Mediated Modelling of Coastal Ecosystem Services:

A case study of Te Awanui Tauranga Harbour

Manaaki
Taha Moana

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Mihi

TE KORORIATANGA KO TE ATUA TE TIMATANGA ME TE WHAKAMUTUNGA OR NGA MEA KATOA NO REIRA TENA KOE.

KA HURI ATU KE NGA AITUA KI RUNGA I O TATAU MARAE MAHA HURI NOA I TAURANGA MOANA HAERE, HAERE, MOE MAI RA.

MIHI MAI WHAKATAU MAI E NGA RANGATIRA KE TE KAUPAPA O TE RA TE ORANGA O TENEI O TATAU TAONGA WHAKAHIRAHIRA TE MOANA O TAURANGA KO "TE AWANUI".

I TUMANAKO NEI, KO TE WHAI I TE ATUA O TE KAUPAPA NO REIRA TENA KOUTOU, TENA KOUTOU, TENA KOUTOU KATOA.

Glossary of Te Reo terms used in this report

TE REO TERM:	ENGLISH translation:
Mihi	To Greet, Give thanks, Pay tribute
Kaimoana / kai / moana	Seafood / food / sea
Mauri	Life force
Pipi	A type of shellfish (*Paphies australis*)
Tuatua (also referred to as tua tua in places)	Ocean pipi (*Paphies subtriangulata*)
Iwi, hapu, whanau	Tribe, subtribe, family
Tangata whenua	People of the land (New Zealand's indigenous people)
Matauranga	knowledge
Kai awa	food of the river
Karakia	prayer
Tītiko	mud snail
Kingitanga	Maori King Movement
Parore	Black snapper (*Girella tricuspidata*)
Keruru, Tui	Native species of birds found in NZ. (NB: "Tui" referred to on p 129 = an alcohol company)
Te Awanui	Tauranga harbour
Manaaki Taha Moana	Care for Seaside, Ocean
Kohekohe	Type of tree (*Dysoxylum spectabile*)
Matuku	Types of Heron (Bird)
Pākeha	European settler
Taonga	Treasured
Kaitiakitanga	Guardianship

Disclaimer

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EXECUTIVE SUMMARY

The Mediated Modelling (MM) component of the Manaaki Taha Moana (MTM) project brought together about 20 key stakeholders for a series of five workshops between November 2010 and May 2011. These workshops were organised around the facilitated construction of a system dynamics model (using STELLA software) to support a complex dialogue about the Tauranga Harbour and its Ecosystem Services.

This report describes the pre-workshop training and preparation, workshops, the pre- and post-survey results, and the Tauranga Coastal Ecosystem Service Model (TCESM) that evolved during the workshops. The report presents key findings and recommendations based on the mediated modelling process. The findings and recommendations address both process issues of community building through the collaborative efforts during workshops, as well as content issues such as gaps in information and the potential to improve the model as a tool to support collaborative and adaptive management. The Mediated Modelling (MM) process aimed to provide structure to a complex, multi-stakeholder dialogue and an element of "science translation" to a collaborative effort on the management of Tauranga Harbour. "Science translation" refers to a simplification of complex data into information that can be used in a dialogue among diverse stakeholders. This report captures the achievements of the MM process within the time allotted, and acknowledges that such a process may easily involve ten rather than five workshops. Given that MM is an adaptive management tool, there is always room for improvement. An integral aspect of the MM process was the training of local capacity to update and change the MM scoping model. The MM scoping model can be used to illustrate the context of future research areas and can be updated with future research results, as they become available, emphasising the adaptive and capacity building nature of this tool.

The goal of the MM process was two-fold:

- A scoping exercise to identify the major research gaps about the state of Tauranga Harbour, thereby helping inform the selection of ongoing case studies in the MTM research programme;

- To provide a neutral space for a broader dialogue among a network of diverse stakeholders, who often meet in contentious processes, through which they could learn from each other, and use the ongoing fact-based dialogue to develop an initial model of the social, cultural, economic, and ecological aspects of Tauranga Harbour, and the interactions of these different aspects.

The majority of participants at the first two workshops agreed that the model should answer the following key questions:

1. What are the three processes or factors that most threaten the health of the Harbour (i.e., what are the causes of the three most worrying symptoms?

2. What are the desired outcomes and indicators of a sustainable Harbour with respect to four aspects of well-being?

3. What are the solutions for ecosystem restoration (what, when, who, and how?) to the identified processes or factors that most threaten the health of the Harbour that can make an impact, and how much of an impact can they make?

4. What social values can we modify to help implement the solutions in Q3?

These questions are very broad and merely provided the context for the model building and subsequent scenarios development.

The project team drafted broad answers to these questions based on the discussions at the workshops and asked the participants to review the answers. The answers were also broad and generally accepted in this form by the participants. Answering the questions in this way assisted in (1) managing the expectations that the answers to the broad questions were unlikely to be very concrete; and (2) confirmed to the project team the appropriateness of the proposed general direction for the MM workshops and some key points to include in discussions.

The answers to the above questions (with minor edits) were:

1. The three major issues (symptoms) that emerge are: 1) sedimentation; 2) eutrofication; 3) loss of taonga species such as kaimoana, habitat. The three driving processes/factors that cause these issues are: 1) increased industrial/economic activity; 2) coastal development and urban pressures and associated pollution; 3) system not "counting" ecosystem services.

2. *Ecological*: Water in the Harbour must be of the same quality as that at the uppermost part of catchment, i.e. clear, drinkable, sustains life.
Social: Valued uses of the Harbour can still occur, e.g., fishing. Mana-enhancing social systems reliant on the Harbour, such as the ability to collect kaimoana, are intact.
Cultural: Mauri of the Harbour is sustained through kaitiakitanga
Economic: The value of ecosystem services is accounted for in the economic system, with appropriate incentives and regulations, so that use of ecosystems is sustainable and does not erode the natural capital on which the economy depends, thus enabling ongoing but sustainable "economic" activity in the region.

3. Future research is recommended to better understand the role of wetlands, mangroves and salt flats as intertidal habitats with potential to accumulate sediments and filter nutrients, acknowledging that such areas may also release sediments and nutrients to the Harbour through cutting or storm events. "Users" of ecosystems or groups/industries that benefit from ecosystem services provided by the Harbour contribute to the maintenance/restoration of those ecosystems, for example, through funds set up specifically for ecosystem services, via taxation or levies on ecosystem goods and services. The system is adapted via incentives/taxes either to encourage individuals/groups to engage in restoration efforts, or to limit unsustainable use of ecosystems.

4. Better integration, so people can see the "whole picture" and how different parts of the system influence other parts; for example, how economic/social/cultural activities impact on the environment, and vice versa. Society needs to become aware that the services they get from ecosystems have values that they will need to support to ensure sustainable natural capital levels. People need to understand the system more clearly, including interactions between parts of the system, how economic/social activities impact on ecosystems, and how ecosystems provide "services".

The workshops were therefore structured to address these questions, to provide more detail of the primary pressures driving ecosystem decline, and to identify actions that currently are or could be implemented, to restore important Harbour ecosystems. The focus was on identifying 'indicators'. As such indicators reflect the most important factors through which their change over time could be represented in a model that would link various indicators in order to assess the overall functioning of the Harbour. The goal was to understand better how Tauranga Harbour behaves as an integrated system that changes over time.

In the context of the "questions and answers", identified scenarios are:

1. What if is there is no limit for urban area/sprawl?
2. What if ES values are higher than currently visible?
3. What if the Harbour carries more international tourists?
4. What if new funding is coordinated into various solutions?
5. What if climate change increases sedimentation by 40% by 2030, as estimated by NIWA?
6. What if nitrogen losses from dairy farms were reduced by 40%?
7. What if various land-use changes to extremes; for example, what would happen if we changed all land in the region to indigenous forest, how great would be the economic loss/gain as a result by 2070?

The post-surveys indicated that participants are intrigued and can see the value of such simulations, if this model is further developed. The process of model building has helped to structure the dialogue around broad questions of this complex issue. However, the findings and recommendations remain process oriented rather than based on content and firm conclusions grounded in the model and its simulations.

While we were able to find reliable data to represent some of these 'indicator' species or activities, such as seagrass acreage in the Harbour or human population increases in the catchment, there were other important indicators, such as shellfish areas, abundance and community composition, for which no reliable data could be found. The intention for the model development was therefore to explore the integration and connections of the four aspects of well-being, with an emphasis on changes over time (i.e., trends). We aimed to interpret and connect issues that were identified during workshop discussions by the participants; concerns or 'indicators' that the research team were not able to find data for, or that were beyond the time available for this stage of the research, were recorded. Issues that were not raised during workshop discussions are not included in the model or the narrative.

Although sea lettuce was initially highlighted as the biggest concern by several participants in the pre-surveys, this issue was not consistently followed up in the workshops. Instead, seagrass and the significant decline in grass coverage were highlighted, particularly in relation to sedimentation and six other impacts (sea lettuce smothering, storm activity, black swans, nutrient runoff, and ozone impact). Although, we were unable to determine the weighting of such impacts on sea grass from either participants' observations or the literature, in general terms sedimentation, nutrient enrichment, and loss of habitat were considered the dominant drivers and hence the answer to Q1.

The abundance and health of fisheries or shellfish populations in the Harbour was modelled qualitatively, as it was discovered that such monitoring is not routinely undertaken, at least not from a western science perspective. However, iwi representatives verbally explained their perception of a decrease in shellfish beds and we used this perception in lieu of available data. In addition, we incorporated a monetary measure for the decreased availability of various culturally sensitive species (cockles, pipi, oysters, green-lipped mussel, scallops, tuatua, flounder, eels, whitebait, snapper) based on an estimated "replacement value"; i.e., the financial cost of having to buy food for cultural events rather than customary gathering. Indirectly, the cost of the loss of shellfish beds is exacerbated by the loss of the passing on of traditional knowledge about such harvesting practices, and the associated breakdown in social structures and negative impact on mana. This loss of cultural knowledge is a long-term impact that was deemed by iwi participants to fall outside the bounds of this round of the MM process. This provides part of the answer to Q2.

While we received some information on urban and industrial wastewater (point sources) it was not in a form we had initially preferred for the model. In addition, "flushing capacity" seems crucial for wastewater dispersion and if such capacity is affected from a hydrological perspective, wastewater may become an exponentially bigger issue even though the output from point sources is not increasing. The spatial aspects of such wastewater concerns are outside the scope of this MM project.

The model has incorporated economic data for various key economic sectors in Tauranga in terms of their relative contributions, but the relationship between the economic activities, land use, and their impact on natural capital and the habitat of culturally relevant species remains weak. It was recommended that this would be further explored in future iterations of the model.

One key goal of this mediated modelling exercise was to develop greater capacity among the local community for 'systems dynamics modelling', so that there would be capability beyond this stage of the research programme for integrated, dynamic systems analysis to be incorporated into decision making about the Harbour. Two members of the Tauranga Research Team developed such modelling skills using STELLA (the software used in this MM process). They are now able to continue to work with tangata whenua and other end users to expand the currently developed model and build STELLA models for other issues of concern. Additionally, throughout the workshops, participants had access to the model, as it was publicly available on the MTM website. Using MM techniques, participants were able to

simulate 'what-if scenarios', both to acquire a better appreciation of the impact of changing various aspects within the model and to support the ongoing dialogue about the Harbour. The majority of the participants interviewed after the workshops indicated a willingness to show the model to non-participants in their sector/organisation.

A summary of the workshop discussions, and the contributions offered from participants about the Harbour, was made publicly available on the MTM website and was used as the basis for ongoing development of the model itself between workshops. Thus, participant contributions at the workshops enhanced the stocktake of existing knowledge about the state of Tauranga Harbour.

Much of the value of the MM process is in the dialogue between participants about what is really going on in the Harbour and the associated co-learning among participants as they hear each other's points of view and experiences. The model-building process aims both to help structure such complex dialogue, and to interlink issues that are otherwise often discussed in a fragmented manner. At a highly aggregated level, the model describes some land-use changes and the ecosystem services affected by such changes. The model aims to connect a growing GDP with a loss in ecosystem service values, which raises the question of whether or not "real" value is being added to the region by current 'economic activities being undertaken in this interdependent system of Tauranga Harbour. A detailed description of the model can be found in Appendix 1.

Participants were surveyed before and after the MM workshops, and a comparison of pre- and post- survey responses was used to help evaluate the perceived value of the MM process. At the final workshop 8 findings, 19 recommendations, and 5 actions were developed. Among the more significant outcomes is that the participant group unanimously scheduled a follow-up workshop to take place in the middle of the year to arrange a self-organising ongoing group (without requiring leadership from the MTM programme) to maintain the momentum created through the MM process, and to enable ongoing input into decision making about the Harbour.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.   BACKGROUND AND CONTEXT

This report is one in a series of reports and other outputs from the research programme "Enhancing Coastal Ecosystems for Iwi: Manaaki Taha Moana" (MAUX0907), funded by the Ministry for Science and Innovation (previously known as the Foundation for Research Science and Technology, and the Ministry of Research, Science and Technology).

1.1.   What is Manaaki Taha Moana (MTM) and who is involved in it?

Manaaki Taha Moana (MTM) is a 6-year research programme led by Professor Murray Patterson (M.G.Patterson@massey.ac.nz), which runs from October 2009 to September 2015. Research is conducted primarily in two areas: Tauranga Moana and the Horowhenua coast (from the Hokio Stream to Waitohu Stream). This programme builds on 'Ecosystem Services Benefits in Terrestrial Ecosystems for iwi' (MAUX0502), Massey University's previous research with Ngāti Raukawa in the lower North Island.

A number of different organisations are contracted to deliver the research: Waka Taiao Ltd with support of Te Manaaki Awanui (previously, Te Manaaki Taiao Trust) in the Tauranga moana case study; Te Reo a Taiao Ngāti Raukawa Environmental Resource Unit (Taiao Raukawa) and Dr Huhana Smith in the Horowhenua coast case study; WakaDigital Ltd; Cawthron Institute; and Massey University. The research team endeavours to engage extensively with local communities and end users through a variety of means. More about the research programme can be found on the MTM programme website http://www.mtm.ac.nz.

1.2.   What is the main purpose of MTM?

The central research question is "how can we best enhance and restore the value and resilience of coastal ecosystems and their services to make a positive contribution to iwi identity, survival and welfare in the case study regions?" Our research therefore aims to restore and enhance coastal ecosystems and their services of importance to iwi/hapū, through a better knowledge of these ecosystems and the degradation processes that affect them. We will utilise both western science and Mātauranga Māori to assist iwi/hapū to evaluate and define preferred options for enhancing/restoring coastal ecosystems. This evaluation of options will also be assisted by the development of innovative information technology and decision support tools (e.g., simulation modelling, interactive mapping, 3D depiction, real-time monitoring) by WakaDigital Ltd. Action Plans will be produced for improving coastal ecosystems in each rohe. The research team will work closely with iwi/hapū in the case study regions to develop tools and approaches to facilitate the uptake of this knowledge and its practical implementation. Mechanisms will also be put in place to facilitate uptake among other iwi throughout NZ. The key features of this research are that it is: cross-cultural; interdisciplinary; applied/problem solving; technologically innovative; and integrates the ecological, environmental, cultural and social factors associated with coastal restoration.

1.3. What are the specific objectives or phases of MTM?

The specific research objectives of MTM are:

Objective One: Develop a knowledge base of coastal ecosystems and their services in the two case study regions.

This objective is focussed on determining the extent of critical coastal ecosystems and their services in both our case study regions (Tauranga Moana and the Horowhenua coast). The relevant research questions are: What are they? Where do they occur? How can they be measured in biophysical, cultural and other terms? How culturally significant are they? How much are they worth or valued?

Objective Two: Determine how to enhance and restore specified coastal ecosystems and their services in the case study regions.

We will work directly with WakaTaiao, Taiao Raukawa, and other agencies in the local communities to harness and build on the knowledge from Objective One to answer the central research question of: 'how can we best enhance and restore the value and resilience coastal ecosystems and their services, so that this makes a positive contribution to iwi identity, survival and welfare in the case study regions?' This will be achieved through detailed case studies in both regions, on topics of most importance to local iwi and hapū in ascertaining how to go about restoring coastal ecosystems and their services. We will work with other groups and local councils who may also be undertaking complementary-focussed research.

Objective Three: Implementation and benefit transfer to other iwi.

A condition of involvement of both Tauranga Moana iwi and Ngāti Raukawa in this research programme is that the research be implemented to bring about real change in the state of coastal ecosystems in their rohe. Both Tauranga Moana and Ngāti Raukawa have catalogued the poor state of many coastal ecosystems in their rohe, recalling, for example, accounts from tribal elders of the abundant kaimoana found 40–50 years ago, but not today. Both iwi groups are committed to arresting these trends and keen, through this research programme, to put in place Action Plans and other mechanisms to improve the quality of the coastal environment. Lessons, knowledge and tools from this research will also be made available for uptake throughout New Zealand and internationally.

1.4. How does this report fit into other work in MTM?

The initial research activities for this first phase of MTM have focussed on Objective One, 'Building Up a Knowledge Base of Coastal Ecosystems and their Services', in both case-study regions. In summary, we have been engaged in: an ecological stocktake of "what is already known" about the state of coastal ecosystems in each rohe, including both Mātauranga Māori and western science knowledge; the creation of a mediated model of Tauranga Harbour and the inter-relationships between the various factors that contribute to its health; and the development of initial information technology tools to help us capture and utilise this critical knowledge and information to bring about restoration to coastal ecosystems. Collectively, these components helped inform the selection of case studies for more in-depth study and tool development in subsequent stages of MTM.

This initial stocktake phase has involved a number of interrelated components:

(1)   Mediated Modelling[1] of the Tauranga Harbour – this component is described fully in this report. Mediated modelling is a tool through which stakeholders can be involved in the model development and eventually use the model to identify and solve problems. Our initial focus has been on Tauranga Moana, and as such will be one of the first worldwide applications of 'mediated modelling' in a cross-cultural research programme. The primary purpose of mediated modelling is to understand the dynamics of the Moana in a 'holistic' and 'integrated' way with an eye to assisting the selection of case studies for Years 2–6 of MTM. Associate Professor Marjan van den Belt at Ecological Economics Research New Zealand, Massey University, led the MM component of the MTM project. More information can be found on our website: http://www.mtm.ac.nz/mediated-modelling/.

(2)   Ecological Stocktake of the Tauranga Moana and Horowhenua coast (from the Hokio Stream to Waitohu Stream). The purpose of this ecological stocktake was to summarise all data/information on the past and current state of the ecological health of the Tauranga Harbour and the Horowhenua coast case-study regions. This stocktake was undertaken to provide a basis for selecting our case studies for Objective Two, and is also a mechanism to communicate our assessment of the ecological health of the respective coasts to our stakeholders. The results of this ecological stocktake will be made available in two main formats – written reports and searchable on-line Digital Libraries on the MTM website that anyone can use to discover what reports and other information exist about the state of coastal ecosystems in the case study regions.

(3)   For the Tauranga Moana case study, a Mātauranga Māori interpretation of coastal ecosystems will also be published. In the MTM programme, we endeavour to find appropriate ways of utilising both Mātauranga Māori and Western science knowledge to solve ecological problems in the case study regions, hence the importance of having a robust Mātauranga Māori research framework.

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[1] For more information, see van Den Belt, M., 2004. Mediated Modeling, a System Dynamics Approach to Environmental Consensus Building. Island Press, Washington D.C.

(4)   Information Technology (IT) tools. One of the key aspects of MTM is the development of IT tools to better communicate the research results and to support decision-making by iwi/hapū end-users and other stakeholders. This IT development is being undertaken and led by Wakadigital Ltd, in conjunction with the other partners in MTM. The initial focus has been on developing the web-based central information repository (see http://www.mtm.ac.nz/client/knowledge_centre-digital_library.php) and a communication portal/website, and updating the eFish database to include new data. Future IT development may involve spatial modelling, simulation modelling (what would happen in 20–30 years if we implemented 'xyz' management option), interactive mapping, 3D depiction (where are the problems occurring), and real time monitoring (e.g., water quality). One of the features of the application of these IT tools is to critically assess their efficacy and appropriateness in the context of Māori-focussed research.

Outputs from these research activities can be found at:
http://www.mtm.ac.nz/knowledge_centre-publications.php

1.5.   What happens next?

The culmination of the above activities helped inform our research team about what knowledge gaps exist regarding the state of the coastal ecosystems and their services in our case study areas, and what the most critical areas are for ongoing investigation. Based on the conclusions of these stocktake exercises, in close collaboration with local tangata whenua, we are undertaking detailed case-study research in both Tauranga Moana and the Horowhenua coast. Further reports will be produced outlining these case studies. Readers should refer back regularly to the MTM website for ongoing updates: www.mtm.ac.nz.

2. MEDIATED MODELLING OF COASTAL ECOSYSTEM SERVICES IN TAURANGA MOANA

2.1. The role of modelling in stakeholder-supported policy mediation

Mediated Modelling (MM) refers to model building *with* (rather than *for*) people; i.e, we aimed to describe a more integrated "story" of the Harbour.

The implementation of a systemic change depends not only on the quality of the proposed system, but also on the broad acceptance of such a systemic change by stakeholders. The relationships among stakeholders involved in systemic changes can typically be unproductive when the various stakeholders hold strong positions about their own perspectives/ interests, as well as those of other stakeholders. For example, environmentalists sometimes blame the production sectors for pollution, whereas production sectors sometimes defend their actions and existence on different (economic) grounds. As a result, these groups often talk past each other. Stalemate positions can eventuate when different stakeholder groups hold very different viewpoints, or when assumptions are made about what another group thinks. A tool such as MM is useful to help negotiate stalemate positions, or to help a group of people come together to discuss an issue of interest to them all, and to break down some of the misconceptions. MM workshops are effective mechanisms through which perspectives are exchanged, facts and beliefs compared and difficult questions pondered in a relatively safe/neutral environment. The facts and beliefs have a chance to be rearranged in such a way that gaps in knowledge can be identified and pursued to improve the shared level of understanding of a system. Improving the shared understanding of the entire group is a valuable aspect of MM, because the knowledge held by individuals can be shared to improve the overall knowledge and understanding of the whole group. Participation from all important groups who are impacted by (or impact on) the issue being discussed greatly increases the possibility that resultant recommendations will be supported by a broad base of stakeholders and, ideally, decision makers who can actually implement actions (van den Belt, 2004).

As a complement (or alternative) to the official, regulatory policy process, stakeholder and public engagement of policy choices on the front end, as through mediation, is increasingly recognised as a preferred practice.For example, "The Environment Court actively encourages parties, where appropriate, to pursue alternative dispute resolution" (http://www.justice.govt.nz/courts/environment-court/procedure-in-the-environment-court/mediation.html). However, while the typical result of a mediated discussion may be a consensus on goals or problems, this provides no help on how to achieve the goals or solve the problems. What may be missing in a mediated policy discussion is a shared level of understanding of the most relevant facts. Organising data and information is often a daunting task and expert model builders are sometimes enlisted to assist. However, an often heard concern is that the recommendations resulting from narrow, specialised models are seldom implemented because they lack stakeholder support. The stakeholders are puzzled by the 'black box' that constitutes the model and do not experience ownership over and commitment to the results, no matter how compelling or reasonable. Figure 1 gives a schematic overview of the model of MM.

Figure 1   Raising understanding and building consensus

*High level of Understanding
of Complex Systems*

Expert Modeling

Specialized model whose
recommendations doesn't get
implemented due to lack of
stakeholder support or
understanding

Mediated Modeling

Consensus on both problem/goals
and implementation pathway or
scenarios, supporting
implementable policies

*Low level of
Consensus*

*High level of
Consensus*

Status Quo

Confrontational debate and
no improvement

Mediated Discussion

Consensus on the goal or
problem but little help on
how to achieve the goal or
solve problems

*Low level of Understanding
of Complex Systems*

Source: van den Belt, 2004

Mediated Modelling uses a process of computer-aided, fact-based mediation to push toward consensus on both problems/goals and the process used to come to a decision, which leads to more effective and feasible recommendations. Recommendations can be in the form of proposed investigations, joint fact-finding or research, or initiation of a focused collaboration or policy advice.

No two processes are alike because the starting position and composition of each group are different. Before a MM process is undertaken, an initial stakeholder analysis is recommended to establish the level of contention, the level of past interaction of the members, how the group is perceived by non-participating stakeholders, and to search for the most far-reaching access into the networks of people holding different perspectives. The degree of envisioned participation and the timing of the participation in a group are also of importance in preparing a MM project (see Figure 2).

Figure 2   Timing of stakeholder participation in model building
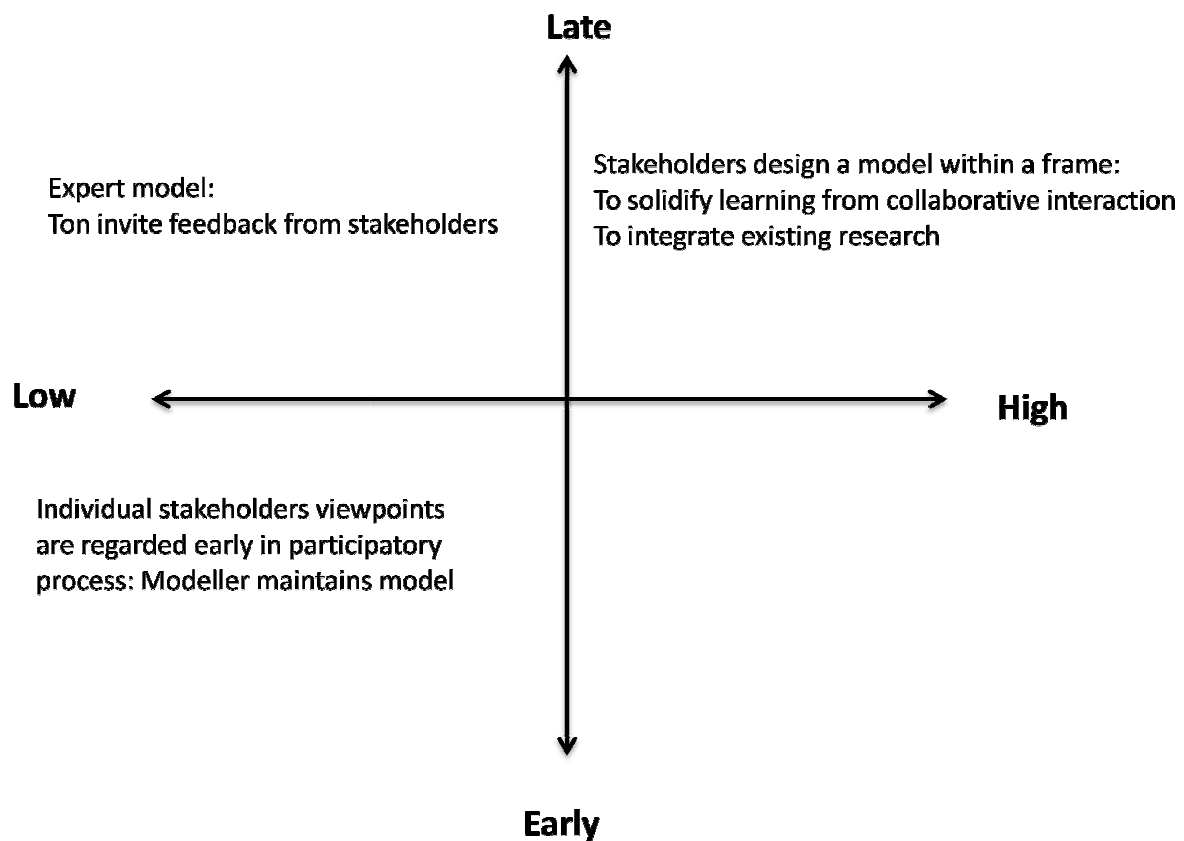
Source: van den Belt, 2004

Mediated Modelling is generally applied at scoping level. The scoping effort can be a broad basis for more detailed models at research or management level. Mediated modelling (van den Belt, 2004) provides a tool with much potential for productive stakeholder involvement in planning and policy-making.

2.2.   The context of the MM case study: Te Awanui, Tauranga Harbour

The context in which this MM project is set is important for assessing what value the MM process had in meeting stated research and participating stakeholder goals and/or how outputs could be used in the future. In addition, describing the context of this MM exercise in Tauranga can assist people who did not directly participate in the workshops to evaluate whether such an approach could be adjusted and used elsewhere or on other topics. Mediated Modelling aims to support a multi-stakeholder quest for collaborative design and evaluation of future solutions. MM is based on systems thinking and therefore we are interested in trends and changes over time and how such changes are interconnected. Systems thinking uses cause and effect mapping to better understand how systems work; system dynamics is the quantitative form of systems thinking, often supported by computer-based modelling. An overview of systems thinking and system dynamics can be found in Appendix 1. Through mapping and modelling, the aim is to build systems thinking capacity to

better understand past trends and how such trends interlink. During an MM process, a group of participants is asked to envision future solutions. By extrapolating the past and exploring what is needed to achieve more desirable levels of indicators, it is believed that systemic solutions for the future are facilitated. The story about the past, captured in a modelling structure, helps people consider their vision for the future, and provides them with the framework and learning to plan for plausible futures. Such learning processes take time and are ideally both adaptive and shared among diverse stakeholders. The following section describes the 'story' of Tauranga Harbour and explains how MM aimed to capture this story in its specific way of 'story telling'.

Figure 3   Map of Tauranga Harbour
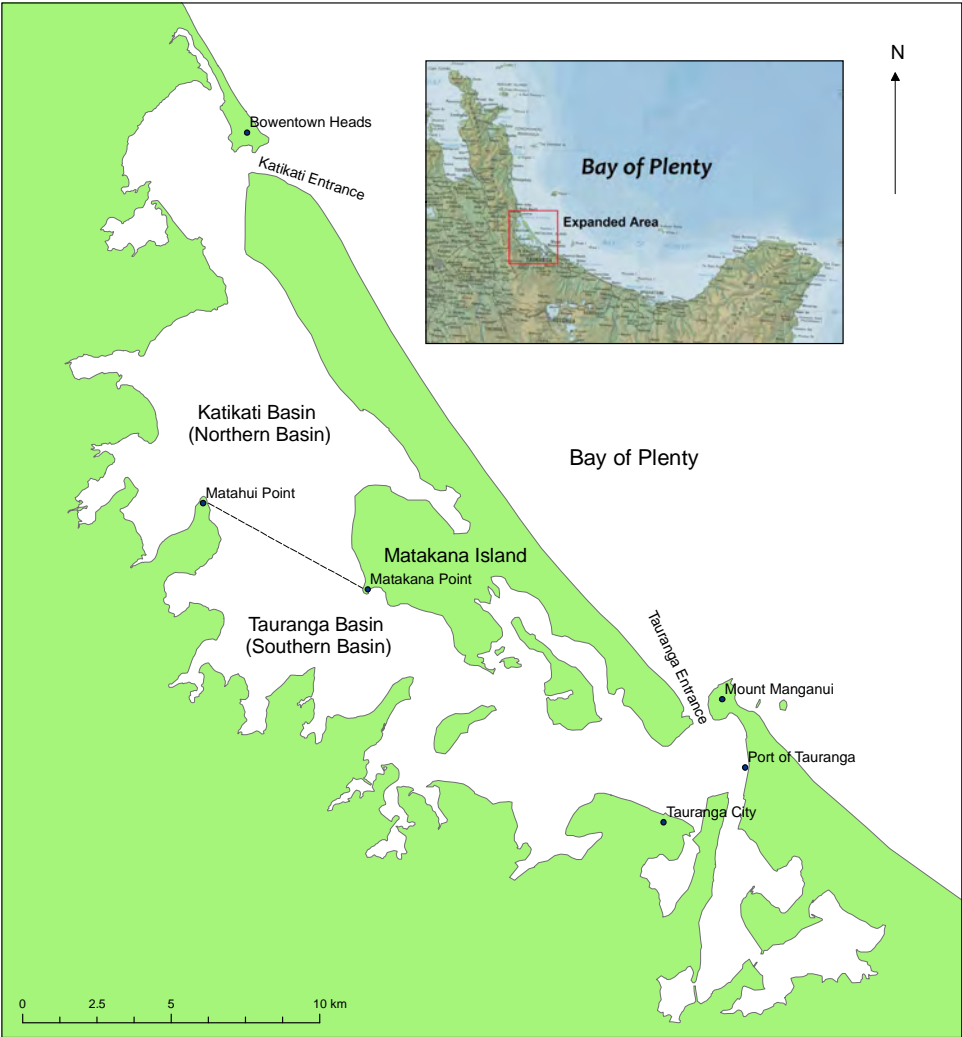
Te Awanui, Tauranga Harbour, is a unique estuary in the Bay of Plenty. One of New Zealand's largest estuaries, the Harbour is regarded as one of the significant areas of traditional history and identity for the present three Tauranga Moana iwi – Ngai Te Rangi, Ngati Ranginui, Ngati Pukenga. Tauranga's attractive climate, abundant kai moana, kai awa, edible ferns, berries and plants, plus a rich store of manu (birds) provided early Māori with all their nutritional needs (Te Awanui Tauranga Harbour Iwi Management Plan 2008). The Harbour has also been identified as an area of

outstanding natural features and landscape, with many sites in the Harbour identified for their ecological and cultural values (EBOP, 1999; Laurie, 2006). A map of the estuary within the region is shown in Figure 3.

The area has seen rapid development since the 1950s through forestry, port activities, horticulture, dairy farming, increasingly attracting professionals, retirees and tourists.

The Harbour catchment is a receiving environment for urban, residential, commercial, industrial, horticultural and agricultural activities. The physical environment and marine ecology of Te Awanui has been significantly altered and modified over the last century. Increased development around the Harbour margins and clearing of significant areas has resulted in greater quantities of siltation and pollution washing into the Harbour, posing a methodical threat to shellfish gathering and the well-being of affected whänau, hapü and iwi. Blooms of toxic algae have placed authorities in an obligatory position to close popular shellfish beds (Te Awanui Tauranga Harbour Iwi Management Plan, 2008, p. 10).

Urban development and the associated increase in economic activity that impact on the Harbour have changed the catchment considerably. The natural capital that underpins the value of the Tauranga Harbour for both Māori and non-Māori is under strong pressure. Pressures include port dredging activities; pollutant and nutrient discharges into the Harbour, including agricultural and horticultural run-off, wastewater/sewage and stormwater discharges; sedimentation; increased tourism and recreational users on the Harbour, and associated issues such as competition for 'space', and introduction of invasive species from ship ballast water. The cumulative impacts on coastal ecosystems have been significant, and this is greatly felt by local iwi for whom the Harbour has been a long-standing source of food. "Te Awanui is an important traditional resource supplying the nutritional needs of whānau that live close to the water's edge" (Te Awanui Tauranga Harbour Iwi Management Plan, 2008, p.12).

The natural capital underpinning the ecosystem services provided by the Harbour is under pressure. At the same time, the flow of goods and services within the catchment, measured in economic terms, has increased. How are these trends interconnected? This narrative is one way to tell a story of the Harbour. By building a model of the crucial trends related to the state of the Harbour, we aim to re-tell the story in a different format, looking for (1) consistent evidence; (2) dialogue and learning among stakeholders; and (3) envisioning of new pathways toward "solutions".

2.3. Mediated Modelling (MM) – one way to help understand a story

MM is a process in which computer model building (rooted in systems thinking and system dynamics) is used as a mediation tool. The MM process starts with an assessment of the context in which the process is to add value, including a Stakeholder Analysis (Appendix 2). In the Tauranga Harbour case study, MM aimed to gain a greater understanding of the key trends and their interactions that impact on

the state of the Harbour, and to identify the critical leverage points that are likely to have the greatest impact (from the perspective of the participants) on the restoration of those areas that are currently degraded. A series of workshops with various stakeholders including tangata whenua was undertaken between November 2010 and May 2011. Participants representing government, industry, farming, business interests, tangata whenua and non-governmental organisations worked together during five workshops to learn from each other and to develop a coherent story about the state of the Harbour. A list of participants[2] and their attendance is included in Appendix 3. During the MM workshops about 20 participants were encouraged to share their views on the state of the Harbour, how it is changing, how this can be observed, and how observed changes may be interconnected.

The MM process worked as follows: parts of participants' stories are interpreted by the facilitator and simultaneously reflected onto a projected computer screen for all to see and comment on. The summarised narratives are used as a guideline for model building between workshops. Over the course of four workshops, a simulation model evolved, and a final scoping model was presented and simulated at the fifth and final workshop in May 2011. Participants shared both facts and perspectives about their understanding of the factors at play in the Harbour. Both facts (when available we interpreted those facts) and perspectives (when facts were not available) were used to create a story with which participants could agree and in which they could recognise a value. The resulting model is not a predictive model, but rather it is a framework to help interpret diverse information and trends. The goal of MM is to help participants more fully understand, and then simulate in a computer model, the broad drivers in the entire 'system' of interacting factors. As the model is "open source", the initial framework developed by the MTM research team and participants during the workshops can in the future be expanded and/or improved by stakeholders. Future updates to this integrative model of Te Awanui to be done in conjunction with tangata whenua who are partners in this MTM research, especially if the model is to include socio-cultural considerations.

The workshops were led by Associate Professor Marjan van den Belt, Massey University, with the assistance of members from the MTM Research Team in Tauranga and Palmerston North. The MM approach was chosen by the Research Team because it can support a group of participants with different interests and perspectives to develop a consensus, based on a common understanding of what to do next. MM is also a useful tool to facilitate ongoing discussion between groups that may not typically have the opportunity to 'hear' each others' perspectives, and to incorporate differing viewpoints about the Harbour into an overall framework for considering how it can best be sustainably managed.

This report describes the preparation, application, and evaluation of five full-day workshops in Tauranga, approximately one per month from November 2010 to May 2011, and presents the resulting model of the Tauranga Harbour. This report is primarily intended as a means of summarising the MM process and the main findings and recommendations for the organisations and groups who participated in the MM

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[2] Disclaimer: The full list of participants includes people who were present for at least one of the workshops and contributed in some way to workshop discussions. The resultant model may not fully represent the views of individual participants or the organisation they represent.

process so that in the future they can use this knowledge for decision making about the Harbour. The report is also useful for the MTM research team, and for other researchers or groups considering MM as a tool in other research programmes.

2.4. Workshop preparation

Before commencing the MM process, the following activities where undertaken:

1. Development of an understanding of MM among the MTM research team as this is a relatively new approach in NZ. As the MTM programme is focussed on tangata whenua capability development, two workshops on MM were undertaken with those tangata whenua in Tauranga who showed interest and aptitude for systems dynamics modelling.

2. Stakeholder identification focussed initially on tangata whenua, but was widened to include other representatives as it proved difficult to find appropriate tangata whenua candidates for the MM process among the key organisations. Tangata whenua candidates with strategic decision making responsibilities for each of the key sectors in Tauranga Moana were difficult to find for the MM process for various reasons. One critical reason was the fact that many of the people in decision-making positions across the various sectors/organisations were not Māori, with many key leadership positions being held by non-Māori people. The MTM team was thus faced with the decision of either developing a model with tangata whenua representatives alone, and abandoning the desire to include key organisations, or opening up the process to include non-Māori. The risk of excluding non-Māori from the process was assessed by the Tauranga-based MTM project team to significantly raise the likelihood that the resultant model would be unlikely to have wide 'reach' across the decision making bodies in Tauranga due to the fact that those key groups would not be represented. Thus, it was decided to open up the MM process to include both Māori and non-Māori, and to ensure that people with decision-making influence from across as many sectors as possible were represented, as well as inviting key tangata whenua representatives.

3. Stakeholder selection and invitation were based on a suggested protocol provided by the MM project leader to the MTM research team (see Appendix 2). The protocol was interpreted and adjusted by tangata whenua to suit their needs.

4. All participants were interviewed by A/Prof Marjan van den Belt to (1) ensure participants' questions about the MM process were answered; (2) elicit an idea of the major concerns the participants had with regard to Tauranga Harbour; and (3) understand the participants' perceptions of the validity of the participant list in adequately representing those key groups in Tauranga who have an impact on the Harbour or are impacted by changes in the Harbour. The results of the pre-survey can be found in Section 3.6.

5. A preliminary model was developed to (1) provide participants at the first workshop with an idea of how a STELLA model could look; (2) provide a starting point that the group could use for ongoing development, if so decided by the group; and (3) allow the new modellers in the Tauranga team to gain experience with the software. The preliminary model can be found on the MTM website.

6. Two members from the Tauranga-based research team were taught how to use the STELLA software. Their task was to enhance the MM process with model-building capacity and pursue the model building in between workshops.

7. A schedule for the planned workshops and workshop activity scripts were developed.

8. The MM section of the MTM website (http://www.mtm.ac.nz/mediated-modelling/) was designed and additional background information was made available to participants.

3.   THE WORKSHOPS

Although six workshops were originally planned, only five happened due to a scheduling conflict for the April workshop.   The limitation to six workshops was imposed by the deadline the MTM project had for the start of subsequent case studies. Personal experience (van den Belt) suggests that a longer period and up to 10 workshops is more likely to solidify all the steps of the MM process, which are otherwise somewhat rushed.   However, this is time consuming for participants who often have to prioritise their time toward short-term actions rather than building the strategic capacity in a community to understand and address complex and pervasive trends.   A request for a commitment to attend 10 workshops using a process too unfamiliar to the participants was deemed unrealistic by the MTM research team. The trade off was therefore made to work within a timeframe and hold five–six MM workshops.

The topics of the five workshops were laid out in principle at the 1st workshop, but slightly adjusted as the workshops progressed.   This resulted in the schedule and progression of topics as laid out in Table 1.

Table 1   Workshop schedule

Date of Workshop	Topic of Workshop
17 Nov 2010	Workshop 1 – Intro, overview, model sectors and land use
15 Dec 2010	Workshop 2 – Ecosystem Services
19 Jan 2011	Workshop 3 – Economic drivers, Values of Ecosystem Services
16 Feb 2011	Workshop 4 – Indicators, Targets, Scenarios and Timelines
4 May 2011	Workshop 5 – Simulation, Findings, Recommendations and Dissemination

The development of the model progressed throughout the workshops.   The summaries from each workshop have incorporated those parts of the model that were consecutively developed and can be found on the MTM website. In addition, the PowerPoint slides that were used to support each of the workshops are also available on the website. This report therefore provides a synthesis of the highlights of each workshop and as well as a model description.

Each of the workshops followed a similar format:

1. Start at 9 a.m. Welcome, karakia, introductions, apologies.

2. Overview of the project, review of achievements to date and goals for the day.

3. Introduction of concepts, software, updates on action points/progress made between workshops (in plenary).

4. Feedback on the model updates and facilitated adjustments to the model in plenary sessions, or through poster sessions.

5. Refreshments provided at set times.

6. Time was usually allocated for discussion on set topics in small groups, with the main points from each small group reported back to the wider group in a plenary session.

7. Summary of tasks for next workshop. Feedback was requested at the end of each workshop by the MM research team on what did and did not work from a process perspective.

8. Finish between 4 p.m. and 5p.m. Individual participants could stay longer for personal guidance through the model after the workshop.

Marjan van den Belt designed and led the workshops and interpreted the dialogue into STELLA icons for a period of time during each of the workshop sessions; both demonstrating updates as well as eliciting new input from the stakeholders. Derrylea Hardy was the note taker during the workshops and recorded/interpreted what happened as well as the actions that should be taken. The feedback from small group activities were recorded and projected on the screen and the presented results have been lightly edited for style only.

After each workshop, the MTM project team members involved in the workshop would spend one day to follow up on actions, data searches and planning before the subsequent workshop in the series. In between workshops, Derrylea liaised with the research team and workshop participants to gain consensus that the recorded summaries, included in Appendix 6, were an accurate reflection of the discussions and findings generated at each workshop, prior to them being posted on the MTM website. The understanding was that if no comments were provided, the notes would be posted on the website about two weeks after each workshop. Aaron McCallion, Sarah Wairepo and Marjan van den Belt then 'built' and refined the systems dynamics model between each workshop, based on workshop summaries and available data gathered with assistance from other members of the MTM team and some workshop participants. Although the Project Team had access to a data inventory (also referred to as the "Digital Library"), the model building pointed toward a need for a level of specificity of data that had not yet been gathered during the stock take. Having project team members familiar with data gathering about the region as well having participants willing to assist with data gathering helped locate and translate data for intended purposes; i.e. understanding regional trends. However, gaps persisted between the type of data participants would like to have to explain regional changes and what was available.

