2023

Pāua Quota Value Bio-Economic Model – based on the PAU 2 Fishery

INSTRUCTION MANUAL

ANZ BANK NEW ZEALAND LIMITED

Table of Contents

Contents

Important Information

This document has been prepared by ANZ Bank New Zealand Limited (**ANZ**).

This document and the Information:

- has been prepared solely for informational and discussion purposes.
- does not constitute advice nor a recommendation to, and should not be interpreted as an, offer to sell or a solicitation of an offer to buy any product, security, instrument or investment in New Zealand or any other jurisdiction.
- does not constitute a commitment to participate in any transaction or to provide, or offer, any financial accommodation or to conclude any legal act of any kind and creates no obligation or liability on ANZ.

ANZ believes the Information to be correct at the time it was compiled but neither ANZ nor its directors, officers, employees, agents, advisers and representatives (**Related Parties**) make any representation as to, nor accept any responsibility or liability whatsoever for, the accuracy, reliability or completeness of the Information or to inform you of any matter that subsequently comes to their notice, which may affect the accuracy, reliability or completeness of the Information.

ANZ and its Related Parties will not be responsible or liable (except to the extent imposed by law) for any direct or indirect loss, cost, damage or expense whether in tort, negligence, contract, equity or otherwise as a result of or arising from the Information not being accurate, complete or being relied upon by you or any other person.

1. Introduction

This manual has been prepared for the Pāua Quota Value Bio-Economic Model (the Model). It provides:

- Purpose of the model
- A model description and structure diagram
- A description of each worksheet
- An explanation of the calculations performed; and
- Instructions for inputting and running scenarios.

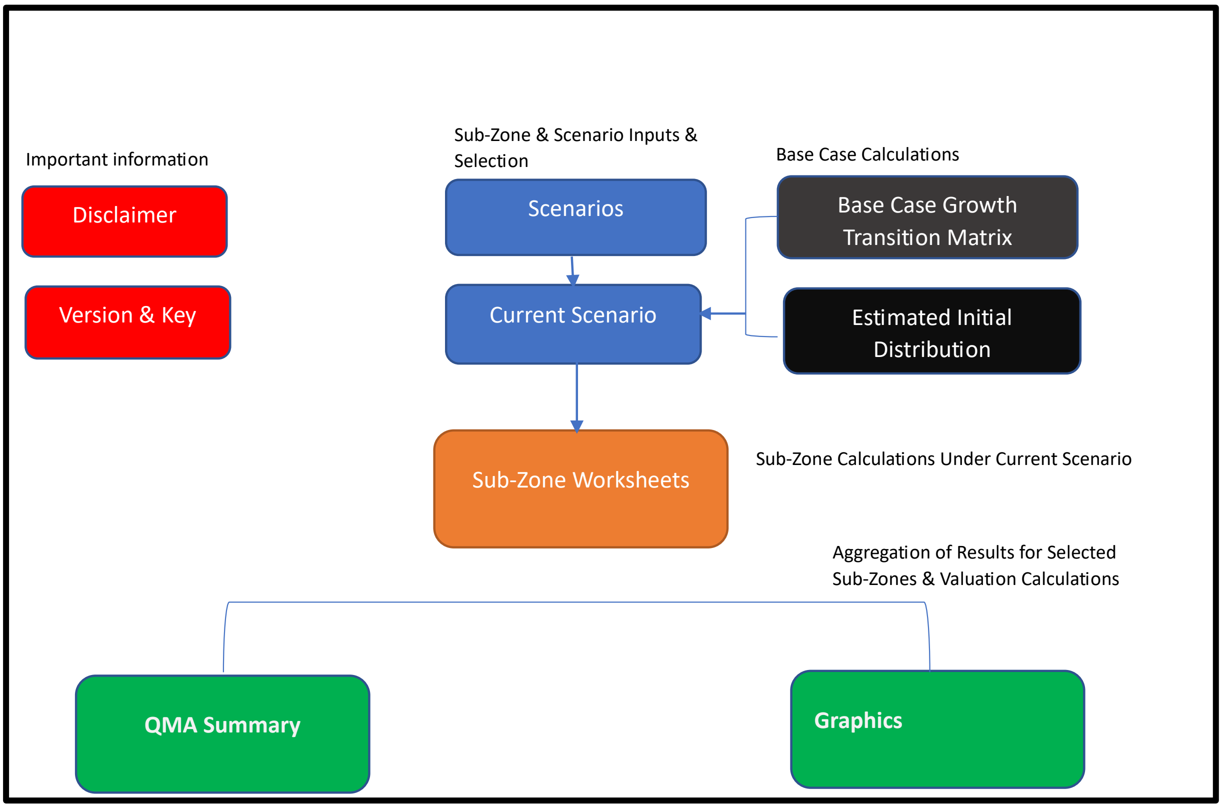
It accompanies the report "Upholding the Value of Pāua Quota – A Research Compendium" that fully describes the work.

