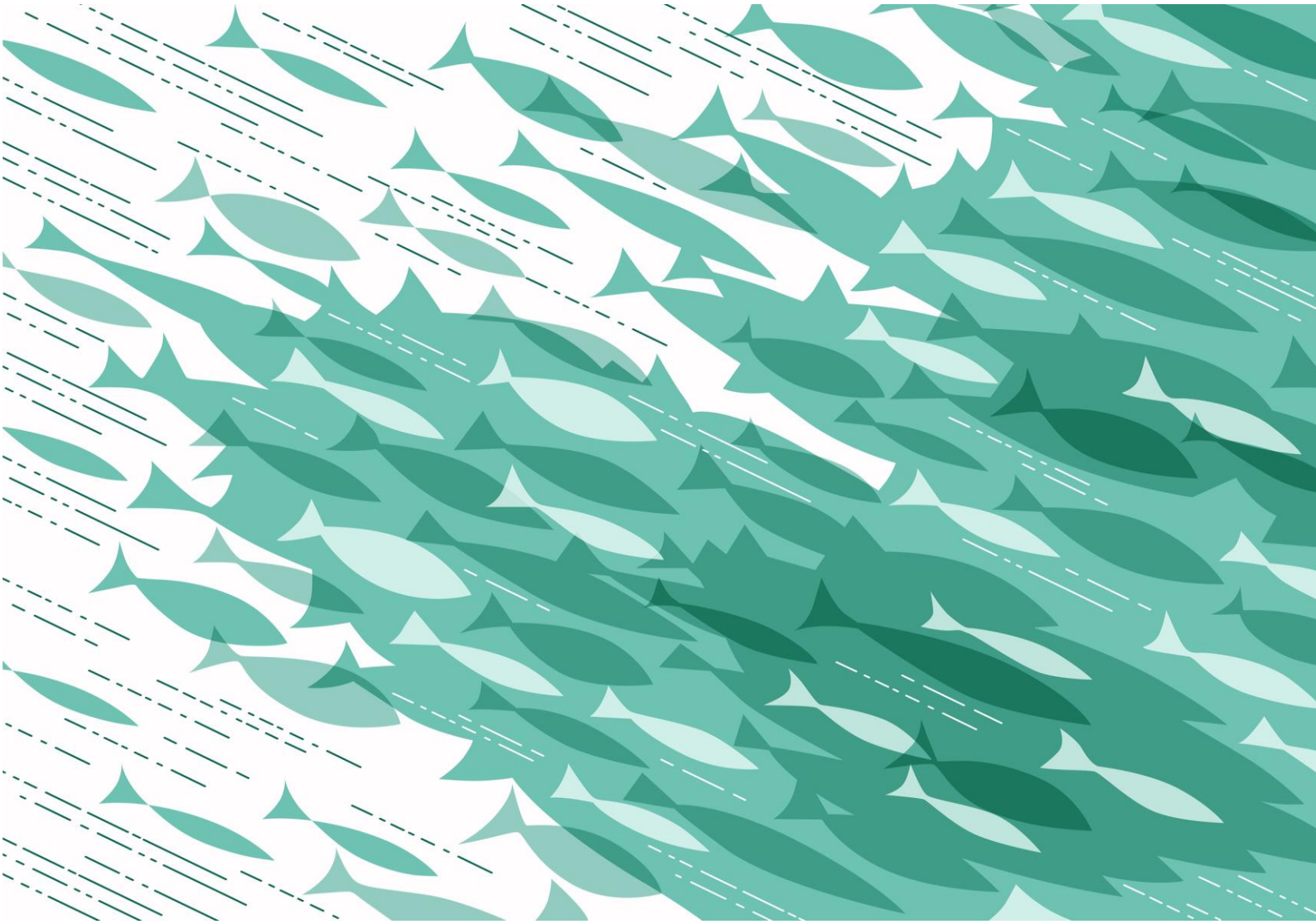

Economic impacts of 2019 Review of Sustainability Measures – East Coast Tarakihi

A Computable General Equilibrium analysis and forecast model

NZIER report to Fisheries New Zealand

August 2019

About NZIER

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NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by Laëtitia Leroy de Morel, Dion Gämperle and Prince Siddharth.

It was quality approved by Chris Nixon and Peter Clough.

The assistance of Sarah Spring is gratefully acknowledged.

L13 Willeston House, 22-28 Willeston Street | PO Box 3479, Wellington 6140
Tel +64 4 472 1880 | econ@nzier.org.nz

Key points

Fisheries New Zealand (FNZ) has asked NZIER to provide economic impact assessments of the proposed Options 1, 2, 3[1] and 4 relating to the 2019 review of sustainability measures for the East Coast tarakihi (TAR) stock and other fish species caught in association with TAR (referred to as by-catch). The four options are compared against a counter-factual which is the situation prevailing pre-1st October 2018.

This report provides estimates for the impacts from Options 1, 2, 3 and 4 on catch volumes of tarakihi and its by-catch. While the figures have been reported as annual impacts and could, in theory, be multiplied by the number of years of the respective rebuild periods to better understand the overall impact of each of the options, it is important to understand that the estimates are not forecasts and treating them as such provides only a rough estimate that could over-or under-state the impact. This is because there exists uncertainty around the precise impacts of the proposed catch limits on the wider NZ economy, such as changes in fisher behaviour and the resilience of other industries to indirect impacts over time. However, these estimates do help to quantify the potential economic impacts of a tarakihi TACC decrease.

This report also discusses how restrictions on catch can increase the price of the annual catch entitlements (ACE).

This report refers to this policy in shorthand as "TACC[2] options".

New Zealand's annual GDP could be reduced by between $6.1 million and $15.9 million depending on the option chosen

New Zealand wide results flow logically from the direct and indirect impacts at the regional levels as a result of a reduction to the TACC.

Table 1 shows the annual macroeconomic impacts of the new TACC options nationally:

- At the national level, annual GDP is expected to fall by $14.83 million (-0.005%) under Option 1, $15.86 million (-0.006%) under Option 2, $6.06 million under Option 3 (-0.002%) and $8.00 million (-0.003%) under Option 4
- National household spending (the best measure of economic wellbeing and discretionary income) is driven by regional household consumption which is, in turn, negatively affected by the decrease in employment and lower wages at the regional level derived from the reduction in TACC levels. New Zealand annual household spending may be reduced by $7.37 million

[1] Option 3 represents the Status Quo (not the counter-factual) in relation to the current review, but as with all options, it includes a 20% cut in TACC level implemented as part of the first stage of the review, in October 2018.

[2] TACC refers to Total allowable Commercial Catch.

(-0.005%) under Option 1, $7.88 million (-0.005%) under Option 2, $2.96 million (-0.002%) under Option 3, and $3.92 million (-0.003%) under Option 4

- New Zealand annual export revenue may reduce by $8.12 million (-0.010%) under Option 1, $8.68 million (-0.011%) under Option 2, $3.30 million (-0.004%) under Option 3 and $4.36 million (-0.006%) under Option 4. Because commercial tarakihi is primarily caught for domestic consumption, a reduction in exports is mostly due to a reduction in by-catch product exports.

Table 1 Economy-wide effects of the new catch limit options

Changes in 2018 $ million per year (real terms)

Indicators	Option 1	Option 2	Option 3	Option 4
GDP	-14.83	-15.86	-6.06	-8.00
Household spending	-7.37	-7.88	-2.96	-3.92
Exports	-8.12	-8.68	-3.30	-4.36
All industry outputs	-18.54	-19.80	-7.18	-9.56

Notes: Each row represents a distinct indicator about the New Zealand economy. These rows are not additive.

Source: NZIER

Canterbury, Bay of Plenty, Nelson-Tasman, Auckland and Hawke's Bay experience the greatest impacts on GDP and household spending under the proposed TACC options

The GDP and household spending impacts would be the highest in these regions because the tarakihi and by-catch industries account for a larger share of the regional GDPs. These regions are also the main ports of origin for commercial tarakihi fishing vessels[3] and, therefore, are expected to be more affected by proposals to decrease the TACC of TAR.

Table 2 presents the annual GDP impacts in dollar-value for these five most affected regions. In Canterbury, for example, annual GDP could decrease by $4.12 million under Option 1, $4.27 million under Option 2 and by $1.46 million and $2.05 million under Option 3 and Option 4, respectively. In the other regions, contractions in regional GDP vary by between $0.61 million in Hawke's Bay (Option 3) and $3.12 million in Bay of Plenty (Option 1) per annum.

[3] See Table 12 in Appendix B.7 for the main ports of origin by regions.