3.1. Workshop One – 17 November 2010

The first workshop was held at the Manaaki Taha Moana office in Tauranga, which proved to be a tight location for a large turnout. Few participants knew all others. The pre-survey had identified some key concerns and those were reported and reflected upon. In general, participants wanted to find out more about the proposed MM process and expressed hope that their participation in the process would help make a positive difference in the state of the Harbour. (See a comparison of the before and after surveys under paragraph 3.6.) Basic guidelines and expectations for the workshop and the modelling were provided by the Mediated Modeller as part of a standard procedure to open a workshop series. The suggested guidelines were reviewed and accepted by the participants without changes (Box 1).

Box 1 – Guidelines for Workshops

Rights and Responsibilities
- It is each participant's right and responsibility to **be unique**. Each participant is respected for the perspective he/she brings to the table. Creativity stems from divergent ideas.
- It is the participants' responsibility to communicate their perspectives as concisely and clearly as possible: **Jargon flag**.
- Nobody knows everything, but **together a group knows more than anyone alone**. Ideas generated in the group belong to the entire group, not to any specific individual.
- Assume that all those present are the **right persons for the task**. Opinions about the balance of the group can be stated through the survey and will go on record.

Behavioural Guidelines
- **Keep contributions short**.
- Creativity can only flow when destructive criticism is withheld. **Withhold judgment** until a participant has made him/herself understood.
- Allow ideas to exist and grow, take them in, actively listen, **listen for possibilities**, allow for the possibility of being inspired even when, based on your rationale, you would prefer to immediately shut out the ideas.
- Ask **questions for understanding** rather than for the purpose of invalidating a contribution.
- A **focus on that which is equally good for all** is maintained.
- The ability to **explain complex information in lay terms** is more valuable than to confuse people with expert language.
- **Disagree without being disagreeable**.

Consensus Enhancing & Conflict Resolution
- Free discussion geared toward creativity is the primary goal. **Consensus is never a requirement**.
- Even though not every participant may be equally happy with a specific modeling step, it is necessary for everyone to be able to **"live with" the range of options**.
- Questions about the **process** can be flagged.
- A request for a **show of hands** (up in the air) is used to identify the perception in the group about a specific issue.
- In the interest of time **group consensus is assumed** if there is "no reasoned and paramount objection".
- Ad hoc meetings with individual participants, groups of stakeholders, or experts may occur as the need arises between the workshops. Preferably announce ad hoc meetings to foster **transparency**.

Modelling Guidelines
- The primary value is in the process of creating the model Model. The final model serves as a means to recreate for others the insights gained.
- A model is always an **abstraction of reality**. A model can only be evaluated for the purpose for which it was designed.
- Synthesis is the art of leaving things out. A minority of the variables that could be chosen should explain the majority of the system's behavior. A **scoping model should aim for simplicity and elegance**, not for a high degree of detail.
- **System dynamics**: modeling for understanding rather than prediction.
- The final model is a joint product of a team learning experience. The **team learning is as important as the final model**.

STELLA software was introduced by means of a short example and within 15 minutes all participants acknowledged an understanding of the basic features. A preliminary model was presented to give participants an idea of what a final model could look like. However, as is commonly the case, the participant group chose not to use a preliminary model as a starting point. Instead, at the suggestion of the MM facilitator, the group chose to start by populating the four-box framework (see Figure 4) with STELLA icons. The four-box framework is an ES framework presented by van den Belt (2011). Figure The STELLA icons (stocks, flows, parameters and information arrows) are explained in Appendix 4.

Figure 4   Dynamic, Coastal Ecosystem Service (E)Valuation

Natural Capital of Estuaries and Coasts
- Near-shore (coral) reefs
- Seagrass beds
- Salt marshes
- Mangroves
- Sand beaches and dunes

Ecosystem Services of Estuaries and Coasts
- Storm protection
- Food
- Habitat
- Nutrient cycling
- Climate regulation and carbon cycling
- Recreation

Governance and Institutions
- Payments for Ecosystem Services
- Adaptive management
- Moratorium
- Integrated Coastal Zone Management
- Conservation
- Education and communication
- Monitoring
- Enforcement

(E)Valuation of Estuaries and Coasts
- Perceived or non-perceived benefits
- Stakeholder participation
- Tradeoffs and decision tools
- Thresholds and dynamic systems
- Scale and system boundaries
- Marketed, non-marketed prices
- Cultural and spiritual values

Source: van den Belt, M. (2011)

3.1.1. Questions posed by the group

In a MM exercise, the emphasis is on understanding (rather than predicting) a system, translating data, and using perceptions and experience to design future pathways. In order to guide model building, the questions the model should address or answer are ideally clearly defined. The narrower the question, the easier it is to develop a straightforward answer. The wider the scope of the question, the more angles the answer can have and the harder it is to maintain a focused and productive dialogue during the MM workshops. However, when addressing topics with high uncertainty and a representation of different perspectives, as was the case here, it is

acceptable to start with broad questions, under the assumption that model building adds structure to the complex dialogue.

During the first workshop, the stakeholders were provided with a model framework for "Dynamic, Coastal Ecosystem Service (E) Valuation" (see Figure 4). Within this framework, the MM participants identified the following four questions that they wanted the model to answer. These four questions thus became the focus of discussion and analysis at subsequent workshops to guide the model-building process:

Q1)   What are the three processes or factors that most threaten the health of the Harbour (causes of the three most worrisome symptoms)?

Q2)   What are the desired outcomes (indicators) of a sustainable harbour with respect to four aspects of well-being [i.e., social, cultural, economic, ecological]?

Q3)   What solutions for ecosystem restoration (what, when, who, and how?) to identified root causes can make an impact, and how much?

Q4)   What social values can we modify [to stem coastal degradation and restore coastal ecosystems]?

These questions were regularly revisited, and sometimes adjusted or clarified, to establish whether the group was on track. They are not very precise questions and we decided to leave them broad to let the model-building structure the dialogue, rather than narrowing the dialogue to fit the model. There are risks and benefits from this approach. On one hand, the dialogue is unconstrained, yet captured by the modellers and/or in a narrative. Reflection on the narrative and changes to the model guide the next step of the workshop and model design. On the other hand, a tight connection between broad questions and model scenarios, and concrete and negotiated action plan based on scenarios is more difficult to achieve. This participant group did not have a specific mandate to develop actions within a timeline and, therefore, the open approach and collaborative effort was deemed appropriate by the MM project team. The post-workshop survey showed that the collaborative effort was indeed highly appreciated by the participants (see 3.6). The answers to the '4 questions' are answered in the executive summary and conclusion section of this report.

3.1.2. Introduction to systems dynamics modelling

Systems thinking
The discussion about the four-box framework (see Figure 4) relates to the notion of 'systems thinking' and 'system dynamics' (see Appendix 4). Systems thinking was briefly introduced as a concept; however, to be used effectively systems thinking requires regular practice. More often than not during MM workshops, the dialogue among participants reverts back to details rather than focussing on overall interconnections; it is the task of the mediated modeller to bring the dialogue back to

inter-linkages as a framework for dealing with such details. System dynamics is the quantitative expression of systems thinking.

Ecosystem services
The four-box framework also led to a discussion about Ecosystem Services (ES). Several participants picked up on the ES concept and some observations were immediately reflected in the draft model. Three reports on ES were suggested by participants to support the model building efforts[3] (Costanza et al., 1997; Millenium Ecosystem Assessment, 2005; DOC, 2009). It was also decided that the second workshop should focus on ES.

The focus on "Natural Capital", from which ES are derived, consumed most of the dialogue, and broad changes in land use and cover in the Tauranga catchment were discussed and modelled conceptually. Apart from six land-use classes, it was agreed that the focus would be on Tauranga Harbour and the changes in natural capital (wetlands, seagrasses, mangroves).

Point and non-point pollution sources
Point sources of pollution into the Harbour, as well as non-point sources, were discussed because representatives from groups with awareness of both sources were present. During the dialogue participants learned from each other what type of information is available. Various topics required "data translation" and this is described later in the report (see Section 4.2).

Spatial explicitness
The concern that this type of model does not deal with geographic (i.e. spatial) differences was discussed. Sedimentation was highlighted as a major concern and it was acknowledged that grouping all land-use types/practices into the same box was inadequate, as they are quite different (Wildlands Report, 2009). Spatially homogeneous STELLA models, such as the Tauranga Coastal Ecosystem Service Model (TCESM), are not suitable to determine where things happen; instead, STELLA models interlink broad trends to scope for the 'big picture' of what is happening in a system. Rather than claiming to be precise (which is an expensive undertaking better reserved for other modelling tools), we aimed in the MM exercise to find approximations to understand overall trends and their interactions, so that the story of how trends in Tauranga Harbour are changing and interrelated, might be retold and the dialogue continued with a higher level of overall understanding. It proved difficult to derive trend data for various land use/cover, as the way such areas are measured is often for specific purposes that provide snapshots in time based on asynchronous definitions. If precision is jointly considered in the objective of the model development, then a joint fact-finding or more distinct process of "data translation" can be negotiated among participants. In addition, just as decision

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[3] *Millennium Ecosystem Services Assessment
(http://www.eoearth.org/article/Millennium_Ecosystem_Assessment_Synthesis_Reports);
*TEEB (http://www.teebweb.org/);
*Costanza et al. 1997 Global study on ecosystem services and their values (a public version:
http://www.ecy.wa.gov/PROGRAMS/wr/hq/pdf/naturepaper.pdf);
*DOC report prepared by Wildland Consultants on Ecosystem Services in Tauranga;
*DOC classification of NZ ecosystem services (http://www.doc.govt.nz/upload/documents/science-and-technical/sfc295entire.pdf).

makers often like to connect the regional level in a spatially explicit manner to local issues, the regional level needs to connect to the national level at a high level of abstractness, to which a spatially homogenous model may well lend itself. This is where MM can assist in the thinking about vertical integration.

3.1.3. Basic structure of model for Tauranga Harbour

Sedimentation
When the group discussed sedimentation and natural capital, mangroves became a focus, particularly their dual role in the system. Mangroves increase as a result of increases in sedimentation and nutrients, which decrease access to kaimoana; however, some tangata whenua representatives maintained that mangroves provide an important habitat for oyster beds, and also provide shelter in the summer-time for tuna (eel) runs, shrimp, and baby tītiko. The group acknowledged that there are two types of mangroves: 1) those that were originally there and associated with kaimoana gathering ("old" mangroves"); and 2) ones that have grown recently due to sedimentation, etc.

Cultural importance of seafood
The cultural importance of seafood stocks in the Harbour for food is important for both Māori and non-Māori. Access to the Harbour for these services is limited in some areas due to sea lettuce, mangroves, and rubbish. Tangata whenua traditionally relied on the Harbour for their existence, as a source of food to sustain the people, and as the basis for many social protocols that underpin their identity. As the kaimoana loss increases, the Harbour becomes harder to access, and shellfish bans appear frequently due to the eutrofication effects of the surrounding areas, there is an increasing detrimental impact on health. To these problems are added the high costs of having to buying kaimoana. The inability to source food also impacts on mana as traditional kaimoana gatherers can no longer provide for whanau, or for the marae. To supply the marae with kaimoana is extremely important; it was the job of the young people, their part in the social structure within the marae. When young people can no longer fulfil this role, and can no longer supply the marae, the impact on mana and identity is critical – children and young people have lost their place in the social structure of their marae. These longstanding social values, included in marae carvings and in many tattoos, tell the story of the people, showing how critical kaimoana has always been to tangata whenua. Kingitanga historically came across the Kaimai for food, but they can no longer be supplied. Not being able to collect kaimoana and supply whanau/hāpu/iwi/guests has a serious impact on Māori. Figure 5 illustrates how this dialogue was captured as it happened during the workshop.

Figure 5   Causal diagram of loss of kaimoana, interpreted from bicultural dialogue at first workshop

The group acknowledged the value of having korero (discussion) about these values, and how the loss of things such as kaimoana impacts on tangata whenua, as well as how all the changes in the Harbour impact on each other. The following questions were asked: Are there ways of ensuring provision of kaimoana in a way that maintains stocks, e.g., aquaculture? What are the natural limits on stocks? The MM process identified the significant research gaps that exist in having culturally-valid indicators or numerical values for capital of importance to tangata whenua. In between the first and second MM workshops, the Tauranga-based MTM Research Team opted not to develop further the cultural values and interactions in the model, choosing instead to focus on the economic and abundance issues related to shellfish harvest, including the "replacement costs" of having to buy instead of gather food for large social/cultural events. During the MM itself, economic values of shellfish value were calculated based on assumed market value of shellfish requirements for food, as were some basic abundance measures through dialogue and perception, and so these were used in the model. Subsequent phases of the MTM programme will further explore the cultural values associated with the Harbour, and will attempt to develop indicators to assess the health of the Harbour from a cultural perspective. Findings could be integrated in a future version of the MM, if so desired.

Population pressure and tipping points
Population pressure was discussed and modelled. Population growth (by birth and migration) is based both on an attractive natural environment (lifestyle) and on economic opportunities (GDP per capita). However, due to interactions between those trends, it is important to understand rates of change and if/when tipping points become evident in the system. For example, many of the issues seen in the Harbour itself start in activities that occur at the top of the catchment, in the Kaimai. Erosion

from farms has only had a significant impact in the last 10 years; earlier it was thought to be of little importance. The group wondered if a tipping point had been reached, whereby the system had 'coped' with more and more erosion, until it was no longer able to 'flush out' sedimentation, and sedimentation then began to build up within the Harbour and cause major problems. The question is now where we are in the "tipping point" system. The collapse of the dam was significant, as was earth movement to create flatland for horticulture; bulldozing the land may have impacted on levels of erosion. It is not clear whether such sediments have been flushed through the system, or have accumulated over time.[4]

Problems, causes, indicators and solutions
The group was encouraged to identify the "problems" in the Harbour, and then work backwards to determine the "cause" of these problems. The idea was to establish some basic "indicators" and provide a baseline against which to measure future improvements, and also to help us recognise whether the implementation of future "solutions" were a step towards achieving long-term goals. It was highlighted that changes to improve the Harbour are already underway because District and Regional Council plans have policies in place for land use. The question remains whether the actions underway are enough to offset the impacts from ongoing trends or are aimed to curb such trends at the root?

There was discussion about the best way to get to a positive solution, given the competing and sometimes contradictory views of what counts as a "problem", and whose responsibility it is to "fix" it. We can apportion blame, but it is actually more effective to recognise how problems occurred and what can be done about them; hence a discussion on indicators was included to provide a link between "problems and solutions". This was expanded on in subsequent workshops.

As tradeoffs were discussed, it became apparent that the crux of the matter is about the "affordability of solutions" as compared with the "affordability of following current trends". It was acknowledged that some economic activity "free-rides" on the environment, but would be marginal if it had to pay for the ecosystem services it uses. Similarly, if owners of Natural Capital (such as forest, wetlands, cropping and pasture etc.) are encouraged to enhance ES on their properties, should their efforts be compensated because society benefits? The modelling effort does not pretend to answer all these issues; however, some basic inter-linkages emerged, which gave the group a rich dialogue and the modellers and data gatherers a direction of where to go to attempt to synthesise the thinking at the broad scoping level (see Appendix 5 for a detailed model description).

"Dialogue" was proposed as the answer to one of the basic questions asked during this workshop: How do we bridge the gap between "economic development" and "local iwi" concerns? ": Participants indicated a need for more dialogue with local iwi about dredging through the pipi beds, for example, to determine exactly how much loss might occur and what other impacts might result. The group agreed that more dialogue between the groups represented at the workshop is required, including

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[4] It was suggested that William Delaney of Coastal Division, Waikato University, could know more about this, and he might be asked by the post-MM end user group to talk on this issue at a future workshop.

dialogue with local iwi; and the MM workshops are a good forum in which such dialogue can happen. It was acknowledged that while it is important to hear the iwi voice, all other stakeholders around the Harbour need to have input. Various sectors in the system are inter-dependent. Further questions were posed by the group: How do we move forward in a way that leaves no one behind? Can we build "trust" between the parties to agree on a path to move forward? See the results of the questionnaire (section 3.6) for partial answers to these questions.

3.1.4. Participant representation

By the end of the first workshop, participants concluded that the dialogue thus far had been good and some important ideas were captured in the model outline. However, to effect real change as a result of these workshops and the model that is built, the group recognised the need for more input and participation from the "economic sector". The members of the present group felt already "converted" to the need to change things for environmental restoration, although there is still a long way to go to reach concrete action. Accordingly, additional outreach to "economic sectors" started in between workshops one and two.

Small group interaction
The small group discussions were very rich (summaries of these discussions can be found in Appendix 5). The participant discussions guided the modelling in between workshops; however, due to the sometimes very specific and otherwise very abstract nature of the observations only a few suggestions could be actively pursued to date for modelling purposes.

3.2. Workshop Two – 15 December 2010

The workshop was held at the Armitage Hotel in Tauranga, to accommodate the large number of participants. The topic was "Ecosystem Services (ES)".

Due to an interest in spatial difference and the concern raised at the first workshop that the STELLA model does not reflect spatial differences, the team located and displayed various maps, provided by Tauranga City Council, of the Harbour and catchment at different points in time to provide snapshots that illustrate how the area has changed. As spatially explicit dynamic modelling was not the intent of the MM, such geographical differences were not included in the model.

The group revisited the Guiding Principles for the Workshops, and introduced five related applicable Māori principles, which were explained to the non-Māori participants. Non-Māori participants requested that the description of these principles be documented, so that people unfamiliar with these concepts could learn them. In the workshops, this request was honoured and the Māori version of the guiding principles was discussed; however, the Māori presenter requested that their description of these principles should not be published.

3.2.1. The questions the model should answer

Generally, model building adheres to the specific questions the modeller sets out to answer. In this case, the questions developed during workshop1 were very broad. These questions set the context for the modelling process, but were difficult to translate into specific scenarios. In an attempt to bridge the gap between broad (visionary) questions and strategic relevant scenarios and based on the discussion at the first workshop, the project team proposed provisional answers to these questions during the second workshop. Apart from minor editing, the questions and answers looked as follows:

Q1)   What are the three processes or factors that most threaten the health of the Harbour (causes of the three most worrisome symptoms)?

A1)   The three major issues (symptoms) that emerge are: 1) sedimentation; 2) eutrofication; 3) loss of such things as kaimoana, habitat. The three driving processes/factors that cause these issues are: 1) increased industrial/economic activity; 2) coastal development and urban pressures and associated pollution; 3) system not "counting" ecosystem services.

Q2)   What are the desired outcomes and indicators of a sustainable Harbour with respect to four aspects of well-being?

A2)
Ecological: Water in Harbour must be of the same quality as that at the uppermost part of catchment, i.e. clear, drinkable, sustains life.
Social: Valued uses of Harbour can still occur, e.g., fishing. Mana-enhancing social systems reliant on the Harbour, such as the ability to collect kaimoana, are intact.
Cultural: Mauri of Harbour is sustained.
Economic: The value of ecosystem services is accounted for in the economic system, with appropriate incentives and regulations, so that use of ecosystems is sustainable and does not erode the natural capital on which the economy depends, thus enabling ongoing but sustainable "economic" activity in region.

Q3)   What are the solutions (ecosystem restoration what, when, who, and how?) to the identified processes or factors that most threaten the health of the Harbour that can make an impact, and how much of an impact can they make?

A3)   Future research is recommended to better understand the role of wetlands, mangroves, and salt flats as intertidal habitats with potential to accumulate sediments and filter nutrients, acknowledging that such areas may also release sediments and nutrients to the Harbour through cutting or storm events. "Users" of ecosystems or groups/industries that benefit from ecosystem services provided by the Harbour contribute to the maintenance/restoration of those ecosystems, for example, through funds set up specifically for ecosystem services, via taxation or levies on ecosystem goods and services. System adapted via incentives/taxes either to encourage individuals/groups to engage in restoration efforts, or to limit unsustainable use of ecosystems.

Q4)   What social values can we modify to help implement the solutions in Q3?

A4)   Better integration, so people can see the "whole picture" and how different parts of the system influence other parts, e.g., how economic/social/cultural activities impact on the environment, and vice versa. Society needs to become aware that the services they get from ecosystems have values they will need to support to ensure sustainable natural capital levels. People need to understand the system more clearly, including interactions between parts of the system, how economic/social activities impact on ecosystems, and how ecosystems provide "services".

The questions and answers were handed out and displayed to the group with an opportunity to comment on them. When no concerns were raised, the group moved on to model building. The revisiting of the questions and answers in a subsequent workshop did not lead to major changes.

3.2.2. Feedback on evolving model

A common response to the demonstration of the first version of the evolving model was that the value of the modelling effort would come from its ability to assess 'Return on Investment' in terms of Ecosystem Services (and social and economic indicators) that can be generated from investments/actions such as, for example, riparian zones or stock exclusion or enhancements to wetlands. Even though the model structure has evolved to such a level that ROIs can be inserted, due to the limited time available this aspect of the model development is referred to potential future updates of the model beyond the scope of the 5 workshops.

There was discussion about where the data in the model had come from. It was explained that one strength of this type of mediated modelling is the fact that it is very open and transparent, and the data in the model can easily be checked by participants, commented on, and changed or updated if/when more reliable data are sourced. Mediated Modelling is not "black box" where a modeller creates a model nobody understands. Even though there is transparency, the model requires the active role of the participant to check and data information and how it was used in the model. The STELLA software was able to be downloaded by all participants via the MTM website (www.mtm.ac.nz), and participants could click into all parts of the model (not just the "Ecosystem Services" segment) and view the data as well as the "notes" that explain data sources in most of the model icons. During each workshop, there were opportunities to check the model and at the data, discuss whether the data sources used were appropriate or questionable, and offer other sources of data. Additionally, participants (and others) were encouraged to contact the MTM team or, between workshops, to visit the offices at 12 Elizabeth Street to examine any aspect of the model in more detail if they wished. Very few participants took the MTM team up on this offer.

The point was reiterated that it is important for workshop participants to engage in the process, to offer up any sources of data of which they are aware, to raise any concerns about the model or the data if necessary, and to speak up during the workshops themselves, where discussion is encouraged. Even with this concern about data, it was also emphasised that the MM process is not about getting all data

identified, but rather about developing a shared understanding of the major changes in the Harbour system, overall.

3.2.3. Ecosystem Services in the evolving model

Restoration activities for wetlands are mostly inland. The Council's Environmental Programme includes Biodiversity; and Riparian Management Programme (enhancing new wetlands). Very few new estuarine wetlands are restored, and the point was made that there is no centralised strategy for wetlands. The Kaimai Catchment Forum doesn't currently include the Harbour and it should do so in order to be effective, given the inter-relationships between catchment and Harbour.

Seagrasses, Wetlands and Mangroves
It was emphasised that seagrasses, wetlands, and mangroves are three important Natural Capitals in the Harbour from which people derive Ecosystem Service benefits. In the plenary session, the participants discussed and completed the schedule provided in Box 2.

Box 2 Ecosystem Services from Seagrasses

Coverage in the Harbour	Ecosystem Services from **seagrass**	Functioning of seagrass in the Harbour (and what impacts on it)	Economic Activities TO which the Ecosystem Services contribute	Economic Activities that impact ON seagrass
-4400ha/ 44.4km^2 in 1959 -2933 km^2 in 1996. - Decrease of 90% subtidal seagrass from 1939 to 1996. -Overall decline 34%. -(Look at NIWA seagass research)	-Stabilise seabed. -Habitat for fishery nursery & adult fish. -Nutrient cycling. -Waste disposal. -Food provision for humans (supporting fish) for local and global population. -Biodiversity – invertebrates unique to seagrass. -Control for sea lettuce because fish it houses eat sea lettuce. -Cultural value of fish in seagrass (mullet and paore, eels). -Health benefits from fish in diet. -Intellectual benefits from fish consumption (link between environ't, human health and education). -Storm protection. -Recreational value	-90% decrease in subtidal seagrass. Thus loss is so substantial there isn't enough left to enable seagrass to function as it should. -Black Swans dec functioning. -Harbour Currents have changed, and damaged/moved some seagress meadows. -Ozone Hole may burn them? -Loss when Sulphur Point reclaimed (20 ha). -Dam burst, increased sediment load in 1982, which ended up on seagass beds and destroyed some. -Other sources sediment load increases: land use, recreation. NIWA (2008) says 66% is from pasture. -Turbidity of water – increased port usage. -Light penetration decreasing. -Toxicity of sediments and pollutants, oil spills etc. -Eutrophication (links to increased phytoplankton, which decreases light penetration). - Suspended sediments + activities that keep them suspended. -Way mangroves are cleared, some end up on kaimoana beds. -Consider variation in sediment: some is heavy and will sink to Harbour floor so doesn't show up in "testing"; others are light and suspended. -Sea lettuce itself impacts on functioning/abundance of sea lettuce.	-Fisheries / Port -Tourism / Port -Education -Health -Others	-Development -Earthworks -Population pressures -Farming (Practices) -Port -Quarrying -Recreation

A similar table was discussed and filled in for wetlands, as is shown in Box 3.

Box 3 Ecosystem Services from Wetlands

Coverage in the Harbour	Ecosystem Services from **wetlands**	Functioning of wetlands in the Harbour (and what impacts on it)	Economic Activities the Ecosystem Services contribute TO	Economic Activities that impact ON wetlands
-Decline	-Management of Stormwater -Nutrient recycling -Sediment trap -Nursery for fish -Flood regulation -Biodiversity -Fibre -Food -Filter for waste -Recreation -Aesthetically pleasing -Cultural value? (varies due to conflicting need for housing). -Used to be traditional food source, not any more.	-Drainage -Infilling -Spraying (which also increases susceptibility of fishery to mutation, sickness) -Pests, e.g., Canadian Geese -Social attitudes -Disease carrying mosquitoes. -Climate Change -Tourism Size is the issues with regards to functioning. Too reduced overall to function effectively.	-Fisheries / Port -Whitebaiting -Recreation -Local Govt -Etc (same or similar as for seagrass)	-Farming -Land Reclamation -Forestry -Etc. (same or similar as for seagrass) -Tourism

As time ran out, we were unable to fill in a similar Ecosystem Service schedule for mangroves. A pattern started to emerge on what the economic sectors impacted on and the benefits derived from Natural Capital. At workshop closure, it was acknowledged that mangroves are a very important factor that warranted focussed discussion. A contentious issue regarding mangroves is whether to keep them or to remove them. If they are removed, the means used to remove them may be important, as well as the removal sites. Positive aspects of mangroves include their ability to trap sediment and provide habitat for fish species. However, in some areas they have taken over fishing grounds, and thus fishers are now forced to travel out to sea to fish as the Harbour is too full of mangroves and sediment. Mangroves are expensive to cut. The Mangrove Removal consent by BoPRC allows removal of approximately 10% of mangroves, based on sub-estuary-level concerns from the Estuary Care Groups. The elevated sediment and nutrient load has increased the rate of mangrove growth beyond "natural" growth rates. It was also suggested that the mangrove growth could be due to fewer frosty days in Tauranga, which increases the growth rate of mangroves. The MTM team aimed to capture this line of thinking in the model.

3.2.4. Maintenance dredging

Maintenance dredging can cause turbidity and stir up sediment, which gets suspended in the Harbour. There are various methods of dredging, and the point was made that to minimise the level of siltation the type of dredging used should match the type of sediment being dredged. Every two years, 300,000–350,000 cubic metres of water is dredged (maintenance), half in the Harbour and half outside. An application is being processed for 15 million cubic metres of capital dredging for the Port expansion, which would be carried out in stages as required. To allow for larger ships, the Port of Tauranga needs to dredge to 16m inside and 17.4m outside the Harbour. Ongoing maintenance dredging will be necessary every two years. In answer to the question whether turbidity levels would be measured to ensure dredging occurs within allowable limits, a port representative explained that such measurement already takes place, and that turbidity is within limits. However, the location of the turbidity measurements and whether such measurements produced accurate data were also queried.

The turbidity levels and locations for measurements are set as consent conditions. Further comment was made that every impact on the Harbour is a consented impact, which makes local government a contributing factor in all the issues. Questions were raised regarding the source of these stated "acceptable" turbidity levels, and which type of science determines what is an acceptable level for different types of environments. The statement that 99% of government consent applications are granted, provoked queries about such high levels of approval. A local government participant explained the consent procedure, which involves with much time and money, including determining the mitigations or conditions of consents. The counterpoint was made that the percentage of Council money spent on the consent process is small compared with Council revenue. Figure 6 illustrates this discussion.

Figure 6   Causal diagram on dredging
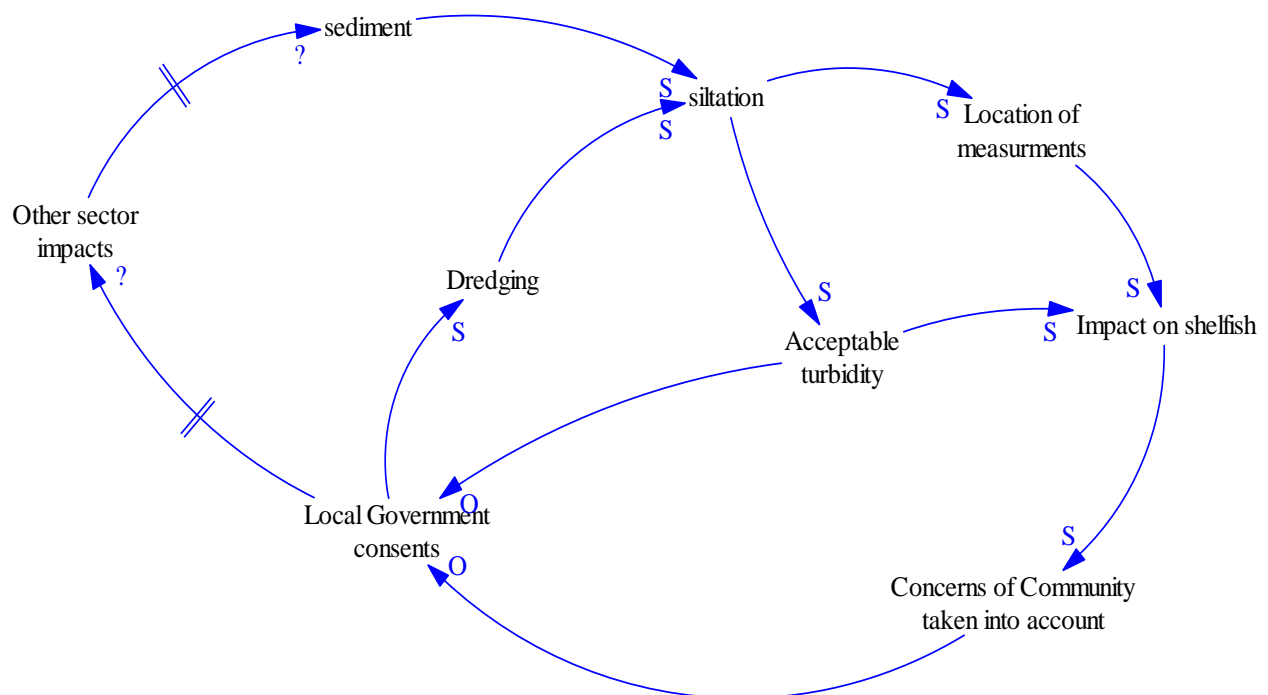
Although such discussions are controversial, they are clearly important, given that people are concerned about such issues, which are often only discussed during consent or litigation processes.
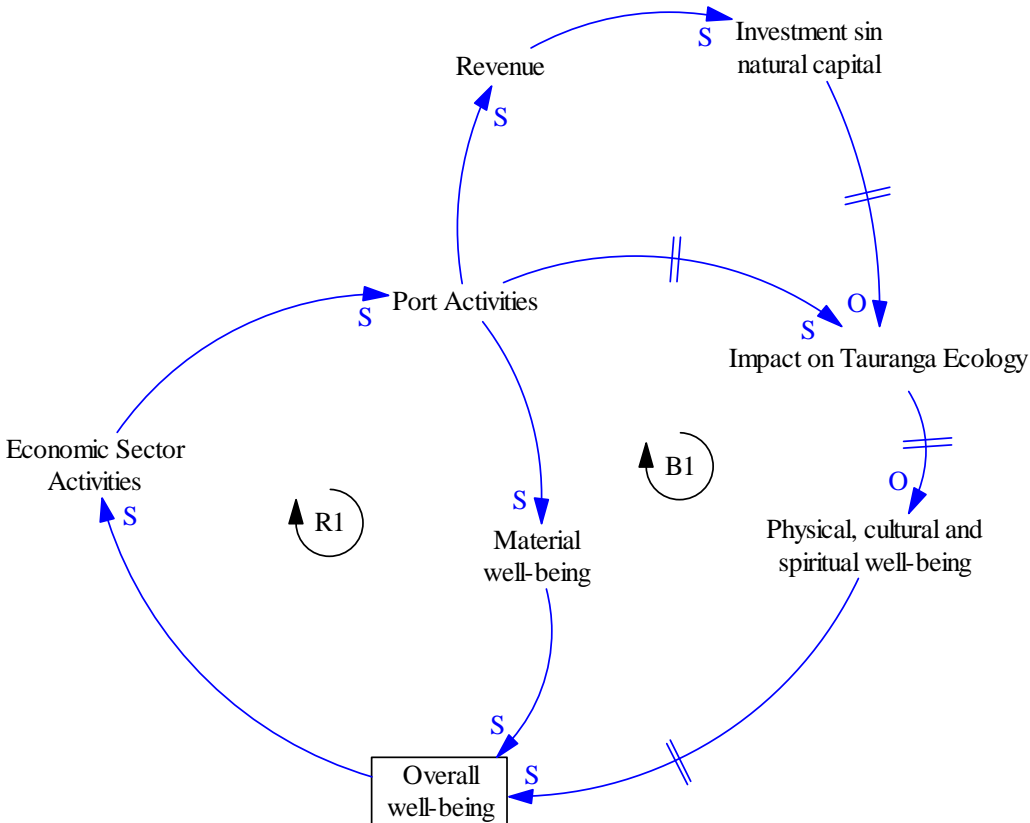
3.2.5. Payment for Ecosystem Services

A dialogue about payments for ES and/or a fund to restore ecosystems was pursued, with participants asking, 'Who pays and who benefits'? In terms of proposed solutions, it had been suggested during the previous workshop that, as a means of corporate responsibility, a percentage of the Port of Tauranga's profit could be contributed to the restoration of Harbour ecosystems to strengthen/restore the services they provide. It was explained that the Port is set up to provide a return on investment, and shareholders' money goes back into dividends or back into Port activity. The BOPRC already administers the Infrastructure Fund and this could potentially be used more for restoration of ecosystem services; however, some participants questioned whether this is what the wider community wants Council money being spent on.

In Tauranga, profit from Port activity currently goes out in dividends, but a new option *could* be, for example, for ES restoration, via the Regional Council" (e.g., the Martha Mine does this now). The Port itself has a responsibility and a moral obligation, but so do the users of the Port, including those industries that use and make a profit because of it, for example, forestry and farming.

The key question the group wanted to reach, which would thus be examined further in the next workshop, was: 'Where would payment for ES come from and go to, and what impact would that have on natural capital (or the state of the Harbour)'? It is clear that international consumers of food exported from the Bay of Plenty "benefit" from the natural capital of this region, but do not currently contribute to the restoration of the degraded ecosystems that initially support that food production. Figure 7 shows a reinforcing loop between the economic sector and port activity (R1) as a fast-acting feedback loop where, in principle, more economic activity leads to more material well-being. However, a much slower balancing feedback loop takes into account the impacts on the ecology of Tauranga Harbour and the much slower impacts that are felt on health, cultural and spiritual well-being; therefore, the overall well-being over the longer term is compromised.

Figure 7   Causal diagram on natural capital restoration

Ecotourism, through which a payment for Ecosystem Services (protection and restoration of them) – for example, a levy paid by cruise tourists – could be introduced. Another idea was the utilisation of the existing Council Land Management Programme (funds are provided by council to farmers for habitat protection through riparian planting) to address sediment and biodiversity.   Could these funds be increased? It needs to be made very clear for taxpayers where any levy will go, and what benefits will be gained as a result (and what losses will be incurred if ecosystems continue to decline), so people understand and will be willing to pay such a levy.

Another idea was instituting a brokerage to auction off ES credits. The group wanted people to be conscious of the services they get from ecosystems; putting a tax on them will accomplish this. However, the counter argument to such levies/taxes was that while the idea sounds good in theory, in practice people often do not like it and may vote against it. The ability of the market to absorb another tax must be taken into consideration. Some people will argue against paying for another environmental levy, "if we already pay for such things through our rates and taxes". The way in which ES are "marketed" will have an impact on people's willingness to pay for them.

3.2.6. Integration decision-making and planning

Ideally, it would be beneficial both if the system was better integrated and all Councils worked together on environmental strategies to be more effective, for example for wetlands restoration; and if there was more Māori co-management. Issues need to be worked through to "make sense" before locals would be willing to engage in ecosystem restoration initiatives. One example raised was that while Councils provide subsidies to protect certain areas, e.g., farm/land owners are left alone and are not compensated for the ES their restoration efforts provide. The ongoing maintenance of any system that was put in place is a major issue – the initial capital investment, including, for example, the subsidy to carry out riparian planting, can often be found, but who continues to provide it? Additionally, planting the right plants in the right sequence is important in riparian margin planting. Native planting is obviously beneficial, but there is also benefit from having some clear grassed land. Some participants felt that if the benefit is "public good", then public money should be put towards maintaining that public good ecosystem as opposed to the cost of mitigation of negative impacts from industry/economic activity. It must also be acknowledged that measures such as riparian planting on farms also benefit the land user who undertakes the improvement, for example, fewer cattle fall into rivers. It was concluded that a carrot-and-stick approach is required because while some people will do things voluntarily, others will only do so if prompted –the model can reflect that a carrot approach is followed by a stick after a specific time lag, such as three years.

3.2.7. In preparation for Workshop 3

A list of Action Points raised during discussions was maintained and ticked off as much as possible over the course of the five workshops.

No reports from small groups are available for this workshop, as the tables for ES of seagrasses and wetlands were developed in plenary sessions.

Based on workshops one and two, the topic of "economics and values of ecosystem services" was confirmed to be appropriate for the next workshop.

3.3.   Workshop Three – 19 January 2011

The primary topic of the third workshop was "economics and values of ES".

3.3.1. Feedback on evolving model

The feedback on the updated model evolved in a dialogue on targets and indicators. Since this was the topic planned for Workshop Four, the summary of that dialogue is reflected in Workshop Four.

3.3.2. Indicators of economic, social/cultural and ecology

Questions raised by participants included: What are the costs for private commercial sectors to invest in Natural Capital and what are the benefits in societal ES? To bring this picture together, the participants worked in small groups on four questions.

These questions (and the answer provided by each small group) were prepared by model building involving: (1) possible funding sources; (2) possible actions to spend such funds on; and (3) potential values of ES. Improvements in ES were then hypothesised to make the Harbour more attractive, thereby attracting more resources to maintain a high quality of both ecosystems and quality of life as a positive cycle. However, the current trends do not necessarily point in a positive direction and, rather, show diverging trends where economic prosperity may go up but ecological prosperity may go down. The full answers developed in small group sessions by the participants are self-explanatory and concise (see Appendix 6). The economic group highlighted relatively standard indicators, such as GDP/capita, number of business start-ups, productivity, and the number of tourists visiting the area. In addition, the percentage of spending of Governmental agencies on the Harbour was recognized as an important indicator, as were "eco-taxes". Indicators relevant to ecology where identified through indicator species, such as whitebait as an indicator for stream health (along with usual water quality indices), cockle health as an indicator species of estuary health, and kereru as an indicator of forest health. Social/cultural indicators included the health and abundance of shellfish, the Cultural Health Index, and recreation. A "sense of well-being" was also mentioned as a desirable index.

During small group sessions, some opportunities for collaborations between territorial and regional authorities were identified that could quickly lead to significant cost savings: the 'back of the envelope' calculation indicated a $1.5M saving. Such opportunities are not modelled and not even specifically recorded in the minutes, but are spin-offs of the dialogue and modelling efforts.

3.4. Workshop Four – 16 February 2011

During the last workshop various indicators where discussed as a representation of economic and other values associated with the Harbour. The topic for this workshop was "indicators, targets and timelines". Box 4 provides an overview of relevant indicators available to support the dialogue about how to interlink such a variety of indicators.

Rather than concrete targets and timelines, the participants discussed the governance aspects.

3.4.1. Governance of indicators, targets and timelines

Monitoring
The monitoring of various indicators was discussed. For point source discharges, the monitoring regimes are well in place with measurements of various concentrations, but public perception could be improved by better communication and education, including how much public funding would be necessary to improve impacts of point source discharges. Non-point sources are more difficult to measure (although this is being developed) and a reliance on the consent process for land-based discharges (rather than into the waterways) was estimated by participants to have improved 80–90% of the nutrient runoff and decreased the need for farmers to import nutrients into the system. There has therefore been a reduction in the impact of discharges on the Harbour as a result of changed land-use practices, for example, changes in rates of sedimentation/nutrient enrichment/ground water leaching. However, the actual rate of impact is site specific and depends on many things, including practices of the individual land owner, soil type, gradient of the land, river/streams running through property or not, and so forth. The nutrient reduction work is only measured and accounted for on a detailed level in the Rotorua Lakes catchments by BOPRC. It

was also noted that the practice of releasing effluent ponds only in the dry summer periods to maximise the reduction in run-off into rivers is extremely effective.

Carrot and stick approach

The question of "guidelines" vs "requirements" was discussed, and although it was acknowledged that there was merit in both approaches, it seemed wiser to use the guidelines approach first and then use the "stick" approach on the remaining proportion who would not change practice voluntarily. Figure 8 illustrates the carrots-and-sticks scenario. The parallel line from policy/consents to targets and regulation/enforcement indicates a time lag or delay in making such a connection, whereas the incentives, education and "carrots" can be deployed first. There is a knowledge gap among some landowners, such as lifestylers, about leaching: while most large farmers are well informed other groups often have little understanding. Guidelines and "carrots" therefore need to provide a clear message that within certain timeframe "sticks" will be developed. Figure 8 demonstrates the relationship between short term incentives and delayed regulation in relation to targets and monitoring activities. These targets and monitoring requirements can be adjusted with a time lag to fit the purpose; either the targets or the policies and their enforcements can be adjusted.

Figure 8   Causal diagram of "carrots and sticks" to influence behaviour
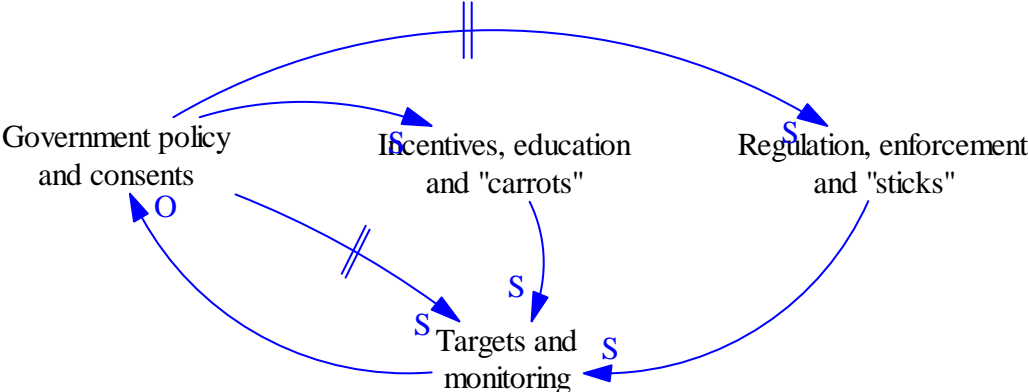
3.4.2. Toward concrete solutions

Herd Housing

It was recognised that while controlling nutrient/effluent in dairy farms is a major issue, so is urine leaching. Acceptability of herd housing is currently low in New Zealand, but was this carried out in cold, rainy months it would be much easier to limit nutrient pollution. A preliminary Massey study has shown that cow housing may reduce urine leaching by around 40% (Christensen et al., 2010). This solution can be simulated in the scoping model.

Riparian planting

Riparian planting was suggested as one solution in the combined sediment and nitrogen runoff conversation, especially since it seemed that the BOPRC Infrastructure Fund references riparian zones as "infrastructure". This would make the "proportion of total margins that are riparian planted" an indicator and targets could therefore be set for it over time. This solution can be simulated in the scoping model.

Seafood beds

While there was general agreement that kaimoana/seafood beds are in decline, there was disagreement over the cause. Is it due to overharvesting (which is a Ministry of Fisheries not a Council issue), or is it due to environmental issues (which is a Council issue)? "State/abundance of shellfish" would make an indicator and targets could be set for it.