2. Purpose of the model

The purpose of the model was to determine the impact to a fishery from differing climate change factors, the flow on effect to the potential number of fish available within a particular size range for harvest under variable climate factors, the potential impacts to the setting of a Total Allowable Catch (TAC) and Total Allowable Commercial Catch (TACC) and therefore the impact to quota rights and interests.

3. Model Description

The model was built in Excel and consists of thirty-nine (39) worksheets. Two (2) of the worksheets allow varying inputs by users to create and select scenarios and sub-zones. The remainder of the worksheets perform calculations, aggregate and graph results, or contain information as illustrated in the structure diagram below.



4. Description of Each Worksheet

4.1 Important Information

This worksheet contains important information which must be read by all users before using the model.

4.2 Version & Key

This worksheet records the current version number of the Model and summarises changes from the previous version.

The key explains the cell colour coding.

4.3 Current Scenario

This worksheet contains a summary of the current scenario. Certain nformation is inputted into this sheet by the user. Please refer below for a list of all inputs. This sheet also picks up information in relation to the scenario selected to be run from the Scenarios worksheet.

Only one scenario is run at a time. The user selects the scenario to run and the sub-zones [1]to which it applies. For example, it might be assumed that environmental stressors may result in growth of pāua slowing and/or mortality increasing at different rates in different sub-zones. The user could create a scenario with growth rates slowing and mortality rates increasing sooner in some sub-zones and then run a different scenario for other sub-zones where slowing growth rates or increased mortality start occurring from a later date. The results of each scenario could then be aggregated to test the total impact on quota value of the combined scenarios and sub-zones.

All the subzone sheets are connected to the Current Scenario. However, only the results for the selected subzones feed into the quota valuation summary.

4.4 Scenarios

This worksheet contains the assumptions regarding:

- biological parameters for pāua (recruitment rate, mortality rate, growth transition matrix and fishing selectivity); and
- fishing parameters (legal limit, total allowable commercial catch, customary, recreational, and illegal catch, management cap).

The user can create their own scenarios by entering assumptions in the row next to the relevant scenario name and then run the scenario by selecting that scenario name on the Current Scenario worksheet from the drop-down menu.

4.5 Base Case Growth Transition Matrix

This sheet contains data from the stock assessment model. Pāua are allocated into length buckets of 2 mm from 70mm up to 170mm[2]. The column at the far left indicates the opening length bucket for

[1] Note - The nature and extent of a Sub zone is determined by the user - For Paua2 divers report their catch across 28 statutory reporting areas a user may choose to apply the model at that level, a combination of those areas or something completely different

[2] The Stock Assessment Model starts at 70mm, this is when juvenile pāua are known to emerge and become more visible.

pāua. The columns to the right show the proportion of pāua that were in that opening length bucket at the start of the year, which moved to the length bucket at the right after one year.