Table 2 GDP impacts in the five most affected regions

Changes in 2018 $ million per year (real terms)

Region	Option 1	Option 2	Option 3	Option 4
Canterbury	-4.12	-4.27	-1.46	-2.05
Bay of Plenty	-3.12	-3.03	-1.22	-1.59
Nelson-Tasman	-1.70	-1.87	-1.00	-1.17
Auckland	-1.98	-1.81	-0.69	-0.90
Hawke's Bay	-1.44	-1.99	-0.61	-0.88

Source: NZIER

Table 3 presents the annual household spending impacts in dollar value for these five most affected regions. In Canterbury, for example, annual household spending would decrease by $1.51 million under Option 1, $1.58 million under Option 2 and by $0.52 million and $0.72 million under Option 3 and Option 4, respectively. In the other regions, contractions in regional household spending vary by between $0.13 million in Hawke's Bay (Option 3) and $2.11 million in Auckland (Option 2) per annum.

Table 3 Impact on regional household spending

Changes in 2018 $ million per year (real terms)

Region	Option 1	Option 2	Option 3	Option 4
Canterbury	-1.51	-1.58	-0.52	-0.72
Bay of Plenty	-0.81	-0.78	-0.30	-0.39
Nelson-Tasman	-0.37	-0.41	-0.24	-0.27
Auckland	-2.05	-2.11	-0.80	-1.05
Hawke's Bay	-0.29	-0.44	-0.13	-0.19

Source: NZIER

Industries closely related could also suffer from a decrease in TACC for tarakihi and by-catch

- With the new catch limit options, upstream industries[4] that supply the tarakihi and by-catch fishing industries with intermediate inputs are likely to be negatively affected. For example:
  - Transport equipment manufacturing, which includes boatbuilding, shipbuilding and repair services, is negatively affected from fewer operating fishing vessels and fewer vehicles transporting tarakihi and its by-catch across regions. The annual industry output decreases by $0.12 million and $0.13 million per year under Option 1 and Option 2,

[4] These are industries classified under the ANZSIC classification system: http://archive.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/industrial-classification.aspx

respectively. Under Option 3 and Option 4, the annual industry output is reduced by $0.04 million and $0.05 million, respectively

  - Construction services (such as electricity and plumbing services) output decreases by an annual $0.22 million under Option 1 and is expected to decrease by an annual $0.23 million, $0.08 million and $0.10 million under Options 2, 3 and 4, respectively. This could be due to less repair needed from vessels spending less time fishing for tarakihi
  - Petroleum and coal product manufacturing reduces by $0.17 million per year under Option 1 and is expected to decrease by an annual $0.18 million, $0.06 million and $0.08 million under Options 2, 3 and 4, respectively. This could be due to a reduction in petroleum fuel products (i.e. diesel, petrol and light fuel oil) required from fewer tarakihi fishing trips and fewer vehicles transporting tarakihi and its by-catch across regions.

- Downstream industries, which use the output of the tarakihi and by-catch industry in a finished or different product to reach consumers, are also likely to be negatively affected. For example:
  - Air transport output decreases by $0.10 million per year under Option 1 and is expected to decrease by an annual $0.11 million, $0.04 million and $0.06 million under Options 2, 3 and 4, respectively. Given that tarakihi is primarily for domestic use, it is the reduction in exports of by-catch that reduces air transport
  - Communication services related to the fishing industry decrease by an annual $0.10 million under Option 1 and Option 2, and by an annual $0.04 million and $0.05 million under Option 3 and Option 4, respectively.
- Industries on which households spend their income are also affected from the potential decrease in household incomes that come through employment and wages, and decreased returns to capital from a contraction of the tarakihi and by-catch fishing industries. Lower household incomes supress domestic demand in industries producing goods and services that are not of first necessity. For example:
  - Food and beverage services (such as cafes, restaurants, bars and takeaway services) annual output decrease by $0.76 million under Option 1, $0.82 million under Option 2, $0.27 million under Option 3 and $0.36 million under Option 4
  - Retail (recreational goods and food retailing) annual output decreases by $ 0.56 million under the Option 1, and by $0.60 million, $0.22 million, and $0.29 million under Options 2, 3 and 4, respectively.

Competing industries would gain from the decrease in tarakihi TACC levels as they compete for resources (labour and capital), but overall national output decreases annually

Partly offsetting the losses from tarakihi and by-catch industries, as well as their supporting industries, is the expansion of competing industries. These industries gain from the decrease in tarakihi TACC levels as they compete for resources (labour and

capital), which become less expensive. Typically, these industries are the labour-intensive and/or export industries, such as services and manufacturing industries.

For example:

- Annual output of business services grows $0.87 million under Option 1 and by $0.92 million, $0.39 million, and $0.50 million under Options 2, 3 and 4, respectively. This industry includes a variety of services such as environmental consulting, agricultural, legal and accounting. With the contraction of the tarakihi and its supporting industries, their workers move to other industries which are expanding, such as other fishing[5] and metal product manufacturing. This implies a greater requirement for business services in these industries, which in turn increases the output of business services
- Other fishing[6] annual output increases by $0.15 million under Option 1 and by $0.17 million, $0.08 million, and $0.10 million under Options 2, 3 and 4, respectively. Labour in this industry could have similar skills to those currently engaged in TAR. This would allow for workers displaced from tarakihi and by-catch industries to move towards other segments within the fishing industry
- Seafood processing output increases slightly by $0.20 million per year under Option 1, $0.12 million per year under each of Options 2 and 3, and $0.14 million per year under Option 4.[7]

  With the tarakihi catch reduced why is it we expect a slight increase in fish processing? Data from Statistics NZ[8] suggests that some fishers will want to continue to fish rather than move to other occupations. When the tarakihi catch reduces, it requires:

  – Fishers to move towards fishing less valuable fish.[9] To maintain profit margins, fishers will need to catch slightly larger quantities of less valuable fish. This causes the catch of the less valuable fish to increase, raising demand for fish processing
  – A diversion of fish typically caught for export into the domestic market. With tarakihi traded mostly on the domestic market, we expect a slight increase in domestic demand for fish that are exported. This could also slightly increase the demand for fish processing.

  We expect both impacts to drive the slight increase in fish processing, although which impact will dominate is unclear. For this to occur depends on the behaviour of fishers. It could be that local factors drive behaviour that reduces catches and processing.[10]

5 Other fishing includes other wild fish species, aquaculture and crustaceans.

6 Other fishing includes aquaculture and crustaceans.

7 Seafood processing industry is considered as a downstream industry but also a competitive industry as it also processes other fish species (e.g. other wild captured fish, aquaculture and crustaceans).

8 Set out in the Input – Output Tables that drives the economy wide modeling.

9 Included in other fishing.

10 However, confirming this will take time and resources that are outside the scope of this work.

- Annual output for metal product manufacturing (iron, steel, aluminium) increases by $0.14 million under Option 1, $0.15 million under Option 2, by $0.06 million and $0.08 million under Option 3 and Option 4, respectively.

  The growth in this industry could be explained by the fact that metal products, previously related to the tarakihi industry, can now be used by other manufacturing industries (wood, metal, etc.) for example.

Overall, national output decreases annually by $18.5 million under Option 1 and by $19.8 million, $7.2 million and $10.5 million under Options 2, 3 and 4, respectively.

Forecast GDP in the fishing industry is between $9.2 million and $23.9 million lower in 2040[11]

- Fishing industry GDP is forecast to grow from $428 million under Option 3 to $657 million at 2040 market price by 2040[12]
- In 2018 market prices, the fishing industry GDP is forecast to be between $400 million and $450 million in the next 20 years
- Canterbury, Bay of Plenty, Nelson-Tasman, Auckland and Hawke's Bay feel the greatest impacts on GDP from the proposed TACC options with real GDP being lower by between $0.44 million and $6.44 million in 2040
- Profits of tarakihi fishers and quota owners are expected to fall by between 18 and 38 percent based on our CGE modelling. However, as long as the demand for tarakihi remains strong, TACC reductions will increase the price of ACE[13] because price is directly related to supply and demand of a good. When supply is restricted, prices can be expected to increase.[14]

[11] The forecasts are in contrast with a scenario where there is no reduction in TACC.

[12] In this report, nominal GDP is the GDP evaluated at current market prices, without adjusting for inflation while real GDP is measured at 2018 market prices.

[13] Quota value is the present value of future ACE payments.

[14] We do not attempt to quantify ACE transfer and quota price forecast due to time and resource restrictions.

Contents

Appendices

Figures

Tables

1. Scope and outline

1.1. Scope

Fisheries New Zealand (FNZ) has asked NZIER to provide economic impact assessments of the proposed Options 1, 2, 3[15] and 4 relating to the 2019 review of catch limits for the East Coast tarakihi (TAR) stock.

The 2019 tarakihi review represents the second stage in a two-stage review aimed at increasing the abundance of East Coast tarakihi. The first stage was a 20% reduction to the TACC implemented in 1 October 2018. All options in this paper are compared to the pre-review levels, i.e. pre- 1 October 2018.

There is a sustainability risk associated the current abundance of TAR on the eastern coast of New Zealand's North and South Islands. Currently, the TAR stock is at 15.9 percent of unfished biomass, which is below its soft limit of 20 percent.

