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'Sustainable Seas' National Science Challenge

Conceptual system maps of 'Blue Economy' activities

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1 Introduction

This report is part of a visualisation and modelling work stream associated with the 'Creating value from a Blue Economy' project funded by the New Zealand Sustainable Seas National Science Challenge (The Challenge). The Challenge objective is to 'enhance the utilisation of marine resources' within environmental constraints and limits. To help it achieve its objective and realise its vision of 'healthy marine ecosystems that provide value for every New Zealander', it has adopted the discourse of a blue economy. Sustainable Seas defines a blue economy as one that will '*generate economic value and contribute positively to social, cultural and ecological well-being*'.

The report is designed to contribute insights into systems-level marine-economy relations that will help grow a blue economy in these terms. Realising this objective requires stimulating new activities and 'transitioning' existing activities into this vision. This report identifies and visualises points and sites of intervention in key economic relations where positive change might be imagined and brought about.

Three types of conceptual economic systems are considered in this report – two types of fisheries (wild and farmed) and eco-tourism. The considerations within are not representations of any particular industry, company or community. Rather, they are intended to provide an overview of the inter-connections, influences and tensions that operate broadly within these systems.

2 Contributing data and methodology

This report uses system maps as a tool for synthesising and communicating these research findings. System maps (also known as a visual output of 'systems thinking') are a tool from the discipline of System Dynamics and have a strong history of being used to help broaden the understanding of a particular system, within a community of interest. For a brief explanation of the approach used to develop these system maps see sections 3 and 4.

While the technical term for one of these system maps is a causal-loop diagram (CLD), the term 'system map' is used here for ease of reference.

The primary source of information for the system maps has been research conducted as part of the Creating Value in a Blue Economy project. This project has involved participation in 20 workshops in which scientists and social scientists, industry, government and community stakeholders, iwi and Māori business representatives have discussed blue economy development in association with Ecosystem Based Management (EBM) over the course of five years. It has also involved a total of more than 45 semi-structured interviews with key industry and government informants and business leaders. The research also draws on a wide range of biophysical and social science research conducted under the auspices of the Challenge.

Associate Professor Nick Lewis discussed the context and findings of that research with Justin Connolly from Deliberate. The system maps in this report were then iteratively developed by these two to reflect the connections and constraints within the wider system of the examples of Blue Economy included here. The report was reviewed by two senior members of the Sustainable Seas research community, one an ecologist and the other a social scientist.

3 What is systems thinking?

The world that we live in is a highly interconnected place of causality and effect. The work of policy development often seeks to respond to undesirable behaviour or patterns being experienced in our natural environment and therefore seeks to influence these causes, to alter or improve the desired behaviour.

'Systems Thinking' is a name often applied to a range of approaches to thinking about issues holistically. One of these approaches is academic discipline of 'System Dynamics'. System Dynamics originated from the Sloan School of Management at the Massachusetts Institute of Technology, Cambridge, Massachusetts in the late 1960's.

Systems thinking, as articulated by the discipline of System Dynamics, is a conceptual framework and set of tools that have been developed to help make these patterns of interconnectedness clearer (Senge, 1990)[1]. They help us understand the structure of a set of various interacting factors that create a behaviour that we are trying to understand. Once these interconnections are articulated, we can better understand which parts of a system are having the most influence on the behaviour, allowing us to identify areas of leverage in order to influence this.

Where the term systems thinking has been used in this report, it refers to the qualitative concepts articulated by the discipline of System Dynamics (Sterman, 2000). The main qualitative tool that this discipline uses to understanding systems is called a causal loop diagram, or a 'system map' (as noted above).

4 The fundamentals of system maps – articulating system structure

At the core of system mapping is the desire to visually articulate the relationships between variables that best explain the behaviour of the system that you are trying to understand. This visual articulation of relationship is known as 'system structure'.

This section outlines important fundamental elements of system structure. These are: feedback loops; how they are correctly annotated; the use of the 'goal/gap' structure (as this can explain how different loops dominant in a system at different times); and stock & flow notation.

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[1] For a detailed introduction to the concepts of Systems Thinking, the reader is referred to *The Fifth Discipline – the art and practice of the learning organisation* by Peter Senge (1990) as an accessible introduction.

Section 4.6 also outlines how the system mapping tool sits at the lower end of a spectrum of complexity, within the tools of System Dynamics. This demonstrates how system maps can be used to inform or work alongside other types of research and methods.

4.1 Feedback loops – the basic building blocks of a system map.

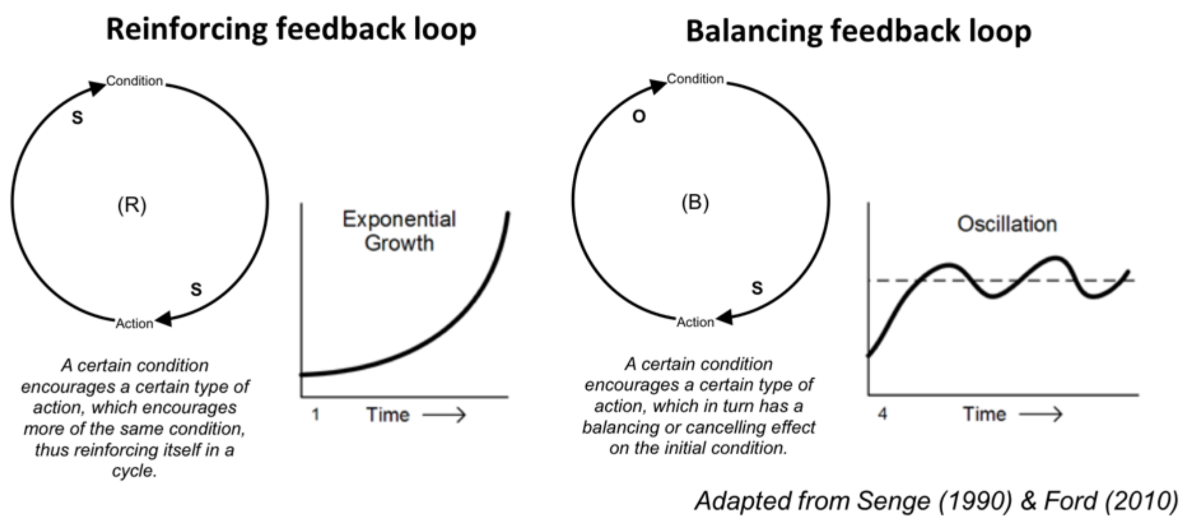
Systems thinking is especially interested in systems where loops of causality are identified – these are called *feedback loops*. There are two types of feedback loops, *reinforcing* and *balancing* (Senge, 1990).

In a *reinforcing feedback loop*, the direction of influence provided by one factor to another will transfer around the loop and influence back on the originating factor in the *same* direction. This has the effect of *reinforcing* the direction of the original influence, and any change will build on itself and amplify. ***Reinforcing loops are what drive growth or decline within a system****.*

In a *balancing feedback loop*, the direction of influence provided by one factor to another will transfer around the loop through that one factor (or series of factors) and influence back on the originating factor in the *opposite* direction. This has the effect of *balancing out* the direction of the original influence. **Balancing loops are what create *control, restraint or resistance* within a system**.

The two types of feedback loop are described in Figure 1.

Figure 1. The two types of feedback loops



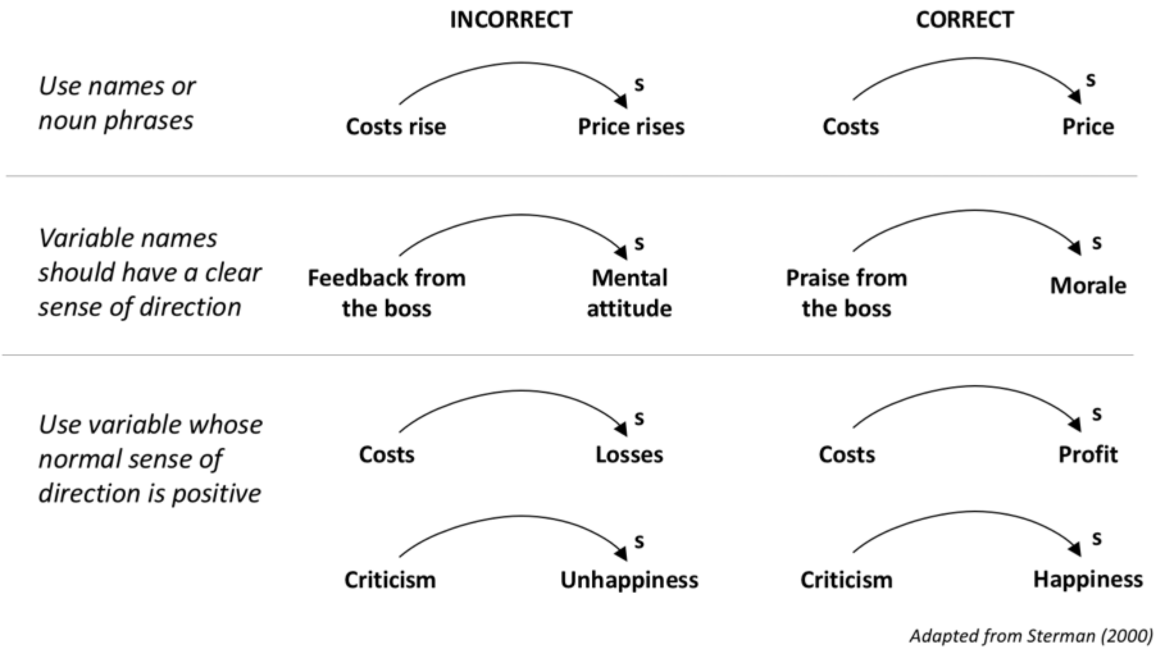
Feedback loops can be made up of more than two variables and can be mapped together to form a system map (hence why it is technically referred to as a *causal loop diagram*). How these interact provide insight into how a wider system operates.

4.2 Labelling variables

An important concept within system maps is the concept of accumulation (or decumulation) – where does 'stuff' build-up (or decrease) in your system? The simple analogy of a bathtub is often used to describe this (see section 4.5 for further explanation of the bathtub analogy).

In system maps, this concept of accumulation is captured by describing variables in such a way that their name implies that they can *increase or decrease*. This means that they should be described as *nouns*; have a clear sense of *direction*; and have a normal sense of direction that is *positive*. Examples to demonstrate this are shown in Figure 2.

Figure 2. Labelling variables

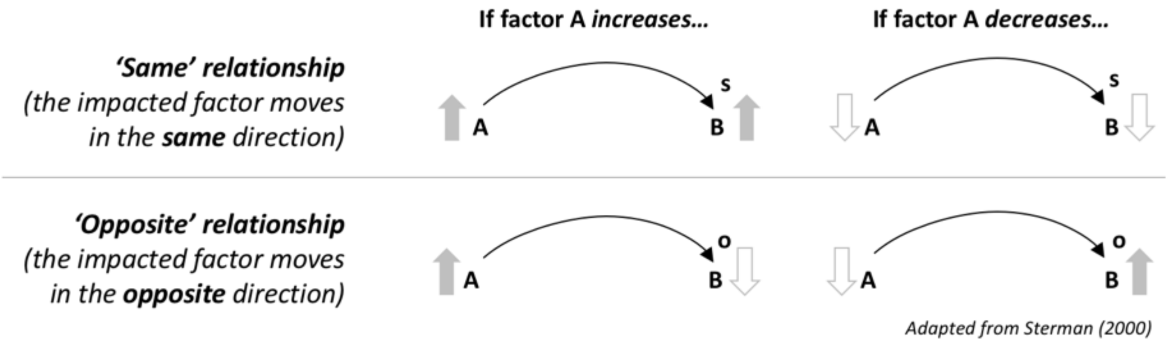


4.3 Annotating loops

Variables within system maps are connected (and made into feedback loops) by arrows, which indicate that one factor has a causal relationship with the next. These arrows are annotated with either an 's' or an 'o' which stands for 'same' or 'opposite'. These terms correspond to the direction of change that any change in the first variable will have on the second variable.

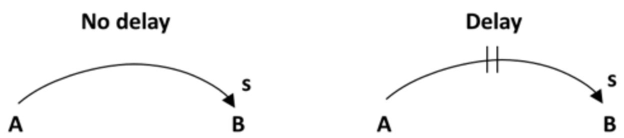
For example, if a directional change in one variable leads to a directional change in the next variable in the *same direction*, it is a *same relationship*. Likewise, if the second variable changes in the *opposite direction*, it is an *opposite relationship*. See Figure 3 for a visual description.

Figure 3. How arrows are labelled in system maps



If there is a notable *delay* in this influence presenting in the second variable, when compared to the other influences described in the system map, this is annotated as a *double line crossing the arrow*. An example of this is shown in Figure 4.

Figure 4. How delays are annotated on arrows



4.4 Goals and gaps – driving individual loop dominance.

Realising that multiple loops are operating within a system is the first useful insight of systems thinking. A further useful insight is understanding that not all loops operate at the same strength all of the time. Different loops can dominate the dynamics of a system at different times. For example, a system might be dominated by a period of growth (a reinforcing loop), but when some kind of physical limit is approached (e.g. the available space in a pond for algae to grow) a balancing loop will start to dominate, therefore slowing the rate of growth.

One useful mechanism for gaining insight into the strength of a balancing loop is the *'goal/gap' structure*. This is a structure that combines both a *desired level* of something (a 'goal'), with an *actual level* of something. This *difference between these variables* is the 'gap' between the desired and actual levels.

The higher the desired level and the lower the actual level, **the greater the 'gap' or difference the stronger the operation** of the loops that this gap influences. The lower the desired level and the higher the actual level, **the lower the 'gap' or difference, and therefore the weaker the operation** of the loops that this gap influences.

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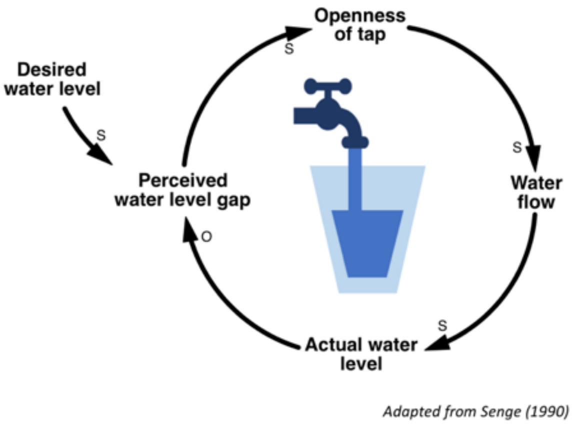
Figure 5. Example of a 'goal/gap' structure in a system map – pouring a glass of water



The 'goal/gap' mechanism can be seen throughout the system maps. A conceptual example is shown in Figure 1 which shows the act of filling a glass of water.