4.6 Estimated Initial Distribution

This worksheet shows the calculations which were performed to derive the estimated initial biomass for the whole of Pāua 2 and its distribution by length bucket. These numbers are hardcoded and have been copied into the Current Scenario worksheet. While the sheet allows for up to 60 years' calculations to be performed, the balance at 10 years has been selected as the opening balance in order to create a biomass of a similar size to the stock assessment model for PAU 2.

a. Sub-Zones

Each sub-zone (currently 31 in total) has its own worksheet. All the worksheets have the same format and perform the same calculations.

The opening number of pāua by length bucket for the relevant sub-zone is picked up from the Current Scenario and then a series of calculations is performed over a 20 year period.

The growth of pāua over the year is calculated by moving the pāua in one length bucket to the length bucket which applies under the current growth transition matrix for the following year.

The population of pāua is increased each year by new recruits and reduced by the estimated number of pāua mortalities as result of

- Recreational, customary, and illegal fishing,
- commercial fishing, and;
- natural mortality ("instantaneous mortality").

The closing balance of pāua is calculated by length bucket and those numbers are used as the opening balance for the following year.

b. Quota Management Area (QMA) Summary

This worksheet contains summary tables of the results for the selected sub-zones and then performs calculations of the quota value using the estimated annual catch. Quota value is calculated on the basis of the discounted net cash flows.

c. Graphics

This worksheet graphs results from the QMA Summary.

5. Calculations

5.1 Estimated Initial Distribution of Biomass for Pāua 2

At the beginning, there are assumed to be zero pāua. The base case recruitment success rate, instantaneous mortality rate and growth transition matrix are assumed to be constant.

Each year, the same number of new recruits is calculated using a formula (constant e(2.718281828459 ^[14.5]). The new recruits are split equally between 5 length buckets (70mm, 72mm, 74mm, 76mm and 78mm).

In the following years, the recruits move from one length bucket to the next based on the proportion allocated to the relevant length bucket for pāua of that opening length.

Each year, pāua numbers increase by the new recruits and then are reduced by instantaneous mortality. The mortality rate is applied to each length bucket. These calculations are repeated over

10 years and the final numbers and distribution by length bucket are assumed to be the total opening biomass for Pāua 2.

The proportion of the total biomass which is allocated to a sub-zone is determined by the user and input into the current scenario.

5.2 Sub-Zone Calculations

The Sub-Zone calculations are made using the Current Scenario information.

Growth transition, which applies for each length bucket is calculated by adding the growth transition amount for that length bucket at that date to the length bucket.

The number of new recruits is calculated as the product of the percentage under the Current Scenario for that date applied to the base recruitment number and the percentage of the biomass allocated to the Sub-Zone. The new recruits continue to be split equally between 5 length buckets as set out above.

Before calculating fishing mortality, fishing selectivity is determined. Fishing selectivity relates to the proportion of pāua within a particular size range that is assumed to be accessible for fishing. The bottom of the range is the length assumption at 50% selectivity. The top of the range is the length assumption at 95% selectivity. Within this range, the proportion available increases with size. The number of pāua available for fishing (the Available Pāua) is calculated by applying the selectivity percentage in the table for that date to the number of pāua in the relevant length bucket for that date using look up tables.

The weight of Available Pāua for the relevant length bucket is calculated using the weight formula from the stock assessment model. The weight for Available Pāua is the sum of the product of Available Pāua numbers for each length bucket by the weight of a pāua of that length.

Fishing mortality because of recreational, customary, and illegal fishing (CRIF) is calculated first. Using the assumptions in the Current Scenario and the weight of the Available Pāua, it is determined whether there is sufficient pāua to satisfy the amount targeted. It is assumed that CRIF only applies to pāua above the legal limit even though customary fishing is not subject to legal size limits. The lower of the two amounts is the amount determined to have been caught. The catch is spread proportionate to the weight of Available Pāua in each length bucket. Next, the tonnage is converted back into pāua numbers by dividing the tonnage caught per length bucket by the weight for a pāua of the relevant length. The Remaining Available Pāua (the RAP) is calculated by subtracting the caught pāua from the Available Pāua to determine both the number and the weight.