According to FNZ's Harvest Strategy Standard (HSS) guidelines, once a stock has fallen below the soft limit (20 percent of the unfished level), a rebuild plan needs to be implemented to replenish the stock to a target biomass. The rebuild period suggested by HSS for stocks like tarakihi is 10 years. When stock abundance is low, reductions to the Total Allowable Catch (TAC) and TACC may be implemented as a means of assisting rebuild of a stock. With a decrease in commercial catch rates, there are both direct and indirect economic impacts associated that are felt throughout the fishing industry as well as in supporting industries.

FNZ is seeking to understand how the reduced commercial catch rates of TAR might affect regional and national economies.

The direct and indirect economic impacts of commercial catch rate decreases are expressed in terms of market outcomes such as:

- Retail market
- Regional and national economies (such as Gross Domestic Product (GDP), household expenditure, exports and industry outputs)
- Potential implications for Annual Catch Entitlements (ACE) price and quota value
- Fishing industry GDP – how will each option affect fishing industry GDP in the long-run?

1.2. Outline

We used NZIER's regional computable general equilibrium (CGE) model of the New Zealand economy to provide economic impact assessments of the proposed four options relating to the 2019 review of catch limits for the TAR stock.[16]

[15] Option 3 represents the Status Quo (not the counter-factual) in relation to the current review, but as with all options, it includes a 20% cut in TACC level implemented as part of the first stage of the review, in October 2018.

[16] Review of Sustainability Measures for Tarakihi (TAR 1, 2, 3 and 7) for 2019/20: https://www.mpi.govt.nz/dmsdocument/35181-review-of-sustainability-measures-for-tarakihi-tar-1-2-3-and-7-for-201920

We provide estimates for Options 1, 2, 3 and 4 to show the impacts on catch volumes of tarakihi, by-catch and other fish species.

Based on discussions with FNZ officials, we incorporate in our model the four policy options associated with different levels of TACC decrease from their pre-2018 levels, and their associated lower outputs in the tarakihi and by-catch fishing industries.

These four policy options are summarised in Table 4.

Table 4 Options for varying TACCs

TAR	Option 1	Option 2	Option 3	Option 4
TAR 1	43%	24%	0% (20% in 2018)	5%
TAR 2	27%	50%	0% (20% in 2018)	10%
TAR 3	48%	50%	0% (20% in 2018)	10%
TAR 7	5%	9%	0% (20% in 2018)	2%

Note: Percentages in the table are percentage decreases.

Source: NZIER, FNZ

We first model Option 3 (Status Quo – 20% cut in TACC implemented in October 2018) and use these results in our new database to model the impacts of Option 1, Option 2 and Option 4 in a TACC level decrease for commercial tarakihi. However, we report the results to reflect the change compared to if no TACC reduction had been set. In other words, the four options are compared against a counter-factual which is the situation prevailing pre-1st October 2018.

For further detail on the methodology, refer to Appendix B for the CGE modelling and Appendix C for the forecasting models.

2. Economic effects of the new catch limits options for the East Coast tarakihi stock

Tarakihi fishing and by-catch industries interact with other parts of New Zealand by employing labour and capital, using intermediate inputs supplied by other industries, and by supplying inputs to seafood processing and other industries.

We used NZIER's regional CGE (hereafter, TERM-NZ) model of the New Zealand economy – to approximate the economic contributions that commercial tarakihi and by-catch industries make to the regions and at a national level.

Regional CGE modelling captures the various inter-linkages between sectors and regions, as well as their links to households (via the labour market), the government sector, capital markets and the global economy (via imports and exports). It is therefore useful for understanding the likely economic impact of policy changes from the proposed TACC levels for the East Coast tarakihi stock. The proposed catch limits only concern the commercial tarakihi fishing industry.

The key benefit of using our TERM-NZ model is that each New Zealand region is modelled as a separate economy but linked to each other through inter-regional trade in goods and factors. TERM-NZ is therefore a useful tool for examining how the proposed TACC levels for tarakihi might impact both the regional and New Zealand economies.

A technical description of TERM-NZ is provided in Appendix A.

2.1. CGE modelling and scenario design

We use our static TERM-NZ model, which looks at 'before' (i.e. current situation) and 'after' (with TACC level decrease). We therefore do not explicitly model the *timing* of the decrease in tarakihi TACC levels. We simply compare the regional and national economies without and with the decrease in TACC levels. Typically, such reduction has specific costs and revenues, each incurred at different periods. We analyse a static scenario that estimates the overall annual economic effects of a decrease in TACC levels for the commercial tarakihi fishing industry.

We determine the flow-on effects of each of the policy options throughout the regional and national economies on GDP, household spending, exports and industry output.

In a standard CGE approach, we let the model determine how capital and labour resources would move across industries and regions based on rates of return and wages. In the context of capital, this assumption implies that private investors are profit-driven and would invest in the next best, profitable alternative with decreases in the tarakihi TACC. Labour would also move to other sectors and regions as tarakihi and by-catch industries reduce their employment capacity. However, not all resources, particularly fishing ports, where tarakihi is an important component of catch, can be reallocated and will therefore reduce their economic contribution.

The difference between the initial and 'reduced tarakihi TACC' economy then provides an estimate of the likely impacts of the new catch limit options on the regional and national economies. In the next section, we present our results as either annual percentage changes or annual changes in dollar values of 'reduced Tarakihi TACC' economy relative to the initial 'without reduced TACC' economy.

Our results are not forecasts because we do not know precisely how the proposed catch limits for tarakihi might play out in the New Zealand tarakihi industry, e.g. changes in fisher behaviour. However, they do help to quantify the potential economic impacts of tarakihi TACC decrease.

More details are available in Appendix A.

2.2. Economy-wide effects

Both direct and indirect effects from proposed catch limits on commercial tarakihi will likely reduce real GDP, employment and household consumption in regional New Zealand. National results are driven by the contraction of the tarakihi industry and its flow-on effects at the regional level.

At the national level, annually GDP can be expected to fall by $14.83 million (-0.005%) under Option 1, $15.86 million (-0.006%) under Option 2, $6.06 million (-0.002%) under Option 3 and $8.00 million (-0.003%) under Option 4.

National household spending (the best measure of economic wellbeing and discretionary income) is driven by regional household consumption which is, in turn negatively affected by the decrease in employment and lower wages at the regional level derived from the reduction in TACC levels.

New Zealand annual household spending may reduce by $7.37 million (-0.005%) under Option 1, $7.88 million (-0.005%) under Option 2, $2.96 million (-0.002%) under Option 3 and $3.92 million (-0.002%) under Option 4.

New Zealand annual export revenue may reduce by $8.12 million under Option 1 (-0.010%), $8.68 million (-0.011%) under Option 2, $3.30 million (-0.004%) under Option 3 and $4.36 million (-0.006%) under Option 4. Because commercial tarakihi is primarily caught for domestic use, a reduction in exports is mostly due to a reduction in by-catch product exports. Table 5 presents the annual economy-wide impacts of new catch limit options for commercial tarakihi at the national level.

Table 5 Headline impacts of decreases in TACC at the national level

Changes in 2018 $ million per year (real terms)

Indicators	Option 1	Option 2	Option 3	Option 4
GDP	-14.83	-15.86	-6.06	-8.00
Household spending	-7.37	-7.88	-2.96	-3.92
Exports	-8.12	-8.68	-3.30	-4.36
All industry outputs	-18.54	-19.80	-7.18	-9.56

Notes: Each row represents a distinct indicator about the New Zealand economy. These rows are not additive.

Source: NZIER

2.3. Regional effects

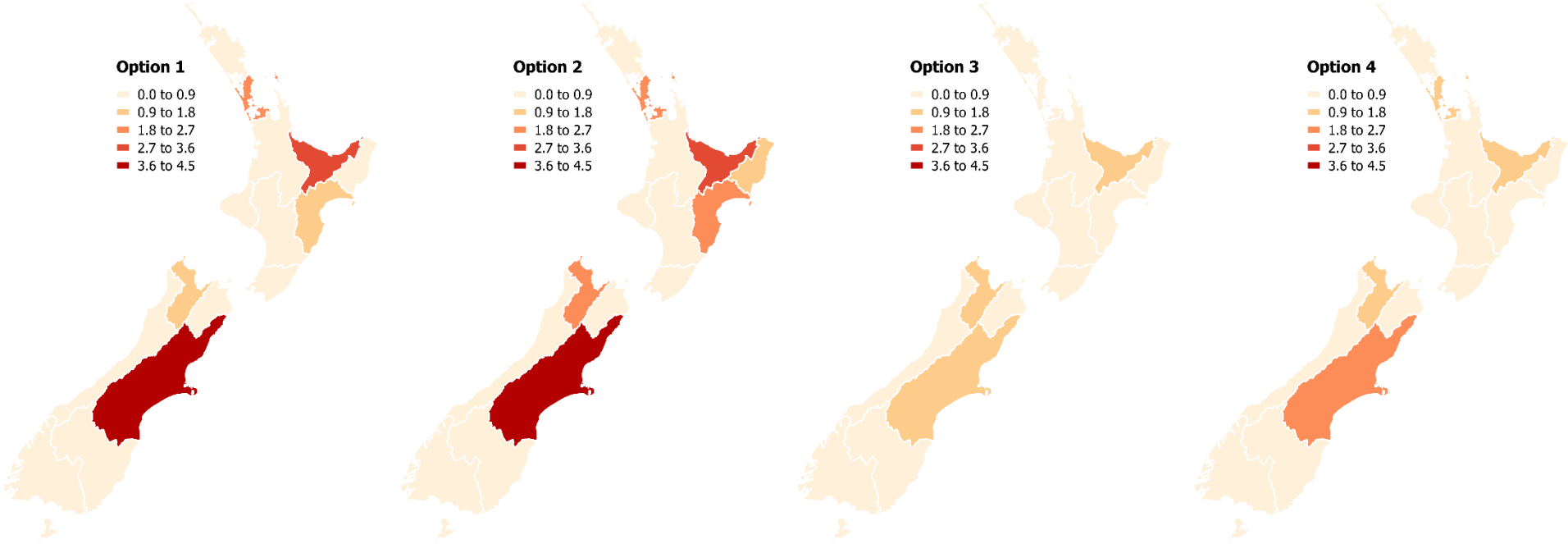
Figure 1, Table 6, Figure 2 and Table 7 illustrate how the decrease in TACC levels could negatively impact regional New Zealand, both in terms of GDP and household spending (our proxy for 'welfare' or living standards).

