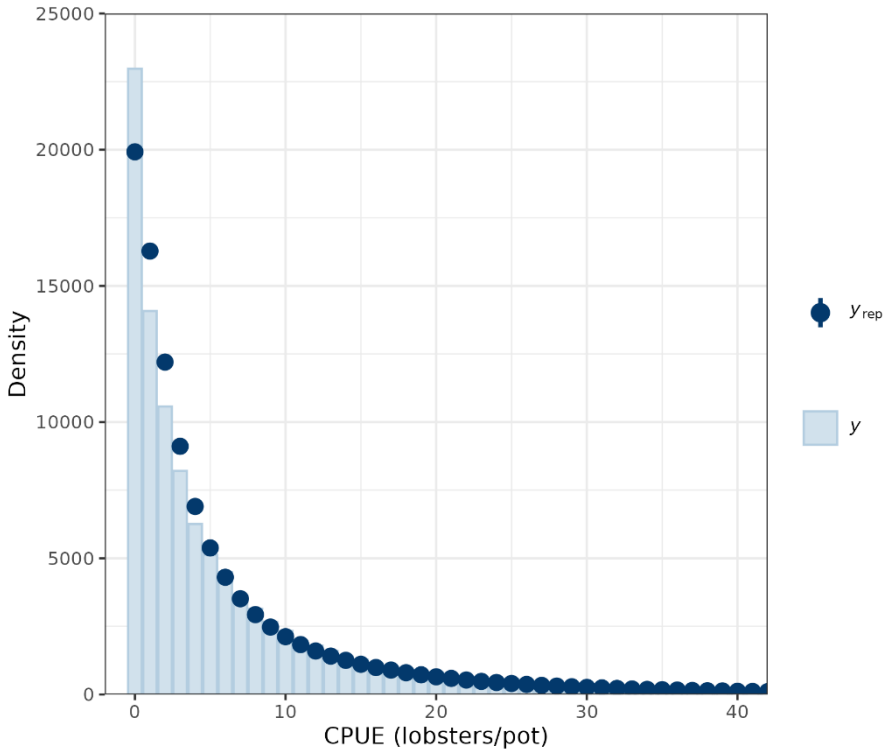

Figure B.3: Posterior predictive check plot showing the distribution of the data (y) and the model prediction (y_{rep}).

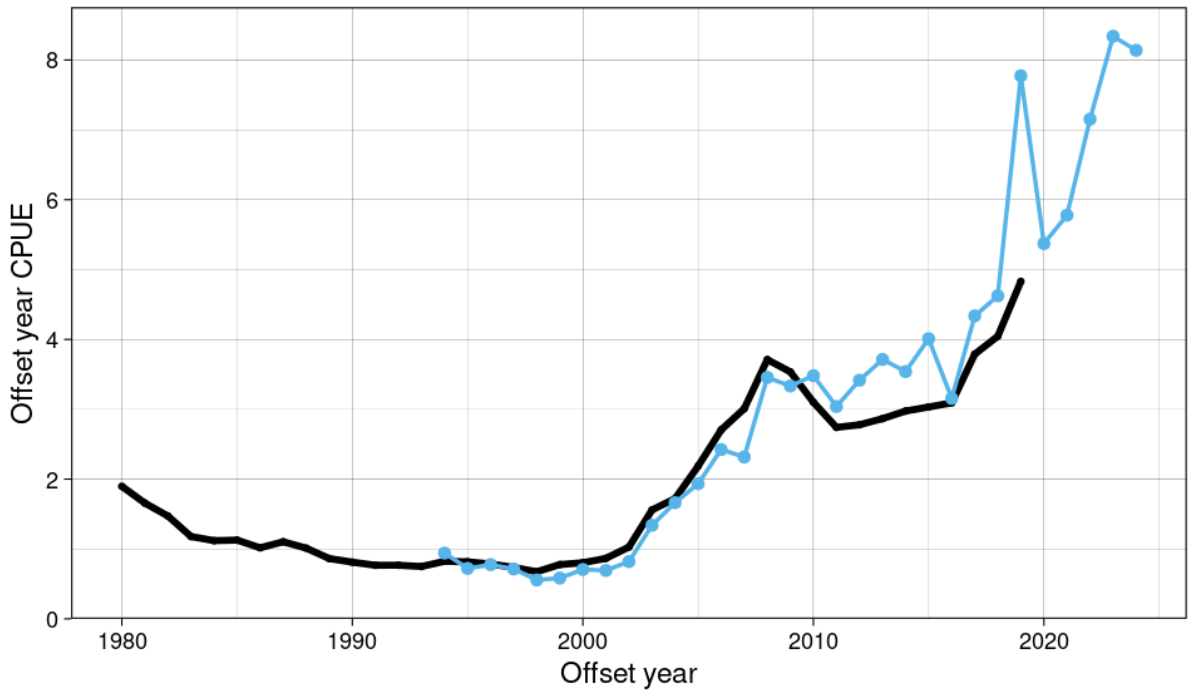

Figure B.4: Offset-year CPUE (kg/potlift) for CRA 8. The black line is the offset year CELR CPUE from the previous operational MP. The blue line is the standardised offset year CPUE from the logbook data rescaled by the geometric mean of the previous series.

Table B.2: Number of records (potlifts) by statistical area and offset year in the CELR/ERS data set used to calculate the CRA 8 offset year CPUE time series. The median of the standardised offset year CPUE index series is also shown.

Offset year	Number of pots								
	922	923	924	925	926	927	928	Total	Index
1994	218	98	790	–	810	1 671	975	4 562	0.941
1995	284	230	1 167	69	1 383	1 905	2 154	7 192	0.722
1996	370	181	1 262	–	1 834	1 538	2 746	7 931	0.776
1997	239	29	739	–	1 412	2 219	2 415	7 053	0.713
1998	32	59	339	–	972	1 765	2 074	5 241	0.556
1999	–	23	216	–	956	1 938	1 651	4 784	0.583
2000	–	–	199	–	690	1 641	1 013	3 543	0.706
2001	–	–	474	–	395	1 273	1 167	3 309	0.692
2002	–	4	404	–	568	1 319	1 125	3 420	0.820
2003	–	50	237	–	696	1 007	993	2 983	1.339
2004	–	22	82	30	806	834	713	2 487	1.663
2005	–	40	224	20	481	1 238	421	2 424	1.934
2006	–	–	180	–	461	1 416	584	2 641	2.423
2007	–	–	277	29	387	901	585	2 179	2.316
2008	–	92	230	–	435	826	652	2 235	3.455
2009	–	169	103	–	335	742	574	1 923	3.333
2010	–	45	102	–	806	1 162	1 218	3 333	3.480
2011	–	35	101	–	694	1 145	856	2 831	3.040
2012	–	–	35	–	840	933	1 009	2 817	3.416
2013	–	–	23	–	489	1 023	860	2 395	3.714
2014	–	–	50	22	542	1 228	998	2 840	3.539
2015	–	–	33	–	792	914	674	2 413	4.010
2016	–	–	–	–	1 116	992	1 057	3 165	3.155
2017	–	–	92	–	1 035	1 006	634	2 767	4.337
2018	–	–	88	–	1 166	1 027	766	3 047	4.624
2019	–	–	118	–	1 113	1 003	601	2 835	7.773
2020	–	–	125	–	666	721	293	1 805	5.372
2021	–	–	201	–	897	927	796	2 821	5.778
2022	–	–	27	–	775	653	488	1 943	7.152
2023	–	–	261	–	1 057	914	577	2 809	8.339