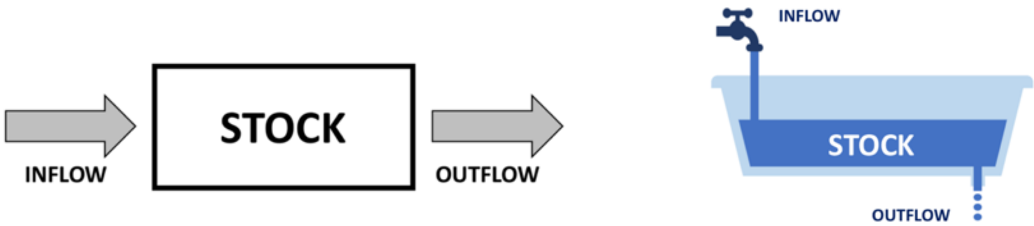
Initially, while the gap/difference between the desired and actual water level is high, the tap will be opened more and the strength of the water flow is higher. As the desired level of water is approached the gap/difference reduces, so the tap is closed further, weakening the flow of water (you don't want the water to overflow the glass), until it is fully closed when the water level reaches the desired amount (Senge, 1990).

4.5 Stock and flow notation

The bulk of the system maps described in this report are made up of variables and arrows as described above. Such variables are the core of system maps. However, in some places selected variables are described in a slightly more involved way – they are shown in *stock and flow notation* – which provides an improved level of insight to the behaviour of the system.

Using a stock and flow notation is similar to a metaphorical *bathtub* (as mentioned earlier). A stock might be anything that we are interested in – number of people, quality of water, level of morale, etc. **Stocks can ONLY increase through more inflow** (the tap in a metaphorical bathtub), **and ONLY decrease through more outflow** (the drain in a metaphorical bathtub), for whatever you are interested in – just like the level of water in a bathtub. This is reflected in the diagrammatic description of a stock and flow (Figure 6).

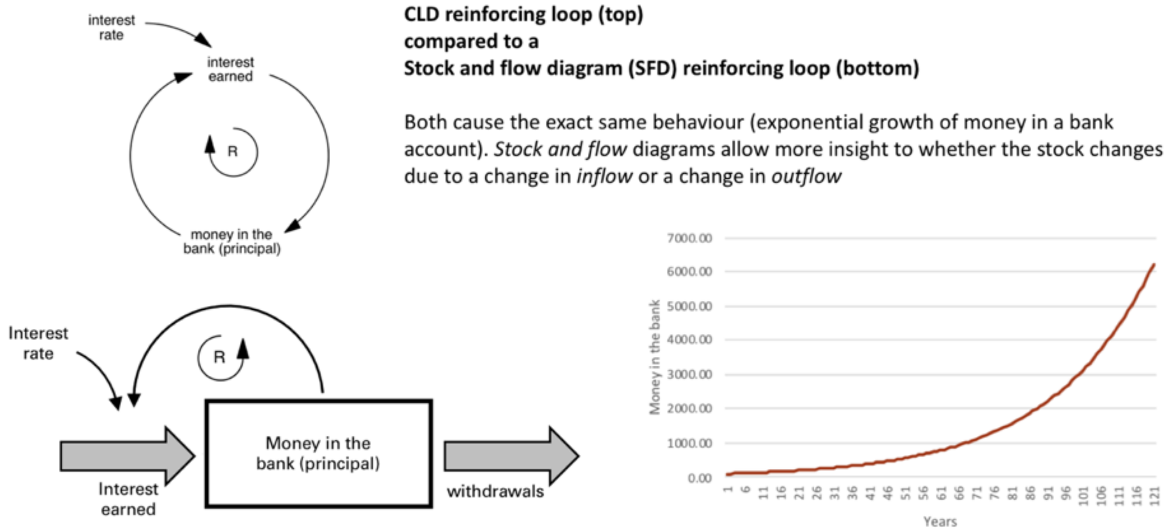
Figure 6. Stocks and flows – the more advanced notations used in System Dynamics



Both basic system maps (CLD) and more complicated stocks and flow diagrams explain the same type of behaviour. Yet the inclusion of stocks and flows allow a greater level of insight to understand whether a change in a stock is due to a change in *inflow* or a change in *outflow* (see Figure 7 for an example).

In this report, the use of stock and flow notation has been included for the underpinning central variables different types of marine *natural capital*, as this is central to the focus of the National Science Challenge.

Figure 7. Comparison of reinforcing loops: System maps (causal-loop diagrams) vs. Stock and flow diagrams



Stocks and flows are the language of simulation modelling in System Dynamics. If any of these diagrams were to be developed into quantitative simulation modelling (in potential future research), then full stock and flow formulation would need to be used. This spectrum of complexity within the tools of System Dynamics is explained in the next section.

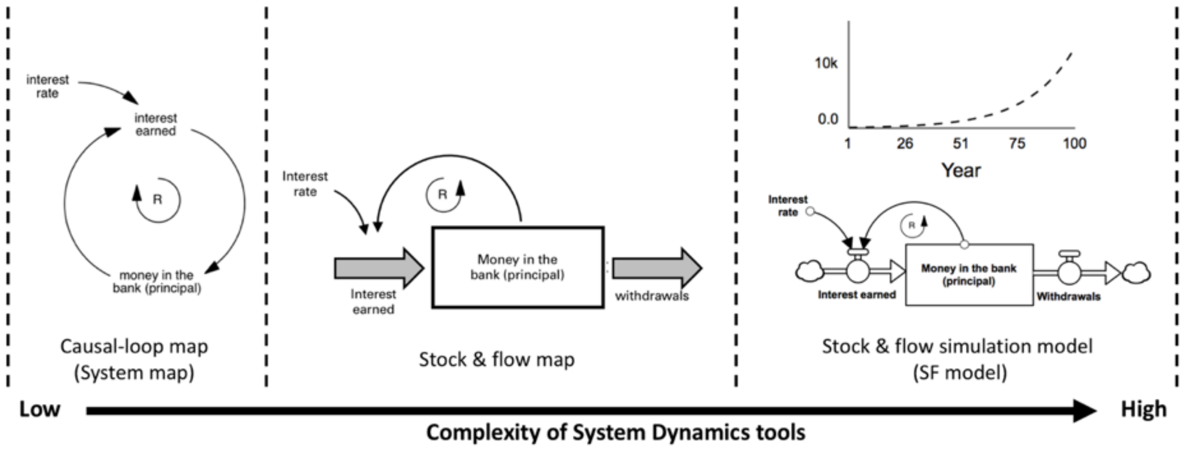
4.6 How system maps can be used

This section briefly outlines how system maps themselves fit within a spectrum of complexity in the discipline of System Dynamics; and how they may be used in conjunction with other methodological approaches.

4.6.1 System maps on the spectrum of complexity within System Dynamics

The tools of System Dynamics themselves exist on a spectrum of complexity. These are shown in Figure 8 which highlights how these varying tools can demonstrate the same system, and to make the point that system maps are not the ONLY possible output from the use of SD tools.

Figure 8. System Dynamics tools exist on a spectrum - System maps (or Causal loop diagrams), Stock and flow diagrams, and Simulation modelling.



System maps (CLD) as developed here, exist at the conceptual (low complexity) end of this spectrum. These can range from using the simple dynamics of a single feedback loop to demonstrate a type of behaviour, to multiple loop systems – themselves reasonably complex.

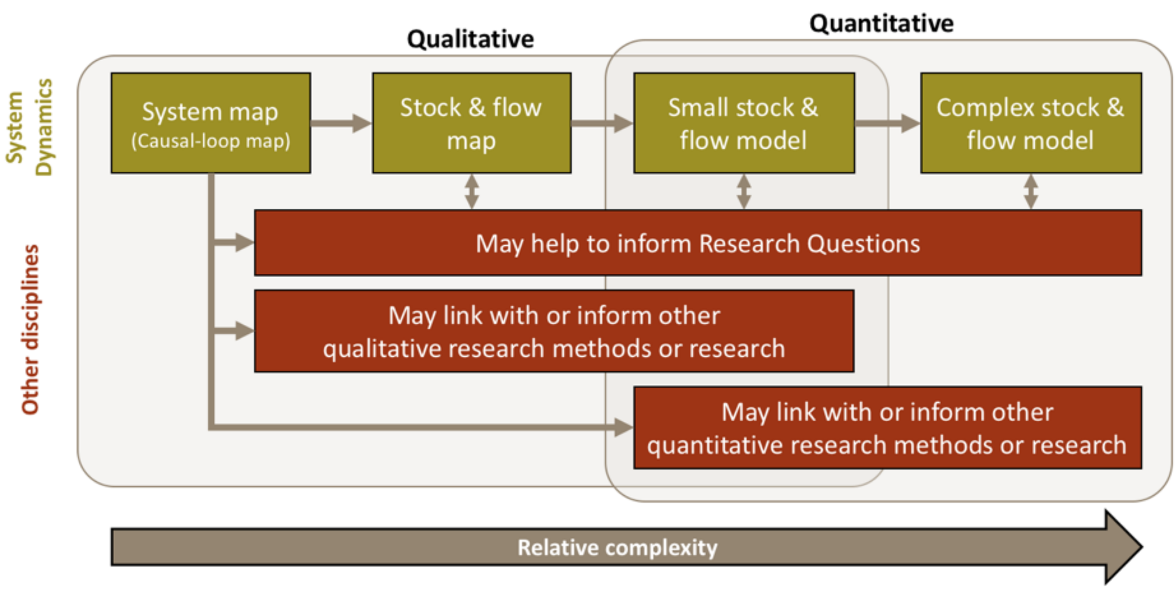
The next steps up in complexity are Stock and Flow Diagrams (SFD). While *natural capital* is represented in the maps within this report using stock and flow notation, these maps are not considered complete of 'full' SFD. This is because SFD usually contain multiple stocks of interest (although not all factors need to be stocks) and their architecture tends to represent a greater level of mathematical functionality. This is because SFD tend to be qualitative representations of the actual functions and equations that would be represented in a stock and flow model. This level of detail has not been achieved in this report.

Computer simulation modelling (based on the stock and flow formulation) is the next step in complexity – that is, actually turning stock and flow diagrams into simulation models. There is huge variability in the types of simulation models that can be developed, with some people advocating that large system insights can be gained from using small scale models (Meadows, 2008), to other demonstrating the utility of large scale and highly complex simulation models (Sterman, 2000).

4.6.2 How system maps may link with other methodological approaches

While system mapping can lead to more complex stock and flow diagrams and simulation modelling within System Dynamics, it may also link with or inform other methodological approaches within a wider research project. A diagram outlining how this can work is shown below in Figure 9.

Figure 9. How systems mapping can link with other research methodologies



Note: There is an overlap of the qualitative and quantitative areas of application because they are not mutually exclusive. For example, for some quantitative relationships in models and their calculations may be informed by research or data, but may need to be assumed via some form of participatory process.

The series of *green boxes* across the top of the diagram in Figure 9 represent the increasing complexity of the System Dynamics tools. The *red boxes* in the lower part of the diagram represent the research questions that may be generated in the course of research; as well as the different qualitative and quantitative methods that may be employed within the research. All of these may be informed by the system mapping process, or a more complex evolution of a system map (for example a small stock & flow model).

For example, a system map may provide insight to the nature of relationships within the system that may inform how a research question is framed. It may also inform the types of people who might be involved (as researchers or as research subjects). Further, the nature of the relationships elicited throughout the system mapping process could also inform other research methods that may be used – either qualitative or quantitative.

Please note that while the diagram above suggests that as research becomes more quantitative it becomes more complex, that is not our intention. Rather, our position is that more precise numerical measures tend to give systems theorists the opportunity to specify more precise relationships and thus add layers of complexity to their models. In fact, in complex worlds, qualitative methods are more likely to capture complexity and make it available for analysis. In complex worlds, systems thinking and causal mapping may be used as a decision-support tool that enables a more holistic view of inter-relationships that may otherwise be missed or excluded from reductionist analyses (Senge, 2006; Pearl & Mackenzie, 2018).

5 System maps – Living Standards Framework focus and Social licence to operate

In the years prior to and during this research, the New Zealand Treasury has been developing a capabilities approach to considering and measuring wellbeing. This is intended to extend the capability of measuring wellbeing in society on more than narrow financial measures such as GDP. This is known as the *Living Standards Framework* (NZ Treasury, 2018). This section briefly outlines the main capitals within this framework and describes how they have been incorporated into the system maps. The four capitals in this framework are shown in the system maps and are introduced as proxies for *Social licence to operate*.

5.1 The Living Standards Framework

Descriptions of the four *Living Standards Framework* capitals are provided in Figure 10. It should be noted that cultural identity is included within social capital and is not articulated as a separate capital.

Figure 10. The four capitals of the Living Standards Framework

Natural capital	This refers to all aspects of the natural environment needed to support life and human activity. It includes land, soil, water, plants and animals, as well as minerals and energy resources.
Human capital	This encompasses people's skills, knowledge and physical and mental health. These are the things which enable people to participate fully in work, study, recreation and in society more broadly.
Social capital	This describes the norms and values that underpin society. It includes things like trust, the rule of law, the Crown-Māori relationship, cultural identity, and the connections between people and communities.
Financial & Physical capital	This includes things like houses, roads, buildings, hospitals, factories, equipment and vehicles. These are the things which make up the country's physical and financial assets which have a direct role in supporting incomes and material living conditions.

Descriptions from NZ Treasury (2018)

5.2 Social licence to operate

Social licence to operate reflects the general level of approval (implicit or explicit) within a community of interest that a company (or activity) has to operate. The four capitals of the Living Standards Framework are used here as a conceptual proxy for contributions to Social licence to operate – the better the state of these capitals *as a whole*, the greater the Social licence to operate for any of the economic activities articulated in these system maps.

The general impact that any risks or interventions have on these capitals (and therefore their impact on Social licence to operate) is summarised in tabular form at relevant times throughout this report.

6 Preface to the descriptions of the system map

System mapping, by definition and necessity, represents the elements within a system at a reasonably aggregated (or summarised) level. This is because the intent of system mapping is to *synthesise the broad inter-relationships* within a system and how they generate the *behaviour* (the dynamics) of the system over time. This is different to other approaches that undertaken highly detailed *analyses of a certain part of the system*, in order to better understand that particular part in detail.