For all four scenarios, the annual dollar impacts on GDP and household spending are largest in Canterbury, Bay of Plenty, Nelson-Tasman, Auckland and Hawke's Bay as tarakihi and by-catch fishing industries account for a larger share of the economy in these regions. These regions are also the main ports of origin for commercial tarakihi fishing vessels[17] and therefore, are expected to be more affected by the decrease in TACC levels.

[17] See Table 12 in Appendix B.7 for the main ports of origin by regions.

Figure 1 Regional GDP decrease

Changes in 2018 $ million per year (real terms)



Source: NZIER

Table 6 Regional impacts on GDP from TACC reductions

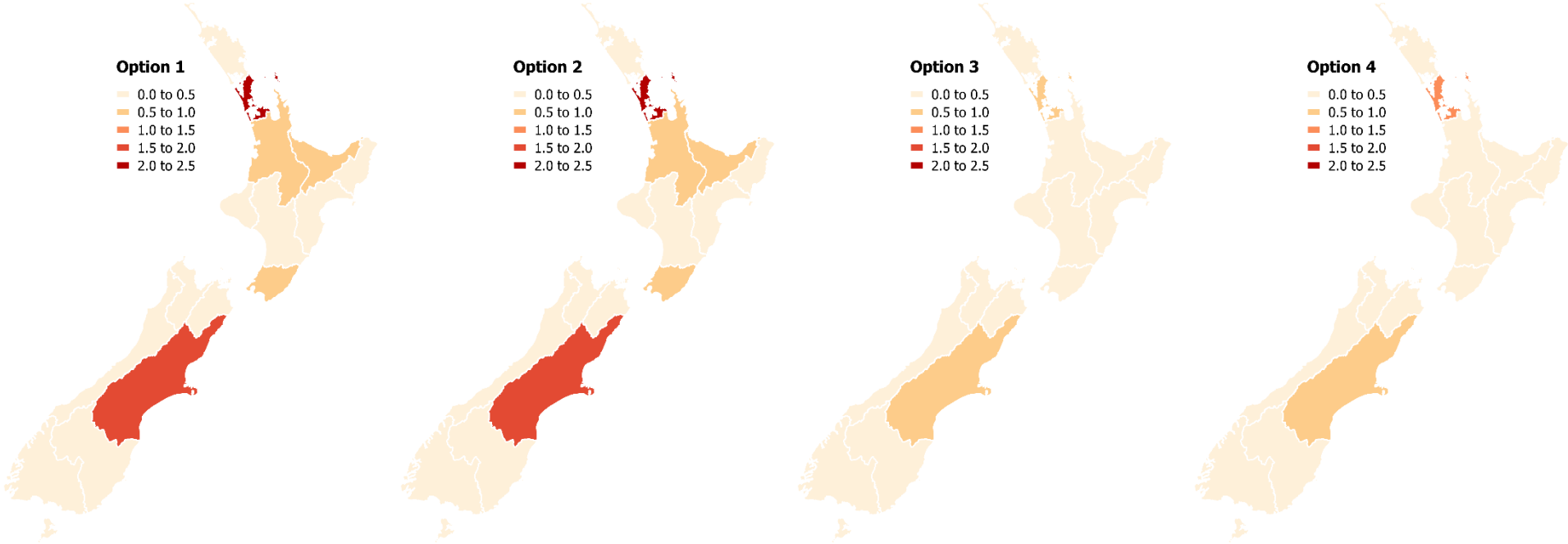
Changes in 2018 $ million per year (real terms)

Region	Option 1	Option 2	Option 3	Option 4
Northland	-0.23	-0.20	-0.08	-0.10
Auckland	-1.98	-1.81	-0.69	-0.90
Waikato	-0.24	-0.26	-0.09	-0.12
Bay of Plenty	-3.12	-3.03	-1.22	-1.59
Gisborne	-0.71	-0.98	-0.29	-0.42
Hawke's Bay	-1.44	-1.99	-0.61	-0.88
Taranaki	-0.07	-0.08	-0.03	-0.04
Manawatu-Wanganui	-0.11	-0.12	-0.04	-0.06
Wellington	-0.41	-0.46	-0.16	-0.22
Nelson-Tasman	-1.70	-1.87	-1.00	-1.17
Marlborough	-0.06	-0.07	-0.02	-0.03
West Coast	-0.43	-0.48	-0.28	-0.32
Canterbury	-4.12	-4.27	-1.46	-2.05
Otago	-0.16	-0.17	-0.06	-0.08
Southland	-0.06	-0.06	-0.02	-0.03
National	**-14.83**	**-15.86**	**-6.06**	**-8.00**

Source: NZIER

Figure 2 Regional household spending decrease

Changes in 2018 $ million per year (real terms)



Source: NZIER

Table 7 Regional impacts on household consumption from TACC reductions

Changes in 2018 $ million per year (real terms)

Region	Option 1	Option 2	Option 3	Option 4
Northland	-0.16	-0.15	-0.06	-0.08
Auckland	-2.05	-2.11	-0.80	-1.05
Waikato	-0.52	-0.56	-0.21	-0.27
Bay of Plenty	-0.81	-0.78	-0.30	-0.39
Gisborne	-0.05	-0.11	-0.03	-0.05
Hawke's Bay	-0.29	-0.44	-0.13	-0.19
Taranaki	-0.12	-0.14	-0.05	-0.07
Manawatu-Wanganui	-0.28	-0.30	-0.11	-0.15
Wellington	-0.63	-0.67	-0.26	-0.34
Nelson-Tasman	-0.37	-0.41	-0.24	-0.27
Marlborough	-0.14	-0.15	-0.05	-0.07
West Coast	-0.04	-0.04	-0.04	-0.04
Canterbury	-1.51	-1.58	-0.52	-0.72
Otago	-0.27	-0.29	-0.11	-0.15
Southland	-0.14	-0.15	-0.06	-0.08
National	**-7.37**	**-7.88**	**-2.96**	**-3.92**

Source: NZIER

2.4. Flow-on effects

Table 8 shows the indirect impacts of decreasing TACC levels for commercial tarakihi across other industries[18] within the New Zealand economy.

Partly offsetting the losses from tarakihi and by-catch industries, as well as their supporting industries, is the expansion of competing industries. These industries gain from the decrease in tarakihi TACC levels as they compete for resources (labour and capital), which become less expensive. Typically, these industries are the labour-intensive and/or export industries, such as business services, other fishing and manufacturing industries.