It was mentioned that scallops used to be found in good numbers, but fishing pressures on them has increased. The use of technology such as fishing boat dredges/trawlers also decimates the seafood beds and impacts on their ability to survive. There was disagreement on whether or not trawling is being done in the scallop beds; while there are rules in place, violations happen. Scallops are included in the model and would make a suitable indicator for which targets could be set. However, no data or data trends could be identified beyond the concern expressed by tangata whenua with regard to scallop abundance.

The degree to which invasive species impact on seafood beds is currently unknown. Based on personal observations, invasive species do have an impact, but seafood beds seem to be able to recover after a certain time period. The scoping model is set to simulate the role of seafood beds.

3.4.3. Dr Mel Green – Sedimentation Research, Southern half of Tauranga Harbour

Dr Mel Green, NIWA, presented research undertaken for BOPRC on sedimentation in the southern half of Tauranga Harbour. His model ran scenarios from 2001 to 2051, examining sediment yield per unit area. Multiplying the sediment yield for various land uses/covers provides the sediment loading. The conclusions included:

a) 64% of sediment runoff comes from pastoral land use; less than 0.5% comes from earthworks;

b) It is predicted that over the next 50 years sedimentation will decrease 5.6% due to land-use change, i.e. increased pavement and hard surfaces reduce the runoff of sediment, but increase the runoff of toxics.

c) When climate change (increased high intensity rainfall events) is taken into account, sedimentation will increase by 40.6%. The effects of climate change magnify sedimentation.[5]

Dr Green stated that the "sedimentation problem" is in the sub-catchments, which is where the battle needs to be fought. The NIWA model identified areas where sedimentation is likely to have greatest impact. Of those areas, those with the greatest potential for "mitigation/effort to address impacts" are Waitao, Kaitemako, Waimapu. Medium potential areas are Te Puna, Oturu, Mangawhai, Waipapa, Apata, Wainui, Aongatete. Areas that are of high cultural/ecological significance may also be worth effort for reasons other than future sedimentation effects.

Land cover is very important for the long term and needs to be addressed in Management Plans. Climate change is projected to impact significantly on the sedimentation in the Harbour, but actions can be taken now to protect/limit damage, using ES to mitigate the changes.[6] These include mangrove control (which is a heavily debated option); replanting/seeding seagrass and shellfish beds in estuaries (NIWA is doing studies on these further north, and lessons could be learned for Tauranga Harbour). It takes 5–10 years to complete the replanting, and it is important to replant in areas where the seagrass/shellfish can spread. Questions that need to be assessed are: how many areas are suitable for replanting, and what would be the maximum area covered by seagrasses and or shellfish beds under an ideal scenario?

Key initiatives that could be implemented as soon as possible to address looming sedimentation issues include restoration (e.g., seagrass, shellfish beds); interventions (mangrove removal (or not); riparian planting); and mitigations.

Participants were clear that land-use change needs to be addressed, because matters needed to be addressed. "You can't keep doing the same kinds of activities that cause high levels of sedimentation and expect that there won't be problems down the track or restore in the face of the same or stronger stressors."

The NIWA model presented by Dr Green did not take into account the effect of riparian margin planting on sedimentation, but it was acknowledged this is an important consideration. Other NIWA studies are looking into this factor for future reference.

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[5] The participants observed that it would be interesting to compare local stories about what happened when the dam collapsed with how the NIWA model projects sedimentation into the future in ongoing research.

[6] The participants raised the possibility of planting on important sites that are subject to great sedimentation, but this has to be assessed against other considerations such as historical places and archaeological site protocols, and the fact that for some people it is important to "see" places of cultural significance and not to have them covered in trees. However, it was acknowledged that if such sites keep eroding, they are being lost anyway, so it is better to have them planted and stabilised, than lost altogether by erosion/sedimentation.

3.4.4. Small Groups

The indicators currently in the model (as at Workshop 4) are:

a) Economic activities/funds indicators. e.g., potential new Harbour restoration funding relative to contribution of industrial sector; direct Tauranga Harbour environmental spending by agencies relative to total spending; value of tourism to Harbour catchment relative to total value; total introduced forest value relative to total value; ecosystem value of the Tauranga Harbour and catchment.

b) Ecology-related indicators, e.g., wetlands in ha, seagrasses in ha, mangroves in ha, total forest in ha; microbial and viral quality of shellfish: length of period harvest ban; various species (species composition and abundance): cockles, oysters, pipi, green-lipped mussels, tuatua, scallops, eels, whitebait, snapper, leading toward a biodiversity index; total ES value; boating, trawling and dredging: number of events per year; total loading (non-spatial) of sediment, *E. coli.*, N, P, toxins.

c) Social and cultural factors, e.g., food: number of days and places that people should not harvest kai from Harbour; swim-ability: number of days and places when people must not swim); social and cultural well-being (measured how?); population and number of households, unemployment, crime, gap between poor and rich (gini co-efficient).

3.5. Workshop Five – 4 May 2011

The topic of the final workshop was simulation of scenarios, findings, recommendations and action plan.

It had been difficult to reschedule this workshop, which had originally been scheduled for mid-March 2011. After an assessment of participants' availability, we found that, at best, we would only be able to gather half our participants, as other participants were unavailable for each available option. The MM project team is confident that the slightly lower attendance was not due to lack of interest, but rather to unfortunate scheduling options. Several new participants attended to learn what had been achieved in previous workshops.

The participants were presented with the concept of the final Tauranga Coastal Ecosystem Service Model (TCESM) (see Figure 9).

Figure 9   Causal map of overall Tauranga Coastal Ecosystem Service Model (TCESM) model
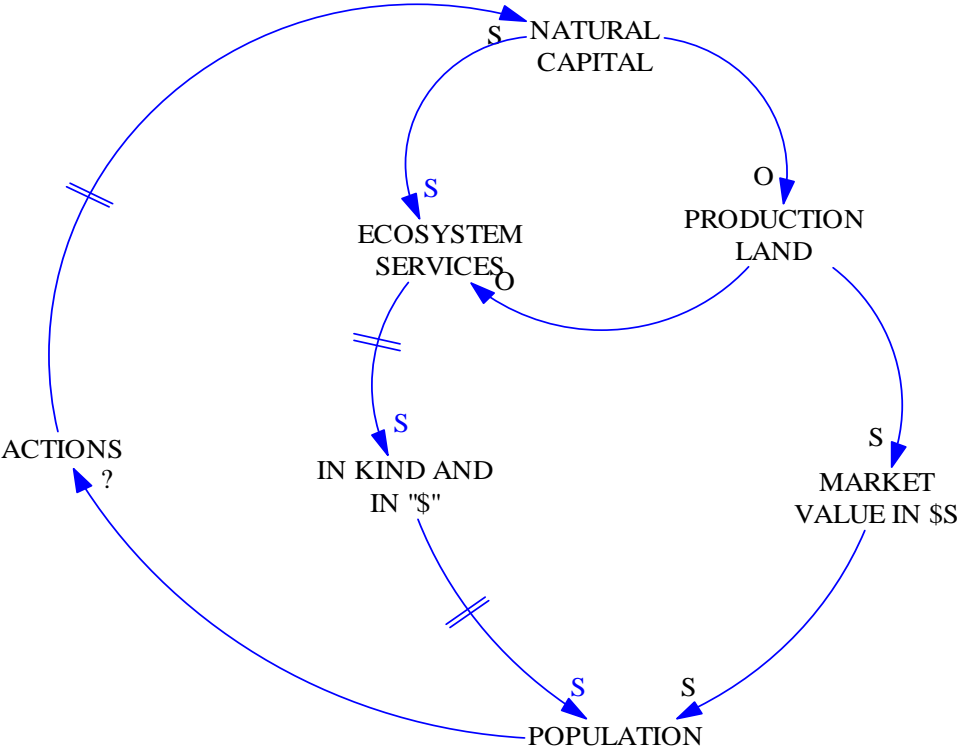
Taking Natural Capital as the starting point, an increase in Natural Capital generates Ecosystem Services. An increase in Natural Capital diminished Production Land and that increases Ecosystem Services. Two parallel processes are visualized. The fast acting process is where Production Land generates Market Value in dollars. The slow and less visible process of Ecosystem Services generate a Non-Market or "in kind" value which can be partly expressed in dollars. Both Market and non-markets values are important. Together these values provide a "true value" and attract (or repel) Population to the Tauranga region. The question is what type of Actions this Population will take (such as restoration activities), which would possibly change Natural Capital after a delayed period of time.

The corresponding graph that resonated the most with the story in the Causal Loop Diagram (Figure 9) is shown in Figure 10; the changes over time of GDP (historic and projected) and the Ecosystem Service Values (based on transferred benefit information rather than readily available information). The "True Value" is derived from adding both these visible Market and invisible Non-Market values.

Figure 10   Base case for GDP, ES Values and the sum of both into a "true value" of Tauranga Harbour
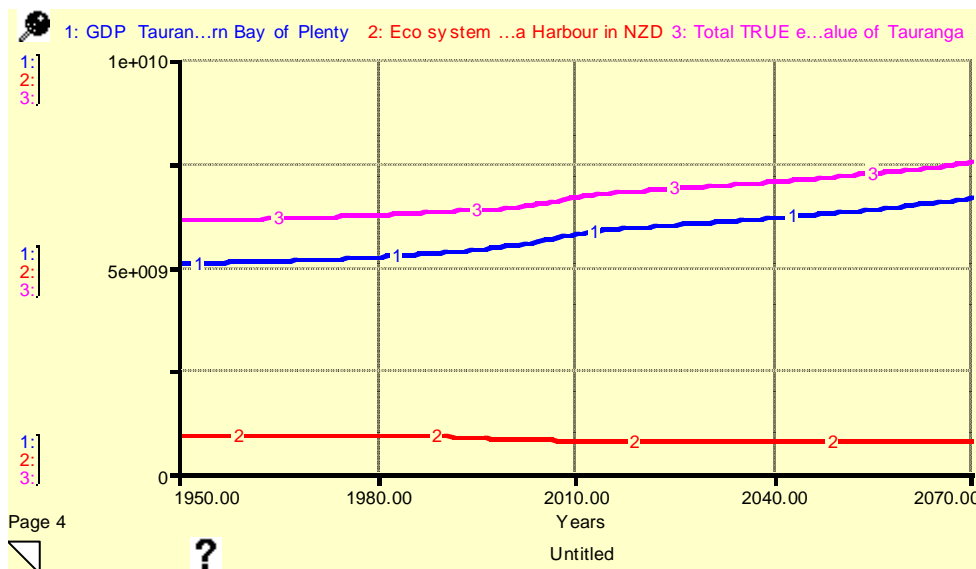
Even though the current version of the model isn't very sensitive, time allotted (including training the Tauranga-based Research Team) didn't allow for additional feedback loops between Economic Activities (represented by GDP) and Ecosystem Services (derived from Natural Capital). It was clear that the direction the model is going in was highly appreciated by the participants.

Simulations were presented by explaining how the model is "calibrated" and what assumptions have been made (see Appendix 7).

The following scenarios were discussed:

1. What if there is a limit for urban area/sprawl?
2. What if ES values are higher than currently visible?
3. What if the Harbour carries more international tourists?
4. What water restrictions reduce the carrying capacity of tourists?
5. What if new funding is coordinated into various solutions?

Each of these scenarios has an impact on multiple indicators; they are discussed in detail in Section 4.3.

The WakaDigital members of the MTM team provided the group with 10 laptops, loaded with STELLA and the finished model. The participants then had an opportunity to gain hands-on experience with running some scenarios and clicking on various icons to learn the source of the information used or what assumptions the modellers had made in entering the data.
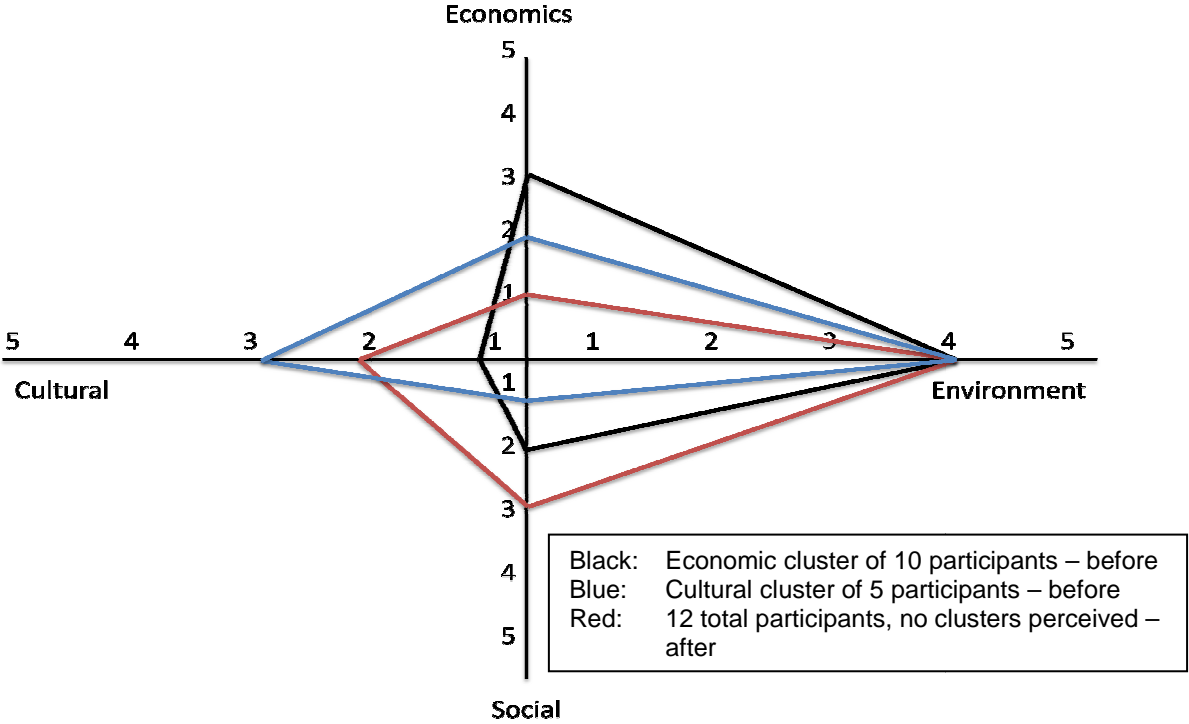
Findings and recommendations had been drafted by the MM research team, based on the notes taken during the previous workshops. These drafts were handed to all workshop participants, and were discussed and amended by group consensus. The results are provided later in this report (see Section 5).

There was little time for action planning following SMART[7]-principles; however, momentum for on-going engagement was established, specifically through agreement to have another meeting later in the year.

3.6. Workshop evaluation – comparative results of pre- and post-workshop questionnaires

The participants were interviewed before and after the series of five workshops; the post survey can be found in Appendix 1. The comparative results are discussed here. Before the first workshop we had aimed to interview all participants and succeeded in reaching 15 out of the 20 people who had agreed to participate in the first workshop. The participants were asked to rank the four aspects of well-being and their relative importance to the stakeholder groups they represented. Figure 11 shows two distinct clusters among the 15 participants interviewed before the workshops: one (black) cluster consistently ranked the economics and environment axes as the most important (10 participants), while the other cluster (red) indentified the Cultural – Social – Environment axes as most important (five participants). After the workshops, there was not much clustering of responses, and the red line averages the ranking by the 12 surveyed participants. Three participants took part in the pre- and post- workshop survey; the comparison between both surveys is therefore not specific, but rather generic. The participants filled out the surveys under the understanding that their answers would be used for research purposes, but that they would not be identifiable. Therefore, the tallying and reporting of the surveys is broadly interpreted by the project team.

Figure 11 Topical interest pre- and post- workshops.

Black: Economic cluster of 10 participants – before
Blue: Cultural cluster of 5 participants – before
Red: 12 total participants, no clusters perceived – after

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[7] SMART = Specific – Measurable – Achievable – Realistic – Timeline

This overview of clusters led us to believe that "environment" provides the "common ground" for this group, but that the understanding of "economics" requires attention. This research project started from a strong social-cultural perspective and it is clear that this area also requires understanding and perspectives. The post-workshop survey shows a clear increase in the rating of cultural aspects. When participants were asked if they had learnt something new, several participants described "ah ha" moments regarding the cultural significance of certain shellfish for iwi.

In the pre-workshop survey, when participants were asked to rank the "state of Tauranga Harbour" on a scale of 0 to 10, where 10 represented a pristine state and 0 a dead zone, on average, the participants rated the current state at 3.1 and would like to see that raised to 8.2 by 2030 (see Figure 12). Realistically, participants thought a 7.2 should be achievable, but feared that it could fall to a 2.3 if business as usual continued and nothing pro-active was done.

Figure 12 Perception of health of Tauranga Harbour
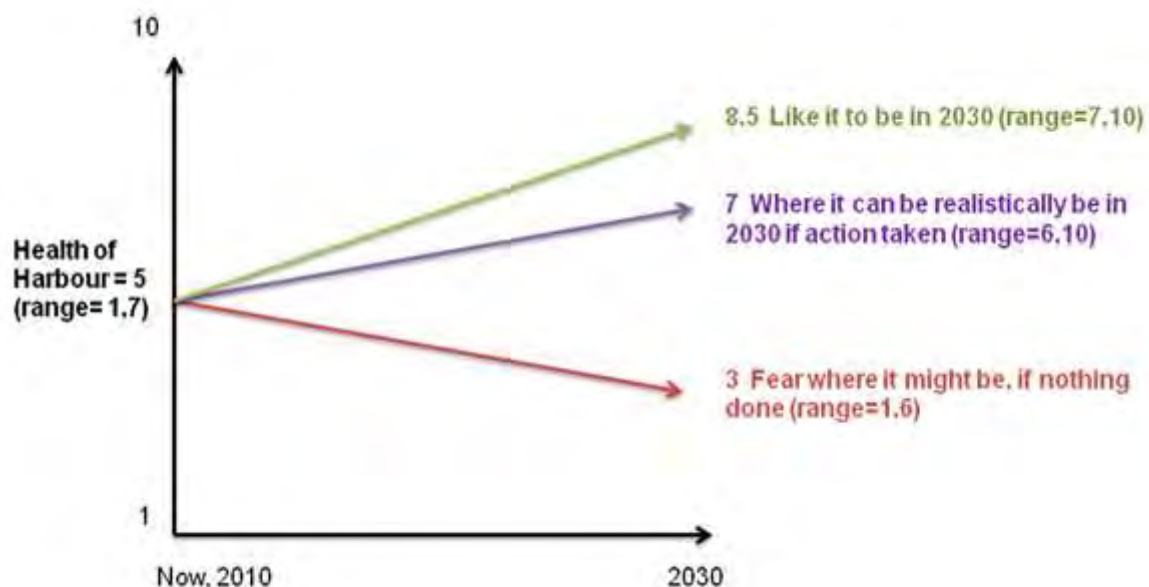
In the post-workshop surveys, participants believed that, on a scale of 0 to 10, achievement of the health of the Harbour was rated, on average, as 7.6. This is higher than the perception of the achievable health of the Harbour before the workshop (see Figure 12).

The perception of the surveyed participants is that: "The outcome of the workshops will lead to moderate (average rating of 4.2 out of 5) improvements of the Harbour".

The participants were asked to rate the participant list (pre-workshops) and perception based on experience (post-workshops) on:

> (1) *Inclusiveness*: the level of inclusiveness of different perspectives;
> (2) *Time preference*: The participants' support of actions that will cost in the short term but have a greater benefit in the long run;

(3) *Leadership*: the prospect that recommendations developed during the MM process will be implemented by those in leadership positions;

(4) *Creativity*: the number of innovative ideas that were generated during the process.

Figure 13 shows that the perception on all four areas increased.

Figure 13 Perception of participant list (pre-workshops) and participant impressions (post-workshops).
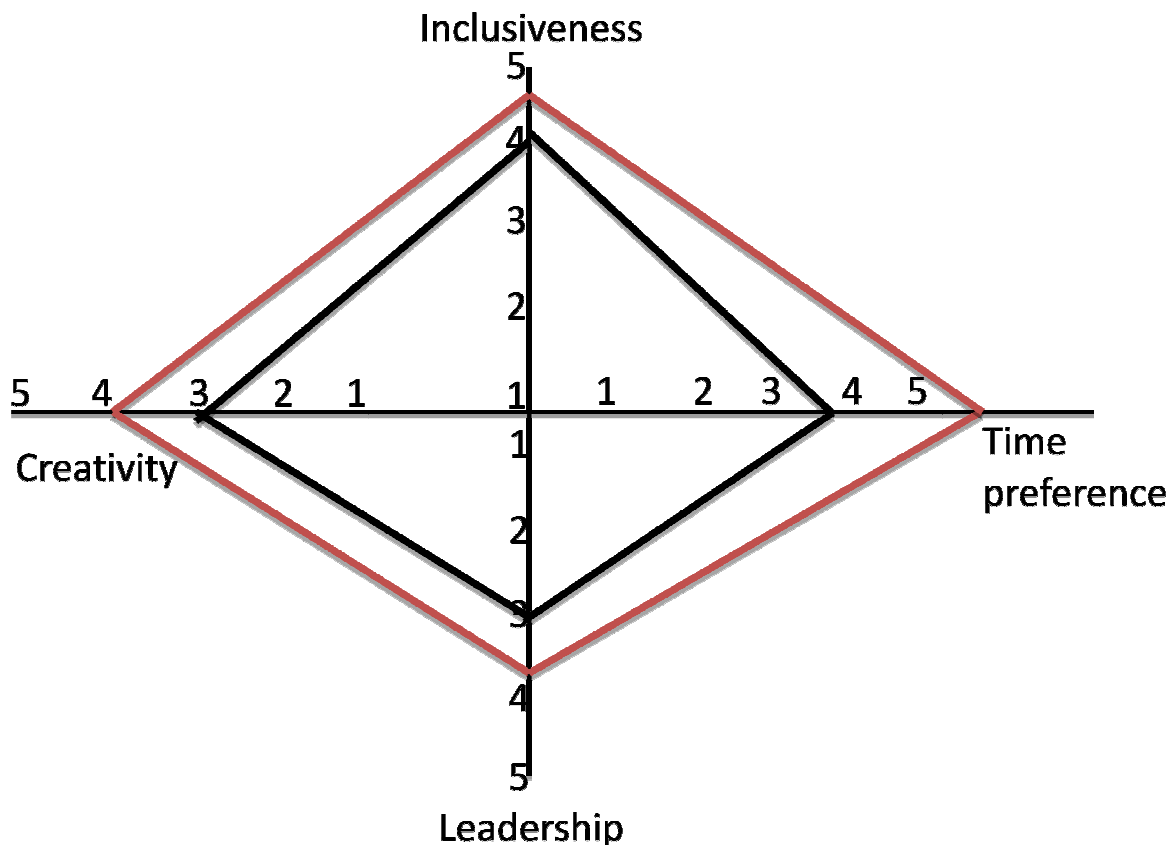
Both pre- and post workshop the perceived level of consensus on was measured on:

(1) how the Tauranga Harbour **currently** "ticks" with regard to social, cultural, economic and ecological aspects;

(2) what the **future goal/vision** for the Harbour is;

(3) how to manage the Tauranga Harbour from its current state **toward** the future goals/vision.

The black line shows the average perception before, and the red line shows the perceptions after the workshop. Of interest is that 'consensus on the goals and vision', in particular, increased quite remarkably, as did 'pathways toward the goals'; 'understanding of the current state' improved from 3 to 4.3 (see Figure 14).

Figure 14 Perception from current understanding, future goals and pathways

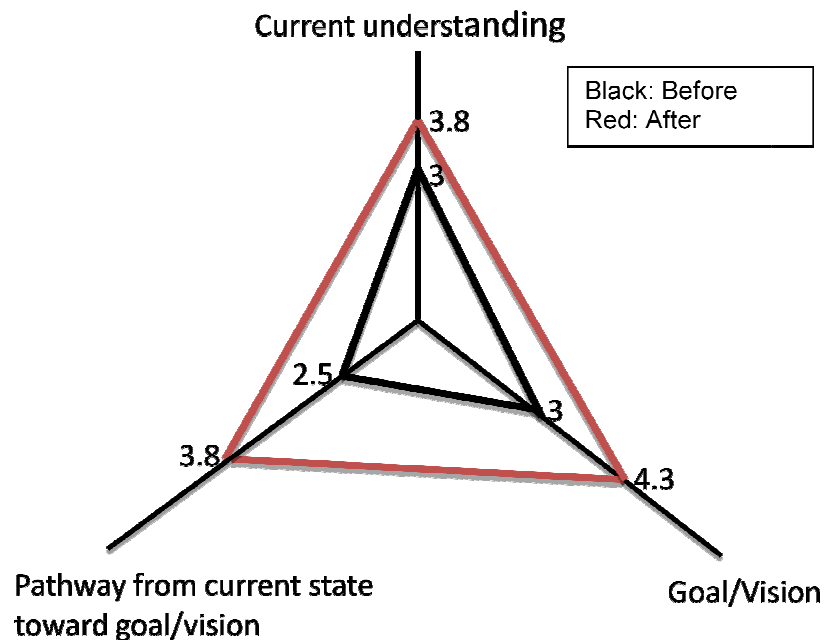The confidence with which the group arrived at good recommendations was rated at 3.8 out of 5, with a spread of ratings from 2 to 5. Those who attended more workshops were more confident that positive recommendations were developed. Some interviewees did not answer the question or rated it as neutral when they missed the final workshop and had not yet seen the recommendations.

Ten of the twelve participants interviewed said they had learned something new from the workshops. The type of insights or learning mentioned by participants included:

- The cultural significance of shellfish, particulary for tangata whenua.
- The impact of sedimentation on shellfish and the state of the shellfish populations.
- The lack of coordination between local and regional governmental organizations as well as the level of politicking. Only marginal plans seem to be currently in place and there is a need for an independent body for coordination and solutions beyond marginal planning.
- The existence of STELLA software and how model building can be used in meetings.
- Surprising consensus on potential sources of funding sources for ES restoration, such as the Infrastructure Fund.
- Ecosystem Services: the realisation that we talk the same language can link ecology and economics.

- Non-market values and ecosystem services and realisation of where the long-term costs should lie.
- The actual building of the model and fitting the pieces together.
- You can get all these organisations in the same room and involve them all.
- Interdependencies on a big chart; we do need a model to bring it all together.
- Open and honest view from those groups who have on occasion been hostile.
- A greater appreciation of the iwi perspective through the discussion on the loss of mana when they were unable to provide the bountiful supply of seafood for which they were historically known when attending nationally important hui.

When asked how well the views of participating sector perspectives were explained, the environmental groups and regional council scored equally highly. The iwi MM representatives and local government scored lower, mainly due to a lack of physical presence. The farming/industry group was rated in between. On average, the various sector voices were heard fairly equally; those who were present had an equal opportunity to be heard if they chose to speak. Most participants valued a facilitation style that allowed for all to have a voice. Of course, it is not known why some of the participants did not continue to participate or come to later workshops. However, most participants who could not participate apologised in advance on the basis of conflicting appointments rather than "disappearing". In addition, word-of-mouth also caused some new participants to show an interest in the workshops and a few new organisations attended the final workshops.

The participants indicated the value of various aspects of the MM process, by rating various factors on a scale from 1 to 3, with 1 being not helpful and 3 being very helpful. The results are displayed in Table 2.

Table 2   Did you find the following aspects of MM helpful?

Aspect of MM	Not helpful = 1	Helpful =2	Very helpful = 3	Average
Facilitation	0	3	8	2.9
Providing a neutral space	0	3	8	2.9
Structuring the thinking	0	4	7	2.8
Focus on change over time	0	5	6	2.7
Choice of topics for the workshops	0	4	5	2.7
Providing a neutral "language"	0	5	6	2.7
Model simulation	1	4	5	2.5
Translating data into "simple" relations	2	4	6	2.4
STELLA software	1	3	5	2.3
Structuring the dialogue	0	8	3	2.0

Eleven of the twelve[8] interviewed participants (the exception thought the group was too large) would participate in additional MM workshops. All interviewed participants (including the participant who thought the group was too large) would recommend the MM process to others. All participants, except two who abstained primarily because they did not think they understood the details of the model well enough, stated that they will demonstrate the model to their networks.

3.7. Participating stakeholders

It is recommended to limit the number of participants in future mediated modelling workshops to between 15 and 20 people. However, if there is more interest than spaces at the table, observers can be allowed. There is a trade-off between the added transparency of a second tier of stakeholders and the fact that observers create an additional need to be managed and often do not "stick to the rules". In the Tauranga case, the participant list fluctuated over the course of the workshops both because participants started to discuss the project with their peers, and because some participants were not able to attend each workshop and another representative attended from their sector/group. The MM project team proceeded without strict enforcement of "observer status" because the dialogue remained positive and constructive and was often enhanced by consistent additional sector representatives, or "observers". Newcomers to the process did struggle at times, mainly because they did not understand the sometimes quite complex discussions that had taken place in previous workshops, or the content of the increasingly complex model. Appendix 3 shows the participant attendance across all workshops. Although the total attendance stayed relatively stable (18–23 participants), 4 participants attended all five workshops, 13 attended 3–4 workshops, and 20 attended 1–2 workshops.

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[8] One participant scored both "not helpful" and "helpful" for all aspects of MM (Table 2) and applied the reasoning that the generic aspects of the MM process are helpful, but that the group in which this tool was deployed was too large. This particular participant's survey was therefore omitted.
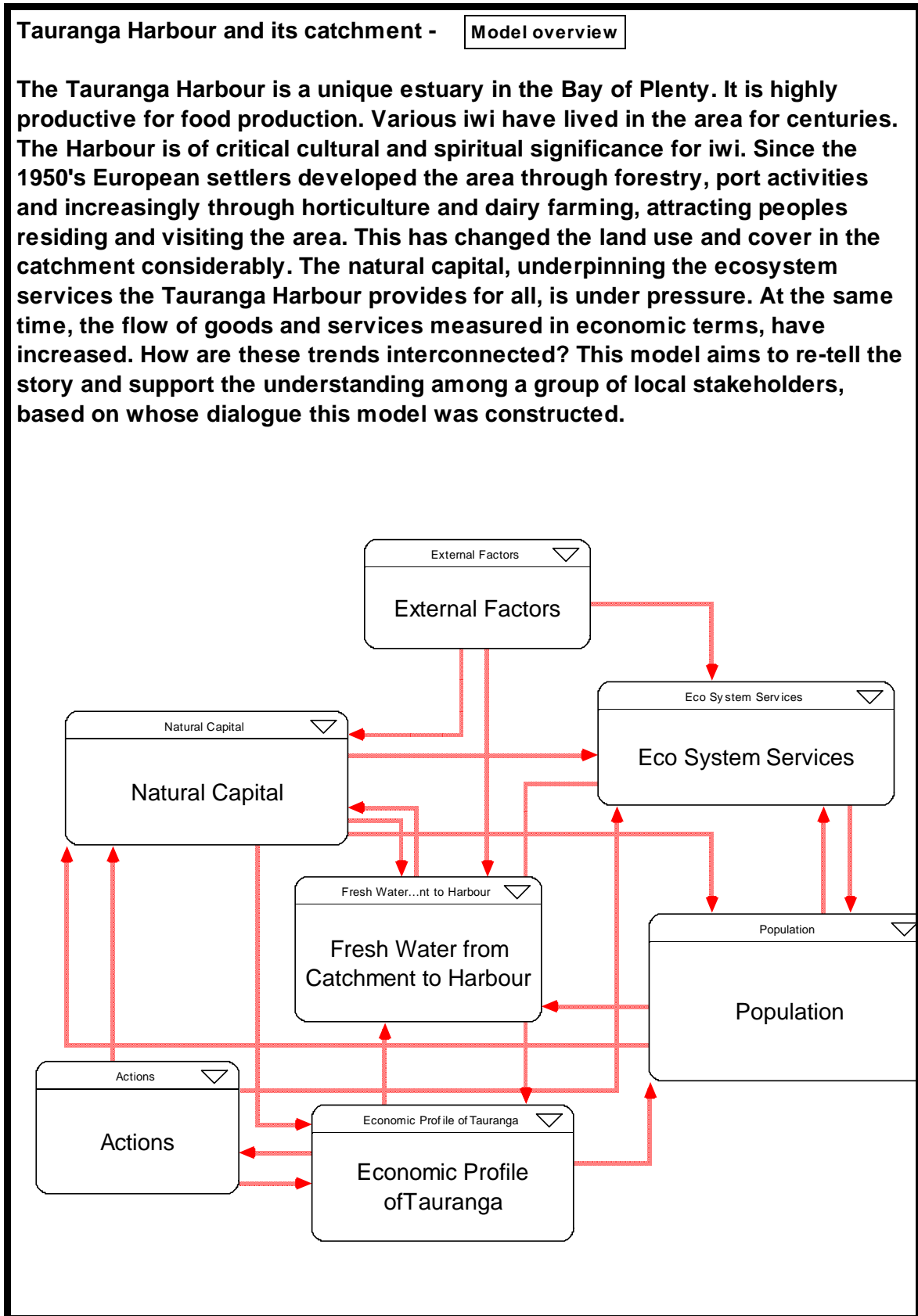
4. THE TAURANGA COASTAL ECOSYSTEM SERVICE MODEL (TCESM)

The model evolved over the course of four workshops, and its final version was presented during the fifth workshop. The model-building process was an iterative process between workshops. It also involved the training of two members of the Māori community who, are part of the Tauranga-based Research Team. Without previous experience in this field, they two members learned how to use the STELLA software and the basics of system dynamics model building. Only one of the invited participants had experience with STELLA model building at the start of this project. The TCESM is a scoping model, and as such is a framework for the various interests and concerns the participants deemed important. The MM project team aimed to interpret the dialogue as well as find relevant trend data to understand the Tauranga Harbour system from an integrated social, cultural economic and ecological perspective. The TCESM is not a predictive model, but rather a model to support learning and understanding of Tauranga Harbour from a more integrated perspective. In addition, it is important to note that a model is always an abstract reflection of reality – it never *is* reality. Nor is a model "magic", as it only does what it is instructed to do. MM-based models are per definition a "work-in-progress" as they are intended to support an on-going dialogue and aim to develop adaptive capacity. The presented model is what could realistically be achieved in the time allotted. A simplified version of what is described in this report is presented on the MTM website using Forio software; this platform supports small STELLA-like models. At 13 December 2011, 58 runs of the model parts presented in Forio were recorded. There are no statistics on how many people have downloaded STELLA software and the model associated with each of the workshops. Participants attending the final workshop did interact with the TCESM model.

4.1. How the TCESM model works

The overview of the TCESM model, shown in Figure 15, can be found on the "interface" when opening the model. The interface also provides the "flight panel" for the model, showing various graphs from 1950 to 2070 with time steps of one year. The graphs illustrate changes that have occurred over the period (1950–2010) based on available data or perceptions. The trends or perceptions about trends are simulated into the future (2011–2070). These future trends are largely a result limiting factors (such as water availability and attractiveness) by assuming balancing feedback loops in the model. Additional information can be found in Scenarios, section 4.3 below.

Figure 15 Tauranga Harbour and its catchment – TCESM Model Overview

Tauranga Harbour and its catchment - | Model overview |

The Tauranga Harbour is a unique estuary in the Bay of Plenty. It is highly productive for food production. Various iwi have lived in the area for centuries. The Harbour is of critical cultural and spiritual significance for iwi. Since the 1950's European settlers developed the area through forestry, port activities and increasingly through horticulture and dairy farming, attracting peoples residing and visiting the area. This has changed the land use and cover in the catchment considerably. The natural capital, underpinning the ecosystem services the Tauranga Harbour provides for all, is under pressure. At the same time, the flow of goods and services measured in economic terms, have increased. How are these trends interconnected? This model aims to re-tell the story and support the understanding among a group of local stakeholders, based on whose dialogue this model was constructed.

On the second layer the four model icons (stocks, flows, variables and connectors; see Figure 16) are used. Clicking on the triangles in the model overview brings one to the details in the model sectors.

Figure 16 Four icons: Stock, flow, converter and connector (red arrow)
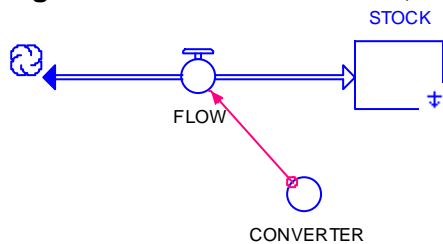
With these four icons, we describe in each of the sectors how issues of relevance have been interconnected. A detailed Model Description can be found in Appendix 5. Double clicking on any of the icons in the model brings the user to the equations describing how the various icons link to each other. The user can also access a "Document" attached to some (not all) icons describing the data, the sources and the way such data was used is described in the "Document" under the relevant icons. If an icon is represented by a "slide bar" on the user-interface and a "Document" is available for that icon, it can be accessed by clicking on the question mark on the slidebar (Figure 17)

Figure 17 Example of slide bar with access to a "Document"
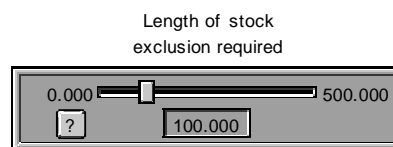
When clicking on the "?" of the slide bar the "Document" will say: "BoPRC can provide figures on the lengths of streams and lengths protected from grazing and the lengths included in formal programmes (this is currently being collated by their GIS analysts). Assume 100 km"

This allows points the user or future model developers in the direction of the data source, as well as the temporary assumption (100 km) that is used to progress the dialogue and the thinking about what the solution of fencing could achieve and how the ballpark costs for it.

4.2. TCESM Model assumptions: data gathering, translation and calibration

MM is based on systems thinking, and starts with the identification of a problem in pre-workshop interviews and in the first workshop. The next questions posed are: what is causing the problem, what does this lead to, and what would a "solution" look like? A "solution" changes undesirable trends into more desirable trends. Reference data become important when asking the following questions: how do we know there is a problem? How do we measure improvements? Assumptions need to be made

to maintain focus on the bigger picture rather than going into increasing detail (a natural tendency). Ideally, these assumptions are made transparent and contribute to the learning experience.

4.2.1. Data gathering

A MM process clearly shows what data are and are not readily available. At the same time the MTM team also undertook a "stocktake of available literature and information" (see our website: http://www.mtm.ac.nz/knowledge_centre-publications.php). The MM project was thus able to draw on some of the information already gathered or rely on a team with considerable contacts and experience accessing desired data. On the other hand, the collection of data required to populate the TCESM was informed by the data needs of the workshop participant group, who identified some additional data sources; some synergy existed between the project components of the MTM research programme. Even when data are available, considerable effort and resources are often needed to translate and transform them into information that can answer participants' questions. This task was a joint effort between the MTM team and various participants. Particular mention needs to be made of the valuable contribution of staff from Tauranga City Council (TCC) and Bay of Plenty Regional Council (BOPRC), in particular, who assisted us by providing reports, data, and advice.

As much as possible, the data sources are mentioned in the "document" of the relevant icons in the model, using or interpreting data or a report. The data sources used to inform the model are listed under the references (page 147). Replicating the referencing of the model icons was deemed irrelevant for this report as the model is made available and is discussed in this report.

4.2.2. Data translation and interpretation

Below are some examples of data translations that were required:

Stormwater discharge
This was perceived by participants as a contributor to water quality compromises. The Tauranga City Council (TCC) offered data for Harbour and freshwater streams. For the MM effort, we were interested in knowing the number of spills over time, but this is difficult to measure precisely or ascertain how many "spills" come from specific breaks at specific sources. Therefore, it was important to determine what the TCC assumptions were regarding how "spills" and "blockages" are counted.

Forests (pests and sedimentation)
The Department of Conservation (DOC) and other experts expressed a concern that the *area* of indigenous forests is not the only determinant of its contribution to ecosystem services; how well such a forest functions is equally, if not more, important. In a qualitative manner, it was explained that factors that have an impact on strata within the forest include possums, deer, goats; pulses in climatic events (Environment Waikato and BOPRC are working with DOC on this); impacts of climate change (NIWA, 2008). Ideally, a scale would be available to translate the complex information and assumptions behind ecosystem functioning, which could be temporarily expressed as a slide bar from 0 to 100% (i.e. 0–1). In the absence of an

agreed-upon evaluation, the base case assumes perfect (=1) ecosystem service functioning. However, based only on the initial dialogue, it could be argued that this number decreases over time and is also costly to maintain (linking it to "economics"), as it is primarily involved in control and eradication of pest species. A slide bar in the model reflects this dialogue and simulates a reduced ecosystem functioning of forest areas.

Spatial explicitness

Concern was expressed that this type of systems model does not deal with geographic differences. Sedimentation was highlighted as a major concern and it was acknowledged that grouping all land use types/practices together is done to understand overall trends rather than support localised actions; for example, the land slope is crucial for sedimentation, as is the location of the forest on the land. To simulate such concerns, we made the assumption that indigenous forests are found on increasingly higher slopes as the area of forests decreases. Therefore, as the area of indigenous forests decreases the sediment runoff yield is expected to increase per hectare as the last indigenous forests are considered marginal for production on increasingly steeper slopes. This is illustrated in Figure 18.

Figure 18 Sediment loading from indigenous forests incorporating the assumption of steeper slopes, increased sediment yields per hectare as less area remains indigenously forested
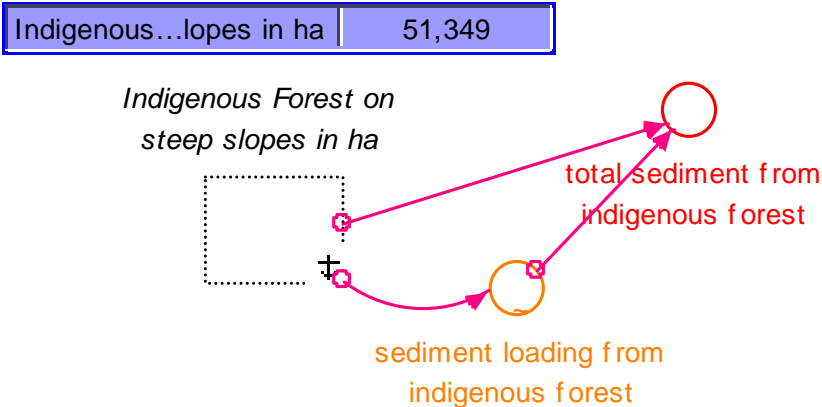

Toward the end of the MM workshop series, the collective understanding of the relationship between sediment and mangroves was increased through the provision of spatial maps and a lecture by guest speaker Dr Malcolm Green, NIWA. However, the depiction of sedimentation and mangroves as sediment traps remains simple in our model. Therefore, the MM modelling team and participants' perceptions drove the direction of the relationship between sedimentation and, for example, factors such as mangrove growth. Updates can be made to the TCESM model if/when alternate solutions or data are identified.

4.2.3. Calibration

"Model calibration is the process of estimating the model parameters to obtain a match between observed and simulated behaviour" (Oliva, 2003, p. 554). It is often difficult to find time series data on aspects of interest, such as land use and land cover changes over time, as published studies typically provide snapshots for single purposes; further, definitions and methodologies between studies, and over time may vary. Following is an example of a time series graph (Figure 19) illustrating observed and simulated behaviour "population", i.e. the number of people residing in the Tauranga area from 1950 to 2010. After 2010, there are no historic data. The model simulates "Population in Tauranga" into the future under various scenarios.

Figure 19   Calibration of population
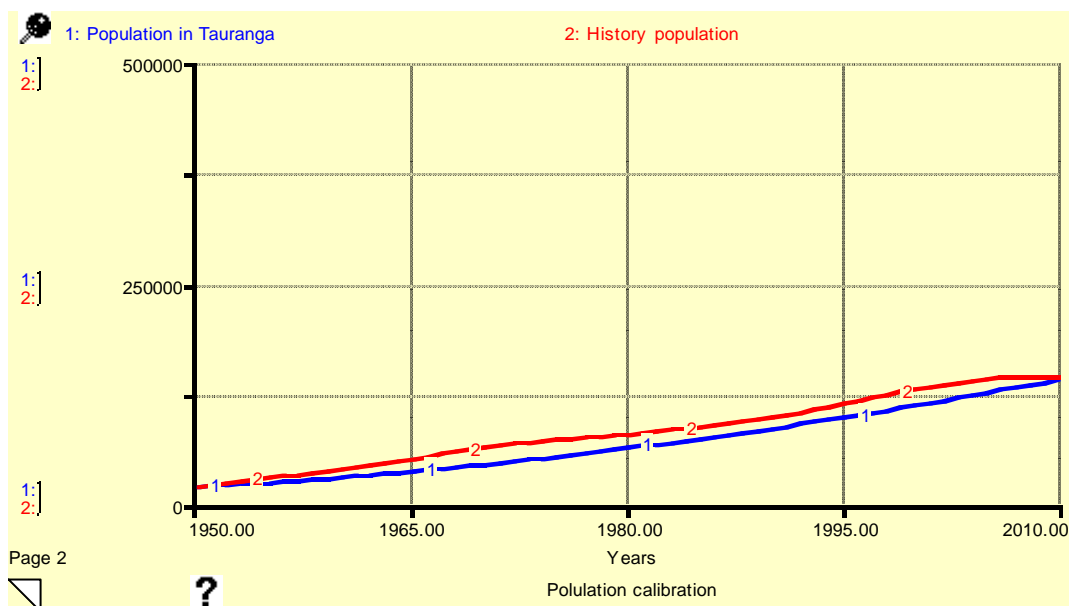
Appendix 7 shows calibrations of the graphs of the historic trend data that were available, compared with the model's interpretation. Available were: population, land area, indigenous forest, introduced forest, scrub, pasture, horticulture/cropping, urban areas, bare earth, sea grasses, mangroves, port activity.