While the general use of systems mapping techniques is to synthesise at an aggregate level, the extent that this aggregation occurs is relative, and therefore scalable. This means that system maps may also be used at a detailed level within a system, where they may act as a synthesis of other highly detailed components. This indicates the flexibility of the tool and their particular application is determined by the particular interests of the researcher.

The systems maps contained within this report are intended as a helpful *companion* to other, more detailed, analyses of the Blue Economy research (or indeed any other research, such as bio-physical) being undertaken in Sustainable Seas National Science Challenge.

The following sections describe the system maps in detail. Three main economic systems are described – wild fisheries, fish farming and eco-tourism. These have been developed with *no particular fish species or tourism activity in mind*. Indeed, an agnostic tone has been taken to the economic activity described, so as to cover as wide a range of potential activity as possible.

As noted in section 5, reference is also made throughout both sets of maps to various *capital stocks* of the New Zealand Treasury's *Living Standards Framework* (NZ Treasury, 2018). This is an attempt to align the system mapping done here, and potentially future research, with the Living Standards Framework.

These Living Standards Framework capitals are variously shown as **simple (or word only) variables** (for Human, Social and Financial & Physical Capital), or as **boxed variables** (Natural Capital) on the map. Where a natural capital is shown as a boxed variable, this is a representation of stock and flow notation (as explained in section 4.5).

While Natural capital is the main focus of the system maps in this report (hence they are shown as boxed variables), each of these other capitals could be the subject of their own system map. Reference to them here is necessarily aggregated, yet this could be developed in further detail in future research.

7 Building on a tradition of conceptual system mapping of renewable resource use

This work sought to generate a system map that was high level and broad ranging, yet still provided useful insight. In order to achieve this, the previous conceptual work of Donella Meadows was loosely used as a base from which to build upon.

Meadows was a highly accomplished systems modeller and a particularly gifted communicator. She came to profile as a co-author of *The Limits to Growth* (Meadows et al. 1974), which received a large amount of attention for its insights when it was published in the 1970s. This work highlighted that if worldwide trends continued, population increase, resource use and pollution would likely result in the erosion of the carrying capacity of the earth and an overshoot and collapse of the world's population, in the latter 21st century. While the insights of this ground-breaking work were considered contentious at the time, they have been reinforced and strengthened through further work since (Meadows et. al, 2004).

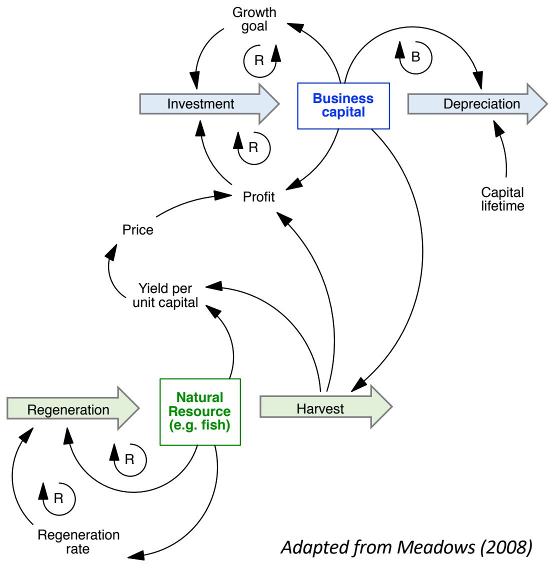
While this *Limits to Growth* work is not drawn on directly here, the concept of carrying capacity, the pressures on a resource and factors in its potential collapse are themes that Meadows returned to throughout her career. In particular, she simply and articulately demonstrates the impact that human harvesting pressures can have on a renewable resource, in *Thinking in Systems – A primer* (Meadows, 2008 (published posthumously)).

In this work Meadows demonstrates the pressures operating within a fishing industry. This diagram is reproduced here in Figure 11.

Two main capitals (or 'stocks') are highlighted in this conceptual diagram – Business capital and Natural Capital (the renewable resource being harvested).

The inter-connections between factors and the loops that create pressure within the system are demonstrated. Reinforcing loops within the system drive growth or decline, while balancing loops are sources of stability or resistance.

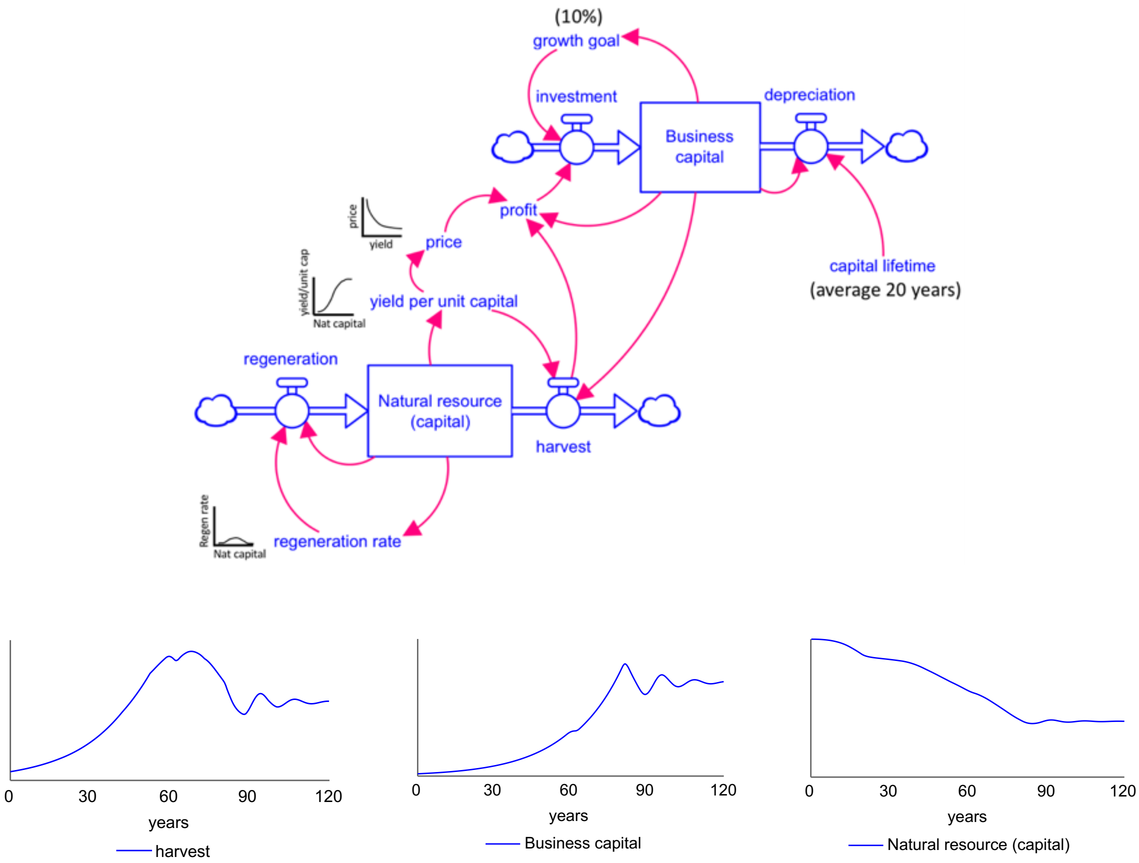
Figure 11. Conceptual system map of a renewable resource business, focusing on two main capitals (or 'stocks')



Those loops that dominate the system most will have a larger impact on the behaviour that is observed within the system. In this case, this raises the question as to whether the loops relating to the investment in capital, versus those regenerating the natural resource will be more dominant.

The work of Donella Meadows also used small-scale stock and flow simulation modelling (as described in Figure 9) to determine the dominance of the loops and infer the behaviour of core system variables over time. This showed that the loops relating to the drive for capital returns tended to dominate, and that most scenarios (e.g., where varying rates of investment or a change in growth goal) tended to result in similar patterns of behaviour, even if the exact trajectory of those behaviours changed with changes in variables. In the case of the conceptual map shown in Figure 11, this tended to result in an overharvest of the resource, a collapse of the natural capital and the inevitable plateauing of business capital (see Figure 12, below).

Figure 12. Small-scale simulation model and behaviour over time for key variables in conceptual business based on renewable resource (as described in Figure 11)



Simulation modelling (even at a small-scale) can be a resource intensive activity and none has been undertaken in this work. Rather, the system maps developed in this report are seen as a pragmatic way of exploring the likely trends of behaviour over time *through narrative discussion*, without the need for complex simulation modelling.

Of course, simulation modelling can be undertaken, and some may be a feature of future research in the Challenge. Primarily though, this work seeks to increase understanding of the core tensions within the systems discussed. If simulation modelling was to result from this research in the future, it would be expected that the work in this report has helped to refine what are the important elements to include within that modelling.

8 How the maps in this research were expanded

Three different system maps were expanded from the conceptual base outlined by Meadows (2008). Two were renewable fishing resources – one being a wild fishery and the other being a farmed fishery – while the other was eco-tourism. All three are based around the use of some kind of marine natural capital.

For all three maps the following broad amendments were made from Meadows' original. The evolution of the maps, described below, informs the layout of the sections in this report.

Firstly, each map was expanded to broadly cover the following (section 9):

1. A **renewable natural resource** is retained as the focus of all maps and labelled ***natural capital***.
2. Recruitment[2] and harvest/catch are retained as flows into/out of this focus resource. **Mortality** was also added as an outflow (not just harvest or catch).
3. **Business capital was adapted** to represent both *Financial & Physical*, and *Human capital*, from the *Living Standards Framework* (NZ Treasury 2018).
4. A **supporting natural capital** was added to all maps. This represents the *underlying* natural capital (non-extractive) on which the renewable natural capital relies. In all cases this was a representation of ocean health as a support to fish stocks.
5. **Influences on price** were added, such as market valuation.
6. **Influences on the natural capitals** themselves were added to all maps: For example, the Quota Management System (QMS), fishing methods, and methods to improve fish stocks for wild fisheries; the pressure of physical volume and impacts of fish farms and methods to reduce that impact, for farmed fisheries; and the impacts of tourism for eco-tourism.
7. The impact of (and impact from) ***Social capital*** (the fourth capital from the LSF) on the system was then added.

Secondly, the potential risks to the systems that had been identified in previous research by Assoc. Prof. Lewis, were added to the maps. This is covered in section 10 and can largely be categorised as market; regulatory; and ecological risks, although there are some additional risks in the eco-tourism example.

[2] Meadows used the term *regeneration* to describe the flow of new animals into a renewable resource through reproduction. In this report, the term *recruitment* has been used, as this is a more technically correct term in relation to fisheries ecology.

9 Description of system maps

In this section the three system maps are described: a wild fishery, a farmed fishery and eco-tourism. Each of these economic activities is treated in isolation, which enables a focus on the specificity of the activity. While each system map has been represented here individually, they are intended for comparative discussion. Simple links between the maps could be developed and used in EBM to identify cross-sector impacts in a multi-use environment.

9.1 Wild fishery system map

A wild fishery, in the context of this system map, is a fishery that relies on a fish stock(s) that exists in the wild and is not contained in man-made aquaculture structures.

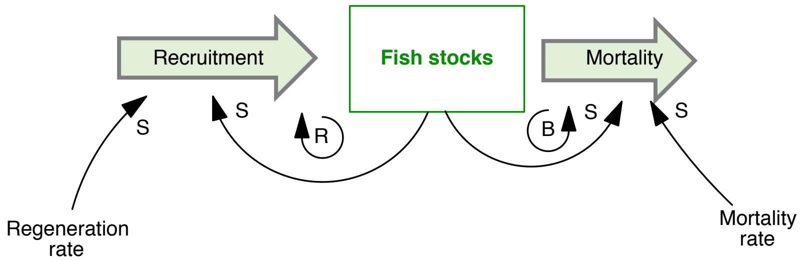
9.1.1 Wild fishery – components

The wild fishery system depends primarily on a stock (or stocks) of naturally occurring fish species. Therefore, the base of this map is fish stocks (deliberately phrased as a plural to allow for multiple species). Like the bathtub analogy earlier, the stocks are only increased through the addition of new fish (from recruitment). In their natural state they are only decreased through mortality.

Therefore, the thick arrow *into* the fish stocks demonstrates the recruitment of new fish into the stocks, while the thick arrow *out of* the fish stocks demonstrates the removal of fish from the stocks through mortality (Figure 13). *Recruitment* is in a reinforcing loop with the amount of fish in the *Fish stocks* – the more fish there are in the population the greater numbers that are reproduced, even if the recruitment rate is held constant. The strength of this loop is influenced by the *Regeneration rate*. The *Mortality* is in a balancing loop with the amount of fish in the *Fish stocks* – similar to recruitment, the more fish there are in the population the greater the numbers affected by *Mortality*, assuming a constant *Mortality rate*. The strength of this loop is influenced by the *Mortality rate*.

This basic system structure, with a reproductive inflow (recruitment) and a mortality outflow, is common across any animal population. In a natural environment with fairly constant environmental limits or constraints, such dynamics will result in an animal population generally finding balance, probably with some slight oscillation. Yet in most environments constant environmental limits are rare, so the population dynamics of such a system are not stable. While this core structure remains valid, dynamic population levels can be explained through the addition of further influences and loops. These causal influences are built up throughout the rest of the system map.

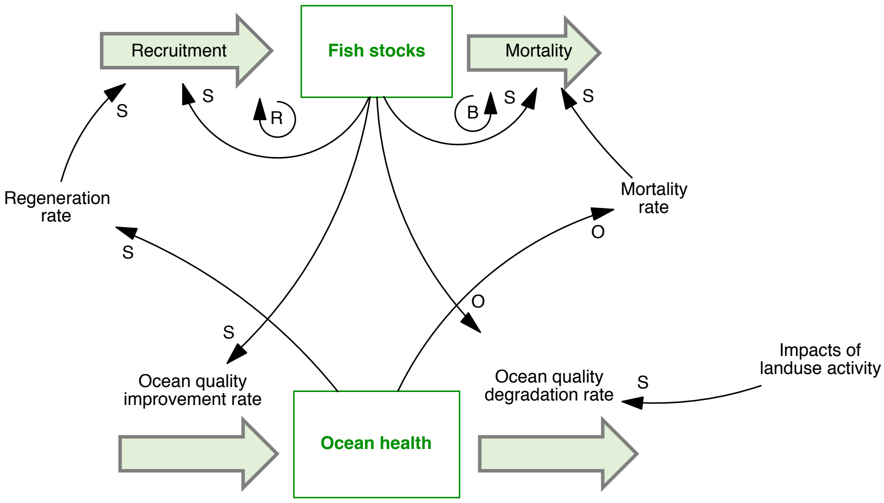
Figure 13. Wild fishery: The basic structure of influences in an undisturbed fish population



As discussed in section 8, a supporting natural capital stock (in this case, ocean health) was added to demonstrate how this underpins the natural capital of fish stocks (Figure 14). This stock is an aggregated representation of that natural capital that supports fish stocks. They are not prescribed here so as to avoid the complication of defining specific supporting factors for different fish stocks. While represented here in the aggregate, individual system maps could be drawn for each of these and this could be explored if future research.