[18] These are industries classified under the ANZSIC classification system: http://archive.stats.govt.nz/methods/classifications-and-standards/classification-related-stats-standards/industrial-classification.aspx

- **Upstream industries** – that supply the tarakihi and by-catch fishing industries with intermediate inputs are likely to be negatively affected. Such industries include construction, finance and insurance, or industries of transport. For example:
  - Transport equipment manufacturing, which includes boatbuilding, shipbuilding and repair services, is negatively affected from fewer operating fishing vessels and fewer vehicles transporting tarakihi and its by-catch across regions. The annual industry output decreases by $0.12 million and $0.13 million per year under Option 1 and Option 2, respectively. Under Option 3 and Option 4, the annual industry output is reduced by $0.04 million and $0.05 million, respectively
  - Construction services (such as electricity and plumbing services) output decreases by an annual $0.22 million under Option 1 and is expected to decrease by an annual $0.23 million, $0.08 million and $0.10 million under Options 2, 3 and 4, respectively. This could be due to less repair needed from vessels spending less time fishing for tarakihi.
  - Petroleum and coal product manufacturing reduces by $0.17 million per year under Option 1 and is expected to decrease by an annual $0.18 million, $0.06 million and $0.08 million under Options 2, 3 and 4, respectively. This could be due to a reduction in petroleum fuel products (i.e. diesel, petrol and light fuel oil) required from fewer tarakihi fishing trips and fewer vehicles transporting tarakihi and its by-catch across regions.
- **Downstream industries** – which use and/or process the output of the tarakihi and by-catch industry into a finished or different product and reach consumers, are also likely to be negatively affected.
  - Air transport output decreases by $0.10 million per year under Option 1 and is expected to decrease by an annual $0.11 million, $0.04 million and $0.06 million under Options 2, 3 and 4, respectively. Given that tarakihi is primarily for domestic use, it is the reduction in exports of by-catch that reduces air transport.
  - Communication services (such as radio, internet, mobile and satellite communication services) decrease by an annual $0.10 million under Option 1 and Option 2, and by an annual $0.04 million and $0.05 million under Option 3 and Option 4, respectively.
- **Household expenditure industries** – Industries where households spend their income are also likely to be affected from decreased income that comes through employment and wages, and decreased returns to capital from reduced tarakihi and by-catch fishing industries. Such industries include consumption goods like food and beverage services, grocery and other goods wholesaling, or retail trade. Such industries also include housing and real estate (which takes a large share of households' budgets).
- **Competing industries** – These industries gain from the decrease in tarakihi TACC levels as they compete for resources (labour and capital), which become less expensive. Typically, these industries are the labour-intensive and/or export industries, such as services and manufacturing industries.

For example:

- Annual output of business services grows $0.87 million under Option 1 and by $0.92 million, $0.39 million, and $0.50 million under Options 2, 3 and 4, respectively. This industry includes a variety of services such as environmental consulting, agricultural, legal and accounting. With the contraction of the tarakihi and its supporting industries, their workers move to other industries which are expanding, such as other fishing[19] and metal product manufacturing. This implies a greater requirement for business services in these industries, which in turn increases the output of business services.
- Other fishing[20] annual output increases by $0.15 million under Option 1 and by $0.17 million, $0.08 million, and $0.10 million under Options 2, 3 and 4, respectively. Labour in this industry could have similar skills to those currently engaged in TAR. This would allow for worker displacement from tarakihi and by-catch industries towards the other segments within the fishing industry.
- Seafood processing output increases slightly by $0.20 million per year under Option 1, $0.12 million per year under Options 2 and 3, respectively, and $0.14 million per year under Option 4. Seafood processing industry is considered as a downstream industry but also a competitive industry as it also processes other fish species (e.g. other wild fish, aquaculture and crustaceans) resulting from the other fishing industry, whose output expands with the contraction of the tarakihi and by-catch industries.
  With the tarakihi catch reduced, why is it we expect a slight increase in fish processing? Data from Statistics NZ[21] suggests that some fishers will want to continue to fish rather than move to other occupations. When the tarakihi catch reduces, it requires:
  - Fishers to move towards fishing less valuable fish.[22] To maintain profit margins, fishers will need to catch slightly larger quantities of less valuable fish. This causes the catch of the less valuable fish to increase, raising demand for fish processing
  - A diversion of fish typically caught for export into the domestic market. With tarakihi traded mostly on the domestic market, we expect a slight increase in domestic demand for fish that are exported. This could also slightly increase the demand for fish processing.

  We expect both impacts to drive the slight increase in fish processing, although which impact will dominate is unclear. For this to occur depends on the behaviour of fishers. It could be that local factors drive behaviour that reduces catches and processing.[23]

19 Other fishing includes other wild fish species, aquaculture and crustaceans.

20 Other fishing includes other wild fish species and crustaceans.

21 Set out in the Input – Output Tables that drives the economy wide modeling.

22 Included in other fishing.

23 However, confirming this will take time and resources that are outside the scope of this work.

– Annual output for metal product manufacturing (iron, steel, aluminium) increases by $0.14 million under Option 1, by $0.15 million under Option 2, by $0.06 million and $0.08 million under Option 3 and Option 4, respectively. The growth in this industry could be due to less metal products required to build and maintain fewer fishing vessels. Instead, capital and labour substitute towards other industries that require metal products.

Overall, national output decreases annually by $18.54 million under Option 1 and by $19.80 million, $7.18 million and $9.56 million under Options 2, 3 and 4, respectively.

Table 8 Flow-on effects on selected industries at the national level

Changes in 2018 $ million per year (real terms)

Industry	Industry type	Option 1	Option 2	Option 3	Option 4
Food and beverage services	Household related industries	-0.76	-0.82	-0.27	-0.36
Grocery and other goods wholesaling		-0.70	-0.74	-0.27	-0.36
Retail		-0.56	-0.60	-0.22	-0.29
Accommodation		-0.34	-0.36	-0.12	-0.16
Education and health services		-0.28	-0.30	-0.11	-0.15
Other personal services		-0.20	-0.21	-0.07	-0.09
Sport and recreation services		-0.17	-0.18	-0.07	-0.09
Property services and dwelling		-0.16	-0.17	-0.06	-0.08
Recreational, clothing, footwear, and personal accessory retailing		-0.13	-0.14	-0.05	-0.07
Finance and insurance	Supporting industries (Supplying and downstream industries)	-0.22	-0.23	-0.08	-0.11
Construction		-0.22	-0.23	-0.08	-0.10
Petroleum and coal product manufacturing		-0.17	-0.18	-0.06	-0.08
Transport equipment manufacturing (includes boatbuilding, shipbuilding and repair services)		-0.12	-0.13	-0.04	-0.05
Road and rail transport		-0.11	-0.11	-0.04	-0.05
Air and other transport		-0.10	-0.11	-0.04	-0.06
Electricity generation and transmission		-0.10	-0.11	-0.04	-0.05
Communication services		-0.10	-0.10	-0.04	-0.05
Horticulture and fruit growing	Competing industries	0.06	0.07	0.03	0.04
Dairy product manufacturing		0.06	0.07	0.03	0.04
Meat and meat product manufacturing		0.07	0.08	0.03	0.04
Wood product manufacturing		0.07	0.08	0.03	0.04

Industry	Industry type	Option 1	Option 2	Option 3	Option 4
Fruit, oil, cereal, and other food product manufacturing		0.09	0.10	0.03	0.05
Metal product manufacturing		0.14	0.15	0.06	0.08
Other fishing (including other fish species, aquaculture and crustaceans)		0.15	0.17	0.08	0.10
Scientific, architectural, and engineering services		0.27	0.29	0.12	0.16
Business services		0.87	0.92	0.39	0.50
Seafood processing (includes processing of tarakihi, by-catch and other fish)	Competing / supporting industry	0.20	0.12	0.12	0.14
Total New Zealand industry outputs		**-18.54**	**-19.80**	**-7.18**	**-9.56**

Source: NZIER

3. Impact in 2040

Fishing industry GDP[24] is forecast to grow from $428 million to $657 million in 2040 market prices by 2040. These forecasts were estimated using NZIER's GDP simulation model. More detail on the methodology can be found in Appendix C.

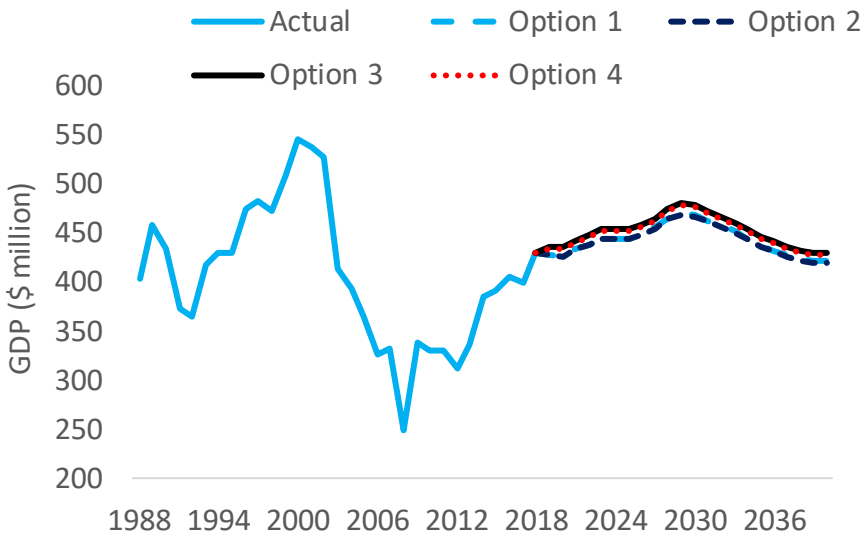
3.1. Fishing industry's GDP forecast

In 2018 market prices, the fishing industry GDP is forecast to be between $400 million and $450 million in the next 20 years (Figure 3). Another reason for static growth is that from 2030, the New Zealand economy is forecast to move more towards services, as more capital is attracted towards services and zero carbon initiatives than primary industries.