4.3.   Scenarios

The following scenarios were discussed during the fifth workshop:

1.   What if is there is no limit for urban area/sprawl?
2.   What if ES values are higher than currently visible?
3.   What if the Harbour carries more international tourists?
4.   What if new funding is coordinated into various solutions?
5.   The following scenarios were identified, but not simulated during the final workshop:

6. What if climate change increases sedimentation by 40% by 2030 as estimated by NIWA?
7. What if nitrogen losses from dairy farms were reduced by 40%?
8. What if various land-use changes to extremes, e.g., what would happen if we changed all land in the region to indigenous forest, how great would be the economic loss/gain as a result by 2070?

As this is a system dynamics model, potential feedback loops can be explored. Data are interpreted as much as possible, but for many of the linkages no data exist. In many cases, the modeller relied on interpretation of the dialogue. In some cases, the modellers made assumptions. Such assumptions are mentioned in the following scenario descriptions:

4.3.1. Scenario One: What if is there is no limit for urban area/sprawl?

The base setting of the model (blue line 1) shows a limitation on the urban area. The historic information indicates that the urban area has increased from 1600 ha in 1959 to 5500 ha in 2001. We assumed a limit of 7000 ha as a desirable level of urbanisation. This may be changed with the slide bar (see Figure 20).

**Figure 20 Slide bar to change the maximum urban area in hectares.**
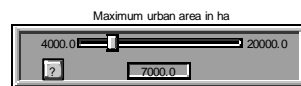
If there is no limit (assume 20,000 ha) on the development for urban area/sprawl, the model simulates the current growth rates into the future uninhibited. Figure 21 shows the comparative graph of population in Tauranga under a) an unlimited or b) limited scenario, of urban area development.

**Figure 21 Comparative graph of population in Tauranga**
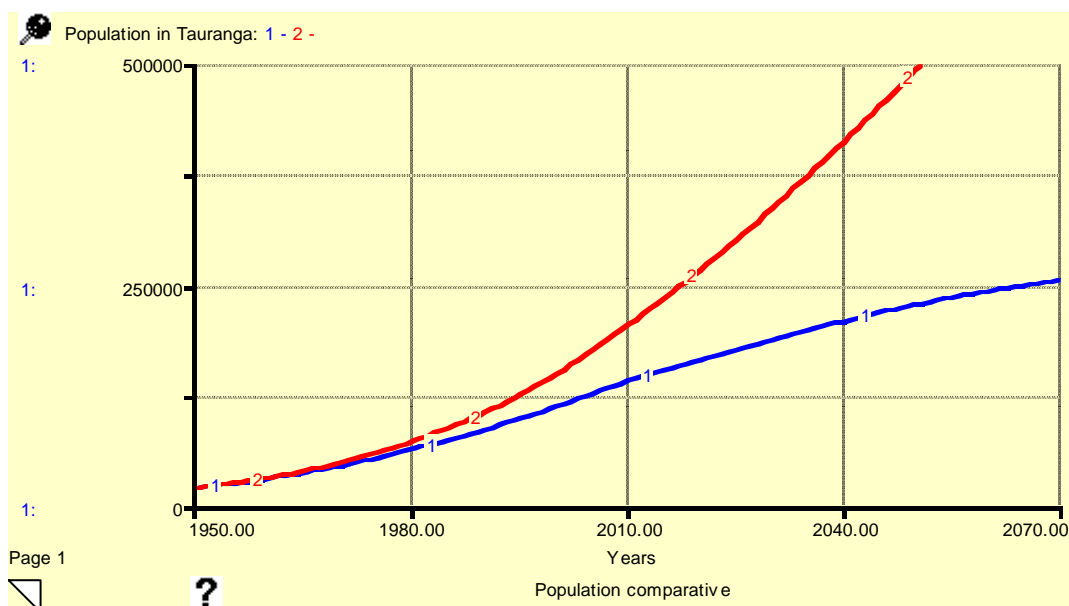
If urban sprawl is unlimited, this could reduce the sedimentation runoff (see Figure 22) due to an increase in hard surfaces.

Figure 22 Comparative graph of Total Sedimentation in tonnes per year under a scenario of limited urban sprawl (1) and unlimited urban sprawl (2)
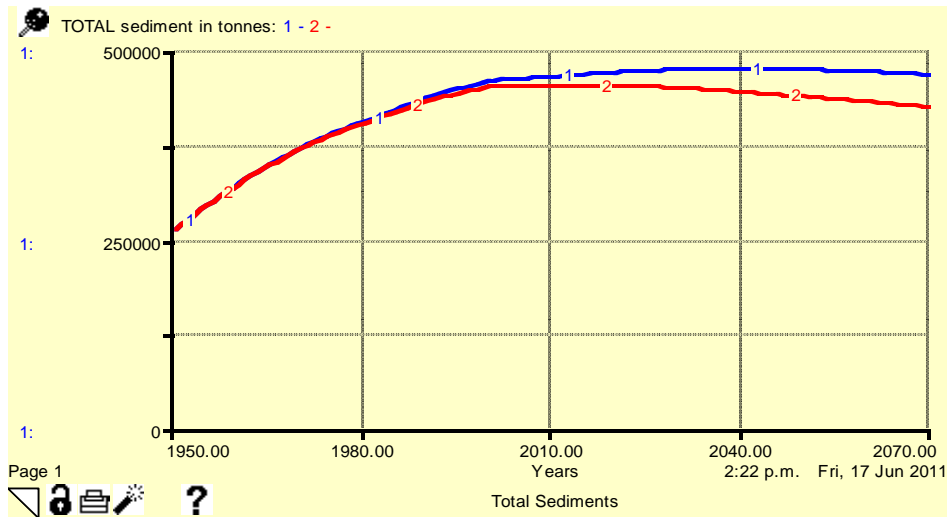
Similarly, nitrogen runoff could be reduced, as the conversion into urban area mainly comes from pasture (see Figure 23).

Figure 23 Comparative graph of total nitrogen runoff scenario 1
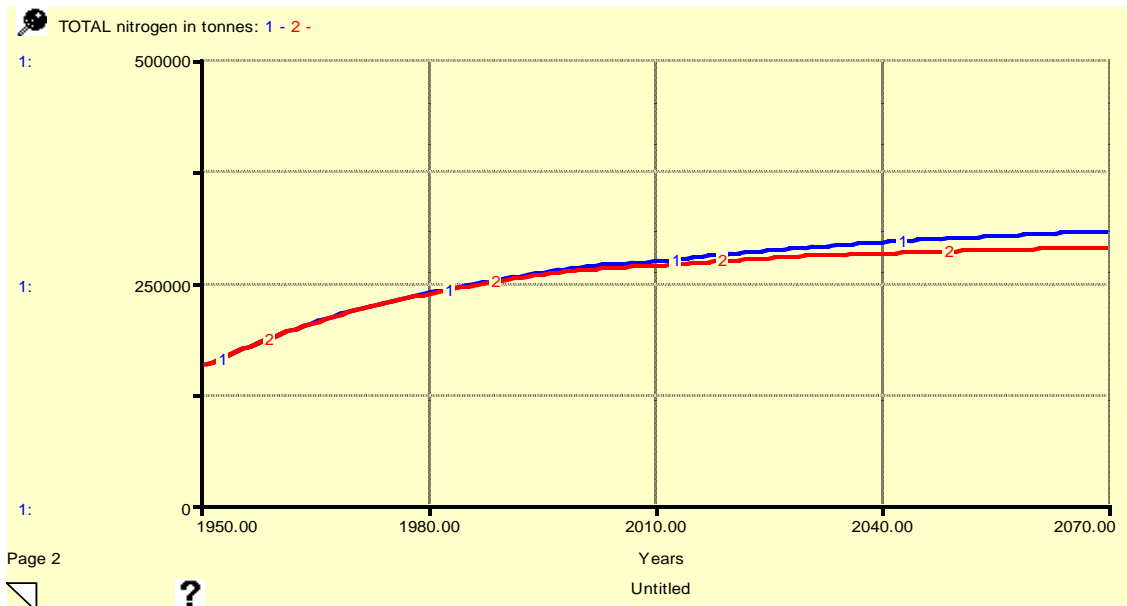
However, this does not mean that increased urbanisation is the solution for sedimentation or nitrogen pollution. Toxic and bacterial runoffs are not modelled due to lack of data. Stormwater/wastewater investments would need to increase significantly under a scenario of unfettered urban sprawl, or spills would increase. It is unclear how sensitive seagrass and shellfish beds are to toxins/bacteria versus

sedimentation and nitrogen (algae blooms), but it is likely that such impacts would also increase.

The modelling team made the assumption that tourists may not find a sprawled Tauranga attractive, although there are no data to support this assumption. While the population grows, unlimited urban development could actually mean that fewer international tourists will reside in the area (Figure 24) due to an assumed reduced attractiveness based on crowding (red line 2).

Figure 24 Comparative international tourists under scenario 1
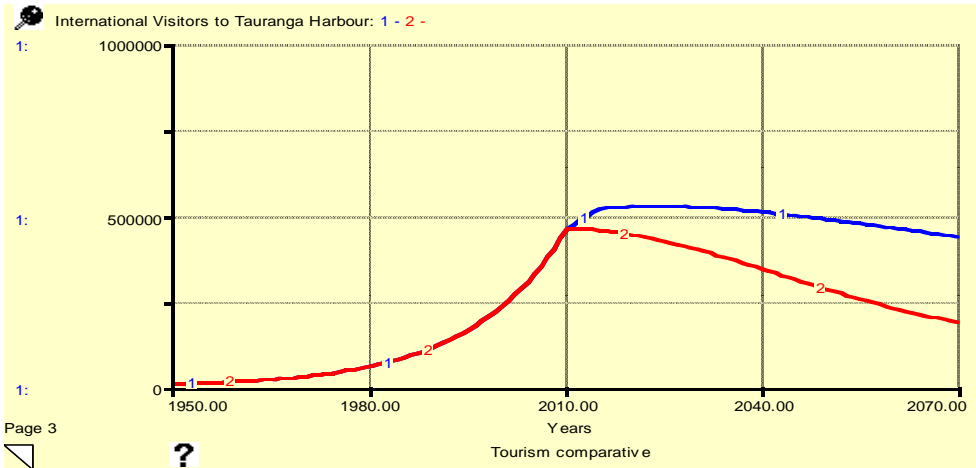
If the assumption that overcrowding reduces the attractiveness of the Tauranga Region is true and fewer tourists will visit the area, this reduces the GDP (in the model) for the Tauranga area under an unfettered population growth scenario (red line 2) as reflected in Figure 25.

Figure 25 Comparative GDP under scenario 1
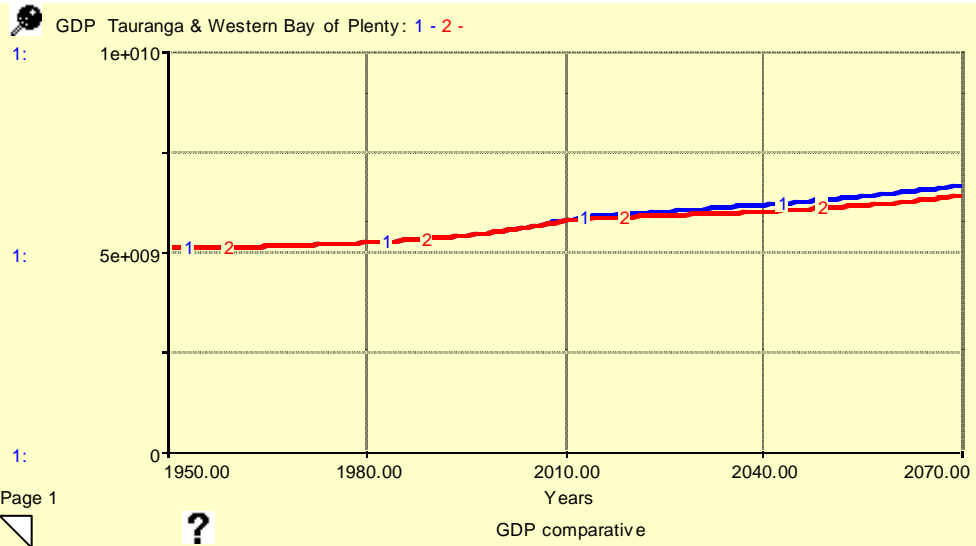
4.3.2. Scenario Two: What if ES values are higher than currently visible?

Currently, the TCESM model attaches very modest values to ecosystem services (ES). This is a main area for further future investigation. Figure 26 shows the base case for Tauranga's GDP (blue line 1) and ES Value (red line 2). The addition of the GDP and the ES Values provides the "true" value of Tauranga (Pink line 3).

Figure 26 Base case for GDP, ES Values and the sum of both into a "true value" of Tauranga Harbour
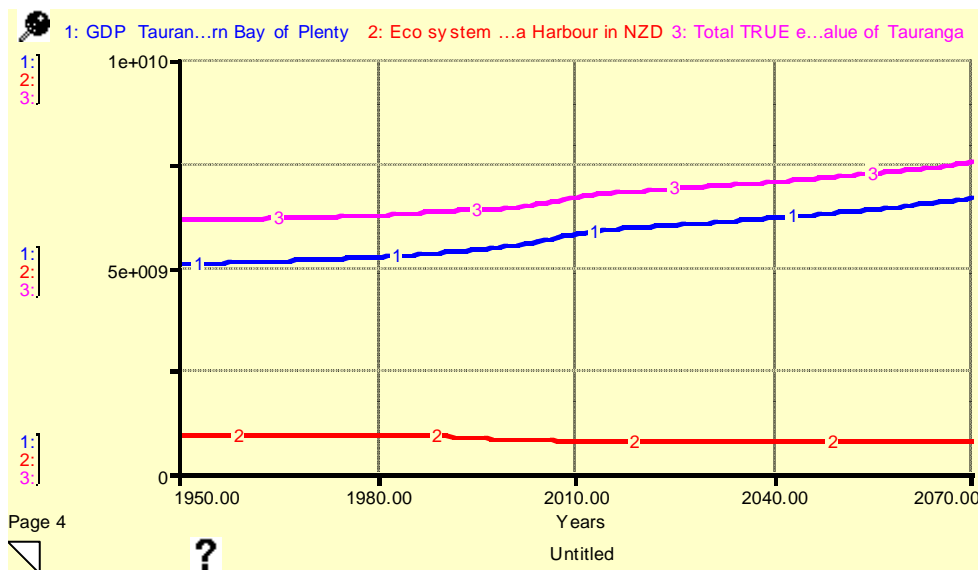
Simply sliding all ES values to their maximum settings provides the comparison illustrated in Figure 27.

Figure 27 Comparative ES value of Tauranga Harbour catchment under scenario 2

Ecosystem value of Tauranga harbour catchment: 1 - 2 -

Page 2

Ecosystem Service Value of the Catchment
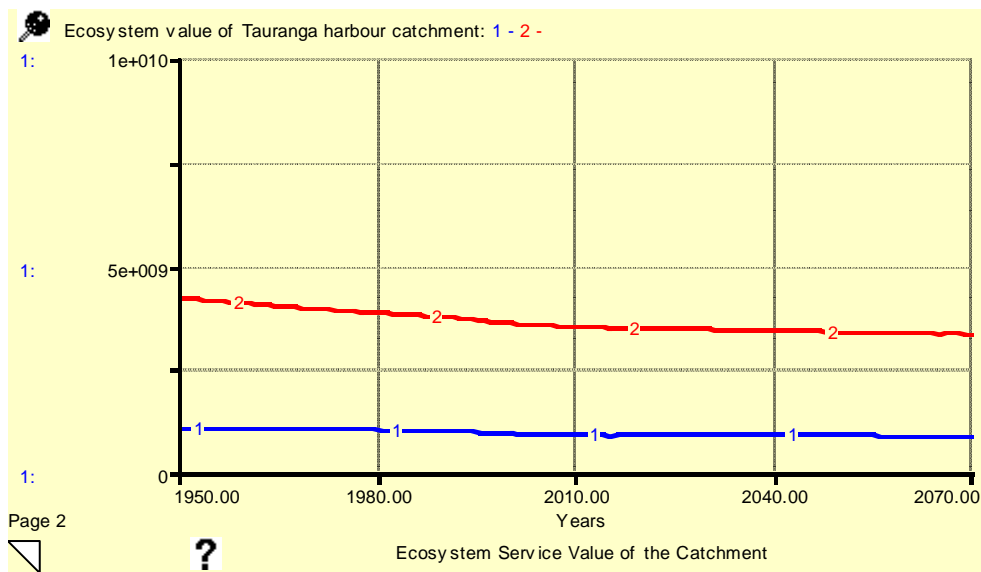
Blue line 1 is base case

Red line 2 reflects the value when sliders for all ecosystem services are moved to their maximum settings. In such case, the ES value of the Harbour could come close to the value measured in GDP, certainly increasing the overall "true value" (Figure 28). This makes it more evident that the ES value is decreasing, which has a "significant" impact on Total True value. We use the word "significant" because the ES value, although there is no accurate way to measure it, it in the same order of magnitude as GDP. We also wish to point out that GDP is also an imprecise measurement.

Figure 28 Visible and increased ES values and impact on GDP, ES Values and the sum of both into a "true value" of Tauranga Harbour

1: GDP Tauran…rn Bay of Plenty   2: Ecosystem v …rbour catchment   3: Total TRUE e…alue of Tauranga

Page 2

GDP vs ES
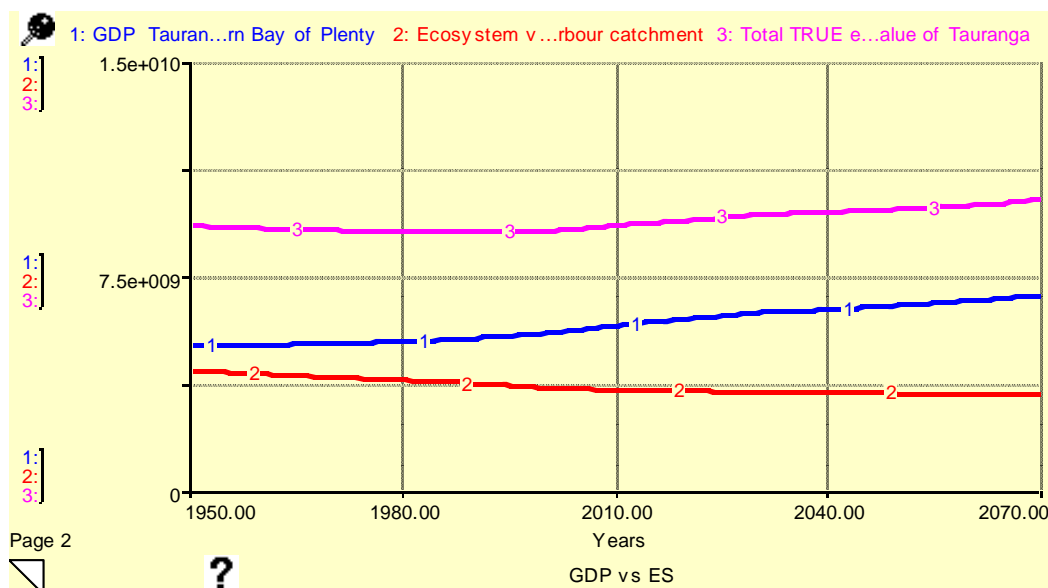
It is assumed that the Tauranga region is gains attractiveness due to two features: Economic activities (expressed in GDP) and Natural Capital and Ecosystem Services derived from it. Figure 29 shows how these two features influence the population growth rate in the model.

Figure 29 Model diagram of Population growth rate sensitive to GDP and ES
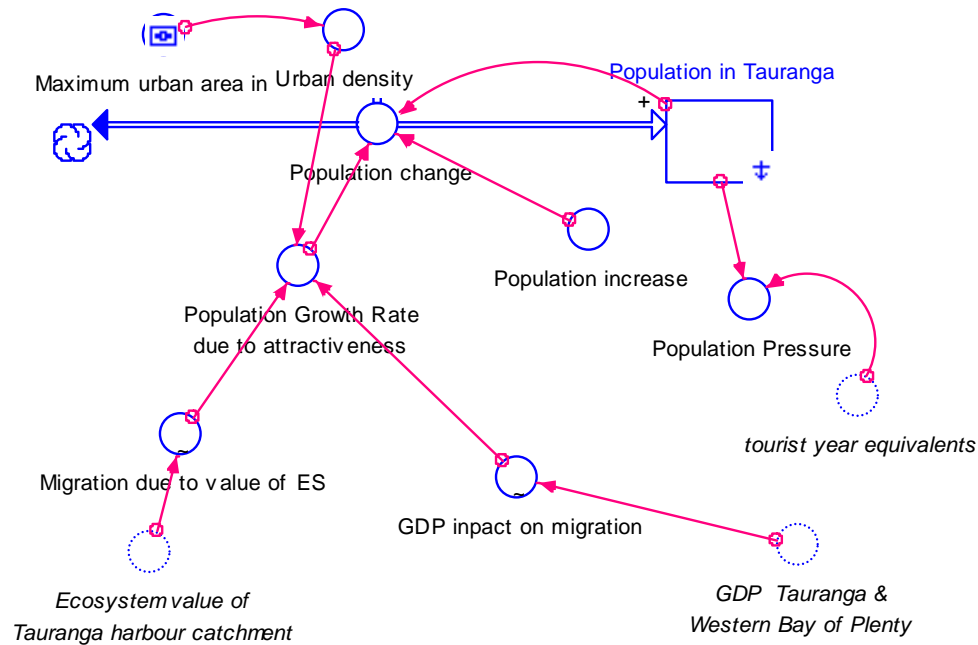
The decrease in Ecosystem Services is trickles through to GDP (see Figure 30).

Figure 30 Reduced GDP based on reduction in Ecosystem Services
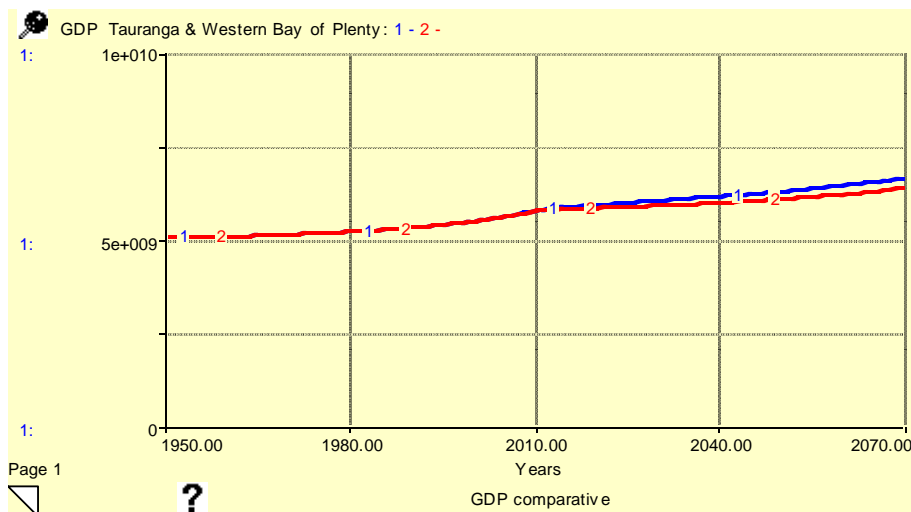
4.3.3. Scenario Three: What if the Harbour carries more international tourists?

Simulating additional growth in international tourism can be done by moving the slide bar in Figure 31.

Figure 31 Slide bars simulating additional tourism capacity
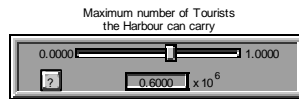
Figure 32 compares the additional tourists under maximum tourist development.

Figure 32 Comparison of additional tourism
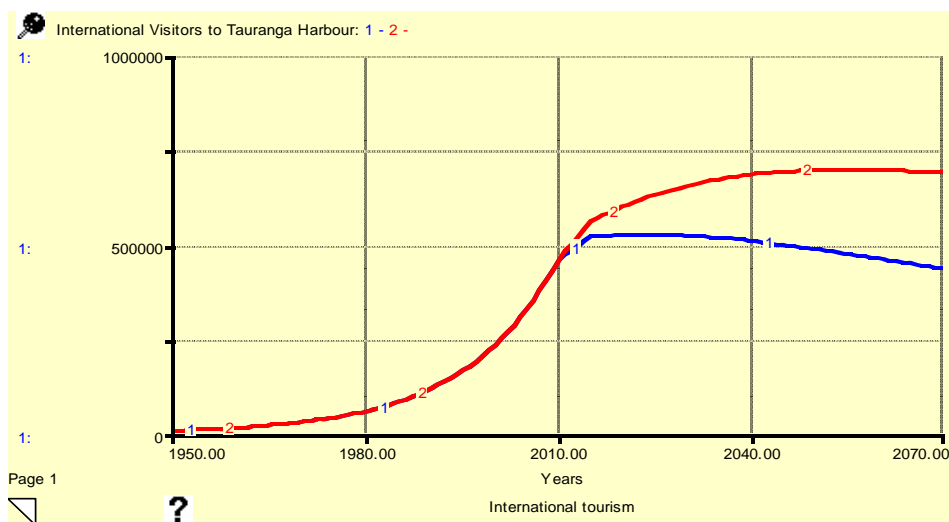
There is currently no feedback or link with ES other than "attractiveness" through crowding. A future version of the model (when shellfish values are better understood) could well include such a link.

However, the TCESM model includes a moderate tax of $5 on international tourists, which would provide income for Harbour Restoration Funding (see Figures 33 and 33).

Figure 33 Slide bar on interface to set the Tourist Tax – base model simulates $5
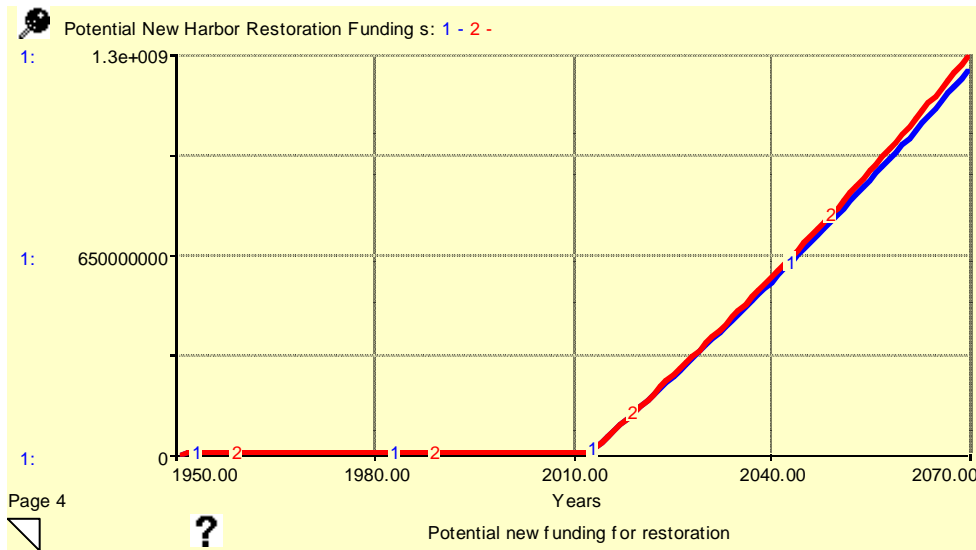
4.3.4. Scenario Four: What if new funding is coordinated into various solutions?

Funding is simulated in the TCESM model via a Tauranga Harbour Restoration Fund from the local Regional Infrastructure Fund, rates, taxes on certain activities (such as international tourism), and from national funding (similar to what was received for the Rotorua Lakes restoration). This funding is allocated in the model to several activities including restoration of indigenous forest on steep slopes. In the absence of details, we assumed a restoration rate that would restore indigenous forests on steep slopes to a little more than was present in 1950 (see Figure 36). In the TCESM model, such forest would be converted from pasture and introduced forests when "switched on" per the switch illustrated in Figure 35.

Figure 35 Switch "on" Restoration Indigenous forest

Restoration indigenous forest

Figure 36 Restoration of introduced forest

Comparative Indigenous Forest
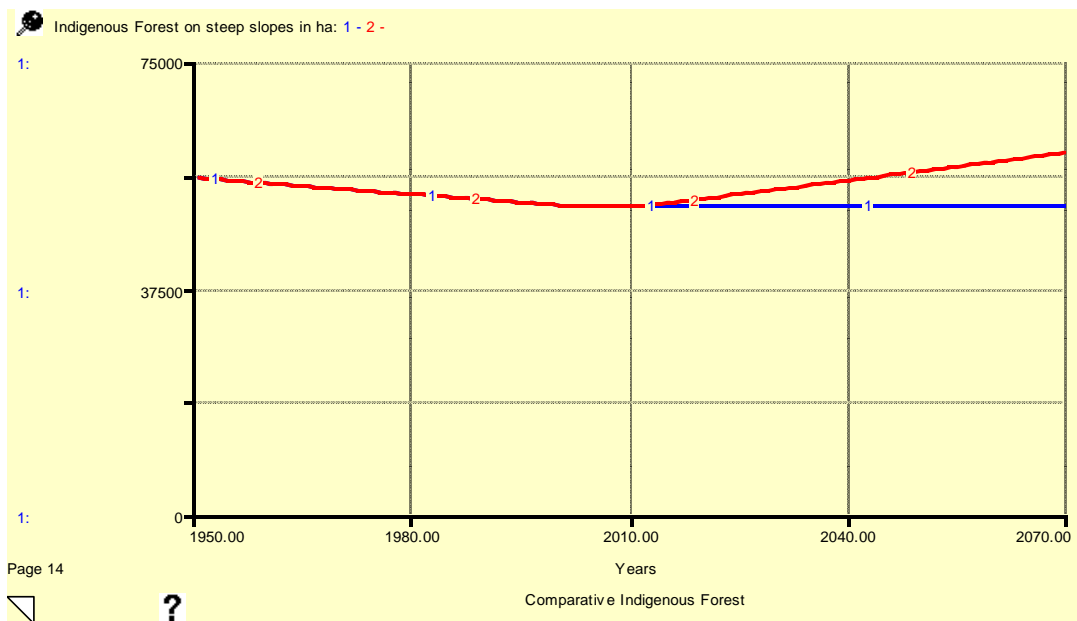
This restoration effort is expected to have a considerable positive impact on the reduction of total sediment runoff (see Figure 37).

Figure 37 Comparative sediment runoff
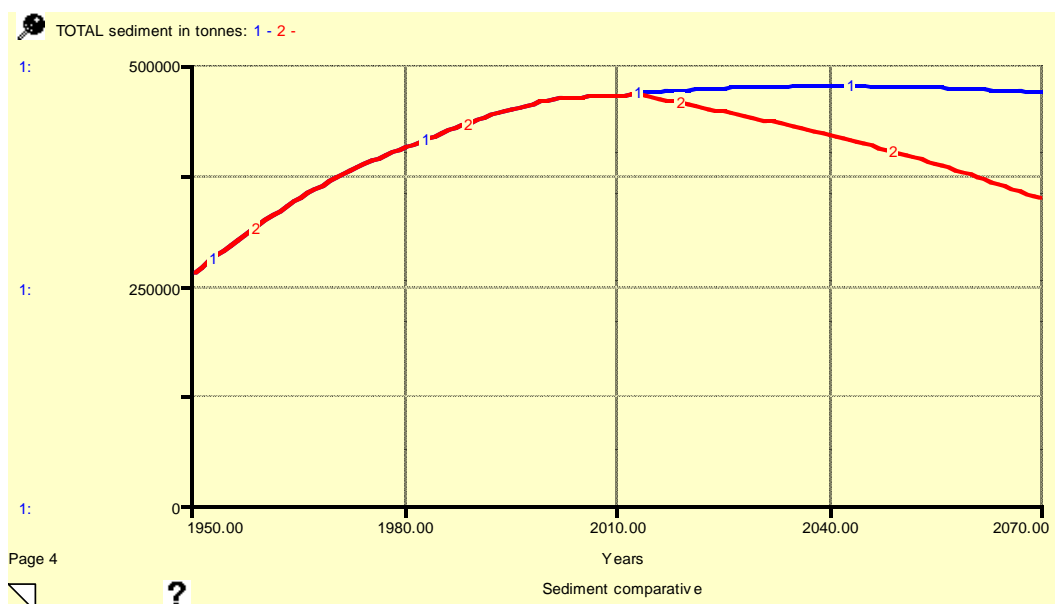
Sediment comparative

Blue line 1 is the base-case scenario without restoration efforts
Red line 2 reflects the Indigenous Forest Restoration efforts

The nitrogen runoff may also be reduced, primarily due to a conversion of pasture back to indigenous forest (see Figure 38).

Figure 38 Comparative nitrogen reduction
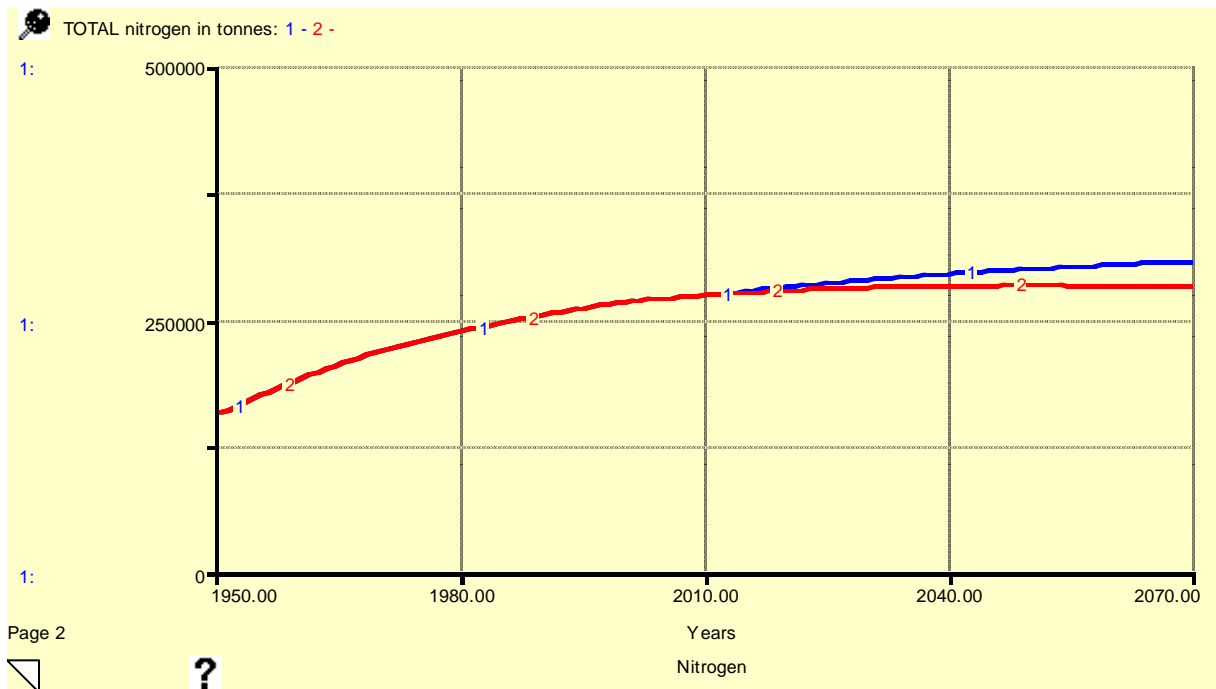
Blue line 1 is the base-case scenario without restoration efforts
Red line 2 reflects the Indigenous Forest Restoration efforts

A small positive impact is then expected on seagrasses (see Figure 39).

Figure 39 Comparative Seagrass
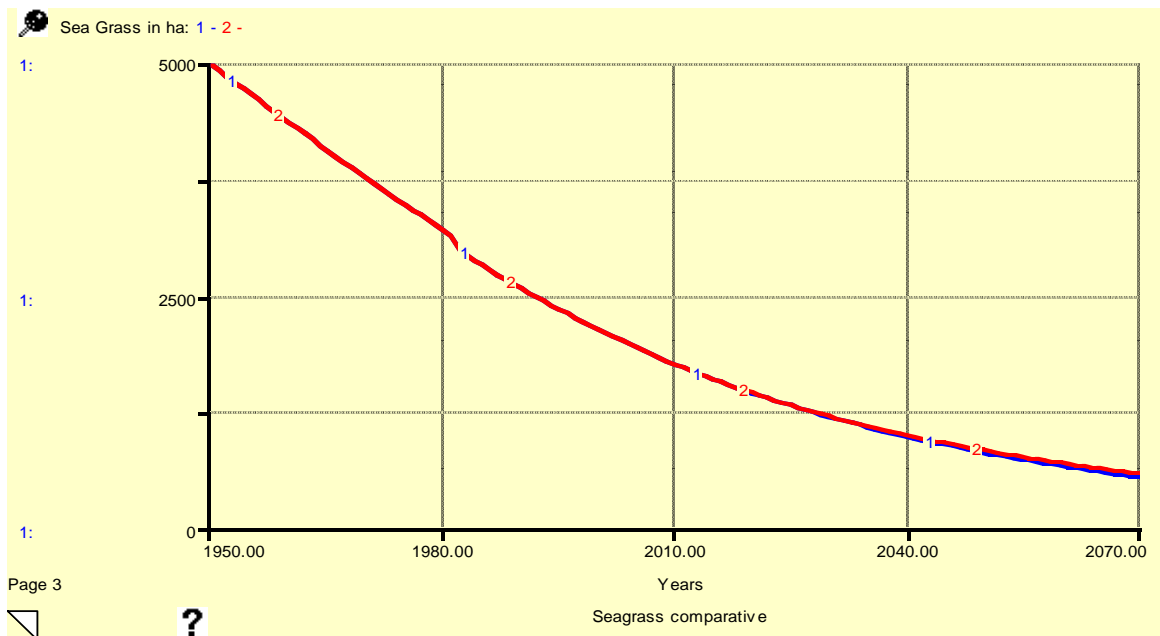
Blue line 1 is base-case scenario without restoration of indigenous forests
Red line 2 reflects the Indigenous Forest Restoration efforts

It should be kept in mind that, in the absence of better understanding about what is required to restore seagrasses, the impact of reduced sediment may well be larger (or smaller).

The model simulates about $19 million in funding, following the model structure in Figure 40.

Figure 40 Model structure of funding sources and spending on possible solutions
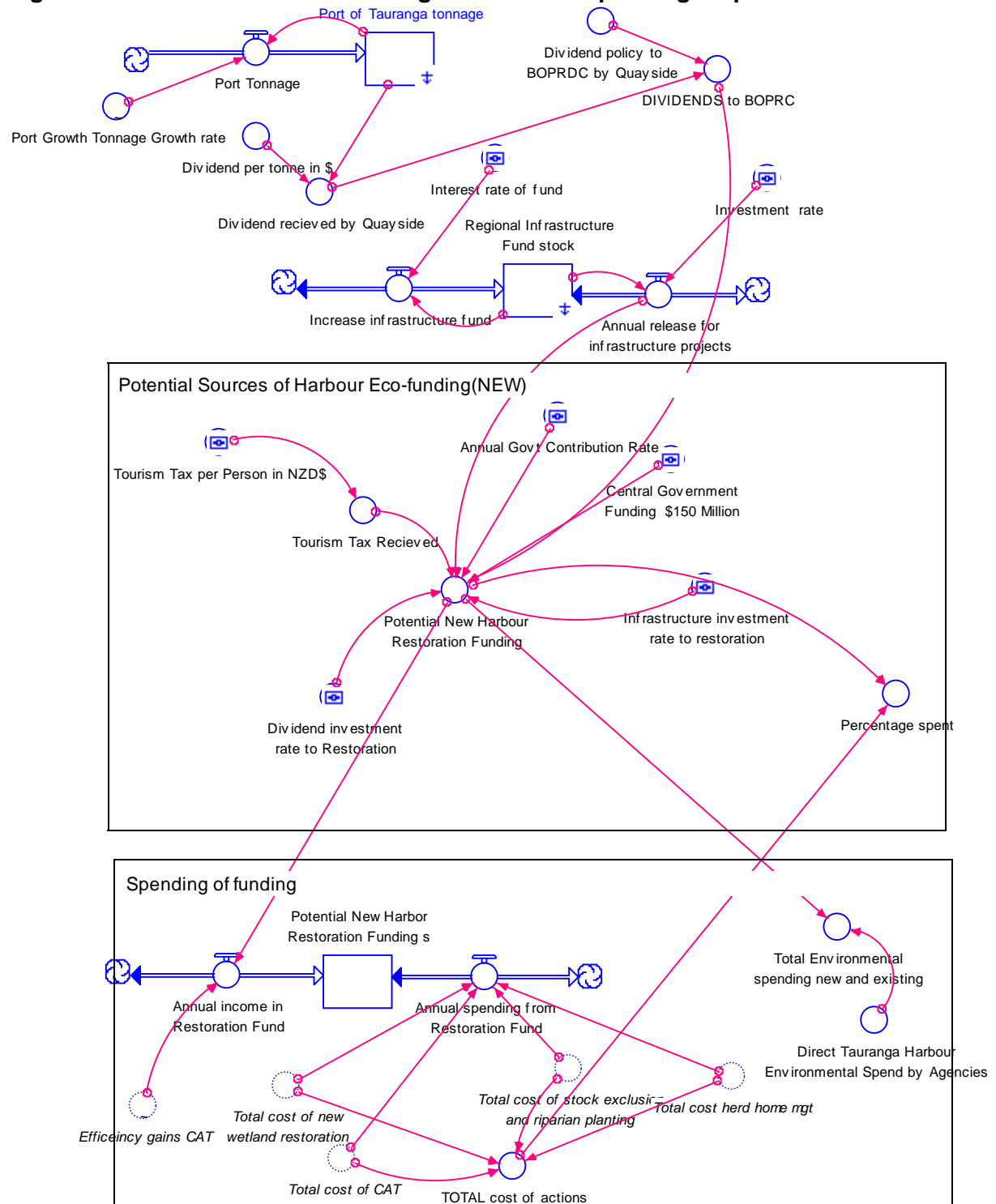
An important funding source (hypothetically) identified by the participants is the Infrastructure Fund derived from Port Activities. As the Port Activities increase, the Infrastructure Fund increases. Depending on the level of interest rate and investment rate, funds become available. The participants identified that riparian planting could count as and infrastructure under the current rules of allowable spending from the Infrastructure Fund. Other sources are rate payers, national government and various taxes. The funding sources are separated in (1) "what's already being spend on the Harbour by different agencies" and "newly identified (or suggested by the participants) funding". This model structure keeps track of ballpark numbers of how much the actions cost and and how much is spent under each simulation. The spending on (restoration and other) actions trigger an impact on natural capital and Ecosystem Services. It is emphasized that this is a scoping model that points in the right direction and supported a complex dialogue, but isn't robust enough to support individual investment decisions. It has the potential to, over time and with future improvements, complement specific Cost Benefit Analysis and regional budgeting processes.

Examples on what the funds may be spent on in this model are stock exclusion, nutrient management through herd homes, indigenous forest, shellfish and wetland restoration and a Common Asset Trust, as represented by the "on" switches in Figure 41.