Fishing mortality from commercial fishing is then calculated. With commercial fishing mortality management "caps" on the amount which can be taken both in terms of weight and number can also be set. The tonnage is limited by the Total Allowable Commercial Catch (TACC). The number is limited by the management cap. The average weight of the RAP is determined firstly. Then the management cap percentage is applied to the number of RAP to check whether the product of that amount and the average weight is less than the TACC. If so, the actual tonnage limit for that year is determined under the management cap. If the result is greater than or equal to the TACC, the TACC applies. The result of this calculation is the Estimated Commercial Catch. After these calculations are performed, the number and weight of pāua caught commercially is calculated in the same manner as the CRIF calculations above and the number and weight of the Total Remaining Pāua (TRP) of all lengths is determined.

Finally, the instantaneous mortality rate is applied to the TRP to calculate the number of TRP mortalities in each length bucket. The net number of TRP after instantaneous mortality is carried across as the opening balance for the following year.

5.3 Quota Valuations

The summary tables calculate the number and weight of pāua for the sub-zones selected along with the CRIF, commercial catches and mortality numbers. The tables below the quota valuation provide the individual results for the selected sub-zones. The aggregate estimated commercial catch for the selected sub-zones feed into the quota valuations.

Two methods are used for calculating the value. Both are done from the perspective of quota owners.

The traditional method involves calculating the internal rate of return over a 10-year period on the basis of the assumed investment value, net cash flows per annum and terminal value. The quota price may be adjusted upwards or downwards depending on the return the investor is seeking for the risk.

The investment value is determined based on the Estimated Commercial Catch and the assumed price per kg of quota. The net cash flows per annum are the product of the Estimated Commercial Catch and the lease rate per kilo net of quota levies adjusted for CPI movements. The terminal value is the product of the Estimated Commercial Catch and the quota price adjusted by CPI.

The capitalised value calculates the present value of the lease rental income net of quota levies adjusted for inflation divided by the weighted average cost of capital. The result reflects the estimated value each year of the investment.

6. Instructions for Inputting and Running Scenarios

The user can only input cells which are highlighted in yellow on the Current Scenario and Scenarios worksheets. Following is a list of each input cell and the information to be entered. Generally, the heading for an input cell will be on the left or at the top of the relevant column in a table where there are a number of different input cells for different sub-zones and/or different scenarios.

6.1 Current Scenario Worksheet Inputs

Heading	**Yellow Input Cell Next To or Below Heading as Applicable**
Current Scenario	The input cell contains a drop-down menu with a list of all the scenarios. The user selects the scenario they wish to run. Only one scenario can be run at a time.
From	The user enters the date from which the modelling is to be performed.
Sub-Zone Description	The user enters a description of the sub-zone, e.g. where it's located and the area it covers.
Include in QMA Summary (Y/N)	The user selects either Y (meaning yes) or N (meaning no) from the drop-down menu for each sub-zone to indicate for which sub-zones they want the scenario to be run.
Total Allowable Commercial Catch (TACC)	The user allocates a portion of the TACC limit in tonnes to each sub-zone as elected by the user.
Historical Customary, Recreational and Illegal Fishing (tonnes)	The user specifies tonnage for customary, recreational and illegal fishing for each sub-zone

% Allocated to Each Sub-Zone	The user enters a percentage in the cell below each sub-zone to indicate what proportion of the total opening biomass they estimate would be located in the relevant sub-zone.
Price	The user enters the assumed price per kilogram of pāua quota.
ACE price at opening	The user enters the assumed price per kilogram for the estimated commercial catch each year
Quota levies at opening	The user enters the quota levies per kilogram for the estimated commercial catch.
Capital growth	The user enters the assumed annual capital growth rate.
Weighted average cost of capital	The user enters the assumed weighted average cost of capital as a percentage.
Adjustment to the Discount Rate for Other Climate-Linked Risks	The user can make a further adjustment to the discount rate used to calculate the capitalised market value of quota by adding or subtracting an amount from or to the weighted average cost of capital. For example, if there were additional risks which needed to be priced into the value, the user might add an amount.