Ocean health influences *Fish stocks* through its impact on the *Regeneration* and *Mortality rates*. The higher the *Ocean health*, the higher the *Regeneration rate* will be and the lower the *Mortality rate*. If *Ocean health* was to drop then the *Regeneration rate* would be expected to decrease and the *Mortality rate* to increase – hence the same and opposite relationships, respectively.

Figure 14. Wild fishery: How ocean health can influence fish stocks



One way that *Ocean health* declines is through an increase in the *Ocean quality degradation rate*, which may be impacted by landuse activity. So, this is shown as an influence on this *outflow from* (read: *decline in*) *Ocean health*.

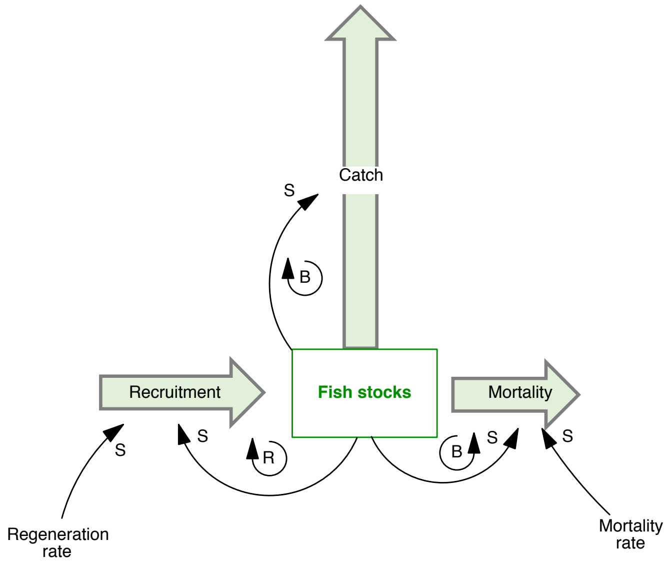
Healthy fish stocks will also have a symbiotic impact on ocean health (depending on the fish stock), so the greater *Fish Stocks* means a better Ocean quality improvement rate, and a reduced Ocean quality degradation rate.

The dynamics of *Fish stocks* are also impacted through the extraction of fish by fishing (*Catch* on Figure 15). This is represented as another thick arrow coming *out of* the fish stocks, as any catch will *decrease* the amount of fish in any particular stock.

Another arrow is drawn from *Fish stocks* to *Catch* to indicate that the level of the catch is influenced by the amount of fish available to be caught. The higher the *Fish stocks*, the higher the likelihood of *Catch* for the same amount of effort invested – all other things being equal.

Additional influences on *Catch* (the second outflow from *Fish stocks*) are explained later in this section (see also Figure 16 and Figure 18).

Figure 15. Fish catch - the depletion of fish stocks through human extraction

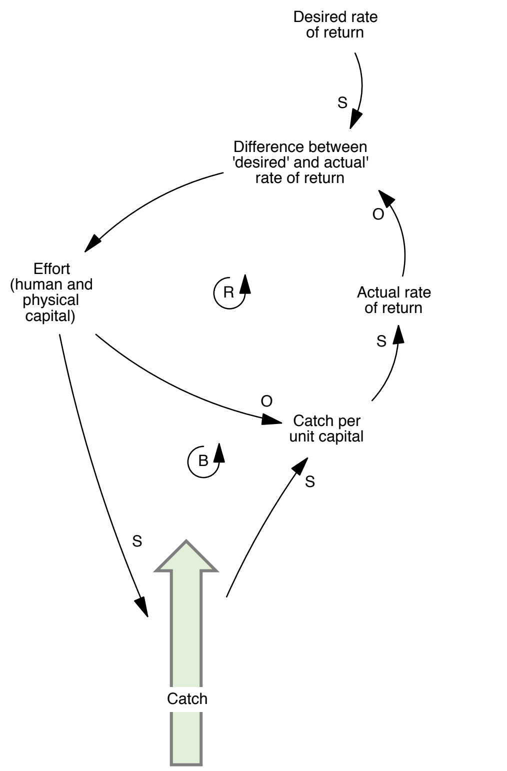


The first of these other influences are the *Effort* put into fishing; the *Catch per unit capital*; and the resulting *Rate of return*. These variously form both a balancing loop and a reinforcing loop (Figure 16). The goal/gap structure described in section 4.4 features in these loops.

There is a balancing loop that describes how *Effort* (as an aggregate description of both human and physical capital) has a 'same' impact on *Catch* – the more effort, the greater the catch (and vice versa), all other things being equal. With a larger *Catch* there is greater *Catch per unit capital*, resulting in a greater *Actual rate of return*. An increase in *Rate of return* reduces the *difference* between the *actual rate of return* and the *Desired rate of return*. If this difference reduces (i.e. the *actual return* is closer to the *desired return*), then this reduces or maintains (certainly it does not increase) any further *Effort*.

At the same time, there is a reinforcing loop that describes how with greater effort, there is also an 'opposite' impact on *Catch per unit capital*. That is, if the effort was increased and the catch remains the same, then the *Catch per unit capital* would reduce.

Figure 16. Influences on Catch - Effort, Catch per unit effort and Profit.



This puts downward pressure on the *Actual rate of return*, which in turn increases the *difference* between the desired and actual rate of return. This is likely to maintain or increase any further effort in an attempt to decrease this *difference (*'gap').

If the balancing loop dominates, then the *Catch* is likely to balance out over time (providing there are available fish). However, if the *Desired rate of return* was to increase, this would increase the likelihood of the reinforcing loop dominating.

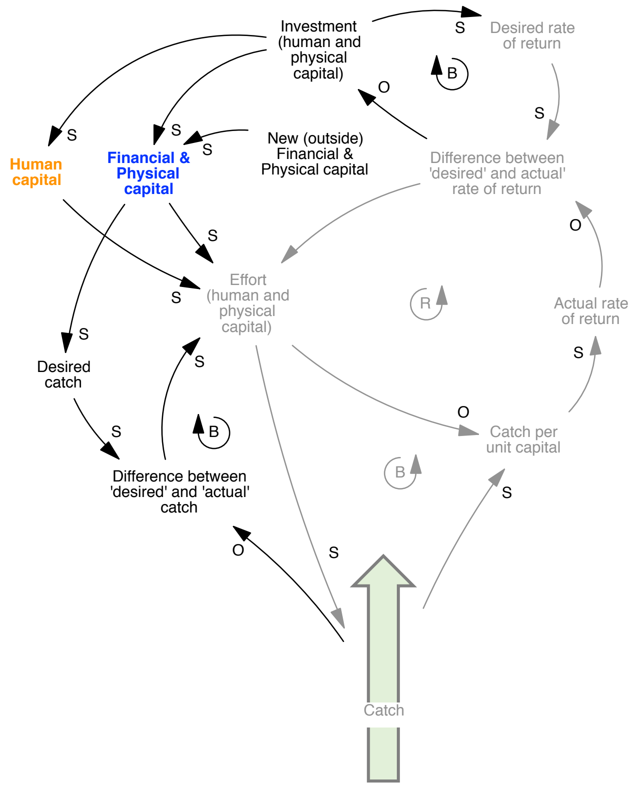
These loops can be expanded to include the impact of the level of the *Desired catch* and the pressures of investment in both *Physical and Human capital* (see Figure 17).

Firstly, there is a balancing loop between *Difference between desired and actual return*, *Investment*, and *Desired rate of return*. As described earlier, the closer the *Actual rate of return* is to the *Desired*, then the lower the *Difference* (the discrepancy between the two). The lower the *difference* (i.e. the closer to the *Desired rate of return*) a business is, then the greater the likelihood of *Investment in Human and Physical capital*. This could take the form of an extended fleet, as well as new staff. Any *Investment* in either human or physical capital, will then drive a greater *Desired return on investment* in order to pay for this investment. In turn this increases the *Difference between the desired and actual rate of return*, which is likely to take the pressure off the desire for investment, until that gap is closed (a balancing loop).

Any investment could increase either or both *Human capital* and *Financial and physical capital*. The greater these capitals, the greater the potential *Effort*. This influence will flow on into the balancing and reinforcing loops described earlier in Figure 16.

An increase in *Financial and physical capital* in particular will drive an increase in *Desired catch* as a means of returning a profit to pay for the investment. However, an increase in *Desired Catch* creates another goal/gap structure with *Catch* (being the 'actual' catch), the 'gap' being the *Difference between desired and actual Catch*.

Figure 17. The impact of a Desired Catch and investment in Physical and Human capital

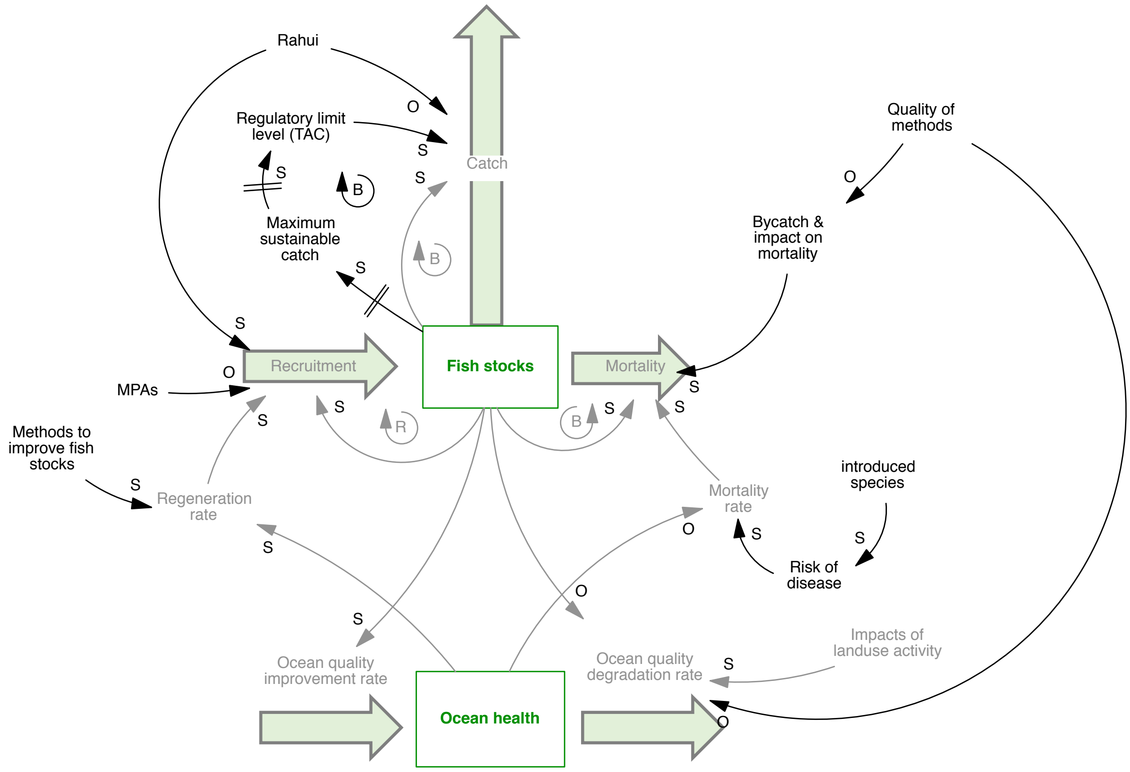


This then operates as an additional balancing loop influencing the fishing *Effort*. An increase in *Desired catch* leads to an increased *Difference*, which drives greater *Effort*, which returns a greater *Catch*, which reduces the *Difference* (all other things being equal), and so on.

These loops demonstrate the multiple and conflicting drivers of fishing *Effort* which flow through to impact on the actual *Catch*.

Unfettered, *Catch* would continue to extract fish from the stock and put pressure on the viability of the *Fish Stocks*. The Quota Management System (QMS) was designed to limit this impact and is represented in the following diagram at a highly aggregated level (Figure 18). Please note that it does not show the full mechanisms of the QMS, rather it highlights that a *Maximum sustainable catch* is set, based on the level of the *Fish stocks* of interest. In turn, this informs a *Regulatory limit level* in the form of a Total Allowable Catch (TAC).

Figure 18. Direct influences on regeneration, catch and mortality



The double-dashed lined lines on the arrows from *Fish stocks* to *Maximum sustainable catch*, and also from there to *Regulatory limit level (TAC)*, represent significant delays in these influences presenting, in comparison to the others influences in the system. This captures the delays in setting (or reviewing) the *Maximum sustainable catch* and the *Regulatory limit*.

One other direct influence on *Catch* is included – *Rahui* (Iwi imposed fishing bans).

Outside of managing the fish catch directly through the QMS or *Rahui*, several other factors are shown to impact *Fish stocks*, and thus, indirectly, *Catch*.

Methods to improve fish stocks has been included to account for how fish stocks may be improved. This would impact/improve the regeneration rate of a fish stock, leading to greater regeneration and an increase in the stock. The imposition of *Rahui* may also improve recruitment, as breeding grounds are left to recuperate. Also, the establishment of *MPAs* (Marine Protected Areas) would also (generally) allow fish stocks to recover through greater recruitment.

Several influences on *Mortality* are also represented. *Quality of methods* represents the quality of fishing methods, which will influence the level of *Bycatch & impact on mortality*, which in turn impacts *Mortality*. This factor is worded so as to represent the impact of *Bycatch* directly, as well as the potential impact on *Mortality* through the destruction of habitat or stress on bycatch that may survive. *Introduced species* and their impact on the *Risk of disease* are also possible impacts on the *Mortality rate*, which will impact *Mortality*.