Figure 41 Switches to simulate the various actions on which funding may be spent
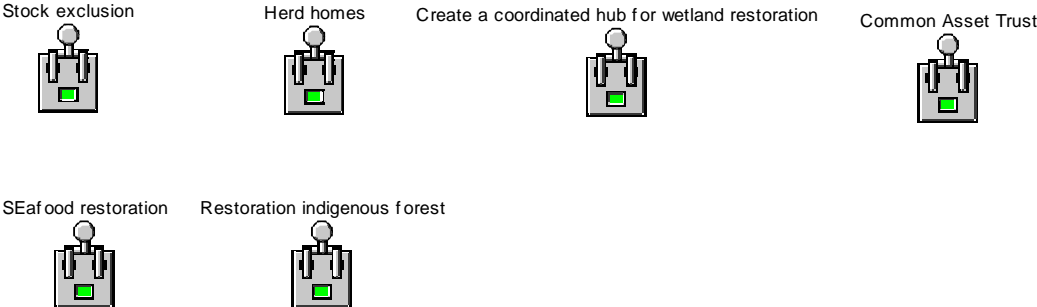
Figure 42 simulates the maximum possible estimated incoming funding and the percentage that would be spent on the total package of solutions. Most of the economic figures (other than GDP and current agency spending) require additional work that couldn't be completed in the time allotted.

Under the "best-case scenario" simulating all possible funding and allocating to identified activities, the ES value of the Tauranga Harbour improves (see Figure 42).

Figure 42 Comparative ES value of Tauranga Harbour
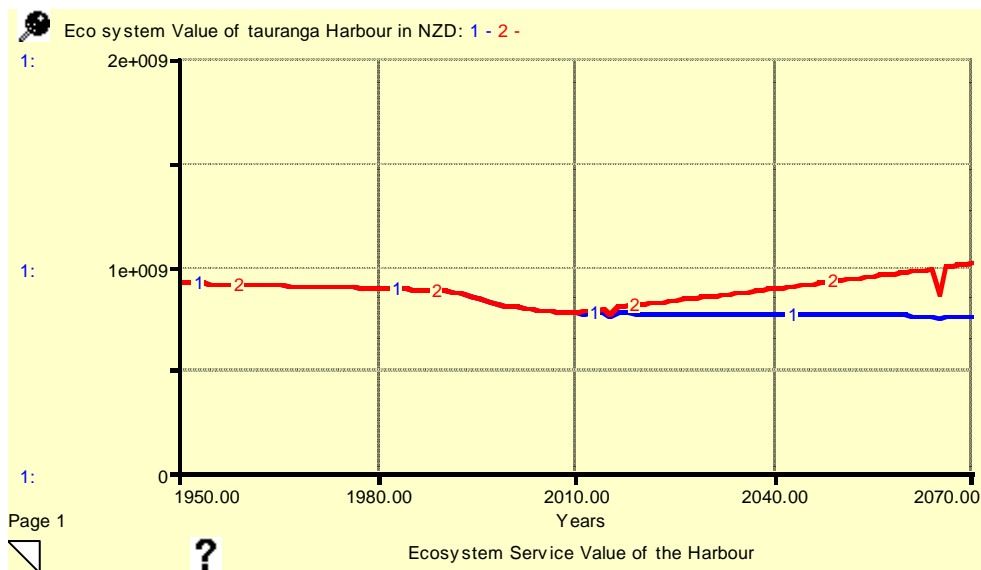
Blue line 1 is base-case scenario without new funding or Harbour restoration
Red line 2 is reflects the best case restoration efforts

The "dip" in 2013 and 2063 reflect a pulse of a 100-year storm event overflowing storm and waste water facilities beyond capacity. These events represent sudden rather than gradual impacts.

GDP is not impacted by such restorative actions (see Figure 43) in this model. To understand both positive and negative impacts on GDP from such actions, additional feedback loops, perhaps based on Economic Impact Assessments and the trade off with Ecosystem Services may be included in future iterations of the model. Time limitations prevented such feedback loops at this point.

Figure 43 Comparative GDP
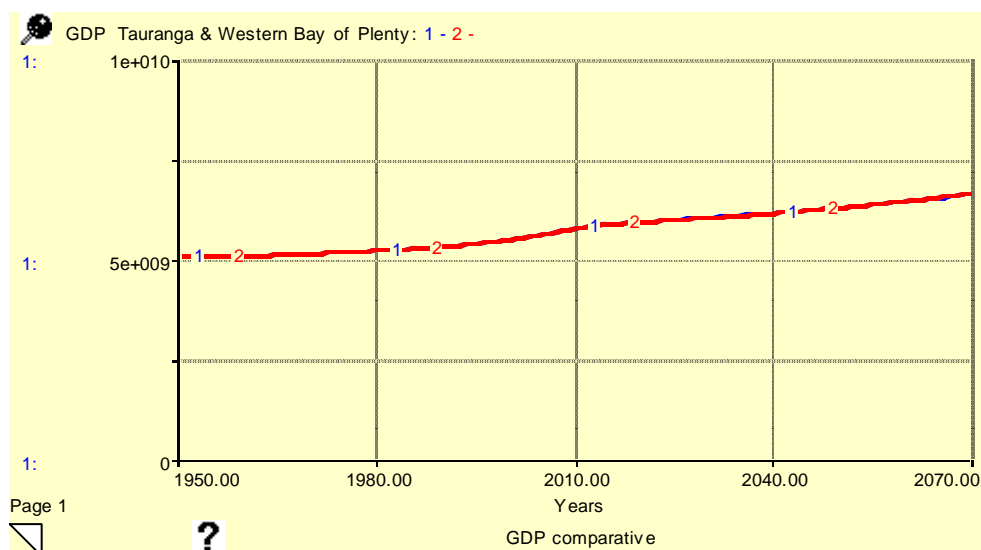
Blue line 1 is base case scenario without new funding or Harbour restoration
Red line 2 is reflects the best case restoration efforts

The improvement of the Tauranga Harbour ES value improves the Tauranga catchment ES value and therefore improves the "true" value of Tauranga (see Figure 44).

Figure 44 Values of Tauranga Harbour when simulating new funding for new restoration activities
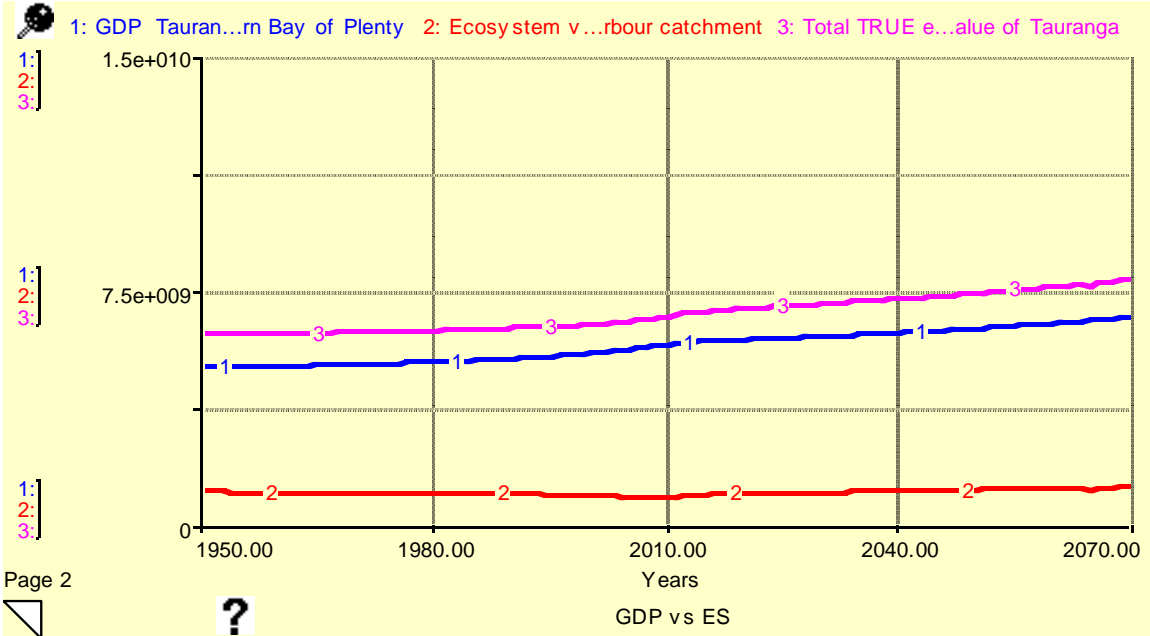
4.3.5. Scenario Five: What if climate change increases sedimentation by 40% by 2030, as estimated by NIWA?

All previous scenarios are simulated under "no climate change". When the climate change switch is turned "on", the model simulated an immediate 40% increase in sedimentation (see Figure 45).

Figure 45 Comparative sedimentation without and with climate change
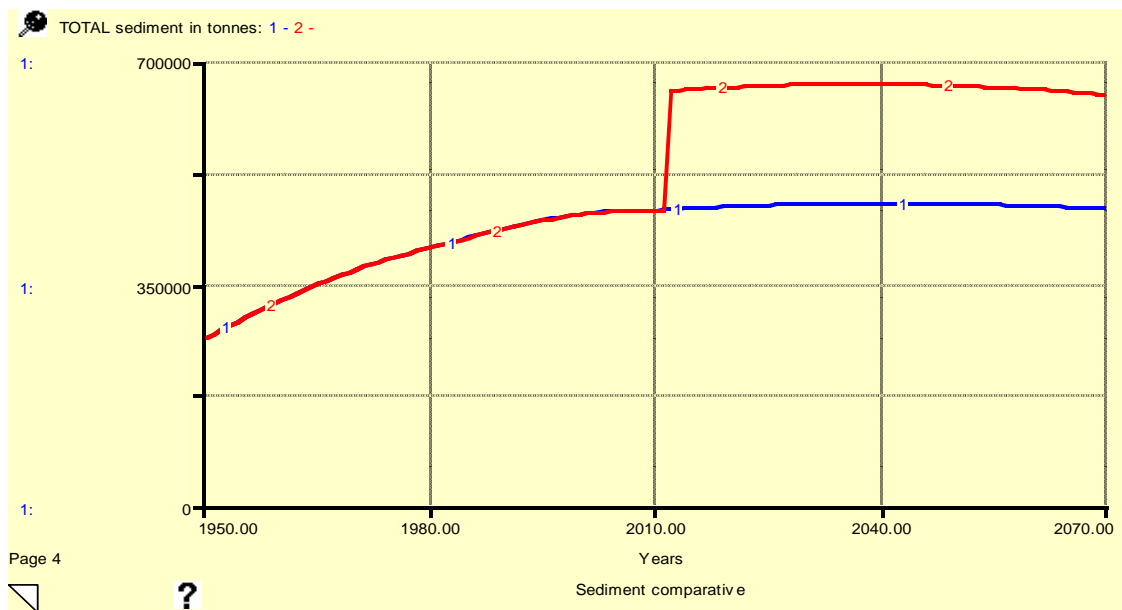
Blue line 1 is the base case
Red line 2 reflects a climate change scenario, starting in 2011

Increased sedimentation due to climate change is expected to have a negative impact on seagrasses, although the exact response isn't clear (see Figure 46).

Figure 46 Comparative seagrasses under climate change scenario
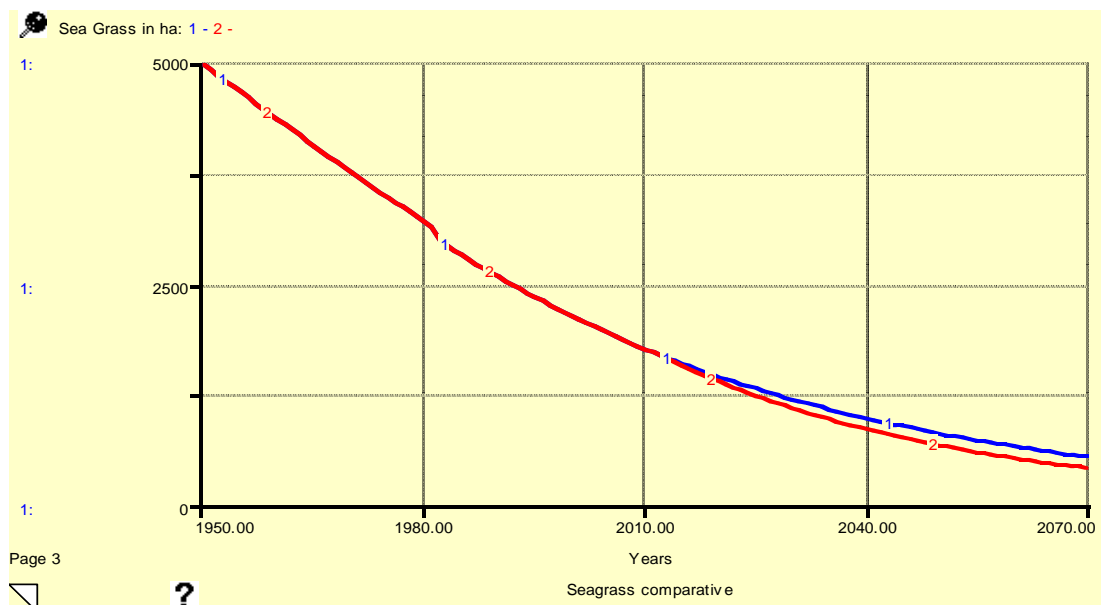
Red line 2 reflects a climate change scenario, starting in 2011

Restoration efforts, such as reforestation of steep slopes, show a more significant improvement compared to "no climate change". Figure 47 shows the comparative seagrass improvement under a climate change scenario. However, all the simulated funding and restoration activities are not significant enough to induce improvement

beyond the current negative trends. In effect, such actions (in the model) may only be enough to offset the impacts of climate change without further improvement.

Figure 47 Comparative seagrasses under a climate change scenario with and without restoration efforts
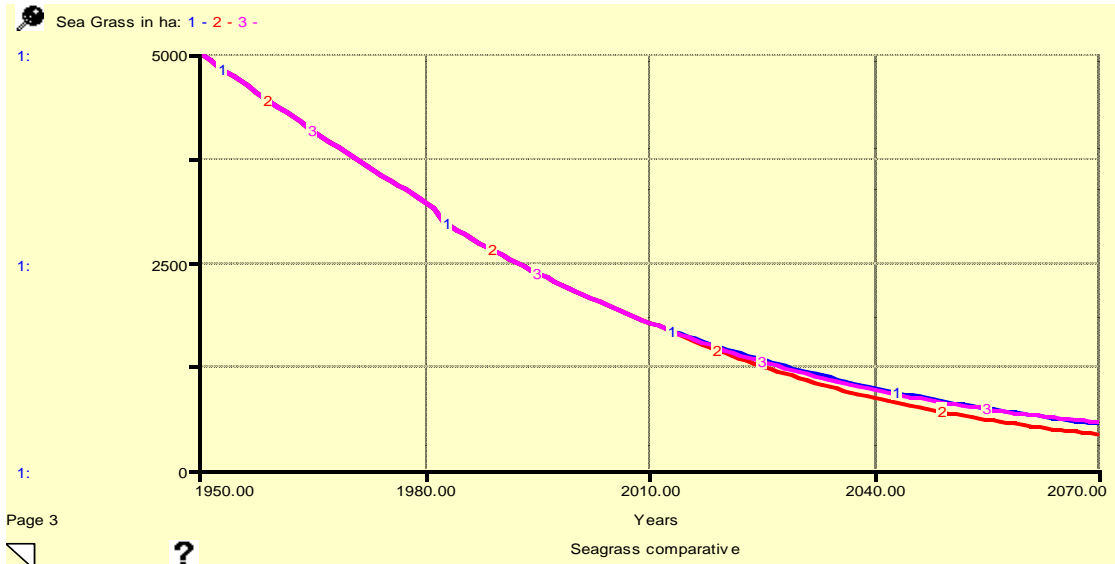
Blue line 1 is the base case
Red line 2 reflects a climate change scenario, starting in 2011
Pink line 3 reflects a climate change scenario and restoration efforts, starting 2011

Mangroves are expected to spread under a climate change scenario as seen in Figure 48, due to fewer frosty days as well as increase sediment runoff, which is thought to cause mangroves to both survive and spread.

Figure 48 Comparative mangroves under climate change
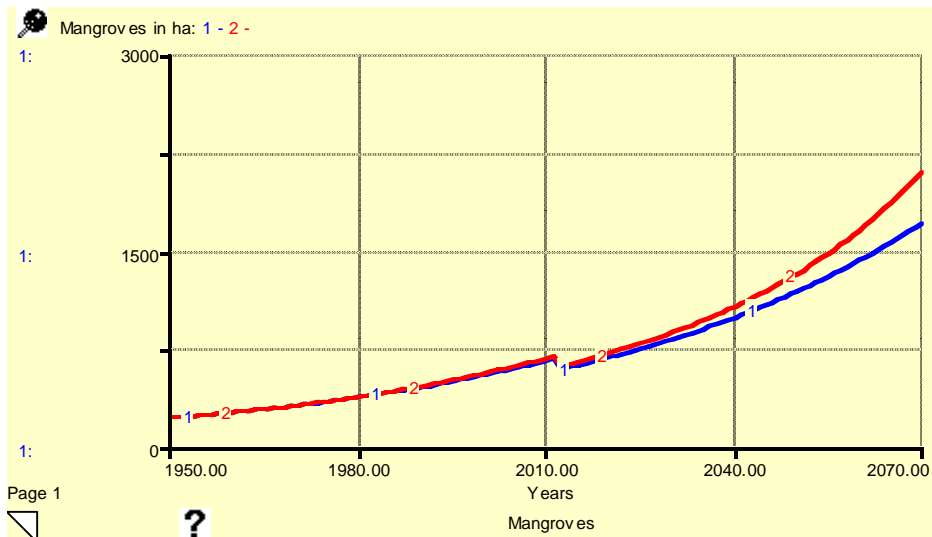
Blue line 1 is the base case
Red line 2 reflects a climate change scenario, starting in 2011

4.3.6. Scenario Six: What if nitrogen losses from dairy farms are reduced by 40%?

Based on Christensen et al (2011), it was assumed in the model that advanced nutrient management of dairy farms through "herd homes" could achieve a 40% reduction of nitrogen runoff. The MM team were unable to source cost estimates for such actions, and the costs in the model are therefore very rough estimates. The goal of including such costs is to provide an example of what type of information would be required to make regional scale trade-off decisions. Figure 49 estimates a $10 million investment for an up to 40% reduction of nitrogen.

Figure 49 Comparative 40% nitrogen reduction
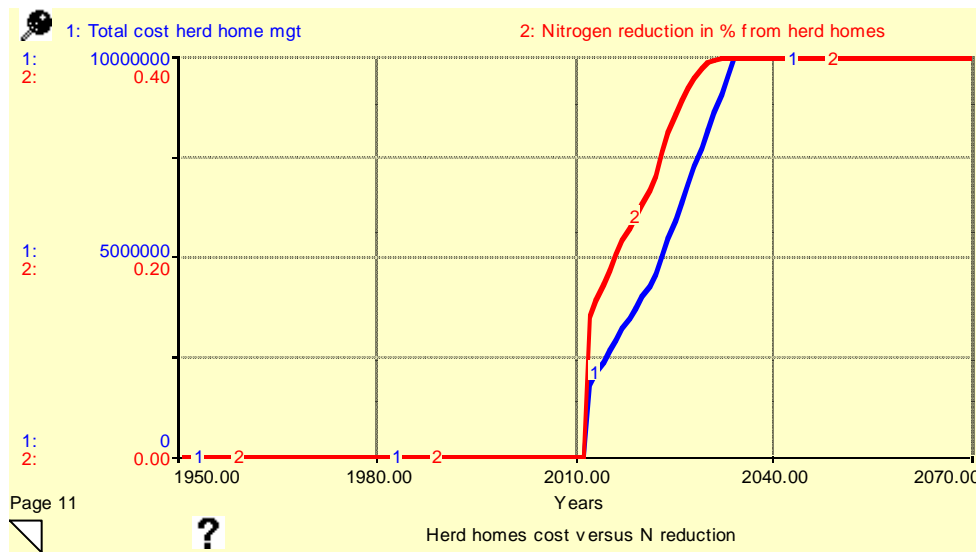
Blue line 1 is the base case
Red line 2 reflects a scenario of full funding for nitrogen reduction, starting in 2011

The model simulates a small improvement in seagrasses (see Figure 50); however, the sensitivities of such actions are based on the estimation of the modellers and would require much follow up research before they could be relied on with any certainty. Future MTM case studies on shellfish may inform such sensitivities.

Figure 50 Comparative seagrasses under 40% nitrogen reduction
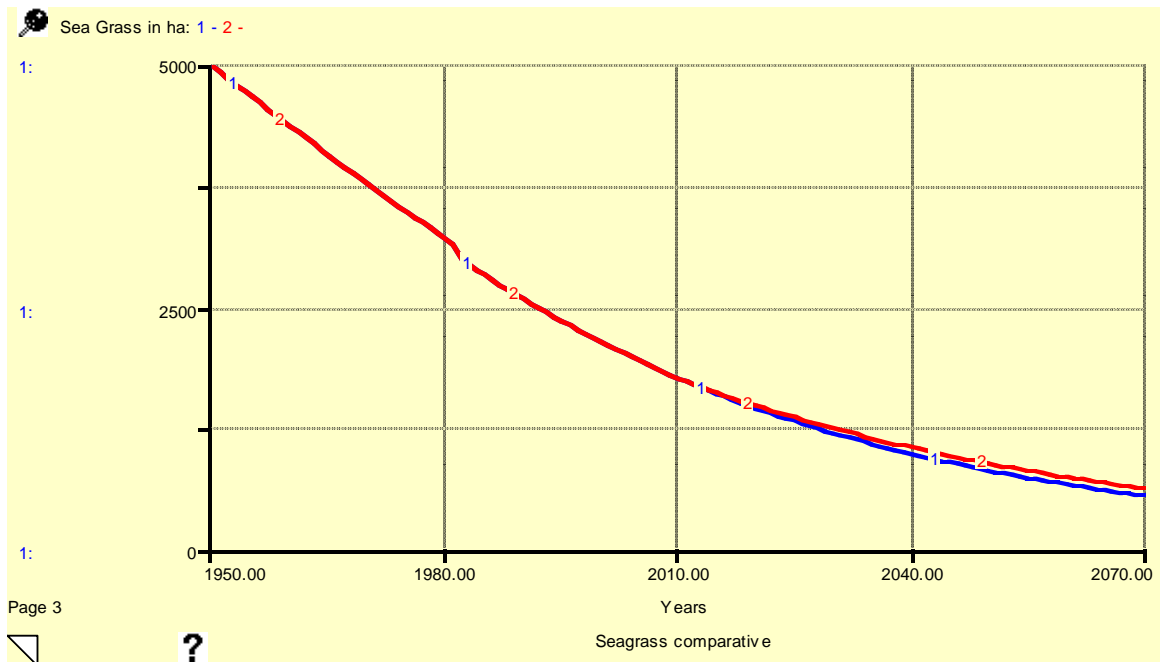
4.3.7. Scenario Seven: What if various land use changes to extremes; for example, if all land in the region was changed to indigenous forest, how much would be the economic loss/gain by 2070 as a result?

While scenario seven was requested as an example of an extreme setting, the current TCESM model cannot accommodate this scenario at this point. A more systemic understanding, including feedback between built and natural capital and associated thresholds, would need to be incorporated and studied. This was not possible in the allotted time.

Additional scenarios can be simulated by changing various slide bars and switches in the TCESM model.

5. DISCUSSION

The discussion addresses both the current status of the TCESM model and the status of the process reflected in findings, recommendations and action plan.

5.1. TCESM Model discussion

The TCESM scoping model reflects the link between economics (built capital, economic activity, potential funding, and expenditure on restoration) and ecology (natural capital and some ecosystem services). Cultural aspects beyond seafood as an ES were deliberately left out of the model until such time as they are characterised sufficiently to enable them to be modelled. The primary link between the economics and ecology in the model is reflected through an "attractiveness index" inducing people to come to or leave Tauranga. The underlying story is discussed in workshop five (see Section 3.5). The scenarios provide an indication on the direction of various trends and the effort it would take to curb such trends. A detailed model description can be found in Appendix 5.

As a scoping model, we do not recommend using this TCESM model for explicit decision making or for Environment Court hearings at this stage. It requires additional effort to:

- improve the assumptions and add interconnectivity through additional feedback loops;

- collect data and change the way data is generally gathered and reported; and

- expand the understanding of the model among stakeholders through tutorial and hands-on practice, demonstrations and updating of the model.

Based on the model building, scenario development and workshop dialogue captured in narrative form, several "findings" were observed (a finding is defined as "a conclusion reached after examination"), in essence a reflection on the process and the model developed 5 workshops. Based on these findings, recommendations were developed and, although time was extremely limited, some actions were formulated. The draft findings, recommendations and actions were also circulated in the final minutes of the workshop and posted on the website.

5.2. Findings

The project had two goals:

(1) A scoping exercise to identify the major research gaps about the state of Tauranga Harbour, thereby helping inform the selection of ongoing case studies in the MTM research programme;
(2) To provide a neutral space for a broader dialogue among a network of diverse stakeholders, who often meet in contentious processes, through which they

could learn from each other, and use the ongoing fact-based dialogue to develop an initial model of the social, cultural, economic, and ecological aspects of the Tauranga Harbour, and the interactions of these different aspects.

The second goal was actively pursued during the MM process as reflected in this report and reported findings below. The first goal was indirectly addressed by the Research Team through interpretation of the workshop summaries, evolving model and identification of the areas where the modellers identified data gaps. The case study going forward is on shellfish communities, as these provide an important Ecosystem Services, with associated Economic values as well as Cultural significance and Ecological Health.

5.2.1. Findings in relation to the MM workshop process

The on-the-spot feedback from workshop participants with regard to "findings" from the MM process provided the following insights:

1. The workshops provided a good networking opportunity.

2. It was good to see the various groups/people around table, and to have an opportunity to see the level of understanding about what is happening in the Harbour. The workshops were safe; there was no holding down of ideas or dismissal.

3. There was an agreement to value the Harbour, albeit for different reasons.

4. Local action toward global optimisation. The workshop process has shifted something. Good framework for multi-stakeholder activities.

5. The process built on the common ground between participants, rather than oppositions.

6. Economic savings can be had by coordinating access to diverse information.

7. The MM process enhances people's ability to easily access information.

8. Identification of gaps in information and plugging away at gaps is important.

9. Various demographic groups forced to look at common good. In addition to "sharing perspectives", the emphasis was on evidence-based research rather than opinions and self-interest.

10. Stakeholders have had an opportunity to discuss the issues and are more prepared for academia to follow up in a coordinated manner.

5.2.2. Findings in relation to model of Tauranga Harbour

In addition, before the final workshop, the MM project team had compiled "draft findings" through observation of the group and from the workshop summaries in a hand-out. The project team did not include preliminary findings based on the model simulations, as the final model was simulated at the last workshop. The participants reviewed the hand-out and amended it as follows:

1. There continues to be a need for consistent compilation and translation of land use data to enhance understanding from an integrated systems perspective.

2. The benefit of the aggregated systems approach[9] used in this MM study is that it allows several separate conversations to come together, and identifies the need for leadership in the absence of "data and certainty".

3. Modelling the "big picture" in this way has identified the need for leadership among groups in the community to take positive action towards the restoration of the Harbour, even in the absence of complete "data and certainty".

4. The disadvantages of the aggregated approach are the lack of spatial explicitness,[10] and the ongoing wish for more data to increase the understanding of the system with "certainty".

5. The "neutral" space within workshops fostered a constructive dialogue between stakeholders, many of whom are often involved in more formal (and sometimes adversarial) processes about the Harbour.

6. Learning occurred among the stakeholders, as they were able both to hear the concerns of other groups, and contribute their own knowledge to the group.

7. Throughout the MM workshops, participants showed an interest in the modelling and the dialogue remained structured due to the modelling process. Participants preferred to experiment hands-on with the model after its completion, instead of during each workshop.

8. An implicit consensus on the desirability of the outcomes (such as abundant and healthy seafood, swimmability, mauri) seemed to exist. This was sufficient to pursue a dialogue to understand how progress could be measured and what leadership could be provided (and actions taken). However, a consensus of the balance at an outcome level with traditional or new economic instruments is not evident.

9. Various indicators are measured but are currently not yet integrated and interrelated to support an adaptive dialogue; it remains a challenge to

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[9] An "aggregated systems approach" refers to a synthesis at regional level (aggregating sub-catchments), and a systems approach refers to changes over time.

[10] A systems dynamics model such as the one used in this study does not allow us to separate individual suburbs or locations within Tauranga Harbour or catchment, but considers the system as a whole.

overcome a fragmented approach in research (e.g., synthesis in addition to analysis of research questions), community building (multi-stakeholder dialogues), and policy coordination (regional and territorial authorities).

10. Leadership and actions in a desirable direction benefit from acknowledgement, promotion and more coordination.

5.3. Recommendations

Recommendations can be in the form of proposed investigations, joint fact-finding or research, initiation of a focused collaboration, or policy advice.

5.3.1. Final Participant Recommendations

The following recommendations were developed with participants at the final workshop. It is recommended that:

1. Coordination with regard to the Tauranga Harbour happens both internal in the Regional Council (RC) and external to the RC.

2. Research on shellfish be coordinated and agreed on what exactly needs to be done.

3. There be an external liaison group for RC at stakeholders AND at technical level.

4. The 10-year plan provides a deadline for this group for putting recommendations forward in the appropriate format.

5. This group finds a name and commits to on-going activities.

6. A role of this group is to take charge of the MM model as a tool. Advise RC. Address issue that came from model.

7. This group approaches the RC as a "group" with recommendations.

8. An end-user advisory group to advise the MTM project.

9. The model be refined and improved.

10. More groups are included.

11. The RC is acknowledged with regard to the coordination of environmental initiatives, and recommends expanding support for Harbour protection and restoration.

12. A better alignment between impact activities with restoration activities is achieved.

13. New models for resource management and allocation are investigated.

14. This group clarifies the link between impact and mitigation in anticipated topics (e.g., dredging and restoration) to provide guidance to decision makers and stakeholders (e.g., TAs, RC, environment court, farmers, other sectors).

15. This group paints vision for BoP as an emerging "centre of excellence" in integrating ecology and economics using ecosystem services concept.

16. The application of the approach is scaled up.

17. This group be part of the global solution rather than defending the clean green image: leadership.

18. This group supports local iwi in their negotiations with the central government, as with the negotiations undertaken in Taupo, Rotorua and Waikato.

19. This group recommends support for pro-active initiatives to solve problems (e.g., identified through monitoring programmes).

20. Adaptive management approaches to the Harbour are implemented.

5.3.2 Recommendations identified during Workshops 1–4:

The following recommendations, amended with the participants, were identified during workshops 1–4 (notes from each workshop are on the website, http://www.mtm.ac.nz/mediated-modelling/) as potential future courses of action:

1. It was clearly very important to consider the cultural "voice" during workshop discussions. However, we did not attempt to model this. A future adapted version of the model could include the results of the on-going Cultural Health Indicator study that is proposed for the next phase of the Manaaki Taha Moana programme.

2. Explore options for an 'offset rates system' to help pay for the maintenance of important ecosystems in Tauranga Harbour, such as impact fees/dispensations for ecosystem damage/restoration initiatives, payment for ecosystem services.

3. While acknowledging the current efforts of BoPRC with regard to better coordination of environmental initiatives (including research) for the Harbour, the group recommends expanding support for Harbour protection and restoration. It is recommended that this be done through a centralised hub to deal with issues about the Harbour and its ecosystems, with all councils working together alongside key community representatives, to enable greater synergies of ideas and effort in the currently fragmented efforts to restore ecosystems in the Harbour.

A formalised group, such as the Mediated Modelling Participant Group, should be established to provide ongoing advice to researcher, Council, policy makers, etc., in the Bay of Plenty regarding the Harbour (see Action Point (1) below). This aligns well with BoPRC's intention to implement "Stakeholder" and "Technical" Groups as part of their coordination and planning for Tauranga Harbour.

4. Target application of the 'Port Infrastructure Fund' in restoration of ecosystems in Tauranga Harbour and in so doing, view natural capital as a valued infrastructure of Tauranga.

5. When implementing policies to encourage sustainable use of the Harbour and its ecosystem services, use "guidelines", "requirements", and "rewards" systems. There is merit to all approaches, but ideally it is good to use a "guidelines" or "reward" approach first, and then use the "stick" approach on the remaining small proportion of the population who will not change practice voluntarily. Transparency of process is the key. The intention is to make Ecosystem Services more "visible" so that when individuals do things to enhance them, they get rewarded and are thus motivated to change behaviour to act sustainably.

6. Utilise the economic/political system to address the erosion of valued ecosystems in the Harbour. Seek central government funds to restore local ecosystems, as happened with the Rotorua and Taupo Lakes restoration projects, and the Waikato River project. This could be matched by increased funding and coordination of effort underway at the local/regional level.

   Further, the group supports local iwi in their negotiations with central government to restore the Harbour, as with the actions taken for Taupo, Rotorua and Waikato.

7. This group supports and will work with BoPRC on their new funded programme for "Tauranga Harbour", proposed in their next 10-year plan.

8. This group will work towards a submission to the BoPRC 10-year Plan for funding to support the ongoing operations of the "stakeholder group" (i.e., the ongoing self-organising group that will include Mediated Modelling participants and others described in (3) above), for "value added" research and initiatives in the Tauranga region by "investing" in ecosystems and ecosystem services.

9. Gain widespread support for, and understanding of, the need for efforts to protect and restore ecosystems in Tauranga Harbour. Community education and comprehensive reporting of monitoring programmes are needed, including the translation and communication of existing science/information about the Harbour to the community in an easily understandable form.

10. Instil a vision for the Bay of Plenty as a "centre of excellence" in integrating ecology and economics (also cultural and social dimensions), by placing a value on ES so that they can be sustained. BoP could be a global model for how to apply this approach successfully. It makes good "business logic" to align with New Zealand's "clean green" brand.

11. BoP to be a global "solutions" leader by developing and applying sustainable models that balance ecosystem services and economic return. In so doing, BoP will enhance its image as a sustainable region, which will add value to the "bottom line" value of industries/companies (such as Zespri, e.g., for whom "public image" is approximately 50% of the value of the company).

12. Ensure better protection for Ecosystems in the Harbour, policies are required that better align "environmental impacters/polluters/users" (i.e., those industries/groups/individuals who have significant impact on the Harbour) with resourcing and implementation of restoration activities.

13. Support pro-active initiatives to solve identified problems, for example, through monitoring programmes. It is not good enough for monitoring programmes to identify problems, but not implement actions to fix those problems in the Harbour.

14. Implement adaptive management approaches to the Tauranga Harbour.

15. Investigate new models for efficient and sustainable resource management and allocation.

16. Clarify the link between impact and mitigation in anticipated topics (e.g., dredging and restoration) in order to provide guidance to decision makers and stakeholders (e.g., TAs, RC, environment court, farmers, tangata whenua, other sectors). The MTM team could work with this group to seek funding for such ongoing research.

17. Research on shellfish to be better coordinated and prioritised, a clear agreement is necessary on what needs to be done to help protect them. Future research is required for pipi, mussels, starfish, sea snails.

18. Clear goals are required about what "levels" are sought for restoration of ecosystems and ecosystem services in Tauranga Harbour; as well as clear plans of how to go about restoring them (i.e., "SMART" action plans).

19. Develop consistent compilation and translation of land-use data to enhance understanding from an integrated systems perspective.

20. Refine and improve the model.

5.4. Actions

Based on the findings and the recommendations, the following concrete actions were proposed by the group (in a very short time frame):

1. Presentation from Taupo Lakes Restoration Group: To investigate new models for restoration, have the Taupo Lakes Restoration Group make a presentation to this group at same time as their first "autonomous" meeting, about their restoration efforts. The group will use the meeting to progress the formalisation of the post-MM group.

2. Presentations to external groups: To carry out a presentation to the external groups, including Councils and the NZ Planning Institute, about the concepts in our model and interactions between ecosystem services and economic activity. Further, individual members can feed back key findings to their own sectors/organisations. A "template" presentation for people to use will be prepared by the MTM Team and posted on the MTM website.

3. Publications & Outputs: The draft report on the MM process and the updated model will be circulated among the participants. Individual participants agreed to work with the MM team on additional articles for later publication. Updates on MTM will be posted on the website (www.mtm.ac.nz).

Box 5 Kaitiaki-led Possum Control

As time was running out and "SMART" action planning was not possible, the approach was used as a demonstration. A quick (5 minute) "SMART" Action Plan was developed for Al Fleming to develop a business case for Kaitiaki-led possum control that both scopes the change in ES functioning of the forested areas from possum eradication, as well as investigates the socio-economic benefits associated with the sale of fur/skins. Al Fleming is to develop a business case for this initiative to present at next workshop.

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6. CONCLUSIONS

The five workshops filled a need in the Tauranga Harbour context by providing a neutral space in which a complex dialogue could take place without the pressure of a mandated outcome. The risk with an open dialogue approach is that it becomes a talk fest. This was mentioned as the biggest concern during the pre-survey. The 12 participants surveyed after the workshops indicated that the process was well received by the Tauranga participants. The recommendations and self-organising action planning, along with an endorsement of participation in future workshops, a willingness to demonstrate the TCESM in the networks of participants, and a commitment to improving and up scaling the model, are signs of a productive process. The survey indicated that, on average, after the five workshops the participants perceived much more clearly the potential for a higher level of integrity of Tauranga Harbour than they had before.

The data gaps remain due to unavailability of data as well as the limited timeframe for the MM process. As a result, the TCESM is a scoping model that can be further developed in the future. However, it is clear that in the absence of such understanding, decisions are made at local level anyway. Data trends are not commonly gathered in a format that easily supports a dialogue about regional trends.

The capacity to build, maintain and expand the evolving model was developed in two iwi members of the Tauranga MTM research team.

The hands-on simulations of the model during the final workshop were appreciated by most participants, and 95% of participants surveyed indicated they would show the model in their networks, but require additional training or support to do so.

The questions the modelling effort set out to answer were very broad. The answers to those questions are also broad. The scenarios are examples of specific concerns within the broad questions.

The model and the modelling effort resonated and achieved its goal at scoping level, while training local capacity to work with STELLA and to continue to update the TCESM.

Most importantly, there is a strong endorsement for ongoing collaboration and collaborative learning among the diverse stakeholder group represented at the workshops. The model building and its potential to support a complex dialogue were appreciated. Realistically, however, the five workshops got the group about half-way to where they would like to be. Accordingly, they expressed their intent to continue to meet as a self-organising group, supported initially by BoPRC.

The main solutions identified by the group were coordination, collaboration, identification of funding sources and various restoration activities. The critical areas for ongoing investigation from a MM perspective are:

1. Sensitivities to sediment, nitrogen and toxins/bacteria to seagrasses and shellfish beds.

2. Improved reporting and gathering of trend data (and data translation) in land use and monitored water quality and in biological trends at regional scale.

3. Additional feedback loops and interconnectivity between economic, natural capital and ecosystem services.

4. How to disseminate the model and modelling capacity for future updating of the model.

The general conclusion reached after examination of the model is that, as a tool for understanding the interconnections and broad drivers of change and trends, the current model is a starting point, with potential to provide support for fostering adaptive capacity among multiple stakeholders; stakeholders in Tauranga have been introduced to the MM tool and understand its potential. The unanimous recommendation was to continue evolving the current model to collate data trends, explore interdependencies between trends and anticipate future solutions, funding and benefits in the form of ecosystem services.

The process of modelling the broad system has supported the dialogue and brought forward new insights such as:

1. There continues to be a need for land use and data translation and compilation and understanding from an integrated systems perspective.

2. The benefits of the aggregated systems approach is that it allows several separate conversations to come together and identifies the need for leadership in the absence of "data and certainty".

3. The disadvantage of the aggregated approach is the lack of spatial explicitness. There is on-going wish for more data to increase the understanding of the system with "certainty".

4. The "neutral" space fostered a constructive dialogue among stakeholders who are often involved in more formal (and adversarial) processes.

5. Learning among the stakeholders occurred.

6. Participants showed an interest in the modelling during the process and the dialogue remained structured due to the modelling process. However, participants want to experiment hands-on with the model only when it is complete.

7. Recommendations can be found in Outcomes, Knowledge and Science Indicators and Leadership/Action Progress. An implicit consensus on the desirability of the outcomes seemed to exist, enough to pursue a dialogue for understanding. However, a consensus of the balance at an outcome level with economic, traditional, or new instruments is not evident. Various indicators are measured but are currently not yet integrated and interrelated to

support an adaptive dialogue; it remains a challenge to overcome a fragmented approach both in research, community building, and policy coordination. Leadership and actions in a desirable direction can be acknowledged, promoted, and more coordinated.

There was widespread support among the group for the continuation of the energy and passion for Harbour restoration that was evident in the MM workshops. Such a formalised group could provide advice in relation to Tauranga Harbour for the many different research entities operating within the Harbour, and for industry, Councils, etc. Thus, it was agreed that the mediated modelling participants from these workshops will continue to meet beyond the final workshop, as an "autonomous self-organising" group. It was suggested that greater involvement of additional participants would be desired, including wider representation from TCC and WBoPDC, and from industry, and from Port representatives (who did attend some of the earlier MM workshops), etc. BoPRC has the ability to call together key stakeholders to participate in such meetings.

Ongoing resourcing would be needed to sustain such a group into the future, for administration/organisation, costs of holding meetings, and for any ongoing research the group might want to undertake. BoPRC intends to set up a Stakeholder Group for Tauranga Harbour, and it was agreed that this worked well with the above recommendation and associated action point. However, it was noted that a degree of separation between Council(s) and the local community/stakeholders is important, and that there will be times when Council may need to step aside (or act as an observer, not a "member"), e.g., if the group decides to collectively put a submission to BoPRC.

As an autonomous, self-organising group (at least initially), this group could have *multiple roles*, including: submissions to Council (in which case Council staff would not participate); as a forum to discuss ideas/concerns/strategies about the Harbour in an open, safe space; as a mechanism for key people across the region to plan for Harbour restoration and sustainable management; and as an "end user advisory group" and to advise researchers, Council, etc., about the Harbour and its catchments. The current BoPRC process, in preparation for its 10-year plan (2012–2022), could maintain momentum in keeping this group functioning beyond the Mediated Modelling workshops.

Due to the grounding of the Rena near Tauranga Harbour in 2011, these follow up workshops were delayed due to resourcing being directed into clean up efforts. However, it is hoped that such workshops will continue in 2012 and beyond.

7. APPENDICES

7.1. Appendix 1 – Post Survey

Post-Workshop Survey of Mediated Modelling of the Tauranga Harbour

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Ecological Economics Research New Zealand (EERNZ) at Massey University
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This survey will help evaluate the five Mediated Modelling (MM) workshops. We aim to use the answers for research purposes. Please, be assured that no respondent will be identifiable in research publications[11]. We will email you the results.

Name:

Affiliation:

1. How many workshops did you attend?
    1
    2
    3
    4
    5

2. Reflecting on the (five) workshops, how do you think the group rates in terms of the following criteria?

    a. <u>Inclusiveness</u>: i.e. the level of inclusiveness of different perspectives.
        1 = very low
        2 = low
        3 = neutral
        4 = good
        5   = excellent

    b. <u>Time preference</u>; i.e. The participants' support of actions that will cost in the short term but have a greater benefit in the long run.
        1 = very low
        2 = low
        3 = neutral
        4 = good
        5   = excellent

---

[11] "This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director, Research Ethics, telephone 06 350 5249, email humanethics@massey.ac.nz".

c. Leadership: i.e. the prospect that recommendations developed during the MM process will be implemented by those in leadership positions.
   1 = very low
   2 = low
   3 = neutral
   4 = good
   5 = excellent

d. Creativity: i.e. the number of innovative ideas that were generated during the process.
   1 = very low
   2 = low
   3 = neutral
   4 = good
   5 = excellent

3. Please, rank the weight that was given to each of the four aspects of well-being during the dialogue and modelling in the MM workshops: 1 = most weight, 4 = least weight

Economic outcome	
Environmental sustainability	
Social impact on the community	
Integrity of cultural values	

4. Do you think there is **<u>consensus</u>** among the participants in the workshops on:

a. how the Tauranga Harbour **currently** "ticks" with regard to social, cultural, economic and ecological aspects?
   1 = very low
   2 = low
   3 = neutral
   4 = good
   5 = excellent

b. what the **future goal/vision** for the Harbour is?
   1 = very low
   2 = low
   3 = neutral
   4 = good
   5 = excellent

c. how to manage the Tauranga Harbour from its current state **toward** the future goals/vision:
   1 = very low
   2 = low
   3 = neutral
   4 = good
   5 = excellent

5   On a scale of 1 (Very low) – 5 (Excellent) what is your confidence level that the participants in the workshops have arrived at a good outcome? Please circle the appropriate number:

  1 = very low
  2 = low
  3 = neutral
  4 = good
  5 = excellent

  If you rated your confidence level as very low or low, please explain what weaknesses you see in the outcome:

  If you rated your confidence level as being good or excellent, please explain what strengths you see in the outcome:

6   What was working well for you during the workshop(s)?

7   What could have been done better during the workshop(s)?

8   Did you learn something new?

  Yes/No

  If yes, what was your biggest eye-opener or aha-moment?