Option 2 will have the largest impact on real GDP in 2040, being $23.9 million lower per annum than if TACC remained at the same level as 2017/18. Option 1 has the next largest impact being lower by $22.4 million. Options 3 and 4 will see real annual GDP being $9.2 and $12.1 million lower than if there was no TACC reduction.

Figure 3 Real GDP for the fishing industry

Real GDP in 2018 prices ($ million)



Source: NZIER

[24] Nominal GDP represent the unadjusted value added (in $) that the industry makes to the New Zealand economy. This compares to real GDP which adjusted to take into consideration changes in price levels and therefore excludes the effects of inflation.

Table 9 shows the regional impact of Options 1, 2, 3 and 4. The regions that will see the largest impact will be:

- Canterbury – real GDP will be lower by between $2.21 million (Option 3) to $6.44 million (Option 2) in 2040
- Bay of Plenty – real GDP will be lower by between $1.85 million (Option 3) to $4.71 million (Option 1) in 2040
- Auckland – real GDP will be lower by between $1.0 million (Option 3) to $3.0 million (Option 1) in 2040
- Hawke's Bay – real GDP will be lower by between $0.92 million (Option 3) to $3.01 million (Option 2) in 2040
- Nelson-Tasman – real GDP will be lower by between $1.52 million (Option 3) to $2.82 million (Option 2) in 2040
- Gisborne, will be see real GDP lower by between $0.44 million (Option 3) to $1.48 million (Option 2) in 2040

Other regions will see real GDP lower than less than $1 million for all options.

Table 9 Forecast fall in fishing GDP

Changes in $ million per year (in 2018 prices)

Region	Option 1		Option 2		Option 3		Option 4	
	2019	2040	2019	2040	2019	2040	2019	2040
Northland	-0.23	-0.35	-0.20	-0.31	-0.08	-0.12	-0.10	-0.15
Auckland	-1.98	-2.99	-1.81	-2.73	-0.69	-1.04	-0.90	-1.36
Waikato	-0.24	-0.36	-0.26	-0.39	-0.09	-0.13	-0.12	-0.18
Bay of Plenty	-3.12	-4.71	-3.03	-4.58	-1.22	-1.85	-1.59	-2.39
Gisborne	-0.71	-1.07	-0.98	-1.48	-0.29	-0.44	-0.42	-0.64
Hawke's Bay	-1.44	-2.17	-1.99	-3.01	-0.61	-0.92	-0.88	-1.32
Taranaki	-0.07	-0.11	-0.08	-0.12	-0.03	-0.04	-0.04	-0.06
Manawatu-Whanganui	-0.11	-0.17	-0.12	-0.19	-0.04	-0.06	-0.06	-0.09
Wellington	-0.41	-0.62	-0.46	-0.70	-0.16	-0.25	-0.22	-0.33
Nelson-Tasman	-1.70	-2.56	-1.87	-2.82	-1.00	-1.52	-1.17	-1.77
Marlborough	-0.06	-0.09	-0.07	-0.10	-0.02	-0.03	-0.03	-0.05
West Coast	-0.43	-0.64	-0.48	-0.73	-0.28	-0.43	-0.32	-0.48
Canterbury	-4.12	-6.22	-4.27	-6.44	-1.46	-2.21	-2.05	-3.09
Otago	-0.16	-0.24	-0.17	-0.26	-0.06	-0.09	-0.08	-0.12
Southland	-0.06	-0.09	-0.06	-0.09	-0.02	-0.03	-0.03	-0.04
Total	**-14.83**	**-22.38**	**-15.86**	**-23.93**	**-6.06**	**-9.15**	**-8.00**	**-12.07**

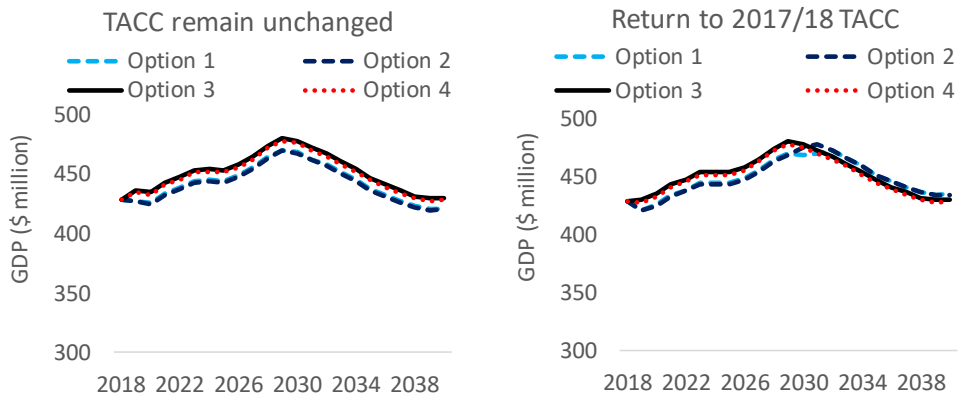
Source: NZIER

As Options 1 and 2 propose a larger reduction in TACC, it is expected that the unfished biomass will return faster (to above its soft limit of 20 percent) than Options 3 and 4. If this is the case, there is a possibility that in the future, Tarakihi TACC may be increased.

In Figure 4, the graph on the left-hand side shows the forecast real GDP if TACC remains at the proposed 2019/20 level. The graph on the right-hand side shows the forecast real GDP if Tarakihi TACC were to return to the 2017/18 level (Option 2 in 2031 and Option 3 in 2030). It shows that, in 2040, fishing GDP for Options 1 and 2 will be over $4.6 to 4.8 million higher than Options 3 and 4 if the tarakihi TACC returned to 2017/18 level. If the TACC for tarakihi does not return to 2017/18 levels, real GDP for Options 1 and 2 will be around $8.6 to 9.6 million lower than Options 3 and 4.

Figure 4 Forecast GDP if TACC returns to 2017/18 levels

Real GDP in 2018 prices ($ million)



Source: NZIER

3.2. ACE transfer and quota value forecast

Profits of tarakihi fishers and quota owners are expected to fall by between 18 and 38 percent based on our CGE modelling. However, as long as the demand for tarakihi remains strong, TACC reductions will increase the price of ACE[25] because price is directly related to supply and demand of a good. When supply is restricted, prices can be expected to increase.[26]

[25] Quota value is the present value of future ACE payments.

[26] We do not attempt to quantify ACE transfer and quota price forecast due to time and resource restrictions.

4. Conclusions

To examine the potential economic consequences across regions and the nation of changes in catch limit for tarakihi, we apply a CGE model of the regional economy to the four policy proposals with respect to TACC reductions to the East Coast Tarakihi stock and its by-catch.

Results suggest there could be between $6.1 million and $15.9 million annual reduction in the national economy, equivalent to 0.002% and 0.003% of national GDP.

These results are not linear, as the CGE model specifically accounts for changes in demand and prices of inputs across the economy, and the adjustment across sectors as some pick up resources shed by other sectors. We see a mixed pattern of negative direct impacts on tarakihi and by-catch fishing industries and supporting industries (construction, air transport, petroleum), and positive indirect effects on other sectors, but overall a reduction in value added in New Zealand.

Under the four options, the fishing industry GDP is forecast to decrease by between $9.2 million and $23.9 million in 2040.

Profits of tarakihi fishers and quota owners are expected to fall by between 18 and 38 percent based on our CGE modelling. However, as long as the demand for tarakihi remains strong, TACC reductions will increase the price of ACE[27] because price is directly related to supply and demand of a good. When supply is restricted, prices can be expected to increase.[28]

[27] Quota value is the present value of future ACE payments.

[28] We do not attempt to quantify ACE transfer and quota price forecast due to time and resource restrictions.

Appendix A Data and assumptions

A.1 Data

FNZ provided us with the following data:

- Fish catch dataset (greenweight catch volume and price for each fish species)
- Time series of TACC
- Time series of port price survey (with unit records)
- Series of estimates on the size of tarakihi catch within the fishing sector for the CGE modelling.

A.2 Assumptions and caveats

Below is a list of caveats and assumptions we made for our modelling and forecasting exercise.

- The model runs we have made depend on assumptions about values and other factors that may change over time
- We use our static TERM-NZ model, which can only look at 'before' (i.e. current situation) and 'after' (with TACC level decrease). We therefore do not explicitly model the *timing* of the decrease in tarakihi TACC levels. We simply compare the regional and national economies without and with the decrease in TACC levels. Typically, such reduction has specific costs and revenues, each incurred at different periods. A more sophisticated, dynamic modelling approach would be required to capture these timing effects. We analyse a static scenario that estimates the overall annual economic effects of a decrease in TACC levels for commercial tarakihi fishing industry.
- There are no comprehensive data sources for all aspects of the economic effects for the proposed TAR TACC options, so modelling depends on a mix of Stats NZ's official data supplemented by information from Fisheries New Zealand.
- Estimates from the CGE modelling are not forecasts because we do not know precisely how the proposed catch limits for tarakihi might play out in the New Zealand tarakihi industry. However, they do quantify the potential economic impacts of tarakihi TACC decrease.
- As tarakihi TACC levels decrease, fishers move to fishing other fish at similar depths using the fishing methods for which they are currently resourced.
- Our CGE database is based on Stats NZ's 2013 Input-Output tables. We then updated this data to 2018 levels using Stats NZ's latest national accounts (November 2018).