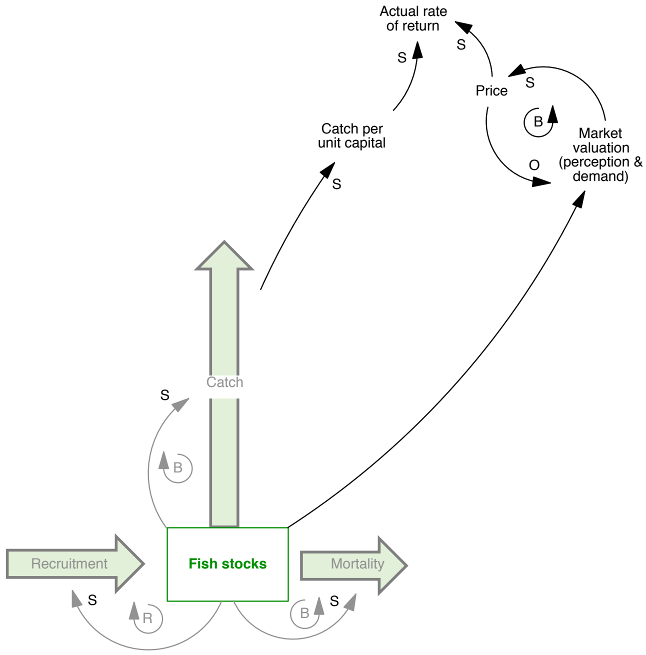
The previous descriptions and figures outline the processes that maintain or improve fish stocks through *Recruitment*, and diminish them through *Mortality* and *Catch*. The following descriptions outline the connections between *Fish stocks, Catch*, *Market valuation Price* and *Actual rate of return*.

Actual rate or return has already been described as a core driver of fishing *Effort*.

The structure outlined in Figure 19 describes the connection between *Fish stocks* and *Actual rate of return*, via market drivers. The higher the possible *Price* for a product, the greater the *Actual rate of return*.

Price forms a balancing loop with the *Market valuation* of the product – if the market (through perception and/or demand) was to determine a higher *Market valuation* for a product, then the *Price* would increase. At the same time however, a larger price will have an opposite impact on *Market valuation* – that is, if a price become too high it may become over-valued. This would result in a reduction in the market valuation. In effect these two things have a balancing effect on each other and this loop describes the dynamic balance that these market forces have on each other.

Figure 19. The connection between Fish stocks, Market valuation, Price and Profit

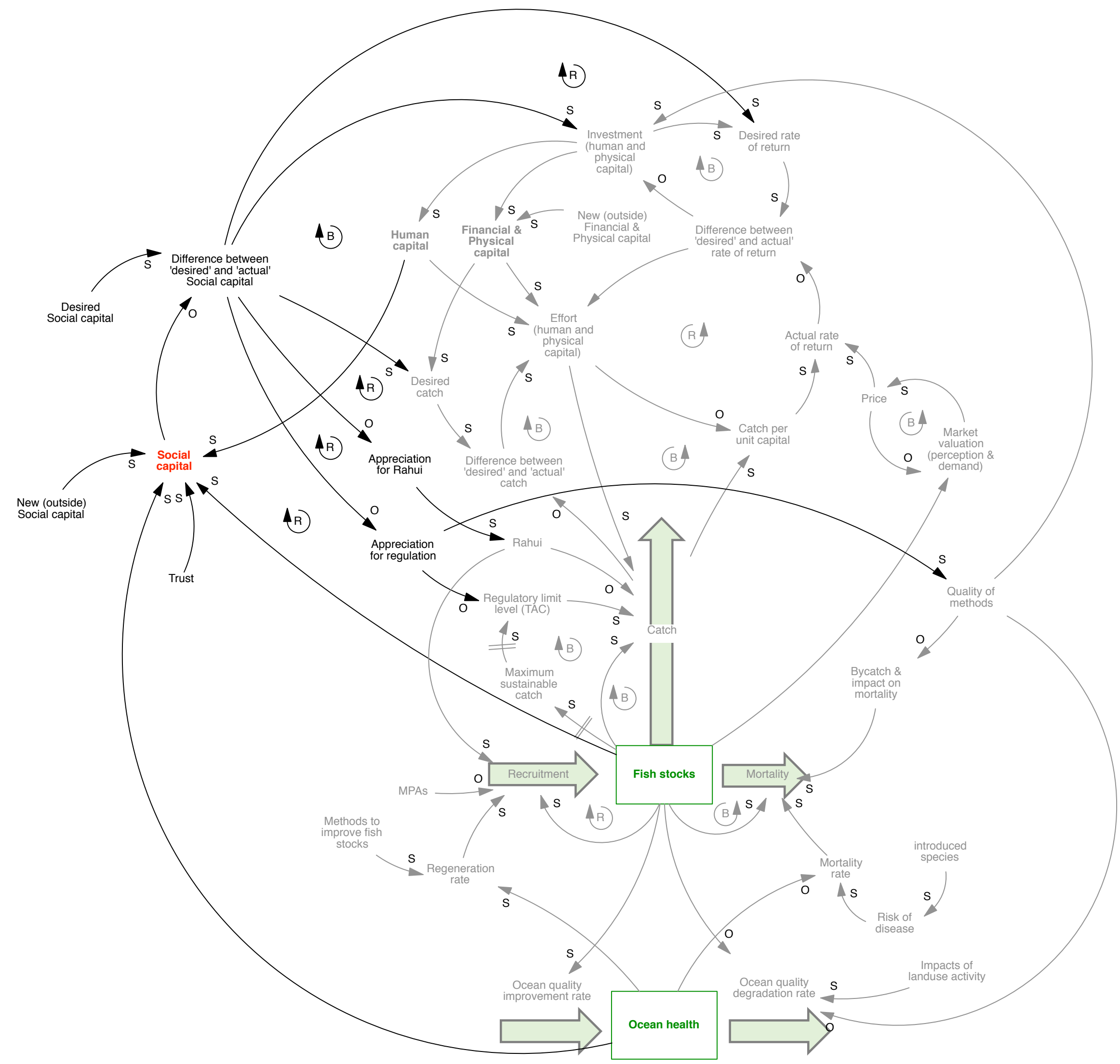


The key external influence of this balancing loop is the level of the *Fish stocks* – the higher the level and better condition this is in, then then greater the *Market valuation*.

The final set of influences and loop added to the diagram are shown in Figure 20 below. These are summarised as the impact on and the impact of, *Social capital* on the wider system.

There are three main endogenous influences on *Social capital*. These are the quality of the *Ocean health;* the levels of the *Fish stocks* that they support; and the level of *Human capital* within the economic activity. Two other exogenous influences are also represented: *New (outside) Social capital* and *Trust*.

Figure 20. The impact on and impact of, Social capital (Wild fishery)



New (outside) Social capital captures new capital that may be brought into the economic activity, or that may occur as a result of migration into an area. This may be directly in the form of attitudes towards the economic activities themselves, or indirectly through the way that they may change or evolve cultural elements of social capital (for instance a greater appreciation for cultural approaches such as *Rahui*).

While *Trust* could be represented as an endogenous variable, it could arguably be impacted by myriad other variables in the system map, yet this would likely change from the perspective of the party reading the system map. Therefore, no direct influences have been represented into *Trust*, but many could be drawn according to the reader of the map.

Social capital[3] itself is also shown in a goal/gap relationship in the system map. The system map structure recognises that both the desire for, and the actual level of *Social capital*, is a fundamental driver of many of the other activities within the system. Representing this with a

[3] Note: Cultural capital is included in the definition of Social capital of the Living Standards Framework.

goal structure – i.e. a *desired level of social capital* – recognises that when an appropriate level is approached (or met), the growth or accumulation of this capital will diminish (or stop). This will have flow-on effects throughout the system. Consequently, no feedback loop is represented as driving up the *Desired level of Social capital* as with the *Desired rate of return*.

This important variable of Social capital is in a range of feedback loops throughout the system – both balancing and reinforcing.

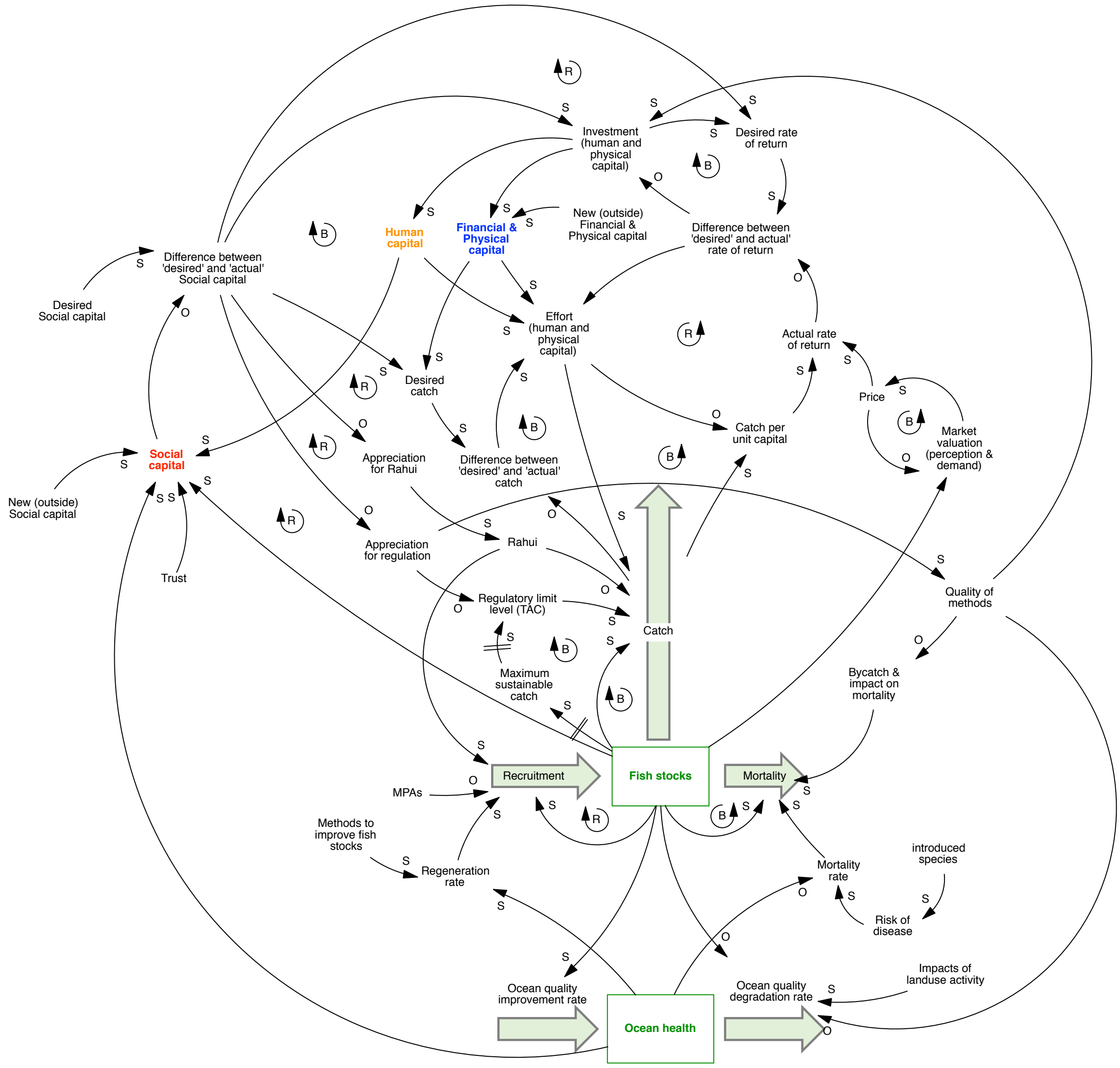
Multiple reinforcing loops exist, all reinforcing because they pass through the natural capital stocks of *Fish stocks* or *Ocean quality*. In effect, a higher level of *Social capital*, in conjunction with a constant level of *Desired Social capital* (therefore a small *Difference*) reduces the need for increases in *Desired rate of return*; *Desired catch*; and *Investment in physical capital*. At the same time, it also increases the *Appreciation for regulation* and the *Appreciation for Rahui*. All of these influences effectively reduce *Catch*, which helps to increase *Fish stocks* and longer term can help to regenerate *Water Quality*. An increase in these two important stocks helps to maintain *Social capital*, thus continuing to reinforce the existing level.

However, it is only in one balancing loop, with *Human capital*. A lower *Difference between desired and actual Social capital* will drive less investment, which results in less investment in *Human capital*. Over time this will have a reducing impact on *Social capital*.

9.1.2 Wild fishery – complete map

The previous section described a Wild fishery system in parts. The complete map for a Wild fishery is shown below, in Figure 21.

Figure 21. Wild fishery – complete map



9.2 Farmed fishery system map

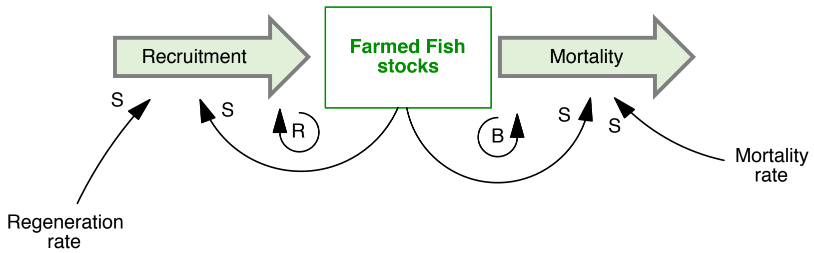
This section describes the system map of a farmed fishery. In this context, a farmed fishery is one that relies on a fish stock(s) that is contained in man-made aquaculture structures. While this focuses on fish, there are likely to be many similarities between this system map and one that might be developed for farmed shellfish, with many of the core structure likely to be transferable.

9.2.1 Farmed fishery – components

Many of the components of the farmed fishery remain similar to the wild fishery. For expediency, these are summarised here.

The basic structure of the primary component, *Farmed fish stocks*, remains the same as for the wild fishery. A stock of Farmed fish, which is increased by *Recruitment* into that stock, and decreased by the natural *Mortality* from that stock (Figure 22).

Figure 22. Farmed fish: The basic structure of influences in an undisturbed fish population



Similarly, the natural capital of *Ocean health* supports the natural capital of the Farmed fish stock. This is again shown in Figure 23.

In a farmed fishery, fish are harvested rather than caught. So, while the basic structure of human extraction remains the same, the flow of fish removed is labelled *Harvest* (Figure 24).