9   The following question is aimed at establishing how well the 'voice's' of the different stakeholder groups were heard.

> a. Do you think the voices of the various stakeholder groups were heard during the workshops?

Stakeholder Representatives	All the time	Most of the time	Occasionally	Not at all
Environmental				
Local Authorities				
Iwi/hapū				
Farming & Industry				
Regional Council				

> b. If one or more of the groups to have been 'heard all the time' please explain what gave them 'voice'?

> c. If one or more of the groups to have been 'heard not at all' please explain why you think they were not heard?

10   From your point of view will the outcome of the workshops lead to:

1 = Further significant deterioration of the Harbour
2 = Further moderate deterioration of the Harbour
3 = Maintenance of status quo
4 = A moderate improvement of the Harbour
5 = A significant improvement of the Harbour

11   Where do you think the quality of the Tauranga Harbour will be in 2030 if the recommendations of the MM workshops are implemented?

Very Low   Excellent

1	2	3	4	5	6	7	8	9	10

13   Did you find the following aspects of mediated modelling helpful?

	Not helpful	Helpful	Very helpful
Structuring the dialogue			
Facilitation			
Structuring the thinking			
Focus on change over time			
STELLA software			
Model simulation			
Choice of topics for the workshops			
Translating data into "simple" relations			
Providing a neutral "language"			
Providing a neutral space			

14   Would you participate in additional MM workshops?

Yes/No

If not, why not?

15.   Would you recommend the MM process to other groups?

Yes/No

If not, why not?

16.   Will you demonstrate the model to other people in your network?

Yes/No

If not, why not?

17.   May we use the answers to the above questions for research purposes?

Yes/No

18.   Are there any other observations or thoughts you would like to share?

THANK YOU FOR YOUR PARTICIPATION!

7.2.   Appendix 2 – Mediated Modelling Stakeholder Analysis

Stakeholder Analysis (SA) is the process used to identify the key people/ organisations that should participate in the MM exercise.   SA is the basis for **Stakeholder Management and helps us think about which people we need to be** involved in the MM for it to be successful, and how to go about managing the process of recruiting people to be involved in a MM project.

Stakeholder Identification:

Working definition of a "stakeholder":
A stakeholder is any organisation or person that will affect or be affected by whatever the key issue is that you will examine during the MM. For MTM, it is "the key issues that iwi/hāpu/hāpui identify regarding the state of coastal ecosystems in Tauranga moana, why degradation has occurred and scope for potential solutions".

Narrow perspective: Limited to stakeholders who have legal and presumed stakes.
Broad perspective: With attention to networks and wider community well-being.

Process:

1. Identification of stakeholders by Carlton and Tauranga-based research team as a starting point.
2. Agree on criteria of what makes a balanced, fair and productive stakeholder group.
3. Prepare material to request input on the evolving stakeholder list from external organisations.
4. Request input for stakeholder list from a wide variety of perspectives.
5. Check for self-referencing and make sure that the stakeholder participant group reaches beyond "business-as-usual".
6. Build a substantial database before selecting stakeholders.
7. Potentially a network analysis, mapping how the people and organization involved are inter-connected and how information flows. This can be done qualitatively or with computer support.

Number of stakeholders:

A number is set between 10 and 20, based on the agreement of the research team and input from iwi/hāpu reps. The team suggests to aim initially for 10–15 stakeholders. When the final participant list needs to be decided, there are often "non-negotiables" that need a place at the table. It is easier to add participants then to come back on raised expectations. Several stakeholders will be polled during stakeholder identification, but may not be invited.

If the interest is high, a mechanism may be designed to observe the workshops and/or additional communication venues such as website or blog.

Stakeholder Interests:

Balancing perspective:
The narrow perspective of stakeholders dictates at a minimum inclusion of certain key stakeholders. Enough space should be left to include a broader perspective to **ensure creativity. Think about management solutions to branch out the stakeholder** group, such as coalitions, shared participation or the option to observe workshops.

Process (Outline and review stakeholder list):

1. Review the list and identify the specific interests these stakeholders have for the topic.

2. Consider the benefit(s) or drawback to the stakeholder of stakeholder participation.

3. Decide if you aim for organisations or individuals. Make sure your follow your own policy.

4. Consider inclusion of a question about the quality of the final stakeholder group at the pre-interview with final participants for research and evaluation purposes.

Key questions that can help you understand who your stakeholders are:

 * What financial or emotional interest do they have in the outcome of this project? Is it positive or negative?
 * What motivates them most of all?
 * What information do they want from you?
 * How do they want to receive information from you? What is the best way of communicating your message to them?
 * What is their current opinion of your work? Is it based on good information?
 * Who influences their opinions generally, and who influences their opinion of you? Do some of these influencers therefore become important stakeholders in their own right?
 * If they are not likely to be positive, what will win them around to support your project?
 * If you don't think you will be able to win them around, how will you manage their opposition?
 * Who else might be influenced by their opinions? Do these people become stakeholders in their own right?

Selection criteria for a FAIR, BALANCED and WORKABLE group:

1. Main branches of interest
    a. Māori Representatives
    b. Government: Local and Regional
    c. Regional elected officials
    d. Utilities and semi-governmental service providers
    e. Industry and business, e.g., Port, Priority 1, etc.
    f. Environmental and other NGOs
    g. Other

2. Balance between supply and demand

3. Politically balanced

4. Gender balance

5. Subjective criteria beyond an attempt to develop a balanced participant group: knowledge of the sector/topic, out-of-the-box thinking capacity, communication skills and implementation and networking capacity.

Proposed process:
1. Determine number of seats

2. Identify the basic, non-negotiable, direct stakeholders' organisations.

3. Identify knowledgeable person with authority to speak for these organisations.

4. Identify the gaps of knowledge in terms of obvious subjects.

5. Identify knowledge and out-of-the-box-thinking capacity.

6. Use spider chart for final balancing.

Check outcome against selection criteria list.

Outcome:

Final participant list, with:
1. Direct stakeholder participant represents one organisation.

2. Stakeholder representative, representing several organisations.

Prepare letter of invitation:
1. What kind of information will participants need?

2. What commitment do you need from participants?

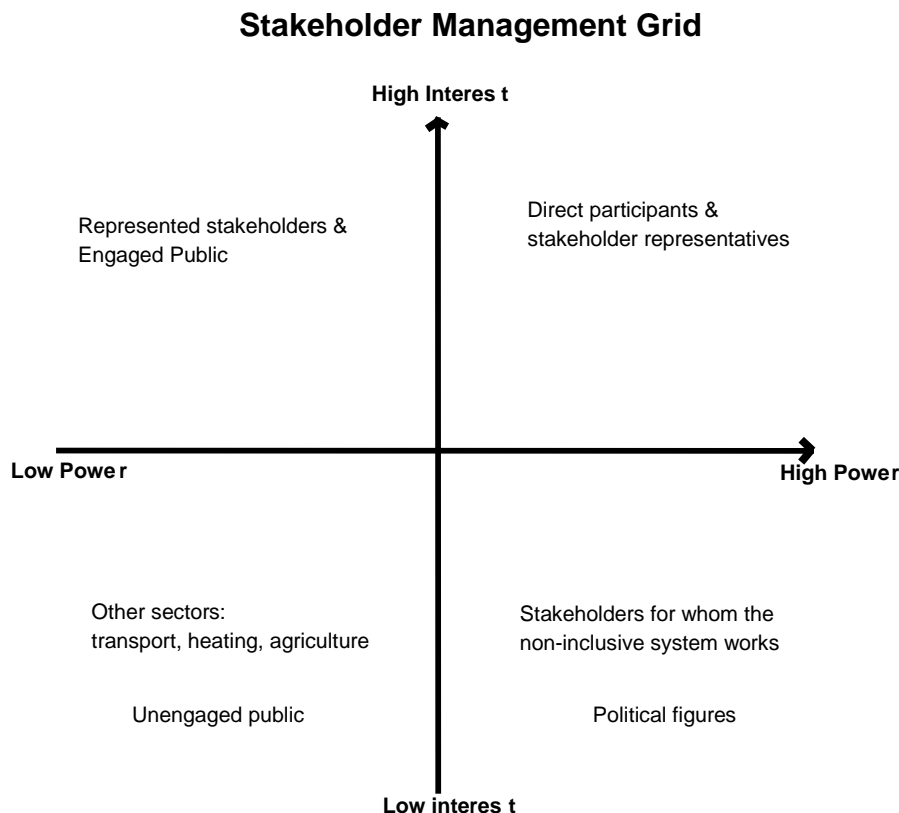3. What is the next step participants may expect?

Stakeholder Strategies

Plan strategies for approaching and involving each person or group:

Formal invitation, initial contact, encourage coalitions, keep informed, involvement as informant, consulted, directly involved in decision-making, involved as co-researchers and co-actors. Consider a website and media contacts.

Stakeholder Management

Positioning potential stakeholders in a management grid helps with stakeholder selection and consequently stakeholder management to support a MM project beyond the approximately 10–20 participants.

Stakeholder Management Grid

High Interes t

Represented stakeholders &
Engaged Public

Direct participants &
stakeholder representatives

Low Powe r   High Power

Other sectors:
transport, heating, agriculture

Stakeholders for whom the
non-inclusive system works

Unengaged public

Political figures

Low interes t

High power, interested people: these are the people you must fully engage and make the greatest efforts to satisfy. These are the MM participants.
High power, less interested people: put in enough work with these people to keep them satisfied, but not so much that they become bored with your message. Often politicians and those with power who monitor the project without contributing. These forces will become active when the issue starts to affect them.
Low power, interested people: keep these people adequately informed, and talk to them to ensure no major issues arise. These people can often be very helpful with the details of the project and/or data gathering. Universities, research organisations and indirect stakeholders often fall in this category. A high level of shared

understanding and a positive attitude among this group potentially serve an implementation phase, due to esteemed peer relationships. If the possibility of meetings in a public space is feasible, this group tends to show up to observe the workshops.

Low power, less interested people: monitor these people, but do not bore them with excessive communication. This is often the general citizenry. Radio coverage has been appreciated in the past.

Timing versus Participation – when to use MM

Timing of participation

Late — Stakeholders design a model within a
frame or under policy determined constraints: To solidify learning through collaborative interaction;
To integrate existing research

Expert model: To invite feedback from stakeholders after model is developed

Degree of participation

Low — High

Modeller maintains the model: To regard individual stakeholders viewpoints are early in participatory process

Stakeholders design model without pre-fixed frame: to scope out relevant questions, research needs or solutions; to build collaborative capacity among stakeholders; to serve as a benchmark for implementation

Early

7.3. Appendix 3 – Participant attendance

The full list of participants includes people who were present for at least half a day of each respective workshop, as noted below, and contributed in some way to workshop discussions. The resultant model may not fully represent the views of individual participants or the organisation they represent.

Organisation	Member	1	2	3	4	5	
Tauranga City Council	Graeme Dohnt	X	X	X			3
Tauranga City Council	Jane Groves	X	X	X			3
Western BOP DC	Glenn Ayo	X		X	X		3
Western BOP DC	Jar Wickham			X			1
BoPRC	Rob Donald	X	X	X		X	4
BoPRC	Stephen Park			X	X	X	3
BoPRC	Bruce Gardner					X	1
BoPRC, Coast Care	Pim de Monchy		X	X			2
BoPRC	Braden Rowson				X		1
NZ Landcare Trust	Kate Akers			X	X		2
Royal Forest and Bird	Al Fleming	X	X	X	X	X	5
Royal Forest and Bird	Eila Lawton	X	X	X	X		4
Department of Conservation	Chris Clark	X			X	X	3
Department of Conservation	Dan Rapson	X					1
Zespri	Alistair Mowat	X	X		X		3
Ballance Fertilizers	Arthur Tsitsiras	X			X		2
Ballance Agri-Nutrients	Nigel Sadlier				X		1
Federated Farmers	Barry Roberts	X	X	X	X	X	5
Federated Farmers	Jay Weeks		X	X	X	X	4
Toi Te Ora Public Health	Trieste Ngawhika	X					1
Customary Fish Committee	Paul Borell	X	X				2
BOP Polytechnic	Dean Tully	X		X			2
BOP Polytechnic	Tim Lowe				X		1
BOP Polytechnic	Andrew Morgan				X	X	2
Port of Tauranga	Rowan Johnstone		X	X	X		3
Tangata Whenua , Waka Taiao*	Sarah Wairepo	X	X	X	X	X	5
Tangata Whenua, Waka Taiao*	Tracey Ngatoko	X	X		X	X	4
Tangata whenua, Waka Taiao*	Carlton Bidois	X	X	X	X	X	5
Tangata whenua, Waka Taiao*/ Manaaki Taiao	Paula Werohia	X	X	X	X	X	5
Tangata whenua, Manaaki Taiao	Whitiora McLeod		X	X			2
Tangata whenua, Manaaki Taiao	Kevin Haua	X	X	X	X		4
Tangata whenua, Manaaki Taiao	Archie Grant		X				1

Organisation	Member	1	2	3	4	5	
Tangata whenua	Neil Te Kani			X			1
Tangata whenua	Hemi Rolleston			X			1
Tangata whenua	Anonymous	X					1
Tangata whenua	Anonymous	X					1
Tauranga Environment Centre (TEC) (TEC had observers for 2nd & 3rd workshops)	Noel Peterson	X	X (+ 1)	(+ 1)		X	3
Wildland Consultants	Lisette Collins		X	X			2
Olsen Contracting (forestry)	Kit Richards			X			1
Chamber of Commerce	Max Mason					X	1
Kaimai Mamaku Campaign Committee	Warwick Buckman					X	1
Trust Power	Kerry Watson					X	1
Postgrad Student	Julien Huteau	X				X	2
Total Participants		**22**	**20**	**23**	**20**	**18**	**103**
MTM Researchers:							
Massey University	Marjan van den Belt	X	X	X	X	X	5
Massey University	Derrylea Hardy	X	X	X	X	X	5
Massey University	Murray Patterson	X			X		2
WakaTaiao (also those indicated with * above)	Lydia Hale	X	X	X	X	X	5
Cawthron Institute	Eric Goodwin	X					1
Cawthron Institute	Dana Clark		X				1
Cawthron Institute	Joanne Ellis					X	1
WakaDigital Ltd	Aaron McCallion	X	X	X	X	X	5
WakaDigital Ltd	Mark Berry	X	X	X	X	X	5
TOTAL ATTENDEES		**29**	**26**	**28**	**26**	**24**	**133**

NB: Mal Green, NIWA attended 10 a.m. to noon, gave presentation about Sedimentation Study, Southern end of Tauranga Harbour at the 4th Workshop.

7.4.　Appendix 4 – Introducing system dynamics thinking

The modelling approach that is used is called 'system dynamics'. The introduction to system dynamics thinking on the High Performance Systems website (www.hps-inc.com/index.aspx) states:

> To make sense of reality, we all simplify it. These simplifications are called mental models. We simulate our mental models in order to determine which course of action to implement, which alternative to choose, which strategies will best achieve our objectives. History shows that our choices and decisions often leave us with holes in our feet because:
>
> - The assumptions constituting the mental models we build are not sufficiently congruent with the reality they are seeking to represent.
>
> - Our simulations of these models do not correctly trace out the dynamic consequences implied by the assumptions in the models.
>
> 'Systems Thinking' is an approach that can help us to construct mental models that are more likely to be congruent with reality, and to then simulate these models more accurately.
>
> Systems Thinking thus increases the likelihood that we will produce the consequences that we intend.

From a system dynamics perspective, we are interested in non-linear behaviour within a system often explained by feedback loops and time lags.

7.4.1. Introduction to STELLA

The system dynamics software used is called STELLA. The software can be found at High Performance Systems, Inc: http://www.hps-inc.com/index.aspx.

A run-time only version is downloadable free of charge and allows you to run models, but not save the changes to a model. You are welcome to download this software and learn how to use it. However, this is not a requirement of your participation. The research team running the Mediated Modelling will be responsible for building the computer model, and for explaining at each workshop what has been done in each step as the model is developed, to reflect the decisions made by participants in each workshop.
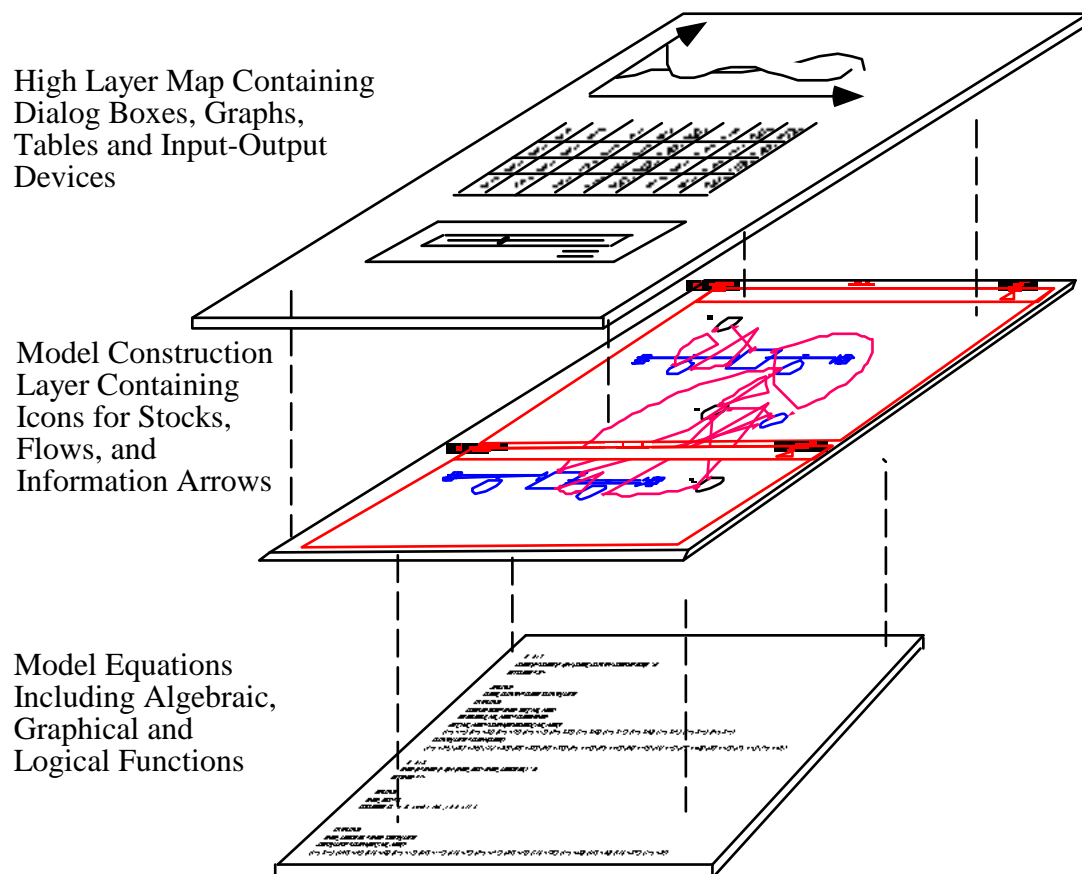
In STELLA, there are three communicating layers that contain progressively more detailed information on the structure and functioning of the model (see Figure 51. The lowest layer contains the difference equation, generated by the model structure in the middle level. This level shows the model structure by icons. The graphic representation of these units are connected and manipulated on the screen to build

the basic structure of the model. This process is made transparent to a group when the computer screen is projected.

The middle layer is displayed during the construction phase. Icons represent the basic structure of the model and provide an input pathway for subsequent data. Once the basic structure of the model is laid out, initial conditions, parameter values and functional relationships can be specified. Input data can be entered in graphical or tabular formats.

The highest layer is the "user interface". In the final stage users can easily access and operate the model from this level. With the use of slide-bars, a user can also immediately respond to the model output by choosing alternative parameter values as the model runs. The model output can be generated in tabular or graphical form.

Figure 51   STELLA Modeling Environment (Source: Costanza & Ruth, 1998)

High Layer Map Containing
Dialog Boxes, Graphs,
Tables and Input-Output
Devices

Model Construction
Layer Containing
Icons for Stocks,
Flows, and
Information Arrows

Model Equations
Including Algebraic,
Graphical and
Logical Functions

Middle Layer: The four model icons

The first task after defining the questions the model should answer will be to choose some model sectors. These are broad conceptual areas or domains that should be included in the model, guided by the questions the model should answer.

In principle, there are four model building blocks or icons: stock, flow, auxiliary variable, information connector (See Figure 52). A stock is a variable important enough to be explained within the model. A stock represents a state variable that embodies an aspect of the system under study. A flow represents the rate of change of a stock. The auxiliary variable defines the rate of change. Information connectors link the auxiliary variables, flows and stocks.

Figure 52 Model icons

Stock

Flow

Auxiliary variable

Information Connector
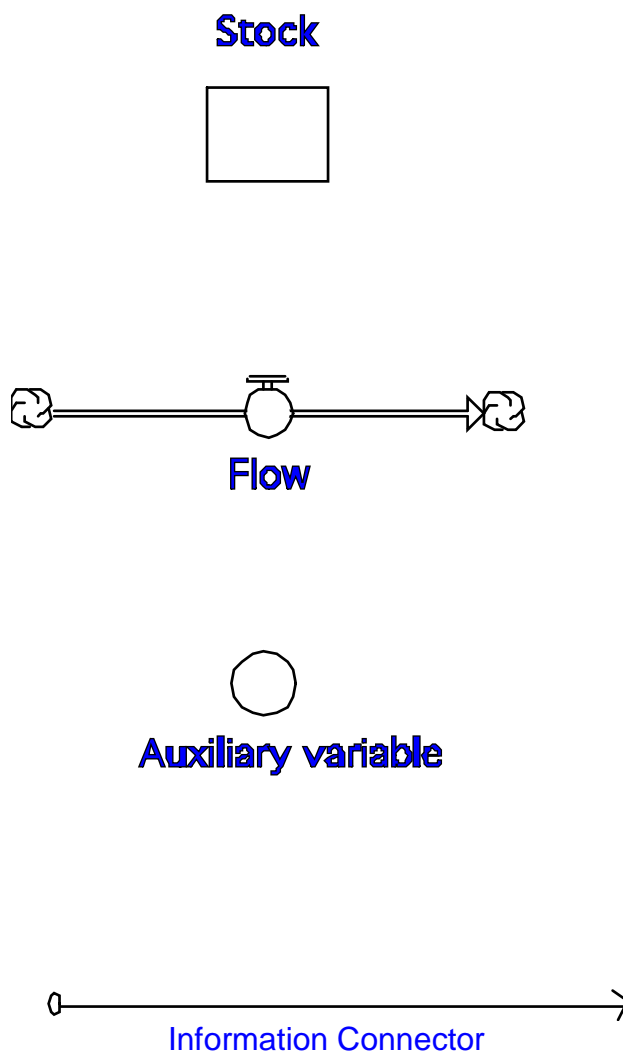
7.5. Appendix 5 – Model description

Referring back to the model overview of the TCESM model in Figure 15, this model description provides additional details of the model sectors, the relationships between the sectors data sources and the some relevant equations. The full STELLA model can be downloaded from the website (www.mtm.ac.nz/mediatedmodelling), where equations are accessible. The model runs from 1950 to 2070, with a time step of one year. The spatial scale is the Tauranga Harbour and its catchments.

Figure 53 Tauranga Harbour and its catchment – TCESM Model Overview

Tauranga Harbour and its catchment -   Model overview

The Tauranga Harbour is a unique estuary in the Bay of Plenty. It is highly productive for food production. Various iwi have lived in the area for centuries. The Harbour is of critical cultural and spiritual significance for iwi. Since the 1950's European settlers developed the area through forestry, port activities and increasingly through horticulture and dairy farming, attracting peoples residing and visiting the area. This has changed the land use and cover in the catchment considerably. The natural capital, underpinning the ecosystem services the Tauranga Harbour provides for all, is under pressure. At the same time, the flow of goods and services measured in economic terms, have increased. How are these trends interconnected? This model aims to re-tell the story and support the understanding among a group of local stakeholders, based on whose dialogue this model was constructed.

External Factors

External Factors

Eco System Services

Eco System Services

Natural Capital

Natural Capital

Fresh Water...nt to Harbour

Fresh Water from Catchment to Harbour

Population

Population

Actions

Actions

Economic Profile of Tauranga

Economic Profile ofTauranga

The following model sectors are discussed:

- Population Pressures
- Natural Capital
- Ecosystem Values
- Economic and Agency Spend
- Actions
- External Factors
- Freshwater from Catchments to Tauranga Harbour

Population Pressure

This model sector simulates the population changes from 1950 to 2070 (Figure 54). It includes the resident population and inbound tourists in the Tauranga Harbour catchment to calculate the effective population pressure. Historic population data are based on Statistics NZ – Tauranga and western Bay of Plenty Population Statistics 1986-2006.

Figure 54 Population model sector
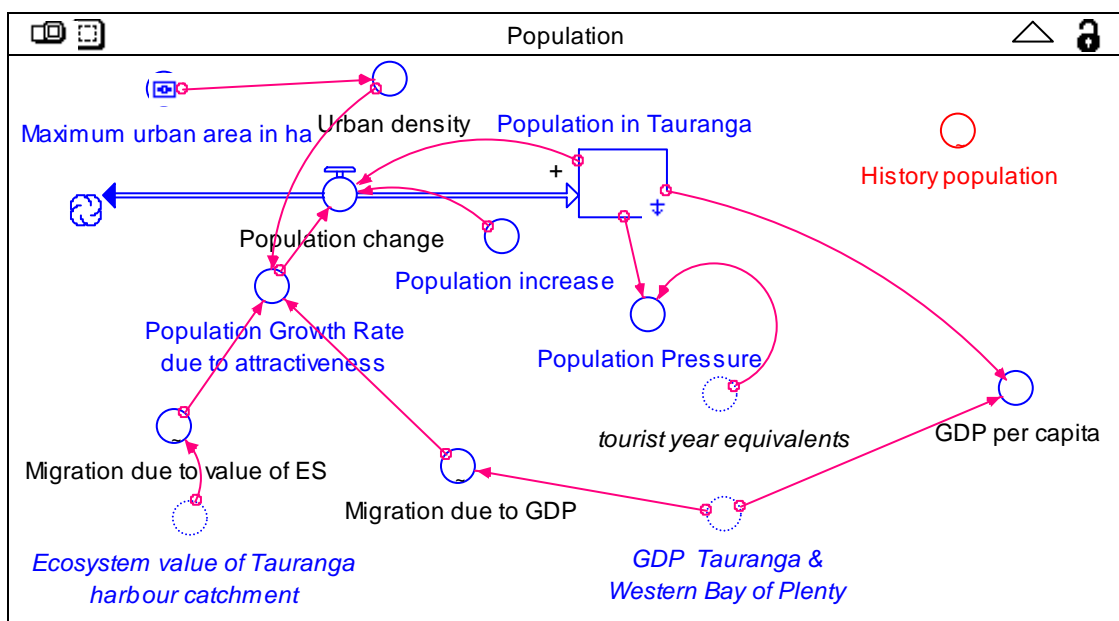
The Population Growth Rate is based on the attractiveness derived from GDP and Ecosystem Services, following equations 1 and 2.

Equation 1:
Population_in_Tauranga(t) = Population_in_Tauranga(t - dt) + (Population_change) * dt
INIT Population_in_Tauranga = 20300

Equation 2:
Population_change =
Population_in_Tauranga*(Population_Growth_Rate_due_to_attractiveness+Populati
on_increase)

Equation 3 reflects a graph of how migration to the Tauranga area decreases when Ecosystem Service values are lower. These are assumed values and the sensitivity of this assumption could be a subject for future research.

Equation 3:
Migration_due_to_value_of_ES =
GRAPH(Ecosystem_value_of_Tauranga_harbour_catchment)
(8e+007, 0.0669), (1.7e+008, 0.0585), (2.6e+008, 0.0522), (3.6e+008, 0.0448), (4.5e+008, 0.0375), (5.4e+008, 0.0294), (6.3e+008, 0.0235), (7.2e+008, 0.0189), (8.2e+008, 0.0137), (9.1e+008, 0.0084), (1e+009, 0.00105)

Total Population pressure combined Tauranga Population and Tourist in equation 4. The number of Tourists is defined in the Economic Sector, discussed below.

Equation 4:
Population_Pressure = Population_in_Tauranga + tourist_year_equivalents

Population Pressure is used in the Freshwater Sector of the model where urban water demand is limited by water availability. As the population grows, so does the water usage, if no efficiency projections are included. Over time, water availability may well become a limiting factor for various economic activities. As an example, Tourism is used as an example of a feedback loop where economic activity is limited by water availability. A future model could assess additional areas where ecosystem services (such as water supply) are limiting economic activities.

The Population Growth Rate also drives the rate of conversion of Pasture into Urban area in the Natural Capital Sector.

Natural Capital

This model sector simulates the predominant and projected land-use and land-cover changes from 1950 to 2070. The icons for historic data are omitted from figure 55 to improve the print quality, but included in the model.

Figure 55 Land Use and Land/Sea Cover

Land use and land/sea cover history (red) and modelled changes in the catchment. The data somewhat matches the landuse categories identified by stakeholders, but not conclusive.
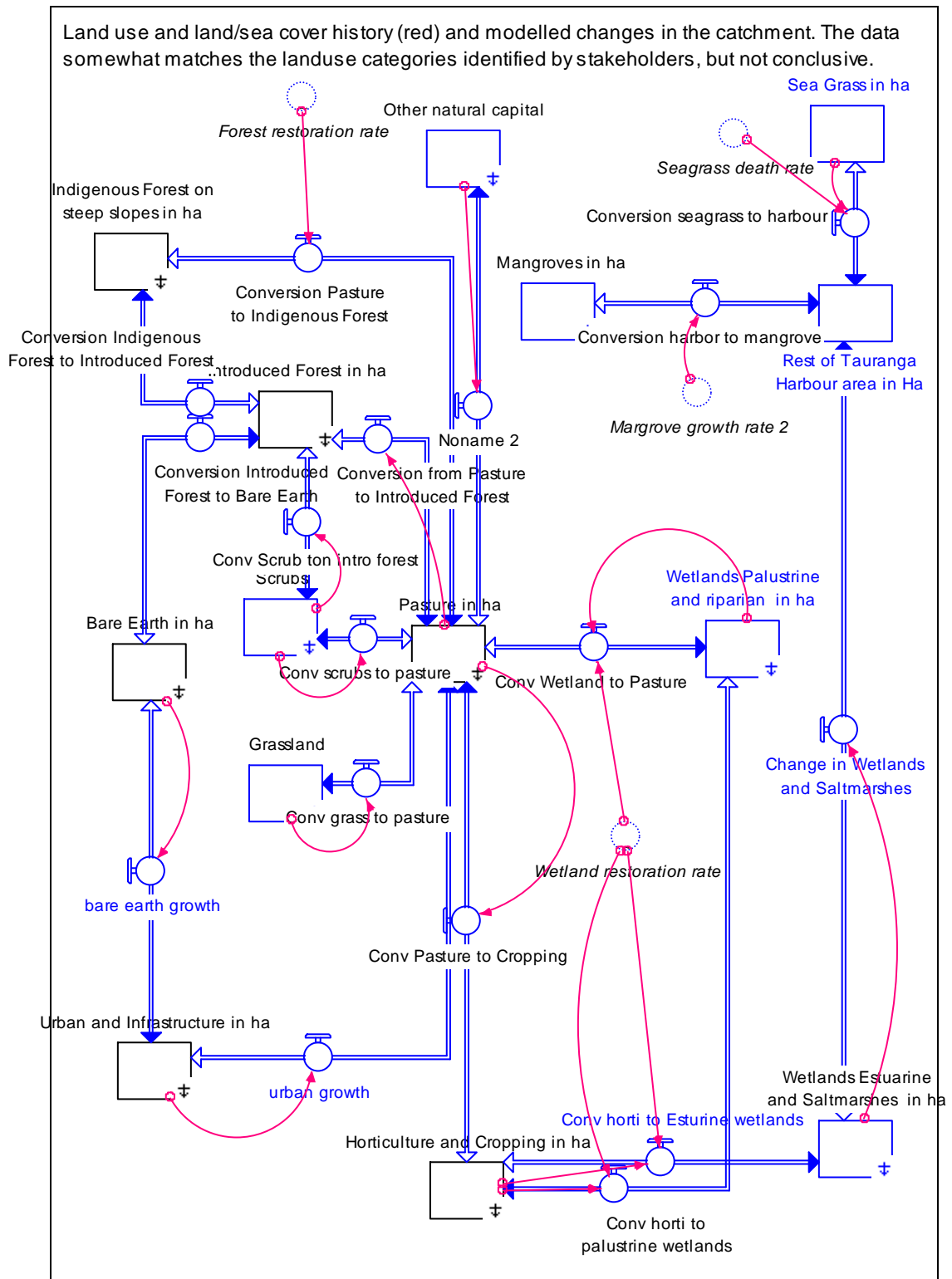
E.g. the stock of Urban and Infrastructure in ha starts with an initial value of 1600 ha in 1950 (equation 5) and increases due to an "inflow" urban growth (equation 5 and 6) defines how many ha are converted each year from Pasture into Urban area. A change in attractiveness (due to a change in ecosystem services or GDP) is

assumed to show up after a time lag of 3 years. Finally, it is assumed that a larger urban spread slightly increases "Bare Earth" (equation 7).

Equation 5: INIT
Urban_and_Infrastructure_in_ha = 1600

Equation 6:
Urban_and_Infrastructure_in_ha(t) = Urban_and_Infrastructure_in_ha(t - dt) + (urban_growth - bare_earth_growth) * dt

Equation 7: INFLOW
urban_growth = Urban_and_Infrastructure_in_ha * DELAY(Population_Growth_Rate_due_to_attractiveness,3)

Equation 8: OUTFLOWS
bare_earth_growth = Bare_Earth_in_ha*.001

The different land uses contribute to the total sediment loads and nitrogen loading into Tauranga Harbour. The land-use/cover drives the yield from various land uses as well as the sediment trapping capacity from mangroves and wetlands (Figure 56). The amount or rate of sedimentation in Tauranga Harbour has increased over the years because of population growth, changing land use and soil disturbance related to development.

Figure 56 Sediment runoff associated with Natural Capital and Land Use

Sediment runoff and trapping from various land use and cover to the best of our knowledge, but not conclusive.
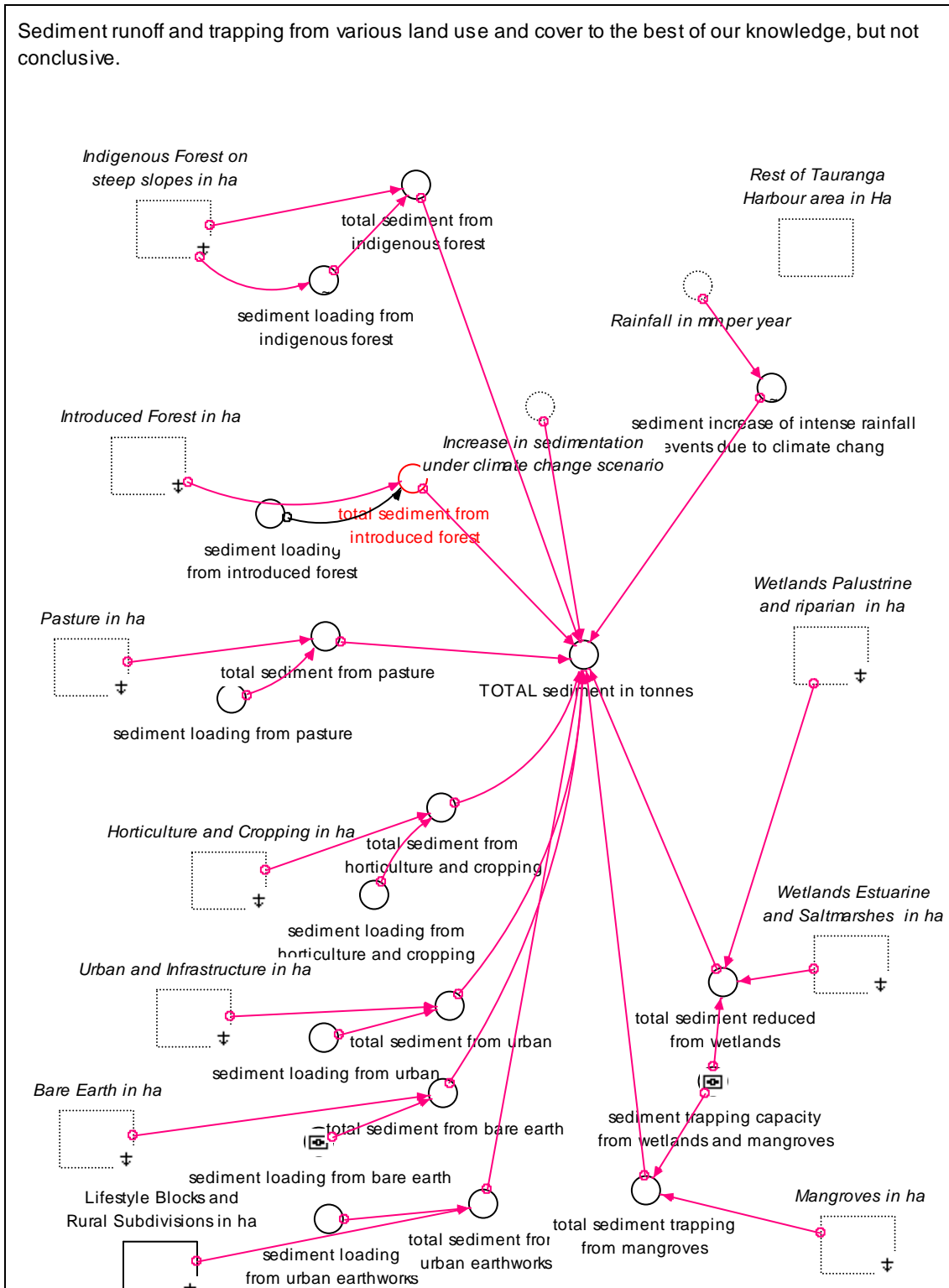
Figure 57 shows the death rate of seagrass and how this is linked to drive the conversion of the stock of seagrass into open water, i.e. "Rest of Tauranga Harbour". Participants observed that there are many impacts on seagrass beds and it isn't clear what impact is dominant or how the various impacts work synergetically, leading to a reduction in seagrass beds. Total Sediment and Total nitrogen, both in tonnes per year, are defined in the Natural Capital sector of the model impacting through a graph under the assumption that more tonnage of sediment and nitrogen increased the seagrass death rate.

Figure 57 Impacts on Seagrass
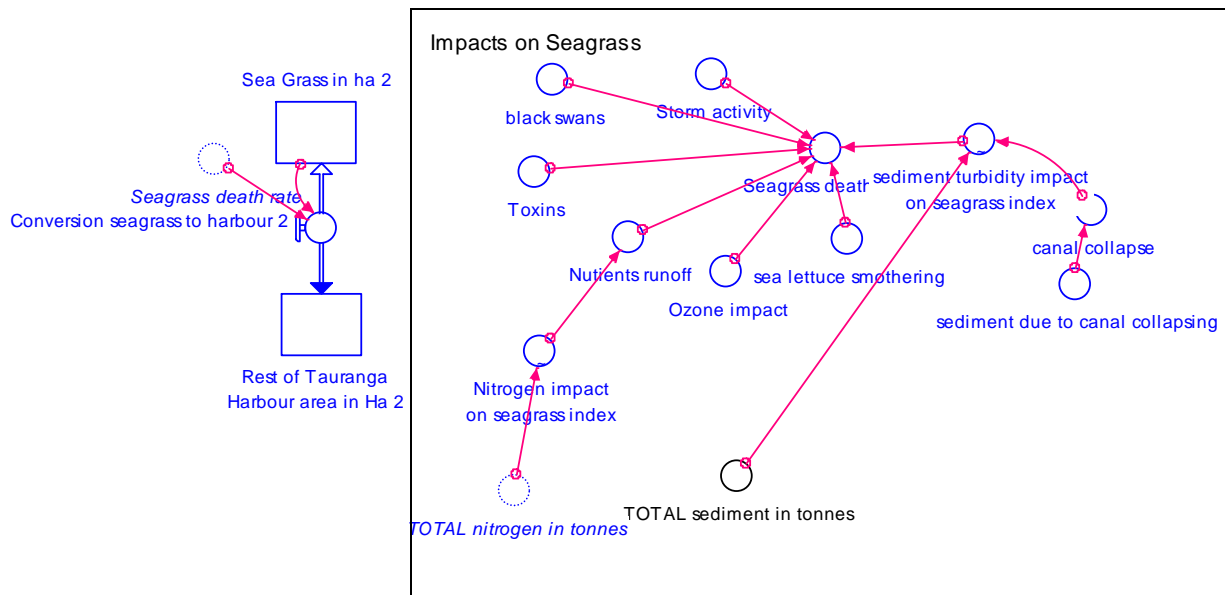
Equation 9 illustrates this relationship of Nitrogen

Equation 9:
Nitrogen_impact_on_seagrass_index = GRAPH(TOTAL_nitrogen_in_tonnes)
(200000, 0.00078), (205000, 0.000855), (210000, 0.000945), (215000, 0.00111), (220000, 0.00125), (225000, 0.00144), (230000, 0.00162), (235000, 0.00188), (240000, 0.00222), (245000, 0.00257), (250000, 0.003)

The graphical relationship between turbidity causing sediments and an impact on seagrass is represented by equation 10. The sedimentation due to runoff yield from various land uses as well as the one time accidental canal collapse is included in this graph (equation 10).

Equation 10:
sediment_turbidity_impact_on_seagrass_index =
GRAPH(canal_collapse+TOTAL_sediment_in_tonnes)
(0.00, 0.00385), (200000, 0.00455), (400000, 0.00665), (600000, 0.00875), (800000, 0.0119), (1e+006, 0.0154), (1.2e+006, 0.0196), (1.4e+006, 0.0242), (1.6e+006, 0.0284), (1.8e+006, 0.0333), (2e+006, 0.0392)

Perhaps it is interesting to mention that some participants had concerns about periodic collapses of river, stream and coastal shores thereby releasing both additional sediments into the Harbour as well as losing productive farm land. This tension could be subject of future investigation and such impact could be added to equation 10.

The 'Total sediment in tonnes' is also linked to 'sediment impact on shellfish' in the 'Ecosystem Services' model sector. In addition, Total Sediment is impacted by Climate Change, as discussed in the External Factors below.

Ecosystem Services

This model sector simulates the services that ecosystems provide to humans as well as the impact of sedimentation, toxins, pollutants, and dredging on these ecosystems. One way of doing this, is to place a monetary value on the 'services' that 'ecosystems' provide humans. Seagrass, for example, provides a number of ecosystem services including trapping and stabilising sediments, nutrient recycling, the creation of high primary productivity, and the provision of habitat for animal and plant species. By placing a monetary value on these ecosystem services, their value becomes 'visible' and decision makers can appreciate their "true worth". A starting point for ES values is presented in Figure 58. The various ES values per Ha per Annum are derived from Costanza et al (1997). Actions such as reforestation and restoration of wetlands increase the ES value from these biomes. To reflect that the way the natural capital functions is relevant to the value in ecosystem services, a slide bar is added (see Circle 1 in Figure 58).