- We only modelled changes in catch for commercially caught tarakihi. We have not looked at the economic impacts of changes in catch or abundance relating to the recreational and customary non-commercial fishing sectors.

Despite these limitations, this modelling indicates the extent of the direct and indirect economic impacts of new catch limit options for commercial tarakihi. As more information and data becomes available, we will be able to carry out further economic modelling as required.

Appendix B CGE modelling

B.1 CGE modelling captures the full impact of new catch limit options in tarakihi and by-catch fishing industries

To capture the full impact of a decrease in tarakihi and by-catch outputs resulting from the proposed catch limit options, we use one of our CGE models.

CGE models are data-driven and used to capture the effects of a new policy or technology affecting economic activity. They capture the economy-wide effects of changes directly on the affected industry, as well as indirectly on supplying industries, competing industries, and factor markets (labour and capital). CGE models show the full effect of a change which includes impacts from indirect effects which aren't immediately obvious. The cumulative impact of indirect effects can outweigh the direct effect of a change.

CGE models also estimate the effect of a policy change on macroeconomic variables such as GDP, household spending and exports.

CGE models are a powerful tool. They allow economists to explore empirically many issues on which econometrics or multiplier analysis would be unusable. For these reasons, CGE models have become widely used internationally (e.g. by OECD, IMF, World Bank) for economic impact analysis.

B.2 Why do we prefer CGE over multipliers?

Multiplier studies[29] are popular for economic impact analysis as they are relatively cheap and produce appealing big figures. However, they are based on several assumptions which requires them to be interpreted and considered with considerable care.

Key caveats include that, in particular, multiplier studies:

- Do not consider the impacts of policy changes on the price of goods, services, intermediate inputs, labour (wages) and capital
- Assume that land, labour and capital are available in unlimited quantities, and at no additional cost to firms
- Cannot consider the opportunity cost of using additional resources in one industry on the rest of the economy – there are almost never any losers (i.e. contracting industries) in multiplier studies.

Because of these assumptions, multipliers overestimate the impacts of a change in a particular industry on the rest of the economy. Both the Ministry of Business, Innovation and Employment (MBIE) and Treasury have highlighted the inherent flaws in using multiplier studies for serious economic analysis.[30] NZIER no longer offers

[29] Also known as 'input-output studies'.

[30] For an overview of these weaknesses, see the New Zealand Treasury and MBIE. Both documents, and Gretton (2013), clearly state that multipliers over-state economic impacts and thus lack credibility for economic analysis. Or in Treasury's words:

multiplier-based analysis to our clients as they no longer align with our independence and reputation for delivering high quality, data-driven analysis.

For all these reasons, we prefer to use CGE models.

A CGE model provides an estimate of opportunity costs between action and inaction, winners and losers. Resources are limited. It also considers price impacts of a policy change and can capture linkages between industries as well as flow-on effects.

NZIER's CGE models are highly regarded amongst government agencies with whom we have worked to conduct policy analysis or sectoral impact studies. This includes MBIE, Treasury, the Ministry of Foreign Affairs and Trade, the Ministry for Primary Industries and the Ministry for the Environment.

B.3 How do CGE models work?

A CGE model consists of equations which describe model variables. It also uses detailed data on the structure of the economy that is consistent with these model equations.

This data provides a snapshot of the economy in a particular year, which is used as a starting point for a baseline (or business as usual (BAU)) against which to compare policy simulations or economic changes.

The model data is linked together through a set of equations which capture how the economy adjusts in response to a policy change. These equations, which are based on the economic theory of general equilibrium, ensure supply and demand for goods, services and factors of production in the economy are balanced, and determine how firms and households react in response to changes in incentives.

Most CGE models are written and solved in a specific software system, usually GAMS[31] or GEMPACK.[32]

In any CGE model, we must choose what is to be determined within the model (the endogenous variables) and what is to be considered external to the model (the exogenous variables). A CGE model is just a way of explaining the endogenous variables in terms of the exogenous variables.

Where we draw the line between endogenous and exogenous variables, and which ones can vary or have to remain fixed, depends on a number of factors, including the purpose for which the model simulations are to be used. The choice that we make is called the model closure.

Determining the closure is a key part of any modelling exercise and it is very important that the modeller be transparent about what is a result of the modelling and what has been imposed by assumption via the closure.

The difference between the initial and the new equilibrium can then be analysed to determine the effect of a policy on a range of economic indicators, such as GDP, household spending, exports, etc.

"Unless there is significant unemployment of people with the requisite skills, **it is therefore likely that multiplier effects do not exist**".

31 General Algebraic Modelling System: https://www.gams.com/

32 General Equilibrium Modelling Package: https://www.copsmodels.com/gempack.htm

B.4 Our CGE model TERM-NZ

NZIER's TERM-NZ[33] model is our bottom-up CGE model of the New Zealand economy and its 15 regions. TERM-NZ is based on a Stats NZ's Input-Output table that identifies the structure of the industries involved. It contains information on 106 industries, 201 commodities and 15 regions.

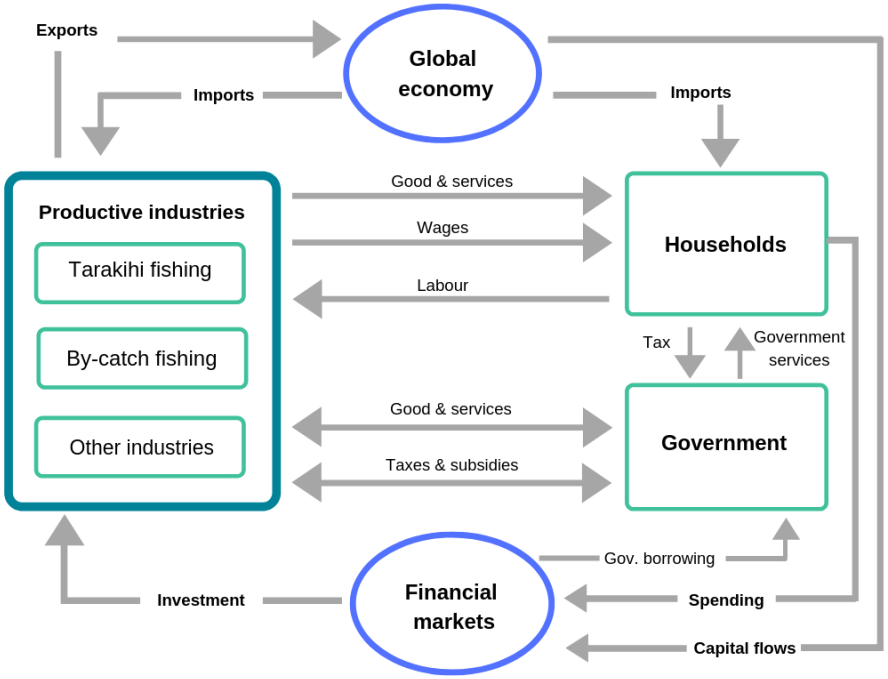
For this study, we have aggregated the model's database to 54 industries and 77 commodities, which include separate sectors for tarakihi and by-catch.

TERM-NZ treats New Zealand's regions as separate economies. This means that we are able to account for region-specific inter-linkages between industries, as well as their links to households (via the labour market), local and central government, capital markets, the rest of New Zealand (via inter-regional trade) and the global economy (via imports and exports).

The model shows how the reduced commercial catch rates of TAR might affect the regional and national economies.

A visual representation of our CGE model is shown in Figure 5. It highlights how the model captures the complex and multidirectional flows between the various actors of the national economy and how they interact with the rest of the world. More technical details on the model are available upon request.

Figure 5 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

[33] TERM-NZ stands for "The Enormous Regional Model" of the New Zealand economy. It was developed at NZIER based on the original Australian TERM model created by Professor Mark Horridge of the Centre of Policy Studies, Victoria University-Melbourne, Australia. http://www.copsmodels.com/term.htm. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

Key features of the model are:

- Each industry can produce a number of different commodities.
- Production inputs are intermediate commodities (domestic and imported) and primary factors (labour, land and capital).
- The demand for primary factors and the choice between imported and domestic commodities are determined by Constant Elasticity of Substitution (CES) production nests. This means an increase in price of one input shifts sourcing towards another input.
- Intermediate goods, primary factors and other costs are combined using a Leontief production function. This means the proportion of production inputs is held constant for all levels of output.
- The production mix of each industry is dependent on the relative prices of each commodity. The proportion of output exported or consumed domestically is also dependent on relative prices.
- Policy impacts are often unevenly spread across industries and regions. To capture these heterogeneous effects, the model uses a 'bottom-up' approach in which the national impacts are the sum of the regional impacts.[34]

B.5 Our modelling approach

We use the static version of our regional CGE model, so that we compare the economy before and after a policy option is applied. There is no time dimension in the static model, so we do not look at how the economy adjusts to a new equilibrium.[35]

The policy option applied disturbs the equilibrium in the economy, and the model calculates changes in demand, supply and prices of inputs (like labour and capital) then reallocates them across sectors according to where they get greatest returns, establishing a new equilibrium after a policy has been implemented.