Figure 23. Farmed fish: How ocean health can influence fish stocks

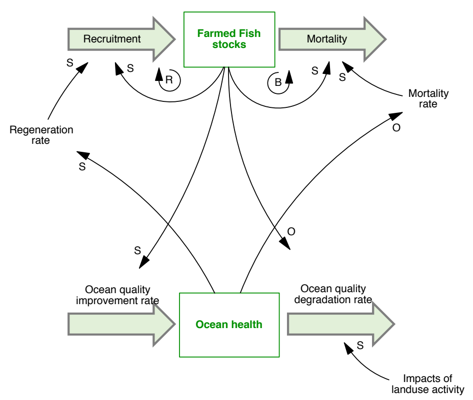
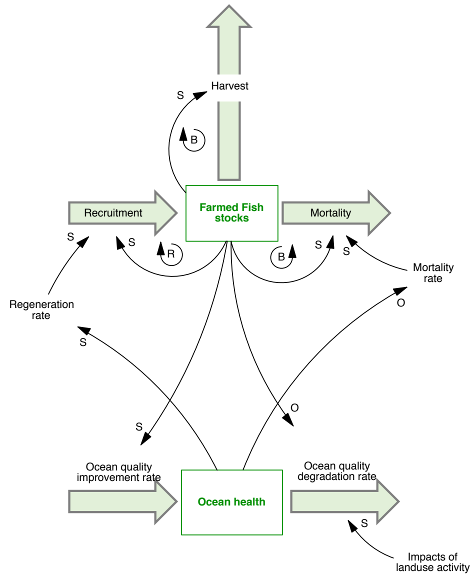


Figure 24. Fish harvest – the depletion of farmed fish stocks by harvest



The fundamental structure (and therefore drivers) of the Farmed fish *Harvest* remain the same as the Wild fishery *Catch*.

Firstly, a balancing loop where an increase in *Harvest* increases the *Yield per unit capital*. All things remaining equal, this increases the *Actual rate of return*, reducing the *Difference between desired and actual rate of return* (i.e. taking you closer to your goal), which in turn reduces the *Effort*. The same or less *Harvest* is required to meet the *Desired rate of return*.

Secondly, a reinforcing loop where any *Effort* expended puts downward pressure on the *Yield per unit capital*, thus reducing *Actual rate of return*, increasing the *Difference between desired and actual rate of return* (i.e. You are less likely to make your *Desired rate of return*), thus reinforcing more *Effort*.

Both of these loops operate at once as shown in Figure 25. That which is operating more strongly will dominate the resulting behaviour in *Effort*.

Figure 25. Influences on Harvest - Effort, Catch per unit effort and Profit.

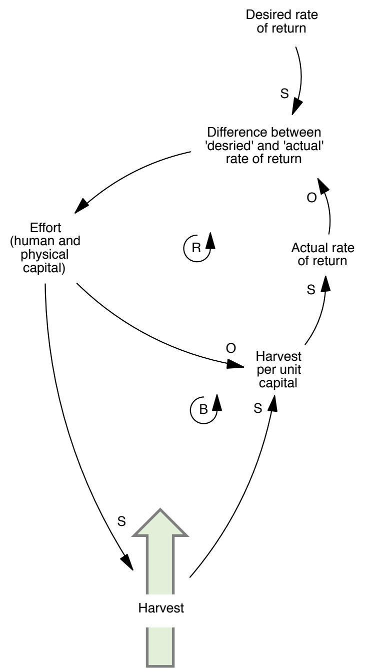
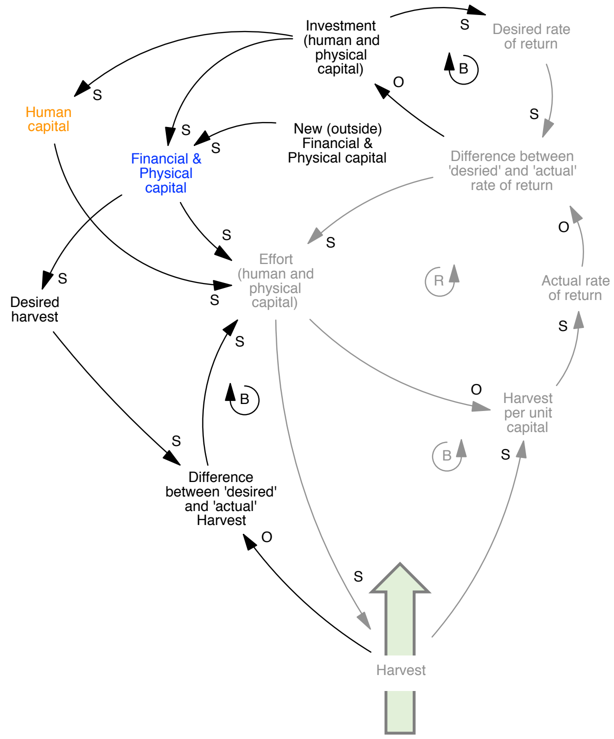


Figure 26. The impact of a Desired Harvest and investment on Physical and Human capital



Similarly, any additional investment in *Physical capital* will likely result in an increase in *Desired rate of return* (to pay for the investment) (Figure 26). In turn this increases the *Difference* requiring a greater *Actual rate of return* to be made to meet the *Desired rate of return*.

Additional *Physical and Human capital* increase the *Effort* expended on farming and increases the *Desired harvest*. This also creates a greater *Difference between the desired and actual* *harvest*, which also puts upward pressure on the *Effort*, in order to further increase the *Harvest*.

This pressure on *Harvest* puts pressure on the underlying *Farmed fish stocks*. All things being equal, the *Farmed fish stocks* will have to increase to meet demand, or the *Desired rate of return* will have to remain at a relative constant – to avoid pressure on the underlying *Farmed fish stock*.

Another similarity between the wild and farmed fisheries is the reliance of *Market valuation* and *Price* on the quantity and quality of the *fish stocks*. With Farmed fish, given the greater awareness of the potential impacts of farming on *Ocean health*, the quality of the *Ocean health* can also be an indirect influencer on *Market valuation* and *Price* (Figure 27).

The influences and relationships described so far are effectively the same as in the Wild fishery. One way that the two fishery systems differ is in the differing impacts on the main fish stocks.

Figure 27. The connection between Fish stocks, Market valuation, Price and Profit

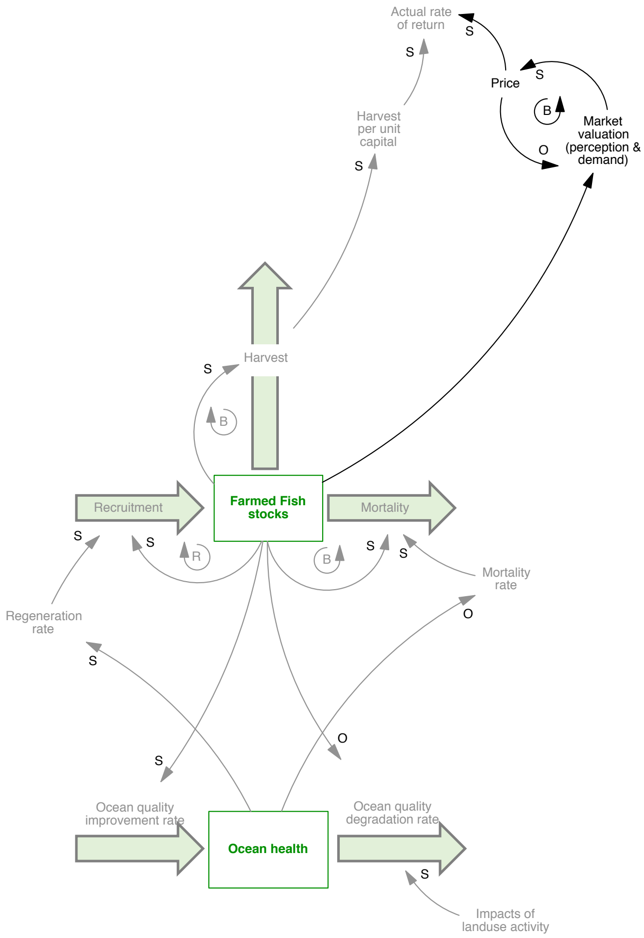


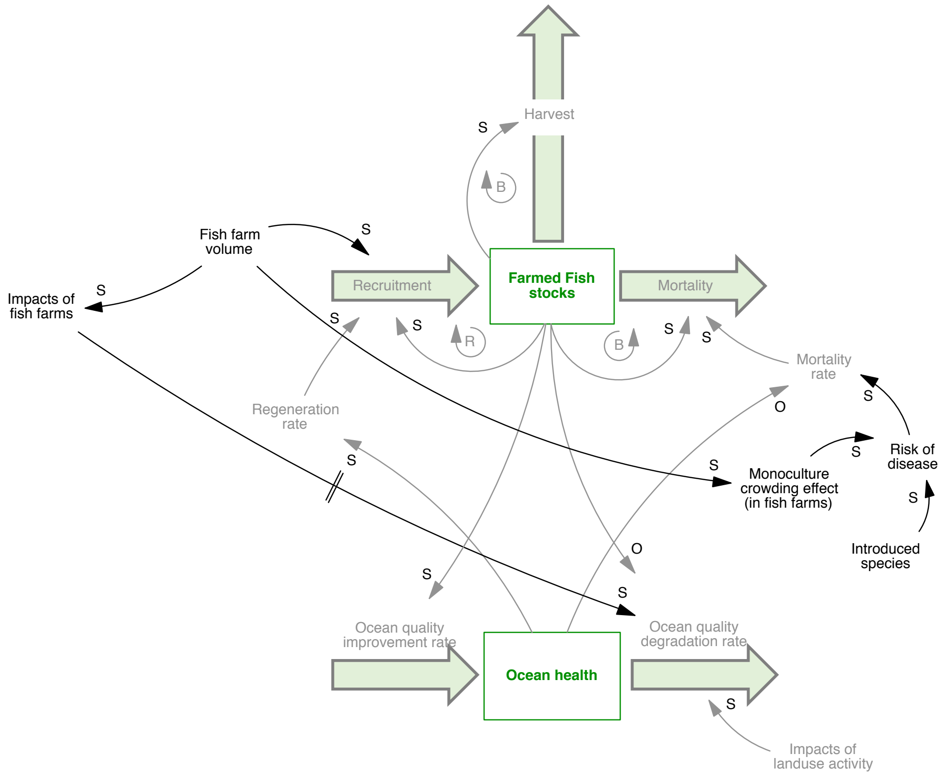
Figure 28 (below) shows how the *Recruitment* of *Farmed fish* is impacted by the Fish farm volume itself.

Thus, the actual *Recruitment* number becomes a function of not just the population size and the *Regeneration rate*, but also the size of the available space for the fish to live in (the carrying capacity of the farm environment).

Any increase in *Fish farm volume* will also increase the *Impacts of fish farms*, which over time is likely to increase the Ocean quality degradation rate, thus reducing the supporting quality of the supporting *Ocean health* and impacting on the *Regeneration rate*.

Any increase in *Fish farm volume* will also increase the *Monoculture crowding effect (in fish farms)*. In turn this will increase the *Risk of disease* which will also increase the *Mortality rate*. An increase in *Introduced species* can also increase the *Risk of disease* (and therefore *Mortality*).

Figure 28. Impacts on Farmed fish stocks



In the Wild fishery, mechanisms for regulating the catch and Improving fish stocks have been established (see Figure 18). This is different to Farmed fish, where there is no quota system. Instead, as the fish are raised in a controlled environment, the size of the *Farmed fish stock* is limited by the rate at which *Recruitment* can proceed, which is primarily controlled via the *Fish farm volume*. The structure of relationships that influence this is shown in Figure 29 (below).

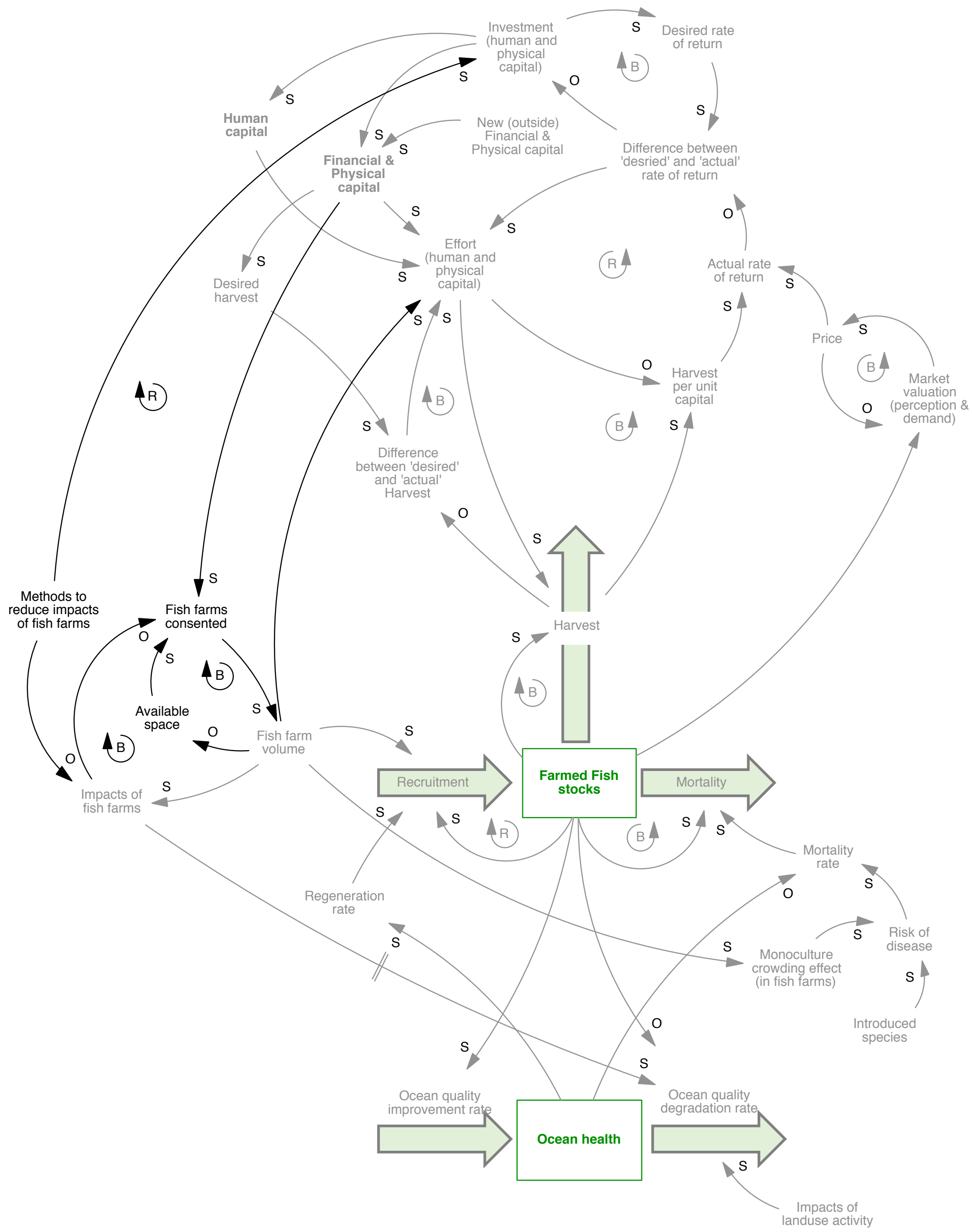
Primarily, the amount of *Fish farms consented* is influenced by the amount of *Financial & Physical Capital* invested, which increases *Fish farm volume (other factors influencing this are considered in the following paragraph)*, which in turn has an impact on the *Effort* put in. This means that these factors are then linked to the reinforcing and balancing loops that exist via the pathways of the *rate of return* and *investment* discussed earlier. More fish farms can be established, if consent is provided. The *reinforcing* loop is likely to dominate (therefore increasing fish farms) so long as *Harvest* continues to be stronger than *Effort*. If increases in *Effort* do not lead to increases in Harvest, then the *balancing* loop is likely to dominate, reducing or cancelling out further investment in consenting of Fish Farms.