Figure 58 Value of Ecosystem Services through Benefit Transfer
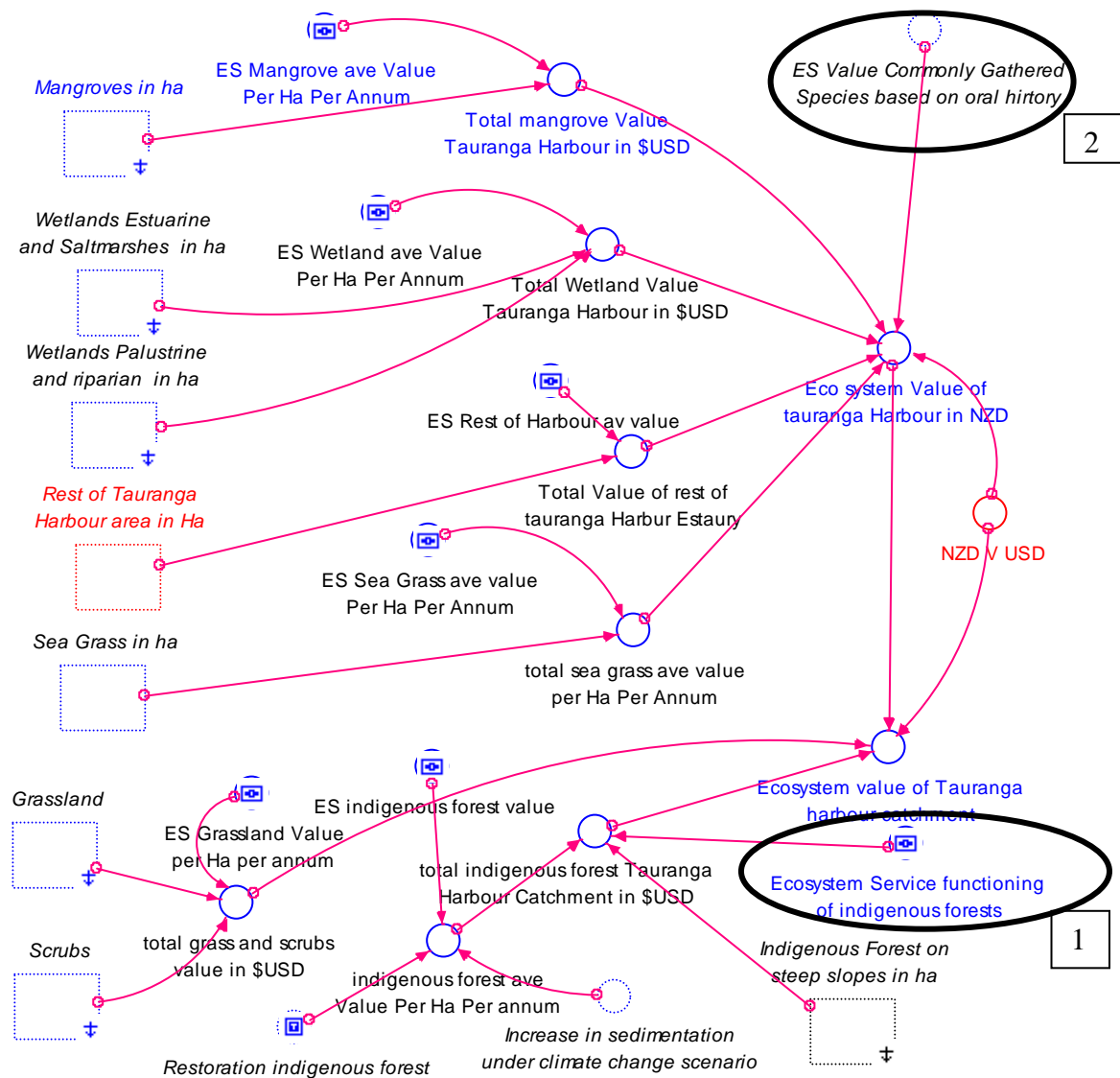
A further monetary valuation can be put on the food resource of commonly gathered species of Tauranga Harbour. The annual harvested values of these species could be measured and the impact of food resource loss via dredging, toxins, shellfish bans and other impacts could be measured over the scenario period (1950–2070). The "ghost" of the icon representing this locally derived ES value of commonly gathered species based on oral history, is circle 2 in figure 58.

The participants indicated that seafood and particularly shellfish (also considered an indicator of overall health of the Harbour) provided important values and should be studies in more detail. Figure 59 shows the model structure developed for the shellfish species of (cultural) importance.

Figure 59 Seafood as an Ecosystem Service

Seafood as an Ecosystem Service and its Value
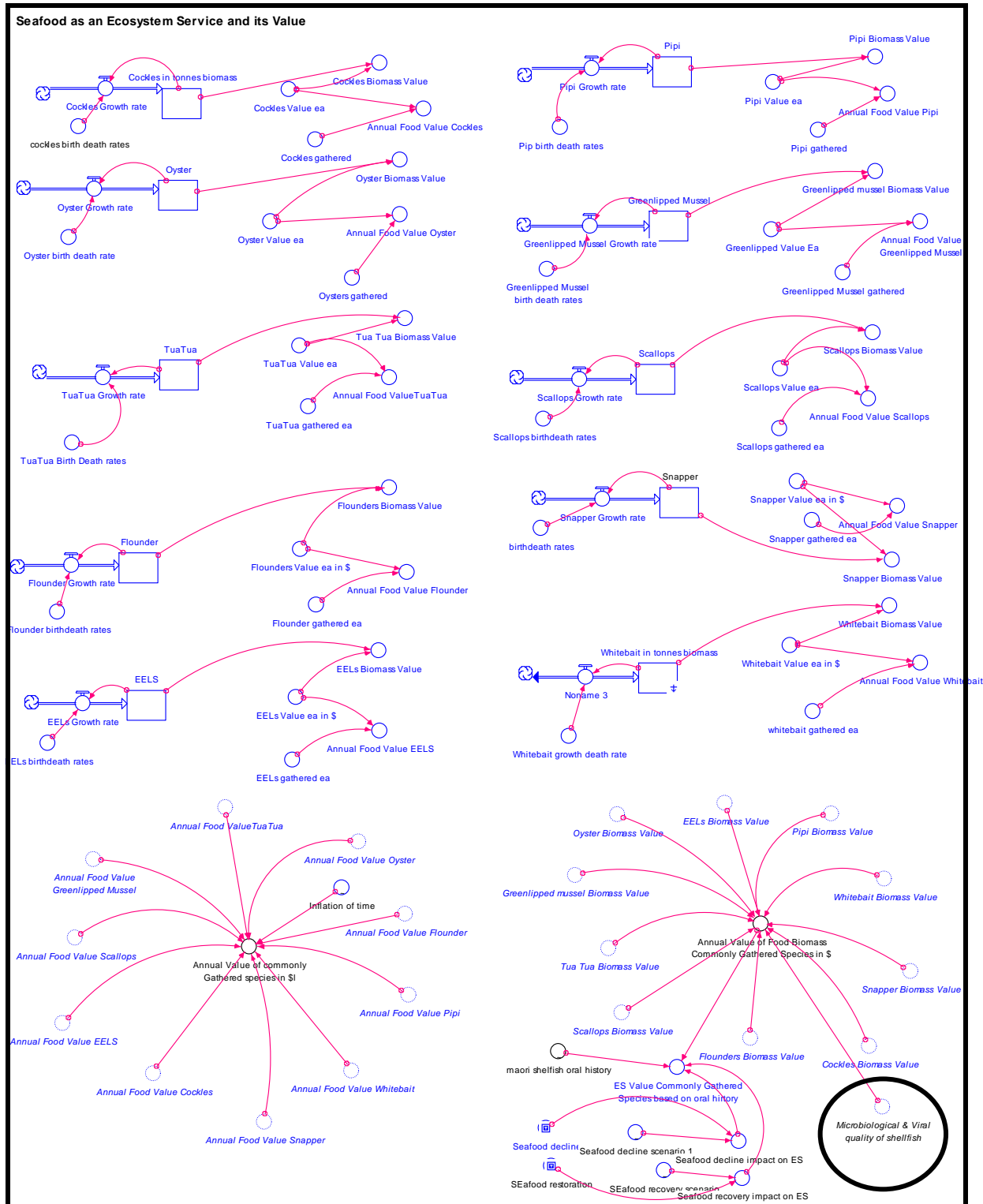
The microbial and viral quality of shellfish (circled in Figure 59) is important as a moratorium on shellfish consumption has been in place for several years now. This is expected to be exacerbated by climate change (see External Factors).

Economic AND AGENCY spending

This model sector looks at the economic impact of the Port and major economic sectors in the region (Horticulture and Cropping, Forestry, Agriculture, Tourism, Port activities); the sector also reflects potential tax revenue for ecosystem restoration and current direct funding spent by regional and local agencies. This sector contains a GDP output of industry in Tauranga and Western Bay (2009). The reader is reminded that GDP was used in the Population Sector to drive attractiveness and therefore migration to the Tauranga region.

As reflected in the description of the workshops and the associated small group work (appendix 6), the participants were eager to jointly identify resources to achieve desired outcomes. The brainstorming with regard to new (and existing) funding sources as well as what actions such funds could be spend on, is reflected in Figure 60.

Figure 60 New funds and spending of funds on actions
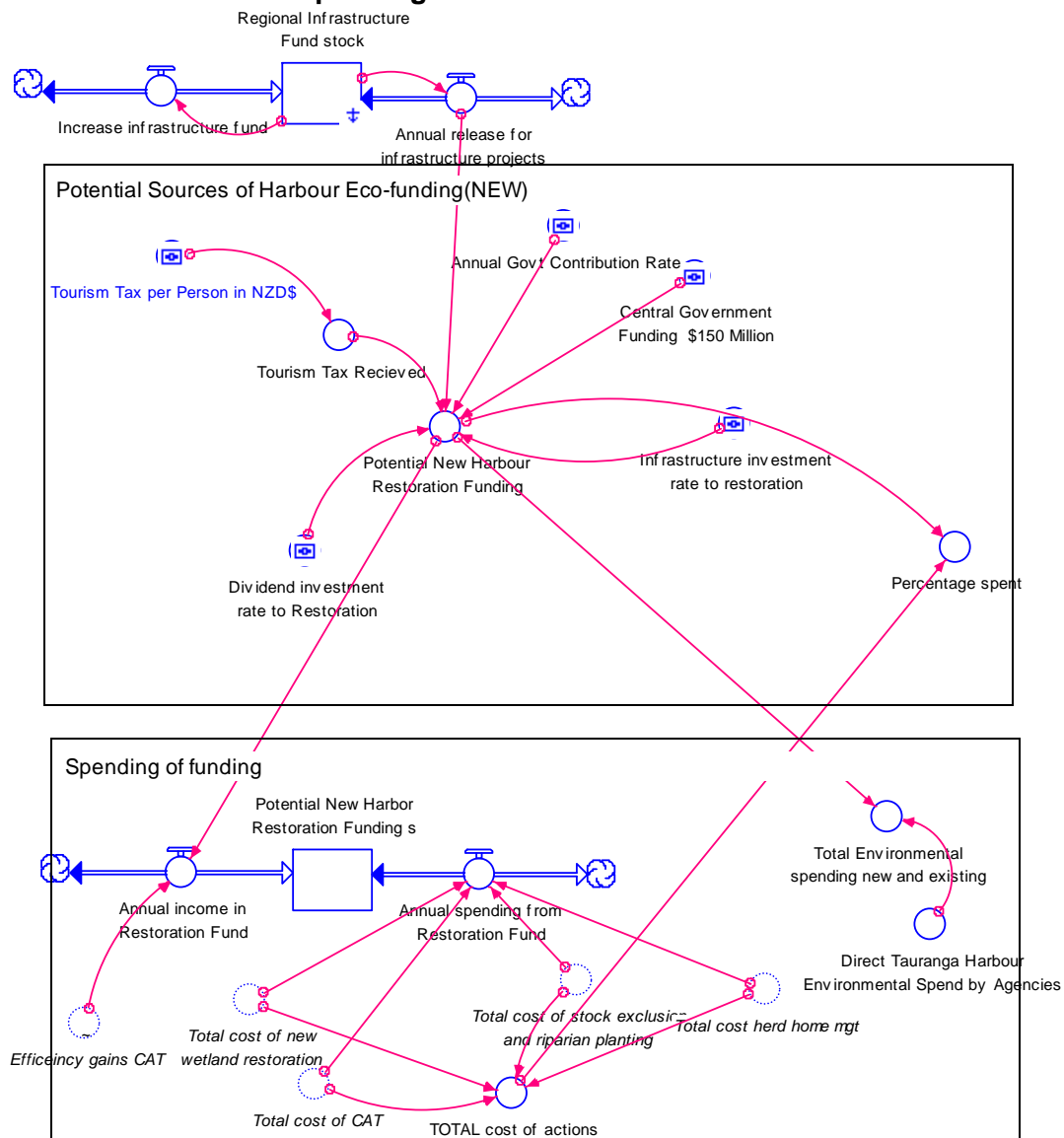
This sub-sector simulates the recreational value of Tauranga Harbour. Although recreational activities are "economic" they also need to be highlighted at an ecosystem service.

The recreational opportunities available on and around the Harbour are a significant attraction for people to live and visit the Bay of Plenty region. The quality of the physical environment and leisure/recreation opportunities are among the main reasons why people move to this area. As an example, Figure 61 represents aspects such as number of boats, ramps, moorings and marinas as well as bathing qualities that participants highlighted in their dialogue.

Figure 61 Recreation value of Tauranga Harbour
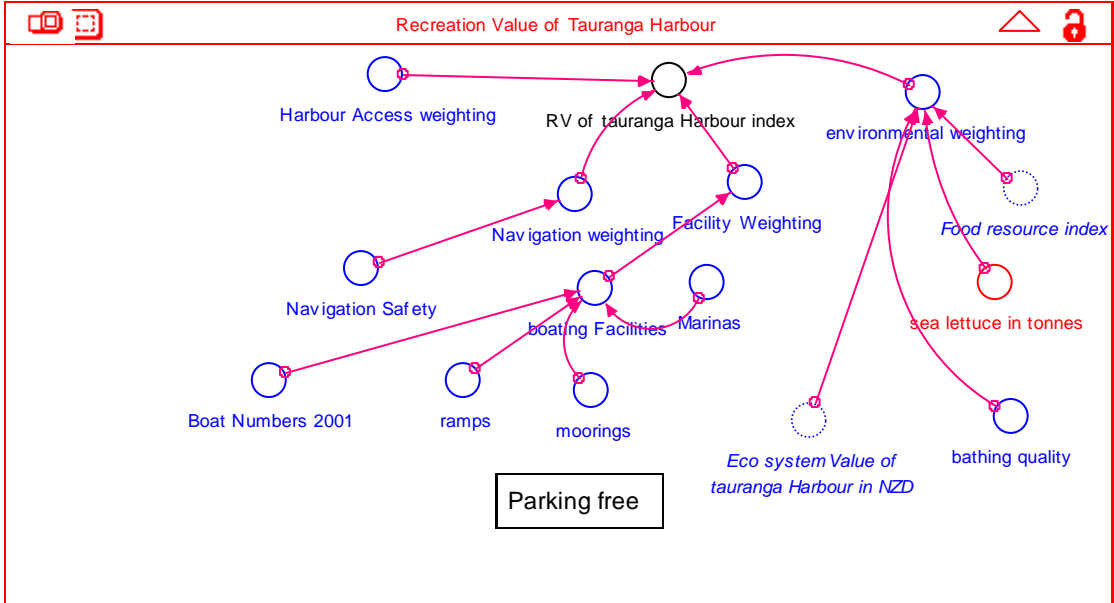
Action

The actions identified aiming to reduce sediment and nitrogen runoff as well as restoration of natural capital, are represented in Figure 62. Specifically, they include: Stock exclusion and herd homes, wetland restoration and restoration of indigenous forests. To reflect the interest of the participants in on-going engagement and collaboratively managing natural capital (also referred to as common assets), the idea of a Common Asset Trust was proposed.

Figure 62 Actions toward improvement of the health of the harbour
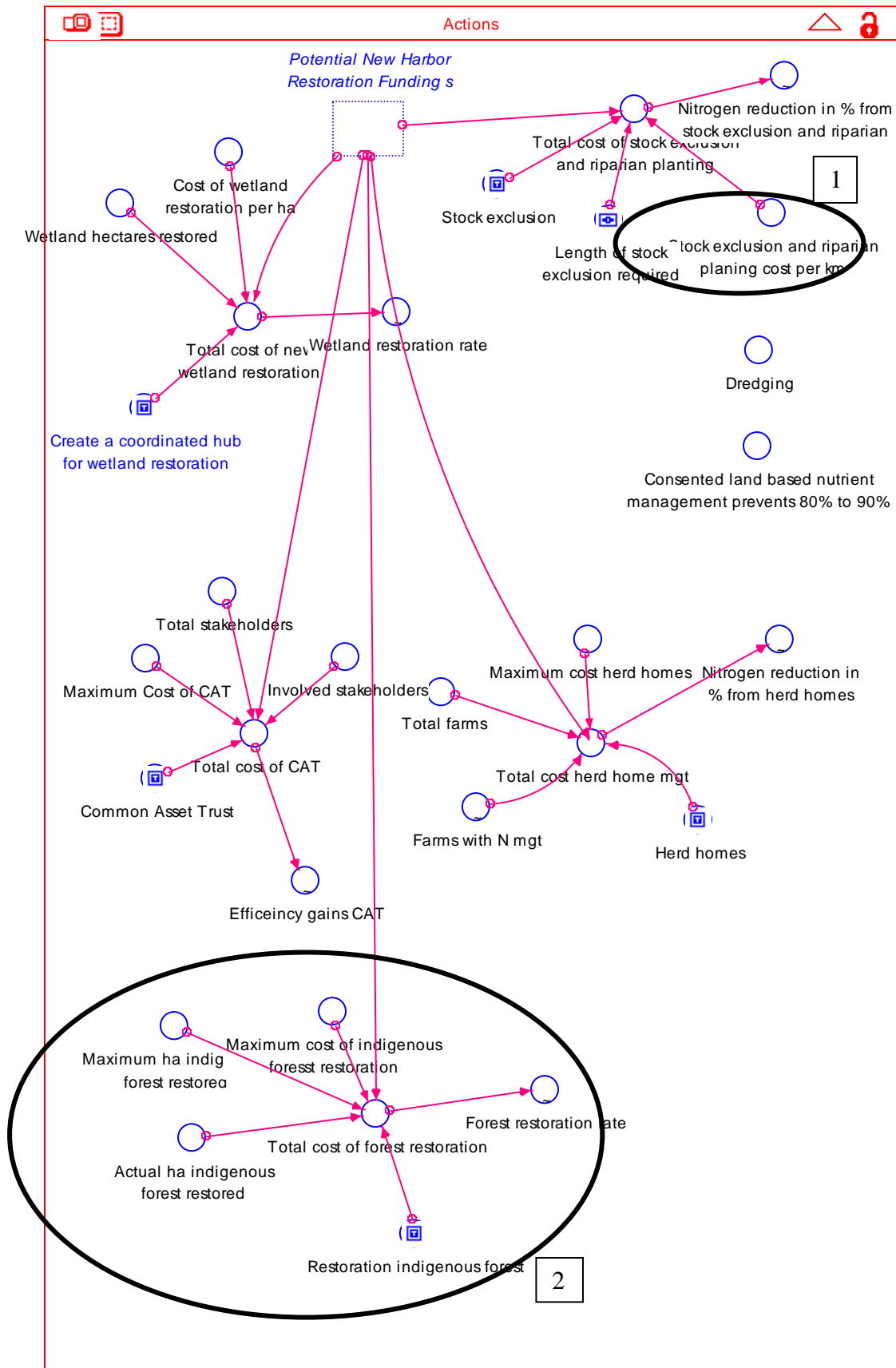
With regard to stock exclusion, BoPRC can provide figures for the lengths of streams, cf. lengths protected from grazing and the lengths included in formal programmes (this is currently being collated by their GIS analysts).

Included in the "Document" of the circled 1 icon in Figure 62 "stock exclusion and riparian planting costs" is:

"A rough guide to costs/metre of riparian planting (but this varies significantly depending on the circumstances) is $45/m – this buys an 8-wire fence on both sides of the waterway, 4 shrubs, and the planting and maintenance of those shrubs. Sometimes there is no planting, which reduces the cost to $25–30/m for a fence on both sides. Sometimes only one side needs a fence."

For restoration of indigenous forests, the equation XX as part of circle 2 in Figure 62 shows how the total costs are derived.

Equation 11:
Total_cost_of_forest_restoration = IF TIME > 2011 AND
Restoration_indigenous_forest>0 AND
Potential_New_Harbor_Restoration_Funding_s>0 THEN
(Actual_ha_indigenous_forest_restored/Maximum_ha_indigenous_forest_restored)*
Maximum_cost_of_indigenous_foresst_restoration ELSE 0

7.5.1. External Factors

The only functioning "external factor", i.e. those factors beyond the control of the stakeholders in the region, is climate change (Figure 63) in this model. Climate change is a Switch which can be turned on or off at the user-interface.

Figure 63 Climate Change
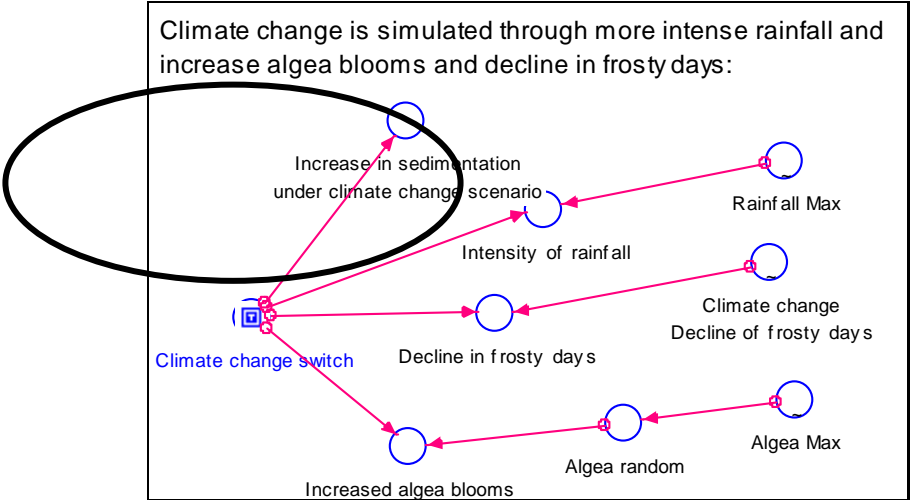
Climate change is a Switch on the User-Interface, as demonstrated in the scenario section 4.3.5. Climate change then impacts on Natural Capital, reflecting increased sediment runoff (Circled in Figure 63). Based on NIWA's results from spatial

modelling in the Tauranga region that 40% more sediment runoff is possible under a climate change scenario (NIWA, 2008) represented by Equation 12.

Equation 12:
Increase_in_sedimentation_under_climate_change_scenario = IF Climate_change_switch>0 AND TIME > 2011 THEN 1.4 else 1

Following the structure for "intensity of rainfall" (in mm) (Figure XX), equation 13 calculates how turning on the Climate Change Switch increases the maximum level of rainfall.

Equation 13:
Intensity_of_rainfall = IF Climate_change_switch >0 AND TIME >2000 THEN Rainfall_Max*1220 ELSE 1295*1220

Similar equations are assumed for decline in frosty days and algae blooms. These equations have not been affirmed through literature.

Figure 64 shows the model structure for "Microbiological & Viral quality of Shellfish. Shellfish are assumed to be impacted on by increased algae blooms and seawater temperature, both affected by Climate Change. Also water quality due to nitrogen and sediment loading was thought to affect shellfish, along with sewage overflow events, which happen at a high rainfall (averaged over a year). High rainfall is a random number generated in the model between a minimum and maximum rainfall. As discussed in equation 13, climate change is expected to increase high rainfall events. The quality of shellfish is related to seafood related sicknesses.

Figure 64 Microbiological & Viral quality of Shellfish
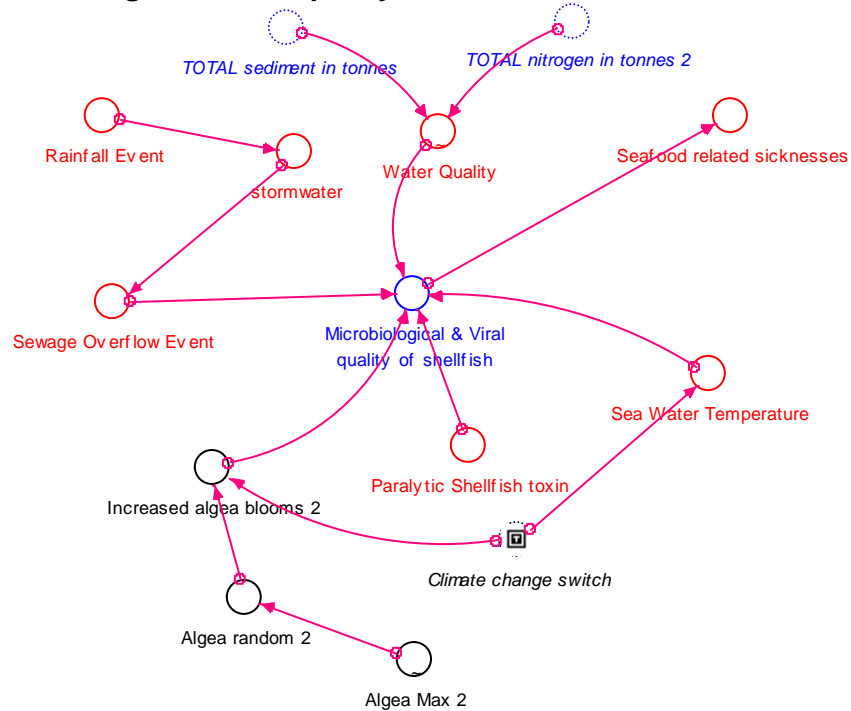
Other "external factors" that were mentioned during the modelling sessions but not actively pursued are shown in figure 65.

**Figure 65 External factors not pursued**
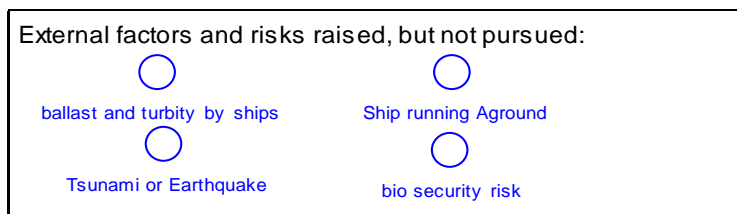
In retrospect, the risk of "Ship running aground" proved to be an acute external factor. A review of how the model structure can accommodate a dialogue among stakeholders to assess the impacts of an external (risk) factors such as "Rena running Aground" may be of interest in the future.

Freshwater from Catchments to Tauranga Harbour

This model sector attempts to make a start at assessing the quantity of available water from the various land uses in the catchment and linking it back to economic activities that may be limited by reduced water availability in the future (Figure 66).

Figure 66 Freshwater availability
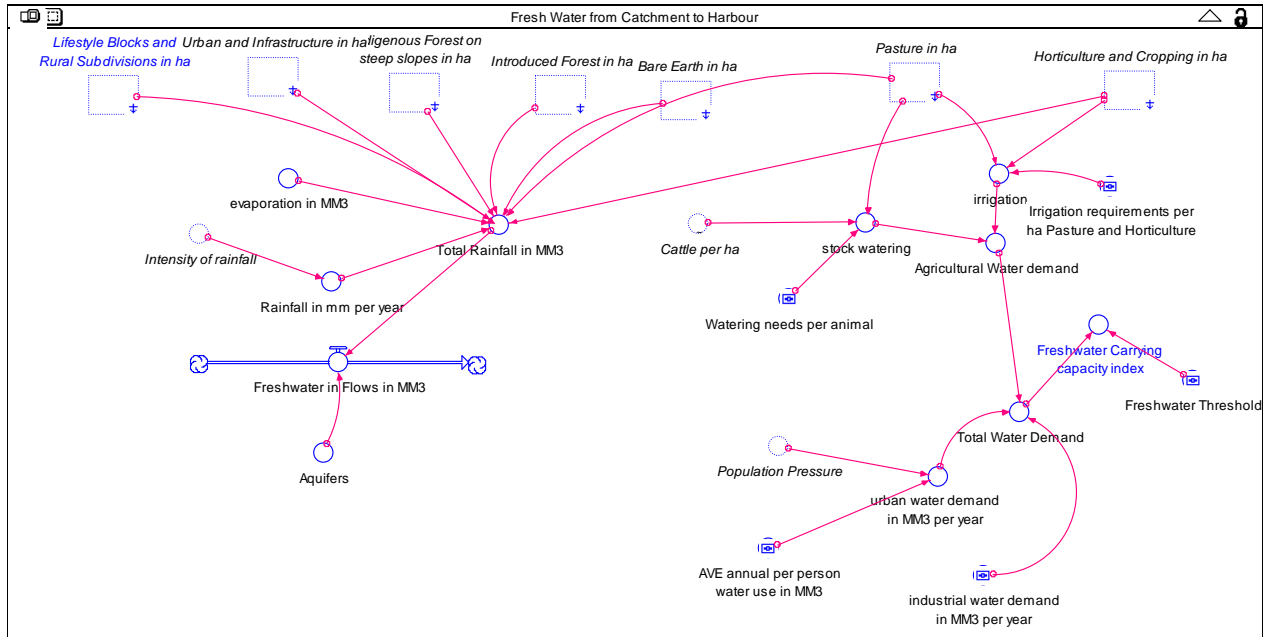
The modelling team tried to accommodate the participant's desire to include water quality impacts from waste water treatment. Background literature was gathered, but time proved too limited to adequately connecting the thinking about point source based waste water treatment into this spatially homogeneous model.

7.6. Appendix 6 – Small Group Reports

7.6.1. Workshop 1 – 17 November 2010

Subgroup 1 Summary: "Solutions, and how to implement them"

- Mechanism for change: voluntary and enforcement mechanisms are required; incentives vs regulations (carrot and stick) – need mixture of both; and need mechanisms for both short and long term solutions.

- Incentives need to be built into the system so that people are motivated to invest in activities that are good for the environment but also good for business.

- Farmers planting trees – this provides an ecosystem service for wider population, but the farmer doesn't get a monetary return for the environmental service that is provided (e.g., reduction in sediment, nutrient to Harbour).

- Kaimai-Mamaku Strategy: a "range of change" slogan (Eila Lawton said our group could use this slogan). A range of mechanisms will be required:
  - -Pest control,
  - -riparian planting/protection,
  - -best practice education,
  - -industry based research and development,
  - -ongoing forums at a regional level, e.g., an organisation such as this group to be a vehicle for change and to lobby for change effectively.

- Land and Water Forum as national umbrella – 53 recommendations on how to achieve change, that could be localised and considered for implementation in Tauranga Harbour.

- Tree planting, examples of this in Raglan Harbour also had social benefits whereby youth got involved in the tree plantings. Gives them a sense of pride and an important task, helps with identity and mana that has been lost from inability to get involved in other things that were once their important role in social structure.

- Carbon sequestration – Could "pool" carbon credits in a region to fund environmental activities (mixed views).

- Farmers needing to mitigate impacts they have on environment, but do not currently get compensation for going over and above.

POLICY:

*Funding streams for works that will improve the health of the Harbour:

- The 'Regional Infrastructure Fund' is administered by the Bay of Plenty Regional Council. It represents profits from the BOPRC share holdings in Ports of Tauranga. The current criterion for accessing this fund does not provide for 'ecosystem infrastructure' projects. The money is used on 'hard infrastructure' projects, e.g., roading.

- BOPRC argue that the Environmental Enhancement Fund is available for environmental projects but this pool of money is relatively small and divided amongst a number of smaller projects.

- A change to the Regional Infrastructure Fund criteria to add integrated catchment management and large-scale forest restoration and biodiversity management projects would address this disparity. 25% of the Regional Infrastructure Fund (2.5 – 5 million over a 5-year period) should be targeted at "ecosystem infrastructure" projects.

- Create a new Ecosystem Restoration fund (collective fund for enhancement).

- Incentives to promote positive environment activity: targeted rates; subsidies.

- Capital expenditure/investment – policy *and* education used to treat/stop negative impacts from occurring.

- Bylaws/legislation, district plans, consent requirements. Council plans are in place through these to manage impacts of development (e.g., stormwater treatment); enforcement capabilities of policy/regulations are unclear.

- Need a way to be able to be tough on people and businesses that don't perform.

- Tertiary treatment of sewage – $132 M.

- Urban plans – low-impact design.

- Wetlands are an example of low-impact designs as an important cog in the solutions process, which could be lost.

- Discussed the need for iwi commitment (resources) as part of the solution to the Harbour problem as their co-operation needed as well.

Subgroup 2 Summary: "Indicators, Roots causes of problems and how to measure them"

- Water quality – this is the ultimate test of health of the Harbour. Take glass of water from top, mid and low points in catchment and see how quality changes. Should be as healthy at bottom of catchment as at top – if not, where are the

pollutants coming from? If water quality is high, then life will be sustained in it, and excessive growth of weeds, etc., won't occur.

- Indicator at top of catchment: indigenous forest structure, stability and turbidity – presence of kereru populations and pests.

- Lower down the catchment: forestry, farming, orchards – presence (or absence) in contributing waters of: fertilizers, pesticides, solids in water, pH levels, heavy metals, sediments. To encourage communities to take pride in having clean unpolluted waterways, have things like "our water is cleaner than your water" campaigns. Measure numbers of whitebait. Degree of riparian vegetation.

- Coastal waters indicators: matuku; health and quantity of wetlands as filters; numbers of invasive species/bio-indicators; fecal input (sewage/stormwater/sediments), black swans are a good indicator.

- Ability to safely collect kaimoana (healthy kaimoana); shellfish, whitebait (although recognize these are localized indicators), eels.

- Eel grass – good indicator that is important for fish nurseries; also sensitive to sediment and pollution.

- Wading bird populations.

- Sea lettuce and mangroves as indicators and possibly not best indicators.

- Source to sea: drinking water to storm water to waste water, evaporation. Regeneration of ecosystems.

Subgroup 3 Summary: "Economic Activities"

- Escalation of Harbour degradation started in 1950s with Port, dredging dumped on land to what is now Sulphur Point.

- Era back in the 1950s-60s was different; e.g., it was 'socially acceptable' to dump discharge straight into the sea; sewage systems would leach into the sand and water. Since then, considerable money ($357,953,000 by Tauranga City Council) has gone into reticulation systems; discharge now goes 950 m into the sea of Omanu. No sewage is discharged into the Harbour. Future options, such as tertiary water treatment as used in places such as Brisbane, are now possible due to technological advances and social attitudinal shifts that were not possible 50 years ago. Solutions we come up with today are likewise limited, as can't account for new technologies that may become available in the future.

- Approx 60% of economics in Tauranga is related to the development of the Port, which thus facilitated continued expansion of both related industry, and port expansions. 2,000,000 cubic metres of additional dredging are planned. This will facilitate further economic growth.

- Spin-off economic activities from development of the Port included Fertilizer plant, opened in 1955, kiwifruit growers, forestry – and much greater importing and exporting. These industries and associated growth in infrastructure (such as roading, bridges) were foundations that that built the city, attracting more people to the region, and attracting more new industry and jobs.

- Growth in the retirement community followed growth in initial industries, and associated economic activity and urban development resulted.

- Tourism sector also related to Port activities.

- Education sector established and grew.

- A problematic issue from economic growth that has occurred is that an adequate proportion of the earnings from this economic activity are *not* returned to the local community.

- Lessons learned from last 40-50 years: sustainable growth of industry – levies in $ for effect on environment. Internalising externalities.

- While there has been loss, e.g., in environmental terms, from the growth in industry and economic activity, much has also been gained to benefit the community; everyone enjoys better roading systems, e.g., question now to be faced is, how to enjoy the benefits of the current economic activities but still enjoy the benefits experienced in the early pre-development period?

- With population increases, there will always be greater pressure on how much is available from the natural environment to 'go round'. Differing opinion about whether population increases have impacted on loss of some species such as kaimoana, and whether population increases and thus increased demand is a key factor for decreased stocks, or whether such declines are due to other factors such as degraded environment and lost habitat for such species.

Subgroup 4 Summary: "Cultural: areas, species, values, impact on people"

- Inability to collect seafood and shellfish impacts on: health; social structures within Māori society; identity of people; education; self-sufficiency in which to provide; status; past present and future benefits available.

- Relationships between land, freshwater, sun/atmosphere, coast.

- Ecosystem restoration is deeply related to restoration of social structures and identity/cultural/knowledge systems for Māori.

- Impacts are spiritual *and* physical. Interdependencies tangata whenua have on the environment, knowledge systems, economic base of tangata whenua to survive is depleted; used to trade between iwi/hāpu based on available resources from environment, but can no longer do this. Māori economic activity inhibited.

- Can't reflect esoteric nature of Māori concepts in the model (e.g., can't incorporate mauri of pipi), but can approximate things like sediment loading, or use mud snails as indicator. Can utilise science and traditional knowledge.

- Significance of water for Māori is critical, as both a purifier and healer. Water quality – consider both perspectives of Māori and non-Māori, as impact it has on food supplies, food webs; spiritual connections; tapu.

- Recreational use values of the moana seriously impacted in some areas due to degradation, e.g., will no longer swim in certain areas.

- Imbalances in decision making structures. Different cultures. Different cultures of people (Māori and non-Māori); + Culture of Councils (local, central regional); + Culture within policies, plans, statements (Councillors); + Culture of Industry (ITOs, organisations); + Cultural of environmental restoration = Produce either ill or good health/wealth/well-being?

- There are interdependencies, inter-relationships between mountains, rivers, sun, atmosphere, sea.

- Need proactive management in decision-making bodies, balanced decision making, and policy change to bring about better health and wellbeing for ecosystems and people.

- Need Māori and decision makers to better understand each other's ways of being and understanding, to lead to better policies and plans.

- What are the barriers impeding position action for restoring ecosystems?

- Look more fully into impacts of plans and policies, e.g., impacts of dredging – how do we know the proposed actions won't negatively impact on ecosystems? Need to take into consideration Māori knowledge and western science.

- Could look at possibility of developing a Cultural Health Index for tangata whenua in Tauranga. Possibility of underlying principles to underlie plans/policies. Descriptors in which to inform practice.

- Mauri life force. Spiritual, physical, relationships, intellectual relationships, knowledge base.

7.6.2. Workshop 2 – 15 December 2010

No small working groups, but tables for ES were produced in plenary sessions.

7.6.3. Workshop 3 –19 January 2011

Group 1 Summary – Economic Activities and Funds

Indicators:

*Per capita income (separate retirees from non-retirees).

*Productivity (+ using technology improvements and efficiency, eco-efficiency ($/environmental impact, litres of water used to produce one apple, etc.).

*GDP, balanced by other (social, cultural, ecological) factors in the model – GDP not to be used in isolation.

*Tourists to region (measured by night stays), should include cruise ships.

*% of $ return to farmers/business, capturing more $ income in product than is currently the case.

*Need indicators on: getting economics right in terms of the Harbour. A trading system on sediments + nitrogen, perhaps? (With capped limits). Needs to be economic benefit to farmers if this is to work and be supported in practice. Eco-tax, who might pay it?

*% of total Council spend on Harbour/coast;

*% of total Council spend on any activity that might impact on the Harbour/coast.

*Business start ups, employment numbers, house prices.

Targets:

*To be the best in NZ for all the above indicators (or at least in the top quartile) – not sure where Tauranga is at the moment in terms of these indicators?

Scenarios:

1. Impact of global recession.
2. Natural disasters, e.g., Kaimai tunnel collapse + earthquakes.
3. Double port size by 2025 – tonnage.
4. Replant catchments in natives.
5. Climate change – Mal's scenario.
6. 50% increase in horticultural land use by 2025, from pastoral land.
7. Agricultural sector in Carbon emissions trading scheme by 2015.
8. Development of Aquaculture industry ($400 M industry) by 2025.

Actions:
Include Primary Sector land-use type values (other than forestry), e.g., dairy, sheep & beef, cropping, horticulture - Information should be requested from various sector representatives such as Dairy NZ, Meat & Wool, HortNZ, etc.
Include Total Nutrient Loads per catchment – Information should be requested from Bay of Plenty Regional Council.

Group 2 Summary – Cultural and Social

Indicators:

This was difficult because there are many things that could be incorporated into the model to assess social and cultural targets and indicators, but there is very little (if any) actual data available as these things have not been measured. We are missing base line information on social/cultural health in relation to the Harbour.

Indicators that were identified include:

*Shellfish: abundance, take, health, cost of harvest (or cost of purchasing in supermarket if can no longer harvest through customary take).

*Tonnes of seafood required for tangata whenua needs (e.g. major events at each marae).

*Customary take figures (but not sure how accurate they are).

*Cultural Health Index that assesses health and wellbeing of the people, and sense of pride/mana in the Harbour (or lack thereof) – perception of the health of the Harbour could be used as an indicator (but how well do people understand what the state of the Harbour actually is?). There is a Toi Te Ora wellbeing indicator (scale of 1-10), but it doesn't tell you why people rate their wellbeing at less than 10 or what the targets are.

* The abundance and quality of seafood is a direct indicator of wellbeing for tangata whenua in Tauranga.

It was noted that indicators are required that address Māori and non-Māori needs.

*Social indicators: index that measures the sense of well-being people have – such studies haven't been conducted.

*EBOP has recently conducted a survey on recreational use of Harbour, and high value was placed on recreational use of the Harbour.

It is clear that we need much more monitoring of shellfish bed health/abundance. The Customary Fisheries Committee has data on what is harvested through permits issued by kaitiaki, but their mandate is not to monitor the health or state of the kaimoana. They have no resourcing to do this.

Group 2 Summary – Ecology

Indicators:

Took a 'mountain to sea' approach in selection of indicators; looked at science-based AND community-based perspectives on the health of the Harbour.

*Water quality measures – suspended solids; E. coli; nutrients; temperature; turbidity; etc.

*White bait

*Cockle health index

* Use of community-based observations through established toolkits, e.g. NIWA's Cultural Health Index for estuaries.

*Forest Health Index – links forest quality, diversity of bird and invertebrate species, carbon sequestration.

In summary: biotic indices for streams (whitebait); cockles for the sea; keruru for the forests.

Action:
*Andrew at BoP Polytechnic said they have done studies and collected data on the some of the above indicators and we are welcome to contact him between workshops for further information/data for the model.
*Look up the Miranda Shorebird Website.

Targets:

*By 2020, all class 6+7 land appropriately managed/used.

*All riparian margins planted and fenced – class 1 streams.

*Wetland restoration to point that they can function adequately.

*Cockles – no further degradation between now and 2020.

Scenarios:

1. Business As Usual
2. Conversion of all/some pastoral land.
3. Clear all forest

Action: Braden (BoPRC) to provide data on what is required to carry out/undertake full riparian planting on all Class 1 streams, or to reach currently targeted levels.

Group 1 – What are potential new funding sources for ecosystem restoration?

a)   Regional Infrastructure Fund (in 10-year Council Plan). This fund is not currently used for ecosystem restoration (there is a misconception that this should only be used for "infrastructure", but this is incorrect as the 10-Year Plan includes that Tauranga Harbour initiatives with a min $2 million threshold in the list of possible uses for the fund), therefore it was considered new money. Use this fund and create a Trust made up on stakeholders from Tauranga to administer the funds for restoration and maintenance of the Harbour and catchment ecosystems. Other bodies could also contribute to this fund: visitors (ships, cargo and cruise ships thru port fees); port (people bringing produce through it, e.g., forestry, horticulture, etc.); other visitors (e.g., airport tax or levy specifically for Harbour restoration, as for Rotorua); boat ramp fee, which includes people outside the area. It is important that any "fees or rates" are used specifically for coastal restoration of natural capital and its ecosystem services and not just put into a general "pot" that is then used for other regional purposes. It would also be important to acknowledge these monetary contributions so they could be offset for their activities, e.g., carbon off-setting, riparian and other replanting. The Trust would have Community Governance, which is cost efficient, and operates with the kaupapa of Harbour Restoration. It could seek National Government matching of funds for leverage.

b)   Carbon sequestration opportunities: Under the Emission Trading Scheme (ETS) you can group credits. The Tauranga area could explore voluntary credits system for tree planning, e.g., riparian planting across a large area and add them all up in order to offset its own emissions against carbon offsets. Understanding carbon and ETS for the region may become a source of income in the future.

c)   Iwi settlement money: With co-management/governance of the Harbour, the iwi could contribute funds towards the fund above. Such funding could also be used for development of tangata whenua initiatives and economic activities that are conducted in an environmentally and socially/culturally responsible manner. This development of Māori business models will build leadership type role for co-management, and could be held up overtime as a model for other regions.

d)   Differential rating system – targeted rates: heavy users contribute more. The solutions/costs would need to be "sold" to the community who may be willing to pay for the benefit to the Harbour in a way that would help them to see that by investing $200 million through levies in coastal ecosystems, they will gain the equivalent of $400 million back through preserved ecosystem services, e.g., sediment reduction could lead to reduced cost for dredging. Would need to ascertain the willingness to pay of the community for a targeted rate.

e)   National Government contributions, as in the Waikato River restoration fund.