6.2 Scenarios Worksheet Inputs

Heading	**Yellow Input Cell Next To or Below Heading as Applicable**
Current Scenario	The input cell contains a drop-down menu with a list of all the scenarios. The user selects the scenario they wish to run. Only one scenario can be run at a time.
Scenario Description	The user enters a description of the scenario which summarises the factors which are being tested, e.g. "mortality rate increases by x% every year, no other changes to base case".
Recruitment Success Rate Over Time as % of Previous Year	The user inputs a percentage each year which indicates whether they think the recruitment success rate will be lower, higher, or equal to the previous year's rate. If the rate is lower, a percentage below 100% is entered. If higher, a percentage greater than 100% is entered. If equal to the previous year's rate, 100% is entered.
Growth Transition Matrix	Each scenario can contain up to five different growth transition matrices. The user selects the growth transition matrix which they want to apply each year from a drop-down menu. The user can also make changes to the existing growth transition matrices
Instantaneous Mortality	The instantaneous mortality rate is applied to the number of pāua remaining in each length bucket after aggregate fishing mortality. The user enters the assumed rate each year. For example, the fishing mortality rate under the base case is 1 minus the natural log of -0.11. The rate can vary from year to year as input by the user.
Size at Which 50% of Pāua are Available for Fishing	The user enters the start of the fishing selectivity range in mm each year. As the length buckets are split in 2 mm bands from 70mm, the even number below the legal fishing limit is used as the start of the range for fishing selectivity. For example, if the legal limit is 125mm, 124mm has been used as the start of the range to ensure that pāua between 124 mm and 126 mm are not excluded from the calculation.

Size at Which 95% of Pāua are Available for fishing	The user enters the assumed end of the range for fishing selectivity in length in mm each year.
Fishing Parameters	The user enters the assumed legal limit. As the length buckets are split in 2 mm bands from 70mm, for the purposes of modelling the even number equal to or immediately below the legal fishing limit should be used. For example, if the legal limit is 125mm, 124mm has been used as the legal limit to ensure that pāua between 124mm and 126mm are not excluded from the calculations.
Total TACC as a % of Opening TACC numbers	The user enters the assumed percentage of the opening TACC which applies each year of the scenario. For example, if no change to the TACC is assumed, the user enters 100%. If a higher TACC is assumed, the user enters a percentage greater than 100%. If a lower TACC is assumed, the user enters a percentage less than 100%. The user can vary the percentages from year to year under a scenario.
Management Cap as % of Numbers of Available Pāua	The user enters a percentage each year for a scenario which represents the assumed number of pāua which can be taken under limits set by management. For example, if management wanted fishing to be limited to 40% of the pāua then available, the user would enter 40% each year. The user can vary the percentages from year to year under a scenario. Otherwise 100% is used.
Customary, Recreational and Illegal Catch (CRIF) as a % of opening Tonnage	The user enters the assumed percentage of the opening CRIF tonnage which applies each year of the scenario. For example, if no change to the CRIF tonnage is assumed, the user enters 100%. If a higher CRIF tonnage is assumed, the user enters a percentage greater than 100%. If a lower CRIF tonnage is assumed, the user enters a percentage less than 100%. The user can vary the percentages from year to year under a scenario.
Consumer Price Index (CPI)	The user enters the assumed CPI change as a percentage for each year of a scenario.

6.3 Running Scenarios

Once the Current Scenario and the Scenarios worksheet have been completed by a user, the user runs a scenario by selecting the scenario from a drop-down list on the Current Scenario worksheet.

6.4 Results

The aggregate results for the sub-zones selected under the current scenario can be viewed on the QMA Summary worksheet. This worksheet shows:

- the movement in pāua numbers each year and the weighted average length of all paua
- the weight of pāua taken under CRIF and commercial fishing;
- the weighted average length of pāua commercially fished; and
- estimated value of the pāua quota for the selected sub-zones.

The graphed results can be viewed on the Graphics worksheet.