At a synthesised level, in addition to these loops involving *Financial & physical capital*, the extent to which fish farms are consented depends on the amount of *Available space* and the *Impacts of fish farms*.

Physical space is finite, so a continued increase in *Fish farm volume* will eventually mean that there is no more *Available space* (a balancing loop). All other things being equal, any increase in *Fish farm volume* will also increase the *Impacts of fish farms*, thus reducing the likelihood of consent (another balancing loop). However, the strength of this balancing loop could be alleviated by investing in *Methods to reduce the impacts of fish farms*. Yet, any effort here will also increase the amount of *Investment*, which will in turn puts more pressure on *Desired rate of return* and the *Effort* put into *Harvest*, so any gains may be short lived.

It is also important to note that the *Impacts of fish farms* may also increase *Ocean degradation*. While this may be a slow operating effect, in the long-term this may lead to a decrease in *Recruitment* and an increase in *Mortality* of the primary fish stock. This may have the counter-intuitive impact of decreasing the *Farmed fish stock* in the long-term.

Figure 29. mechanisms for regulating the catch and Improving fish stocks

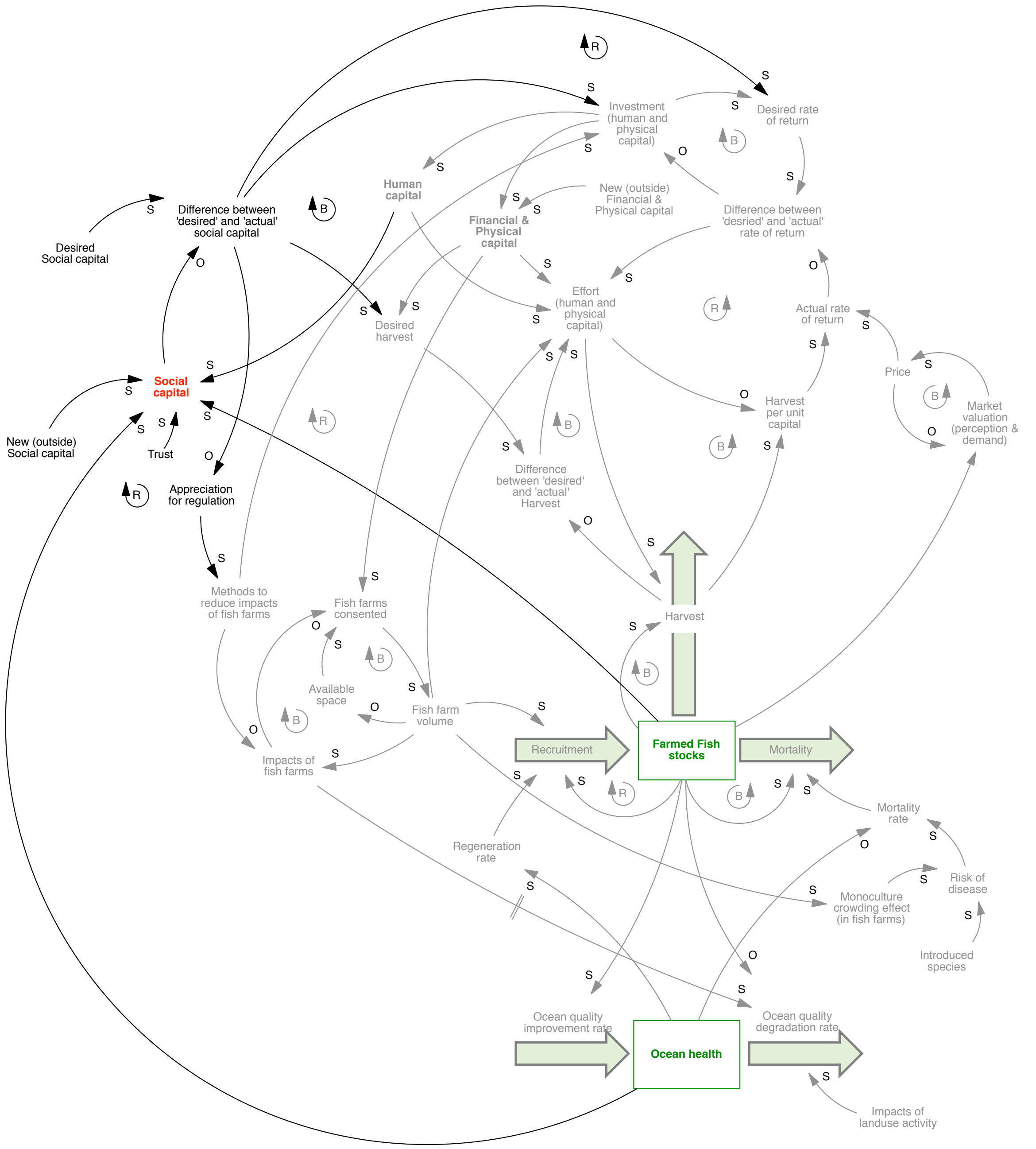


The final figure shows how *Social capital* connects with the wider system. Much like the Wild Fishery example, the main exogenous influences on *Social capital* are potential *New (outside) social capital* and *Trust*.

The same goal/gap structure also operates, where the difference between the desired and actual level of social capital will drive influences and activities that will generate more social capital in the longer-term. Reinforcing loops will become weaker as the desired level of social capital is reached. The exception of human capital operating in a balancing loop remains (see Wild Fishery section for explanation).

Social capital tends to influence social factors such as the *Desired rate of return*, *Investment* and societies *Appreciation for regulation*. In turn it is influenced by *Natural* and *Human capitals*.

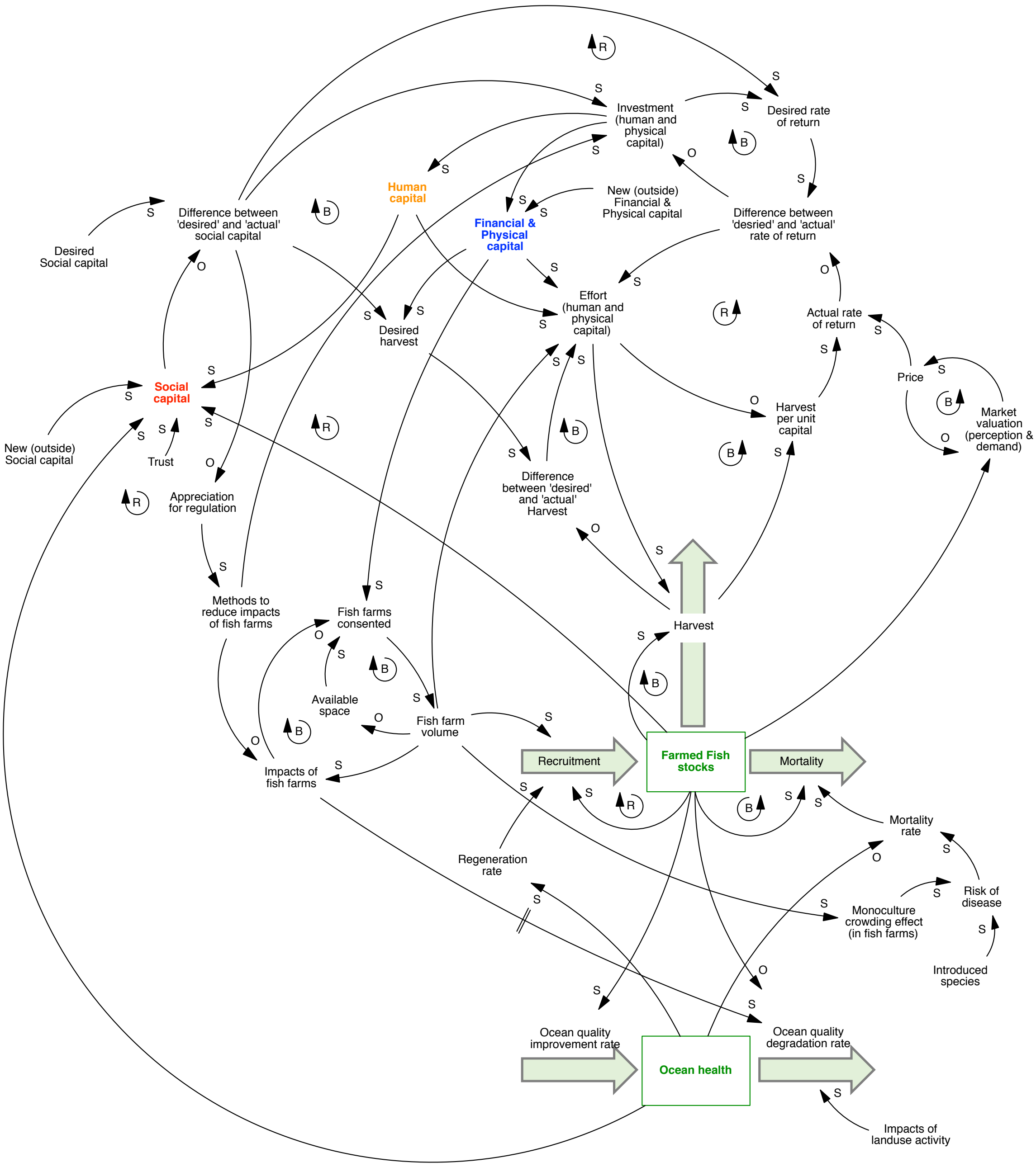
Figure 30. The impact on and impact of, Social capital (Farmed fish)



9.2.2 Farmed fishery – complete map

The above section described a Farmed fishery system in parts. The complete map for a Farmed fishery is shown below, in Figure 31.

Figure 31. Farmed fishery – complete map



9.3 Eco-tourism system map

This section describes an eco-tourism system map. Eco-tourism in this context refers to low-to-no impact tourism activities that utilise marine natural capital.

9.3.1 Eco-tourism – components

This section outlines the main components of the eco-tourism system map.

Like the two fishery systems, eco-tourism depends primarily on stocks of natural capital. In this case these are more than just fish, so they are represented in the system map as *'Product' natural capital* and the *Quality of 'Supporting' and 'Landscape' natural capital*. These two types of capital respectively represent the broad categories of consumptive and non-consumptive resource use by tourists.

'Product' natural capital represents the consumption of natural capital as a product, even though the capital is renewable. This means that this capital is then not available for other tourists to use. For example, if a tourist catches (and keeps) a fish or hunts an animal, that fish or animal is no longer available for another tourist to catch or hunt. Similarly, if a tourist buys local produce (like drink or food), then this drink or food is no longer available to other tourists.

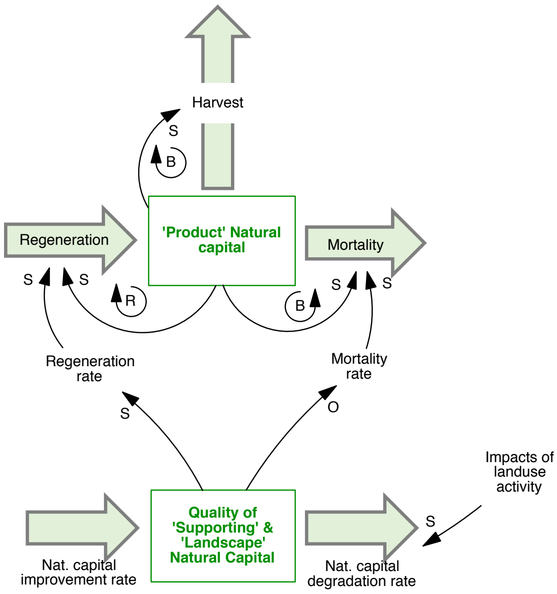
'Supporting' or 'Landscape' natural capital on the other hand, represents the stock of natural capital that either: supports the *'Product' natural capital* because this depends on it – like fish stocks depend on ocean health; or people visit New Zealand to experience – the landscapes and scenery that are distinctly New Zealand and are not able to be taken home by tourists (except as memories or photographs). Often these two capitals are the same thing, but not always. Any one tourist's use of this capital does not directly diminish another tourist's ability to use that capital. For example: views of an alpine landscape can be enjoyed by many without diminishing others ability to view it; people kayaking on the ocean or whale-watching does not diminish other tourist's ability to do the same activity, as the natural capital itself is not diminished.

Having said that, high numbers of tourists may mean there is a crowding effect that would impact on any one individual's *enjoyment* of that capital. This is dealt with elsewhere later on, with a *Crowding effect* variable (see Figure 33).

Tourist activities utilise either *'Supporting' or 'Landscape' capital* only, or a combination of *'Supporting' or 'Landscape'* and *'Product' capital*. Hiking, whale-watching and scenic flights are all examples that use *'Supporting' or 'Landscape' capital* only. A fishing charter or hunting trip on the other hand, draws on both – by providing an *experience* in the environment (non-consumptive – *'Landscape' capital)*, while also seeking to catch fish or animals to take home (consumptive – *'Product' capital*).