B.6 Tailoring the model's database

The model's database has been sourced initially from Stats NZ's 2013 Input-Output tables. We then updated this data to 2018 levels using Stats NZ's latest national accounts (November 2018).

We have expanded our standard CGE database by separately identifying tarakihi, by-catch and other fish from Stats NZ's initial Input-Output table which only has an aggregated fishing industry and another aggregated seafood processing industry.

To do so, we used catch volumes (greenweight kg) by fish species and corresponding port prices from FNZ to estimate the value of tarakihi catch at $13.8 million and by-catch at $7.7 million for 2018. When port prices were missing, we applied the

[34] The regions in the model are: Northland, Auckland, Waikato, Bay of Plenty, Gisborne, Hawkes Bay, Taranaki, Manawatu-Wanganui, Wellington, Nelson-Tasman, Marlborough, West Coast, Canterbury, Otago, Southland.

[35] These fluctuations may have significant impacts in their own right and could be captured in future research by using our more sophisticated, dynamic CGE model.

weighted average price (by greenweight) for the corresponding fish species volume. When we had no price using this method, we used the weighted average price across all fish species. Note that the value of tarakihi includes tarakihi as a by-catch. The value of targeted tarakihi alone is estimated at $11.9 million ($1.8 million tarakihi caught as by-catch from targeting other species).

We then used the composition of the fishing industry (from Stats NZ Input-Output table) to build the tarakihi and by-catch industries. We estimated the value of the tarakihi industry at $40 million and the value of the by-catch industry at $22 million (Table 10).

Table 10 Composition of the tarakihi and by-catch industries

2018, $ million

Fishing industry*			Tarakihi	By-catch
Intermediate consumption	Share	$m	$m	$m
Fish	18%	240	13.78	7.69
Crustaceans	16%	216	0.0	0.0
Fishing Services	2%	22	0.7	0.4
Fish preparation	47%	615	18.6	10.4
Machine & equipment	17%	216	6.5	3.7
Commercial property services	1%	1	0.0	0.0
Research & development	0.1%	2	0.0	0.0
Total	**100%**	**1312**	**40**	**22**

Note*: Fishing industry composition is based on Stats NZ IO table.

Source: NZIER

B.7 Scenario design

The policy option applied disturbs the equilibrium in the economy, and the model calculates changes in demand, supply and prices of inputs (like labour and capital) then reallocates them across sectors according to where they get greatest returns, establishing a new equilibrium after the policy has been implemented.

Based on discussions with FNZ officials, we considered four policy options associated with different levels of TACC decrease for commercial tarakihi, and lower outputs in the commercial tarakihi and by-catch fishing industries. The four policy options are: Option 1, Option 2, Option 3[36] and Option 4. Table 11 shows the options from varying TACCs provided by FNZ.

We first model Option 3 (Status Quo – 20% cut in TACC implemented in October 2018) and use these results in our new database to model the impacts of Option 1, Option 2 and Option 4 in a TACC level decrease for commercial tarakihi. However, we report the results to reflect the change compared to if no TACC reduction had been

[36] Option 3 represents the Status Quo (not the counter-factual) in relation to the current review, but as with all options, it includes a 20% cut in TACC level implemented as part of the first stage of the review, in October 2018.

set. In other words, the four options are compared against a counter-factual which is the situation prevailing pre-1st October 2018.

Table 11 Options for decreasing TACCs

TAR	Option 1	Option 2	Option 3	Option 4
TAR 1	43%	24%	0% (20% in 2018)	5%
TAR 2	27%	50%	0% (20% in 2018)	10%
TAR 3	48%	50%	0% (20% in 2018)	10%
TAR 7	5%	9%	0% (20% in 2018)	2%

Note: Percentages in the table are percentage decreases.

Source: NZIER, FNZ

Table 12 shows the main port of origin within each region and their regional shares in percent. Results within this table were created by mapping ports of origin and their corresponding regional councils. We then aggregated the greenweight by port of origin to each region.

Table 12 Main ports of origin for commercial tarakihi fishing

Shares are based on greenweight by port of origin for 2018

TAR	Regions	Port shares of origin
TAR 1	Northland	13.93%
	Auckland	36.51%
	Bay of Plenty	40.98%
	Rest of NZ	**8.59%**
TAR 2	Gisborne	27.54%
	Hawke's Bay	39.22%
	Bay of Plenty	26.61%
	Wellington	4.45%
	Rest of NZ	**2.18%**
TAR 3	Canterbury	82.81%
	Otago	4.56%
	Nelson-Tasman	12.00%
	Rest of NZ	**0.63%**
TAR 7	West coast	37.04%
	Nelson-Tasman	53.61%
	Wellington	5.94%
	Marlborough	0.02%
	Rest of NZ	**3.39%**

Source: NZIER, FNZ

Table 13 shows the regional policy options applied for the CGE modelling. These policy options were estimated by pro-rating the TACC option levels from FNZ (Table 11) with the regional shares of port of origin (Table 12).

Table 13 Regional policy options for new TACC

In percentage change

Regions	TAR	Option 1	Option 2	Option 3	Option 4
Northland	TAR 1	-6.552	-3.657	-3.047	-0.762
Auckland	TAR 1	-17.173	-9.585	-7.987	-1.997
Bay of Plenty	TAR 1 & TAR 2	-26.620	-24.360	-14.406	-4.962
Gisborne	TAR 2	-7.602	-14.077	-5.631	-2.815
Hawke's Bay	TAR 3	-10.825	-20.047	-8.019	-4.009
Wellington	TAR 2 & TAR 7	-1.536	-2.828	-2.140	-0.578
Nelson-Tasman	TAR 3	-8.571	-11.032	-13.513	-2.317
Marlborough	TAR 3	-0.001	-0.002	-0.004	0.000
West Coast	TAR 7	-1.917	-3.451	-7.668	-0.767
Canterbury	TAR 3 & TAR 7	-40.001	-41.668	-16.667	-8.334
Otago	TAR 7	-2.203	-2.294	-0.918	-0.459

Source: NZIER, FNZ

B.8 Closure

Given that a decrease in TACC has an immediate effect, we assume a short run model closure in which the following assumptions are made:

- National real wage is rigid, and the national employment adjusts
- Labour is completely mobile between industries and partially mobile across regions
- The short-run rates of return to capital adjust to maintain fixed national investment. However, capital is mobile between industries and regions
- Regional household consumption follows regional wage income. National household propensity to consume is fixed
- Foreign currency prices of imports are naturally exogenous
- Real government consumption is also exogenous.

Results are reported as dollar values and percentage changes from the counterfactual, in which no policy change has occurred.

B.9 Interpreting the results

The CGE technique calculates impacts as changes relative to the baseline level. Results are then reported as percentage changes from the baseline forecast.

In analysing the modelling results we track the impacts as they flow through the economy, beginning with the **direct** impacts on the tarakihi and by-catch fishing sectors. We then analyse the flow-on or **indirect** impacts. It can aid understanding to split indirect impacts into the following categories:

- **Supporting** industries – industries that support or supply the tarakihi and by-catch fishing industries with intermediate inputs are likely to be negatively affected. Such industries include seafood processing, transports, etc.
- **Household** expenditure industries – industries that households spend money on are likely to be negatively affected from decreased income that comes through employment and wages, and decreased returns to capital from a reduced tarakihi and by-catch fishing industries. Such industries include housing and real estate (which takes a large share of households' budgets), and those for consumption goods like the retail trade.
- **Competing export** industries – industries that benefit from the decrease in tarakihi fishing industry's as they compete for resources.

The national results flow logically from the regional direct and indirect impacts. We focus on key macroeconomic variables such as GDP, exports, and household spending which we use as a proxy for wellbeing.

Appendix C Forecasting methodology

Fishing industry GDP

To estimate regional GDPs, we apply a bottom-up approach by first determining GDP at the area unit level then summing up the corresponding area units under each region to get the regional level GDPs.

To estimate GDP, we use two sub models:

- population simulation
- economic growth and labour simulation sub models.

Both sub models use a wide range of inputs such as annual inputs from Stats NZ, and Census data to simulate results at the area unit level.

For population simulation, in addition to input data from Stats NZ, we use a sub model for migration between regions. Outputs for the population model are population (by age and sex), households by type, average age of households, number of people per household, labour force and long-run employment.

Economic and income sub model inputs are regional GDP, national and industry multifactor productivity growth, trend growth in industry GDP, historical covariance between industries in economic activity (using a Vector Auto Regressive (VAR) model), relationship between GDP per capita and household (HH) incomes. Output of the model is:

- GDP by industry and region
- household incomes by type and region.