Group 2 – What are the opportunities for re-directing current funding through policy instruments, e.g., through the *10-year planning cycle*?

a)   BoPRC has funds for "Riparian Protection" (25% cost by BoPRC, 25% cost by Western Bay Council) and "Biodiversity Plans" (targeted at high value sites in region, up to 75% of cost). However, point made that some land owners cannot afford to pay the other 50/25% and to make this work better, a rates rebate system would need to be applied also, especially in areas where the environmental gain is high. Multiple-owned Māori land owners, e.g., don't necessarily have the funds to pay for the other 50% required, so could funding be targeted to these land owners if/when best benefit to public good can be gained?

b)   WB Council also has an Environment Fund that comes from rates, plus a levy on new subdivisions. This fund is available for Ecological Protection.

c)   Could look at an incentives scheme, e.g., planting on steep slopes to prevent erosion, pay a greater proportion of cost to the landowner, depending on how much it is likely to contribute to sedimentation. Don't only consider benefit in immediate area, but what is it worth to downstream communities to help pay for fencing?

d)   Efficiencies could be made by redirecting or integrating projects together; Councils working together on environmental issues would result in a saving overall and get more benefits, e.g., comprehensive stormwater/waste management; wetlands restoration; freshwater. This would save money and allow more to be done overall.

d)   Western Bay and BoPRC Councillors are currently keen to promote the Harbour, so if good proposals are put to them, they are likely to be supportive. Lobby effectively for additional money.

e)   Change grants to reflect need; i.e. what land use change is likely to affect the greatest positive impact – then prioritise the rates rebates or grant schemes to those things. If there are two aims to an initiative (riparian AND ecological protection), then the landowner should be able to receive both grants. Can achieve soil and water protection AND biodiversity protection from riparian planting.

g)   A greater impact can be achieved by restoring larger sections, not just riparian margins.

h)   Incentives schemes need to include "maintenance" activities as well, not just restoration.

i)   Implement "mandatory" riparian fencing/planting schemes down the track, only when majority are already doing it. Need to take into consideration the public good of such schemes. Farmers have issues with the regulatory approach because if you want to do something that is in the "public good", then the public should help pay for it. At the same time, it must be acknowledged that there is also benefit to farmers from undertaking such initiatives. Thus, it is important that landowners who put

money into restoration initiatives are compensated/assisted to do so, OR that "everyone else" who benefits from the initiative also has to pay for it.

j)   We need to know the $ value of improved ecosystem services that can be gained through such initiatives, e.g., what is the $ value of increased pollinators from protecting biodiversity. Getting an idea of the "worth" of ecosystem services is critical, e.g., what is the benefit/cost of things like ecological corridors through to Bay of Plenty? In the Waikato they have done Willingness to Pay studies on the value of having tui go through their gardens to pollinate plants, etc. There is increasing information about such values in overseas studies, but very little specific to NZ; there is also controversy over the valuation methods used to determine ecosystem service values.

k)   Ecological Connectivity is critical. With a functioning, intact ecosystem the area can gain a lot of services. Do people understand this connectivity? What are the key components of the ecological system without which the overall system fails to function?

Group 3 – How can the coastal (ecosystem and cultural) values be made more visible? *What resources are required?*

The group took a 'mountains to sea' approach, and didn't just focus on the coastal values:

a)   'Ecosystem services' is a big, complex, and hugely important subject that is new to most New Zealanders. Thus, to effectively educate the community will require a multi-faced approach to target their brain (through education), heart (relational approach) and pocket (possibly through a general or targeted tax on resource users).

b)   Education: raising awareness so that the wider community comes to care about ecosystem services and better appreciates the benefits from the environment; and how ecosystem services are contributing and interlinked. Also raise awareness of what the LACK of ecosystem services would mean for society.

c)   Use humour to achieve this, e.g., Tui billboards ("The best things in life are free! Yeah right!").

d)   Utilise personalities in the region who have a passion for the topic.

e)   Use case studies to show best practice (e.g., farmers who implement things that provide wider benefit to the public) as well as examples of "worst case" so people can see what the eventual end point is if you continue to let ecosystems degrade.

f)   Science forums: independent and objective, Harbour week, science cafes, enviro-schools educational curriculum.

g)   Mountains-to-sea field trips.

h)   Marae visits to hear from Māori about cultural values, historic use and management of natural coastal resources and connections to the land, and ecosystem services benefits of the catchment.

i)   Regular, long-term features in newspapers to educate the public about the various ecosystems services provided by the coastal environment in the Tauranga region.

j)   Use Environment Enhancement Fund and Community Funds to showcase Ecosystem Service benefits and protections.

k)   Web adverts about ecosystem services.

l)   Ecological Footprints undertaken in communities so that people better understand their individual impact on the natural environment and on the ecosystem services which are shared by the whole community.

m)   TV and radio programmes focused on ecosystem services in the Tauranga region. Power in media campaigns: e.g. Keep NZ Clean.

n)   Use targeted communication plan to reach different groups. Employ advertising professionals to design effective media campaigns (multi-cultural), so it impacts on people's hearts *and* minds. BoPRC Communications Team is working on this type of community catchment management initiative, which evidences political will for this type of thing.

o)   Some ES benefits are not "visible", e.g., nutrient cycling, so need to raise awareness of these through documentaries which are descriptive and visual.

p)   Local focus is important. Focus at sub-catchments; call community public meetings and talk to public about state of the environment.

q)   Provide info to public and interest groups on funding sources to address Ecosystem Services.

r)   Determine the resources required to achieve this: $, coordinating body, staffing, political will, time, and commitment. It could take decades for the concept of 'Ecosystem Services' and their value to sink in.

s)   If increase a tax, people need to clearly see how this levy will directly benefit the ecosystem. etc., e.g., if there is a levy put on fishing, then it will need to be shown how that levy will be spent to help fish/fishery. Change people's perceptions about what they "owe" and can "take from" ecosystems.

t)   Suggestion to add "stomach" to the initial focus points (brain, heart, pocket) – use image of catching the first fish with your father – very powerful image and connection to the coastal environment.

u)   Cultural Values – tangata whenua values are important, but also recognise the cultural values of pākeha and other groups who have lived in NZ for generations, who have their own oral history of resource use and care for the environment.

v)   People within organisations who are passionate about something, e.g., the state of the Harbour, can come together to make a difference. There is great potential power within the collective of this workshop group that should not be underestimated.

Group 4 – Is there an optimum level or threshold for (economic) activity in the Harbour, *e.g., what activities are nearing threshold? How can this be evaluated?*

a)   YES! There are clearly optimum levels for any activity that impacts on the Harbour. Determining what they are is the tricky thing, because different people will put their "acceptable level" at a different threshold, and will have different indicators. Activities happen in an incremental matter of which the cumulative effects over time are difficult to assess. However, if there is widespread acceptance that people don't want things worsening in the Harbour, then effectively the threshold is already reached.

b)   The economic focus of the question itself was questioned, and it was argued that continued economic growth might be the wrong way of approaching the situation. Marjan explained the global initiative of "Zero Growth", where you don't have to increase throughput or scale of activity. Keeping the system in balance is the key. Question becomes what is the optimum scale of material throughput? What type of activities do we want to encourage in the catchment, to ensure the system stays in balance? If you get the first three questions right (that the earlier small groups addressed), then Q4 becomes irrelevant. The impact level of the (economic) activity is the key issue. Can we decrease the impact that economic activities have?

c)   There was discussion about the Smart Growth strategy, and associated population growth projections and infrastructure spends associated with such projections. Hard to get populations growth projections correct. Port of Tauranga's growth estimates are substantial – Port growth will depend on growth of other activities that use the Port. There is the issue of estimate growth projections becoming truth, because action is then acted upon those projections.

d)   What if we overshoot desired levels, and just keep doing the same levels of activity regardless? The current neo-classical economic model is one approach. An alternative economic model is based on Māori kaupapa, interactions with the land and sea with benefits for the environment specifically factored in, e.g., importance of natural foods, veggie gardens, sustainable back yards, recycling waste; living in a way that doesn't compromise your own existence.

7.6.5. Workshop 5–4 May 2011

No small groups during the final workshop.

7.7. Appendix 7 – Calibration between historic trends and model behaviour from 1950 to 2010

Population

If the population grows under the same growth rate observed from 1950 to 2010, then the current population of 145,000 would grow to 1,200,000 in 2070. We assume a balancing feedback loop from GDP per capita and increased inequality to reduce such an extreme growth scenario. In addition, we assume that, when ecosystem services decline, the area is less attractive and population growth slows. Population and tourism are significant drivers of the Tauranga Harbour ecological economics system changes. Population is endogenous (i.e., it is determined within the model) to the model.

Figure 67 Calibration of population
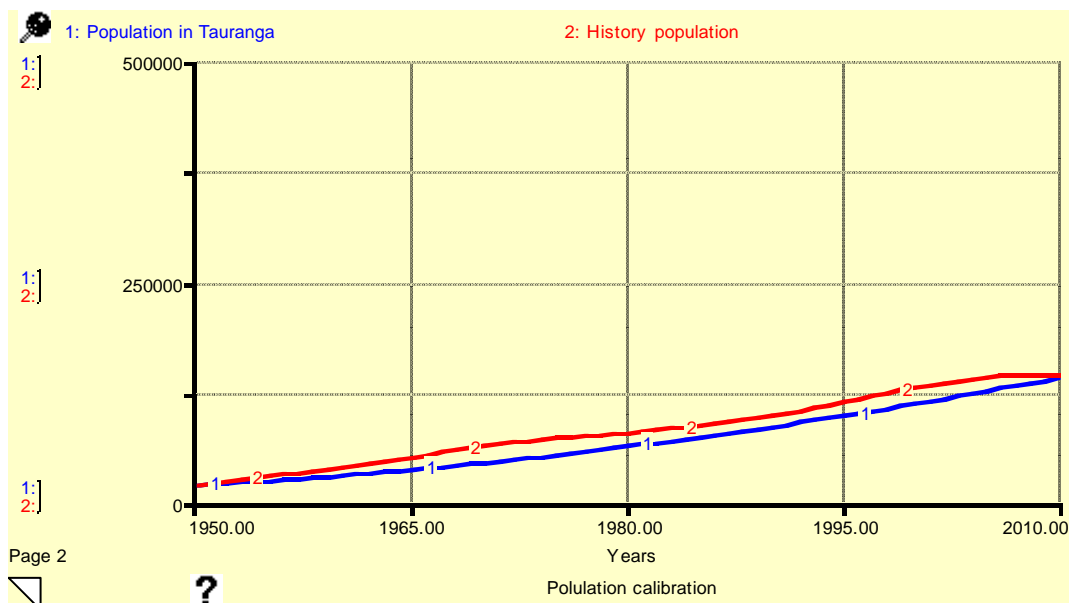
Tourism

The number of yearly international tourists visiting the Tauranga area is steadily growing, and currently about 440,000 per year (NZ Stats).

Figure 68 Calibration international tourists
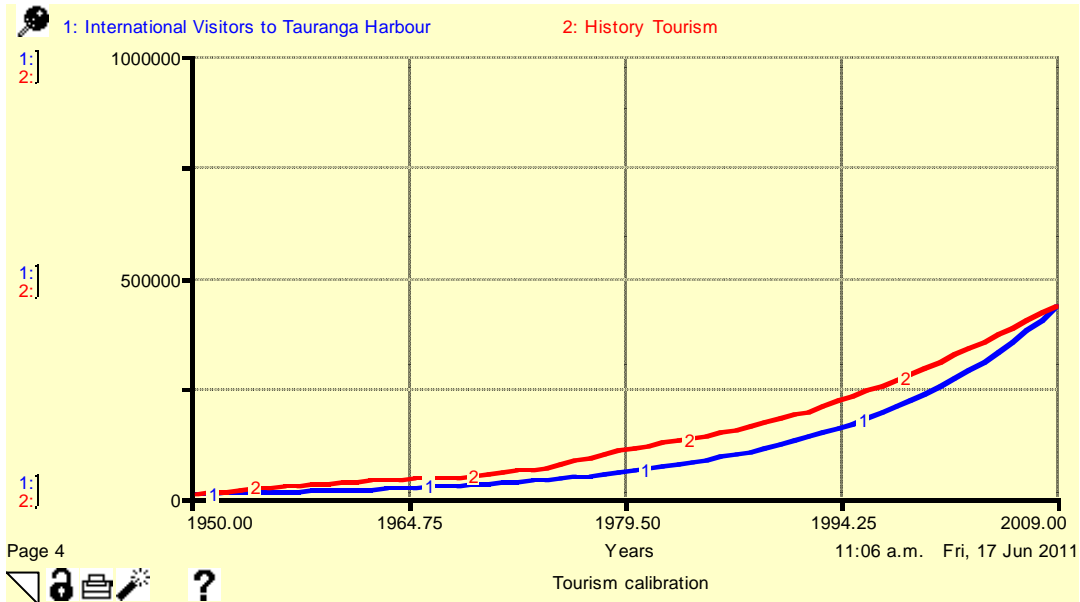
Natural capital

The data for land-use changes are gathered from a patchwork of databases. Some historic trends are available; however, when those trends are added, the sum would infer that area in the catchment was "created". This is a fairly typical result when land-use changes over time are studied. The model "conserves" the catchment area at 255,000 ha, which is consistent with "observed behaviour" that catchments do not change that much over a 60-year period, hinting at data gaps and inconsistency.

Figure 69 Calibration of total area

128
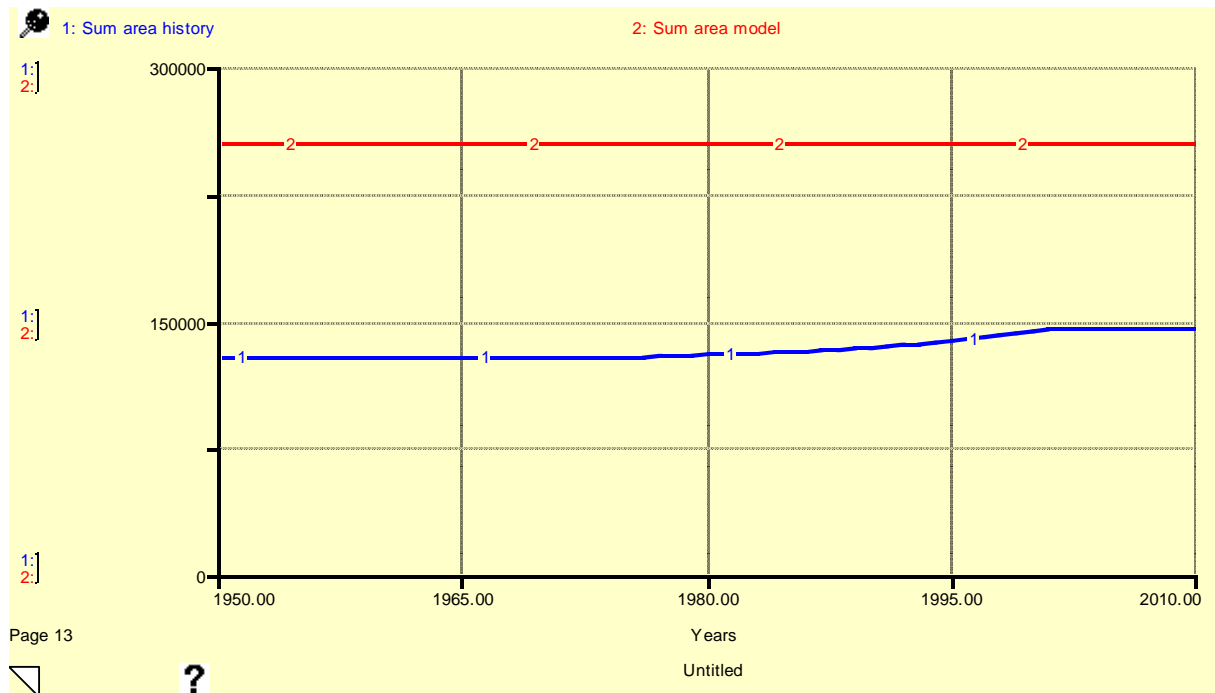
Indigenous Forest

According to the data, not much indigenous forest has been lost since the 1950s and the model is well calibrated to the data (Figure 70). Most indigenous forests were already cleared and converted before the 1950s.

Figure 70 Calibration indigenous forest
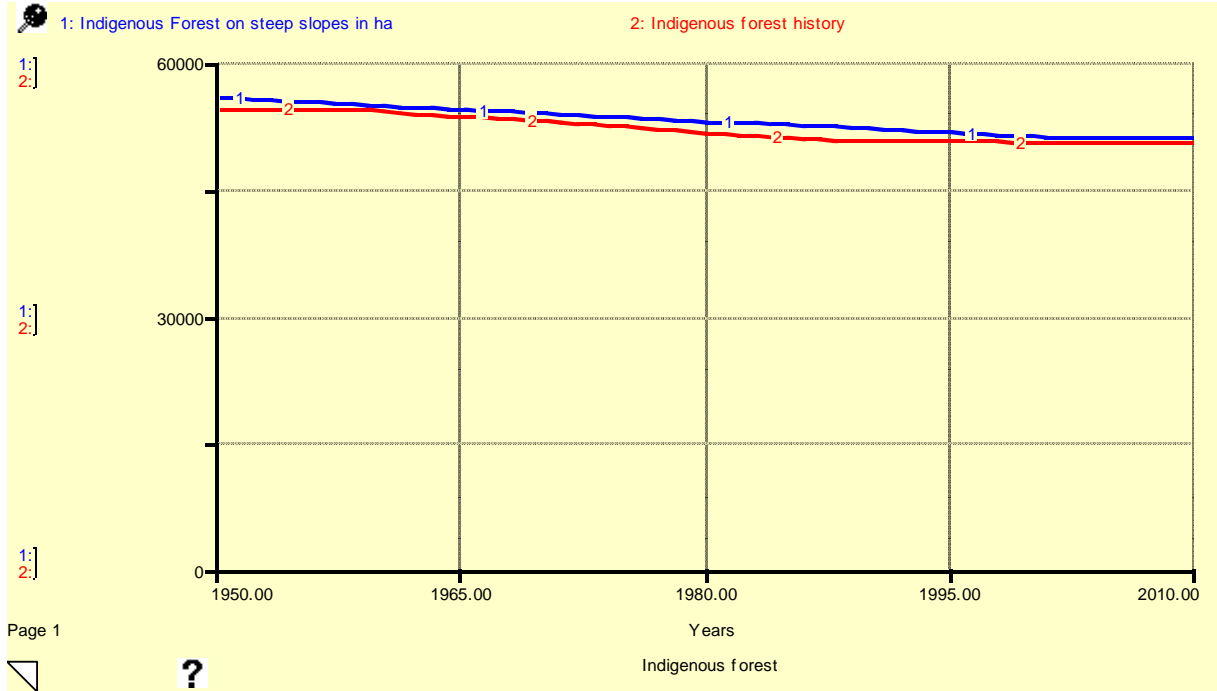
Introduced Forest

Introduced forest is calibrated with a data set on exotic forest (Figure 71). Introduced forest was believed to be converted mainly from indigenous forest (Kit Richards, PF Olsen, pers. comm.). In addition, in the model we converted a substantial amount of scrubs but still cannot build up our stock of introduced forest to reach the amount of introduced forest. The reason is likely that knowing the number of converted area into production forest (which adds direct economic value) has been more important than knowing what was "lost" (indirect values) in the process. Data were available until 2001; we could find no data on the most recent decade in the time allotted.

Figure 71 Calibration introduced forest
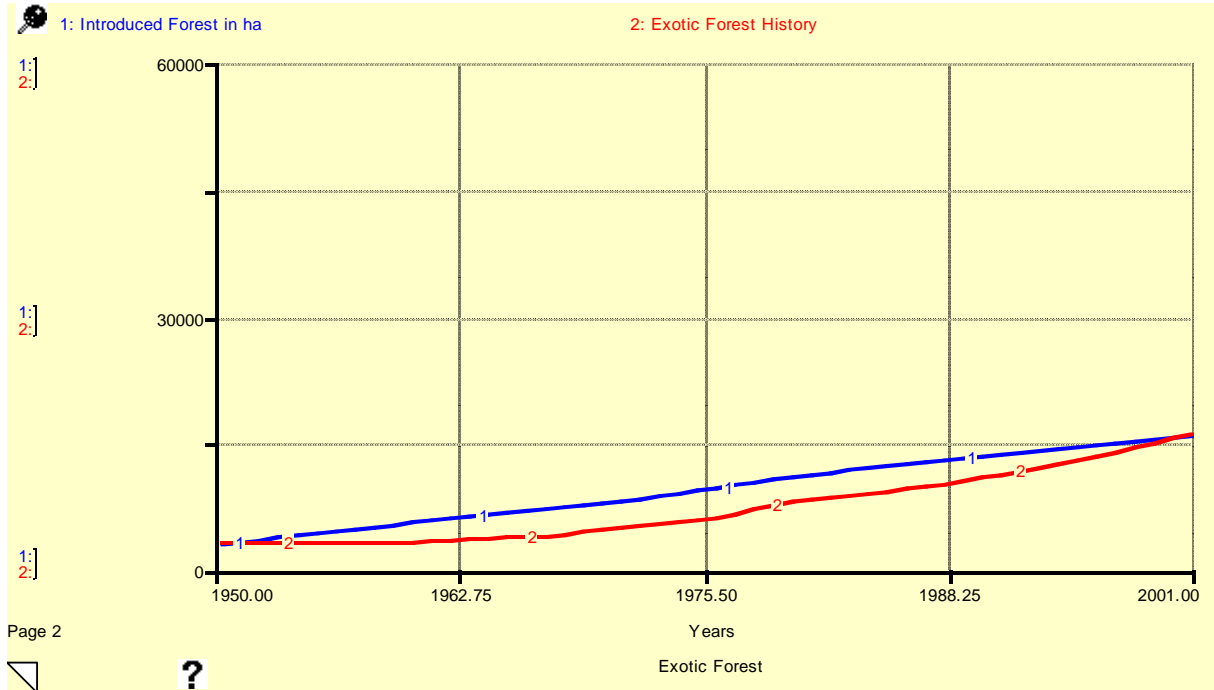
Scrub

The data on scrub and grassland were assumed to be "natural capital" and in the model these stocks were converted into introduced forest and pasture in the model. For the "lack of consistent data" reasons mentioned before, we opted to use Scrub and type of natural capital that was converted into production areas (forest and pasture) in the model to make up for "missing area".

Figure 72 Calibration Scrub
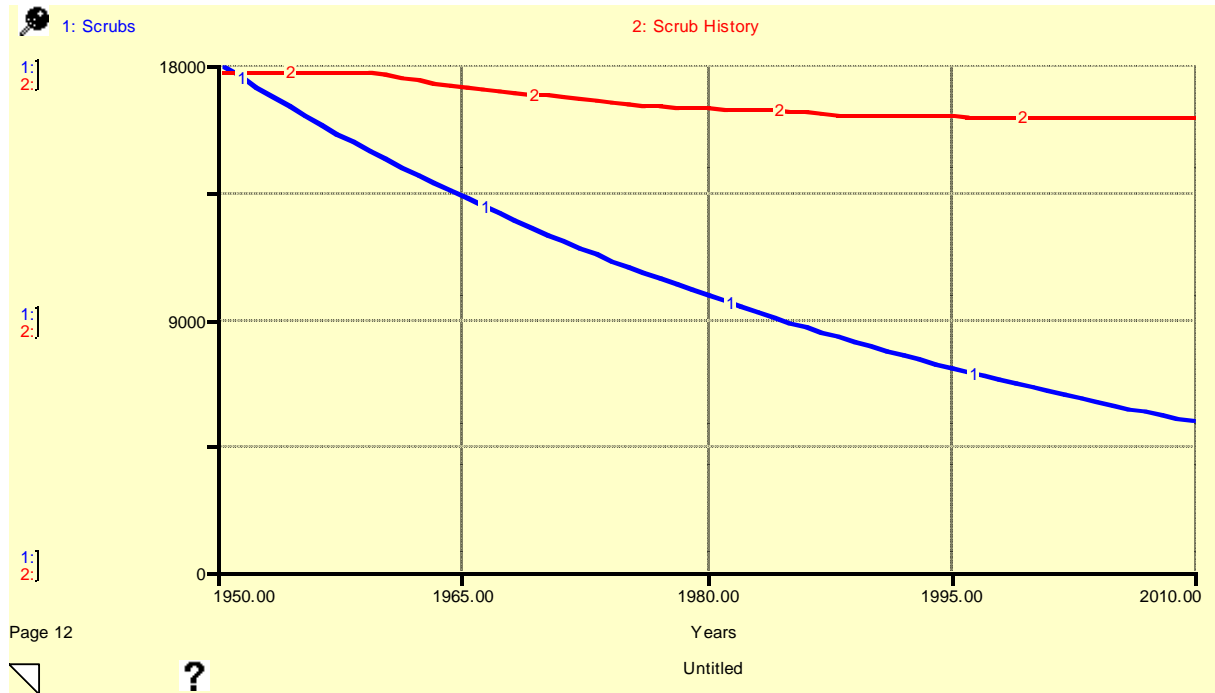
Pasture

Pasture is assumed to be converted from grassland, scrubs, wetlands, and indigenous forests. To date, we did not find good data on the trends of Pasture over time. The conversion into Pasture is perceived to have halted (Barry, Federated Farmers, pers. comm.)

Figure 73 Calibration grassland and resultant pasture
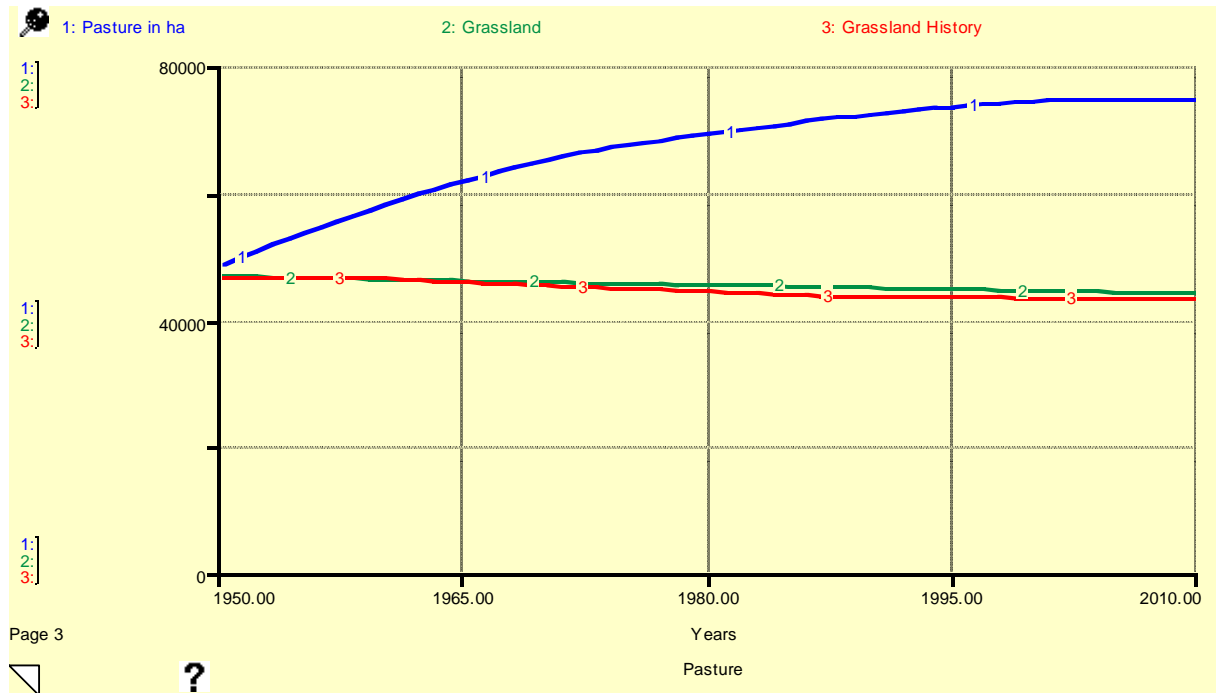
Horticulture and cropping

The data on horticulture and cropping has shown a significant and almost exponential increase over the past two decades. We opted to calibrate the model with a more average growth rate, otherwise, the future expansion of horticulture and cropping would (according to the model extrapolation) dominate the area. See also scenarios.

Figure 74 Calibration horticulture and cropping
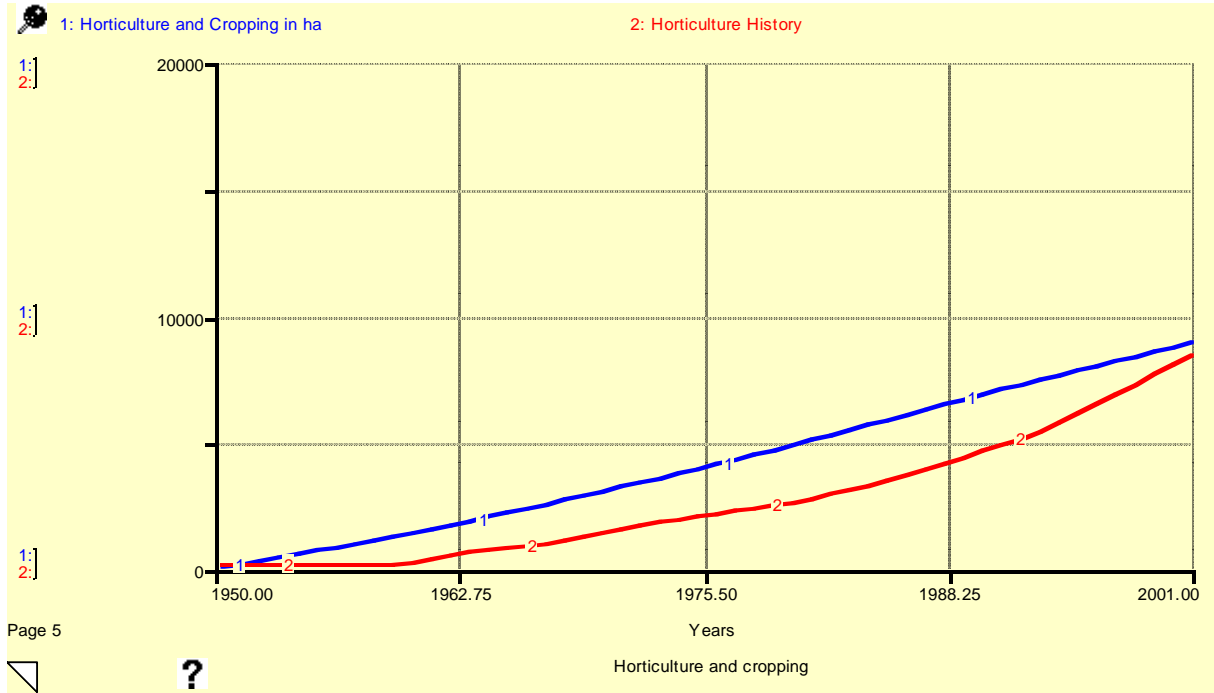
Urban area

Similarly, the urban area simulation follows the historic data on an average basis, where the most recent urban growth is much steeper than past growth.

Figure 75 Calibration urban area
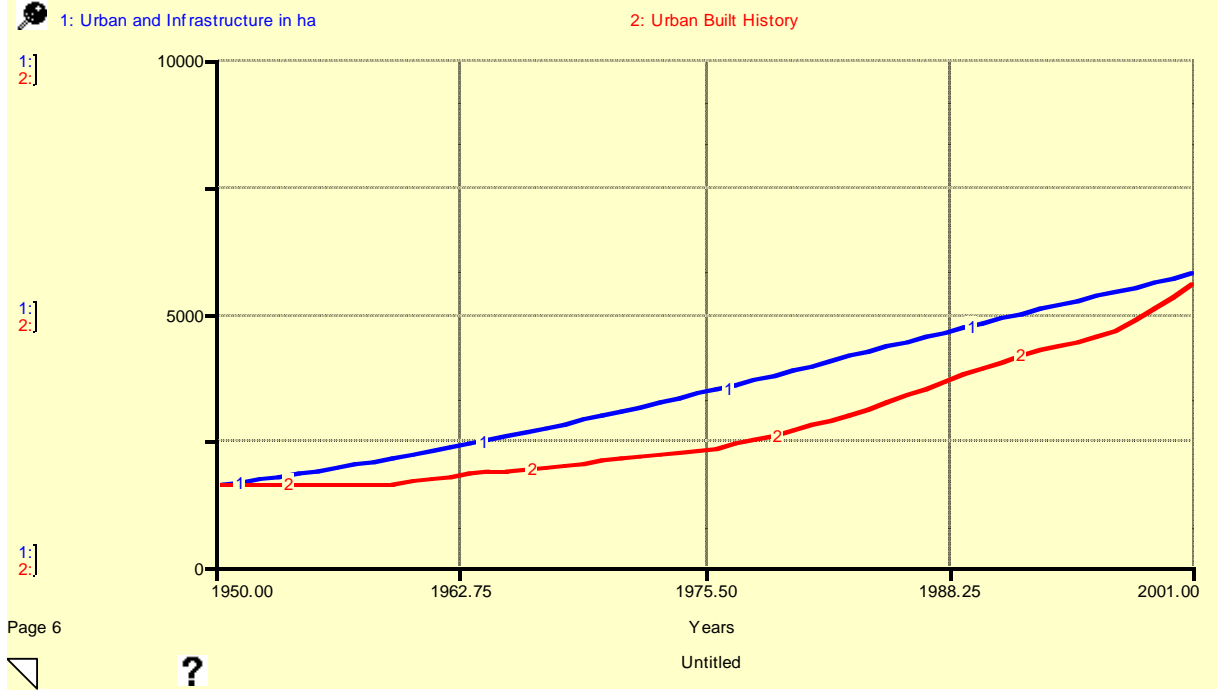
Bare Earth

The simulation follows the data set for bare earth. This is a small area, has been left it in the model because bare earth has a high yield per hectare of sedimentation.

Figure 76 Calibration bare earth

Bare earth at scale 100x smaller than other land use/covers
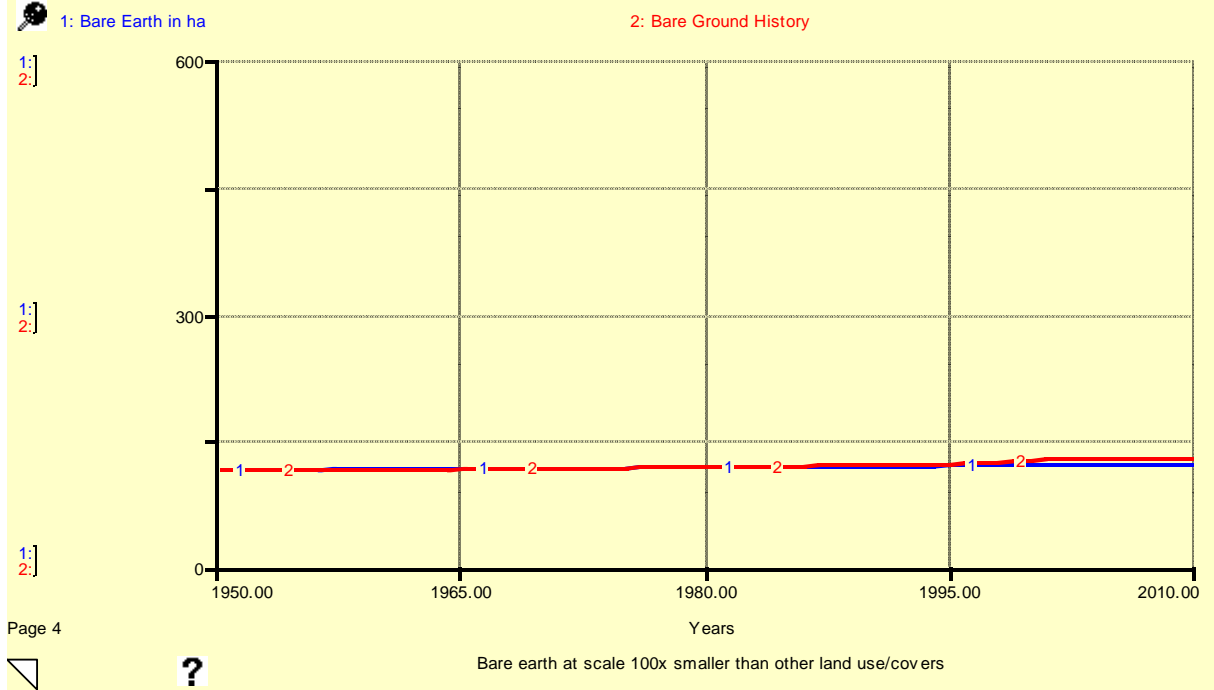
Seagrasses

The seagrass simulation calibrates well with the dataset, which started in 1959. Recent data (ending in 1996) seem to indicate a slowing down in the decline of seagrass area. To compensate for the lack of data, we opted to follow oral history, which indicates an ongoing decline of seagrasses. The straight line between 1950 and 1959 means that there is no data available for that period.

Figure 77 Calibration seagrass
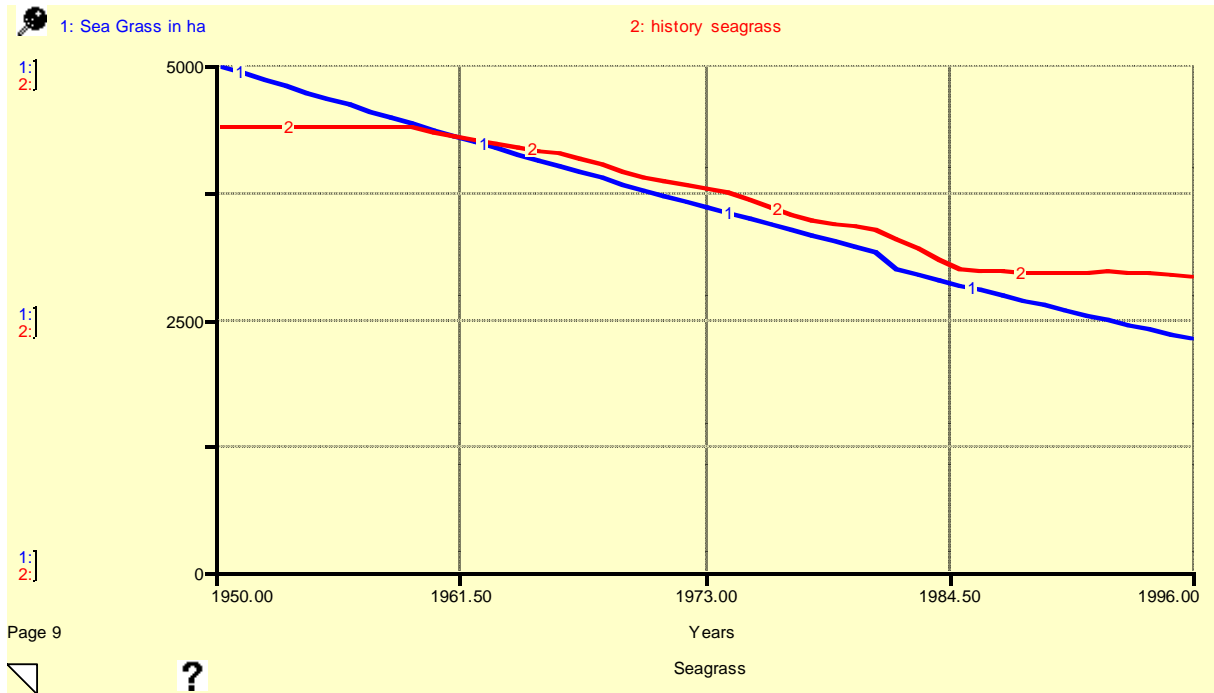
Mangroves

The mangrove simulation follows the data used and data are available up to 2010.

Figure 78 Calibration mangroves
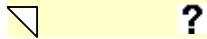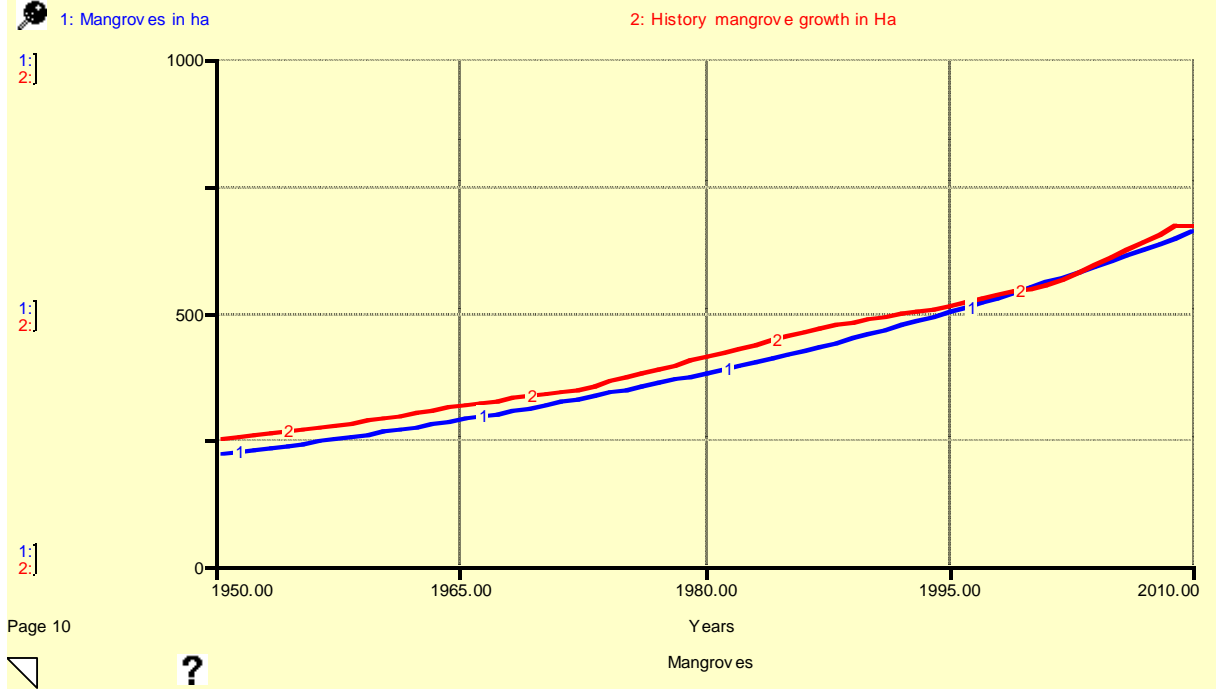
Port Activity

The model follow the historic port activity measured in tonnage shipped very well. The model assumes a decreasing growth rate, currently at 2.5% per year.

Figure 79 Calibration port activity
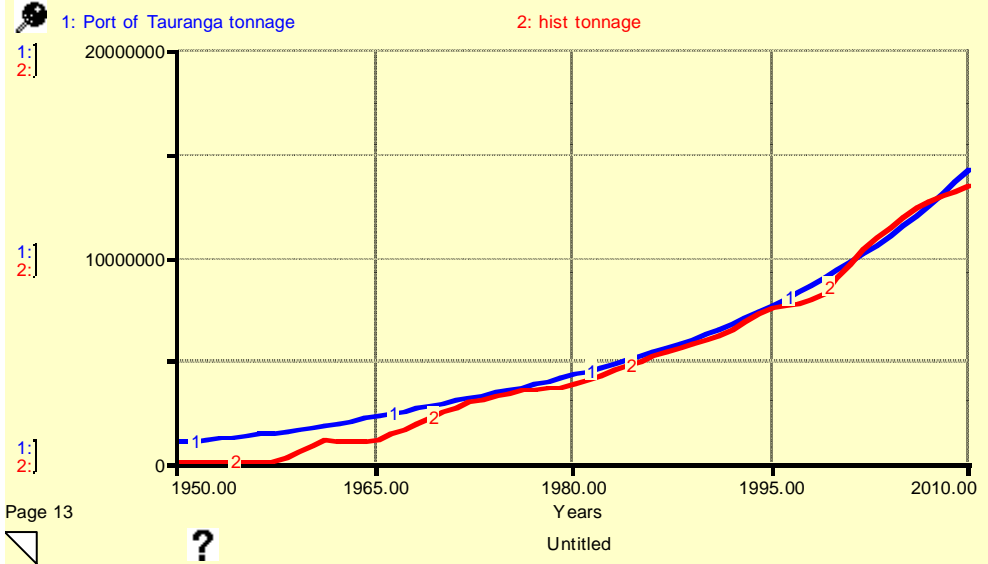
Some "calibration" is simply between data trends provided and narratives found elsewhere, e.g., the data trend for wetlands shows an increase in wetlands, where the narrative states a significant historic decrease. When in doubt, the model follows the narrative of the participants. As we know of no western science data trends for shellfish beds, we have used the perceptions of iwi representatives, which indicate a decline.

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