For the purposes of this report, activities that are based ONLY on 'Product' capital have not been considered. This is because the harvesting of 'Product' capital is broadly that activity described in the operation of an export market or activity. Both the Wild and Farmed fisheries are examples of these – where much of the product will be consumed offshore, without the associated *experience* of being in the country as well.[4]

Figure 32. Eco-tourism: The basic structure of 'Product' natural capital based on 'Supporting' or 'Landscape' natural capital



Consequently, both of these capitals form the basis of this system map. The *Quality of 'Supporting' and 'Landscape' natural capital* is shown as supporting *'Product' Natural capital* (see Figure 32).

As demonstrated in the two fishery system maps, *'Product' natural capital* usually involves the harvesting of some kind of live product (either plant or animal). So, this stock has a reinforcing loop from the amount of capital to the *Regeneration*[5] of that capital; as well as balancing loops from the amount of capital to both the *Mortality* and *Harvest* of the capital.

The general connections from *'Supporting'* to *"Product' natural capital* is via its impact on the regeneration and mortality. The greater the *Quality the 'Supporting' capital,* the greater the *Regeneration rate* and the lower the *Mortality rate*. The opposite would be true if the *Quality of 'Supporting' capital* was to drop.

One other direct way that *'Supporting' natural capital* may decline is through an increase in the degradation rate, which may be impacted by landuse activity.

Having established these two capital stocks as the primary stocks in the eco-tourism industry, how they interact with both *Consumptive* and *Experiential (non-consumptive) tourism* is now explained (and shown in Figure 33).

Tourism delivered refers to a unitless concept that is the result of the *# tourists*, their *Average visit length* and their *Average spend*. This portrays that the amount of *Tourism delivered* can be influenced by any combination of these three factors. If *# tourists* were limited, the level of

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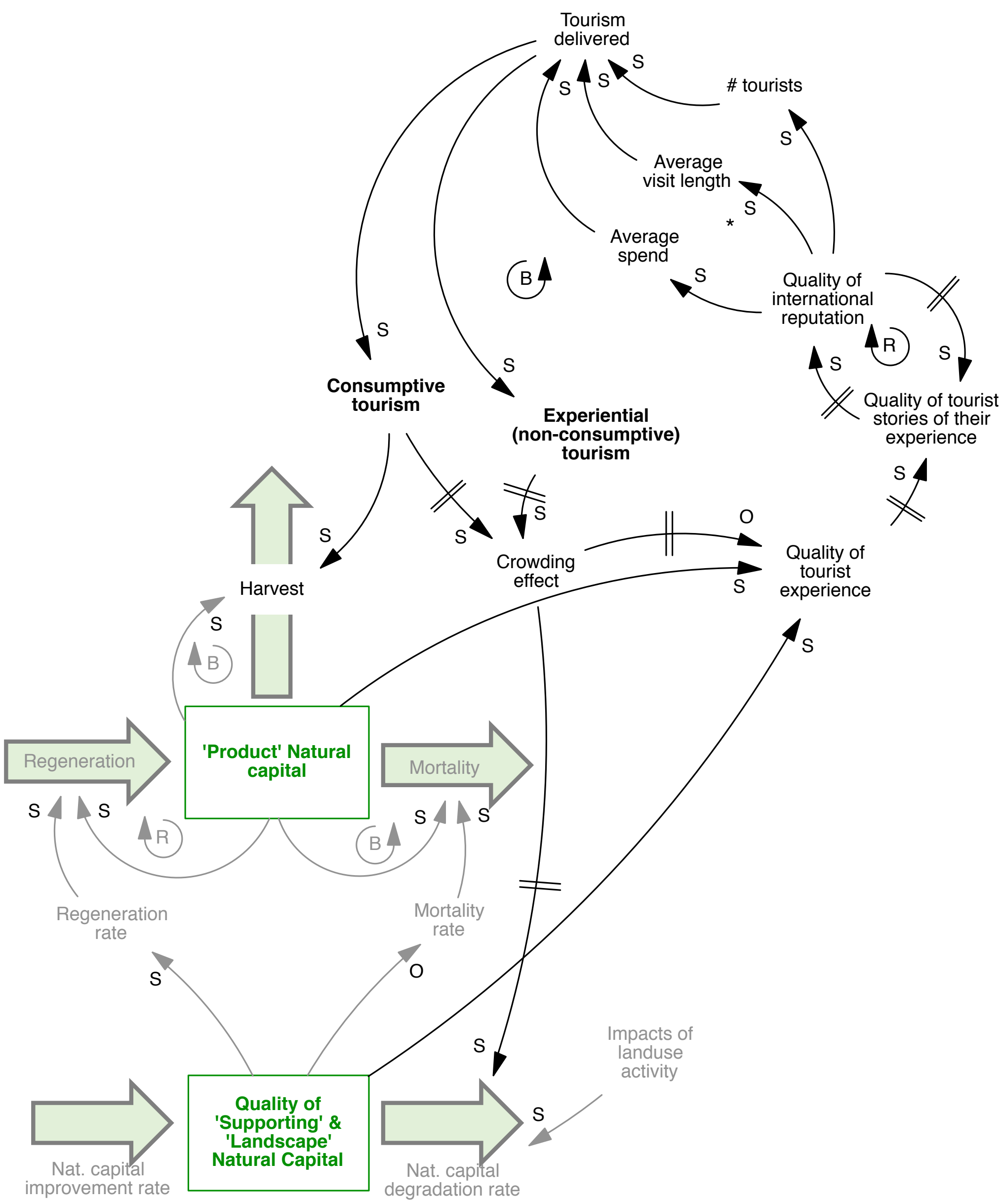
[4] It is noted that the multiple service industries that support tourists in New Zealand are excluded here. Examples include things like supermarkets selling food, mobile phone operators selling SIM cards, and transport companies providing transport. For simplicity these supporting industries have not been included, although their very real and necessary existence and contribution to the economy is noted.
[5] In the fisheries examples the term *Recruitment* was used to describe the regeneration of fish stocks as this is commonplace in ecology. In this map the term *Regeneration* is used in order to apply to a broader range of marine fauna.

Tourism delivered could be maintained if the *Average spend* or *Average trip length* were increased.

It has already been noted that, while *Consumptive* and *Experiential (non-consumptive) tourism* are separate types of tourism, they are often both contained in the same tourism experience. Therefore, they are represented in the map as two separate nodes, both of which are influenced by the amount of *Tourism delivered*. An increase in the amount of Tourism delivered could lead to an increase in either or both types of tourism.

Figure 33. The relationship of Consumptive and Non-consumptive (Experiential) tourism with 'Product' and 'Supporting' & 'Landscape' natural capital



Only *Consumptive tourism* interacts with *'Product' natural capital*, through the amount that it takes via *Harvest*. All other things remaining equal, an increase in the *Harvest* will lead to a decline in the level of *'Product' Natural capital*.

The volume of both types of tourism have an impact on the *Crowding effect* experienced by tourists. With low *Tourism delivered* there would not be expected to be a *Crowding effect*. Yet if the amount of *Tourism delivered* grew to such an extent that crowding was an issue, then this would (over time, hence the delay mark) be expected to have an opposite impact on the *Quality of the tourist experience* (reducing it).

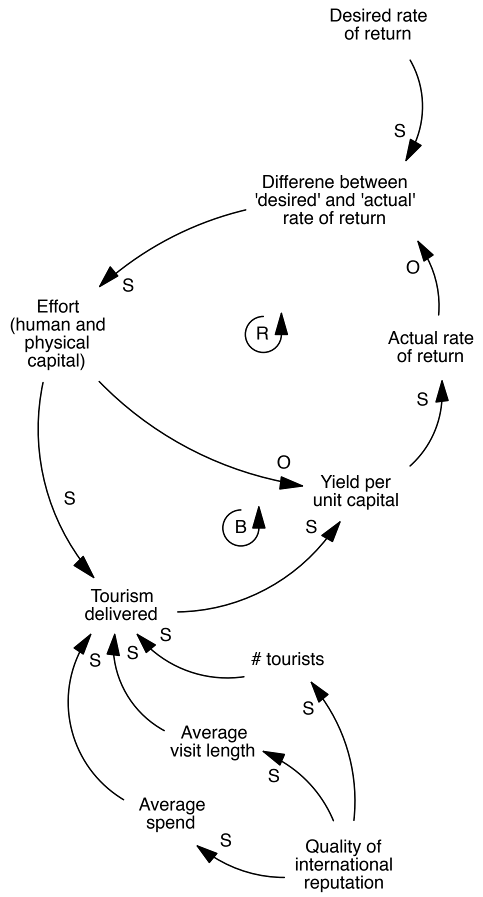
There is also a delayed influence from the *Crowding effect* to the *Natural capital degradation rate*. This is to account for the potential impact that large numbers of tourists may have on the integrity of *'Supporting' & 'Landscape' Natural capital* itself. If tourist numbers are not managed, even though the capital is not consumed, the quality of it may be eroded. For example: over-used or eroded hiking trails; people-shy or overly protective marine animals.

The *Quality of the tourist experience* is also impacted by the two main natural capital stocks. Effectively the tourism experience is driven by the quality of the place/activity people are visiting AND how many other people are there at the same time.

The *Quality of the tourist experience* is the primary driver of the *Quality of tourist stories of their experience*. This is a variable that captures the quality of word of mouth referrals from tourists who *have* visited, to other tourists who *may* visit. This *Quality of tourist stories of their experience* operates in a **reinforcing loop** with the *Quality of international reputation (with a delay in both directions)*. This captures the phenomena where direct experience (word of mouth) will take time to impact on reputation, and that reputation may also have a delayed impact on the *Quality of the tourist stories of their experience*. In effect, the quality of a tourist's story may be, in part, impacted by their perception of the reputation before they arrived.

The *Quality of the international reputation* completes multiple **balancing loops** – via the two types of tourism and also the # *tourists*, *average trip length* and *average spend* – back to the amount of *Tourism delivered*. An excess of *tourism* may increase the *Crowding effect*; potentially impact the stocks of *'Product' Natural capital*; and may even harm the *'Supporting' or 'Landscape' Natural capital*. This would impact the locations *International reputation* and eventually lead to a decline in all or any of the # *tourists*, *average spend* and *average trip length*. If this happened, it would take consumptive pressure off *'Product' Natural capital* stocks, allowing them some ability to recover if they were low.

Figure 34. Effort, Tourism delivered, Yield per unit capita and Rate of return



Having described the two types of tourism and how they relate to the Natural Capitals, the relationship between Effort, Tourism delivered, Yield per unit capita, Rate of return is described (Figure 34).

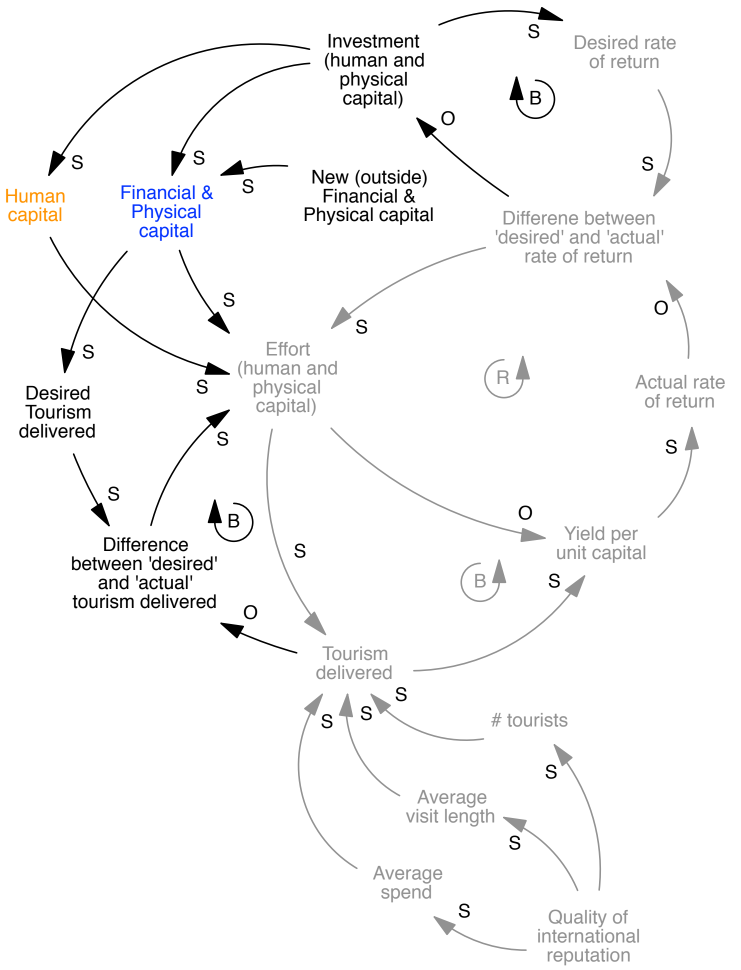
In this system, *Tourism delivered* is the same as *Catch* or *Harvest* in the previous fisheries examples. Therefore, the relationship between *Effort*, *Tourism delivered*, *Yield per unit capital* and the *Rate of return* is the same as in these previous examples.

Again, there are two loops operating here: More *Effort*, leading to more *Tourism delivered*, greater *Yield* and a greater *Rate of return*, will mean that the *Desired rate of return* is being met, which will **balance out** the amount of *Effort* required.

Yet at the same time, Greater Effort also *reduces* the *Yield per unit capital*, meaning that there may be a greater difference between *Desired* and *Actual rates of return*. This will **reinforce** the need for greater *Effort*. The strength of either loop at any one time will determine which dominates.

As per previous examples, these loops are now be expanded to include the impact of a level of *Desired tourism delivered* and the pressures of investment in both *Physical and Human capital* (Figure 35).

Figure 35. The impact of Desired Tourism delivered and investment on Physical and Human capital



There is the (now familiar) balancing loop between *Difference between desired and actual rate of return*, *Investment*, and *Desired rate of return*. The closer *Actual rate of return* is to the *Desired rate of return*, then the lower the *Difference* (the discrepancy between the two). The lower the *Difference* (i.e. the closer to the desired profit a business is, then the greater the likelihood of *Investment in Human and Physical capital*. This could take the form of new plant, capital or new staff.

Yet again the greater the *Investment in capital*, then the greater the *Desired rate of return* will be in order to pay for this investment. In turn this increases the *Difference* which is likely to take the pressure of the desire for further investment, until that gap is closed.

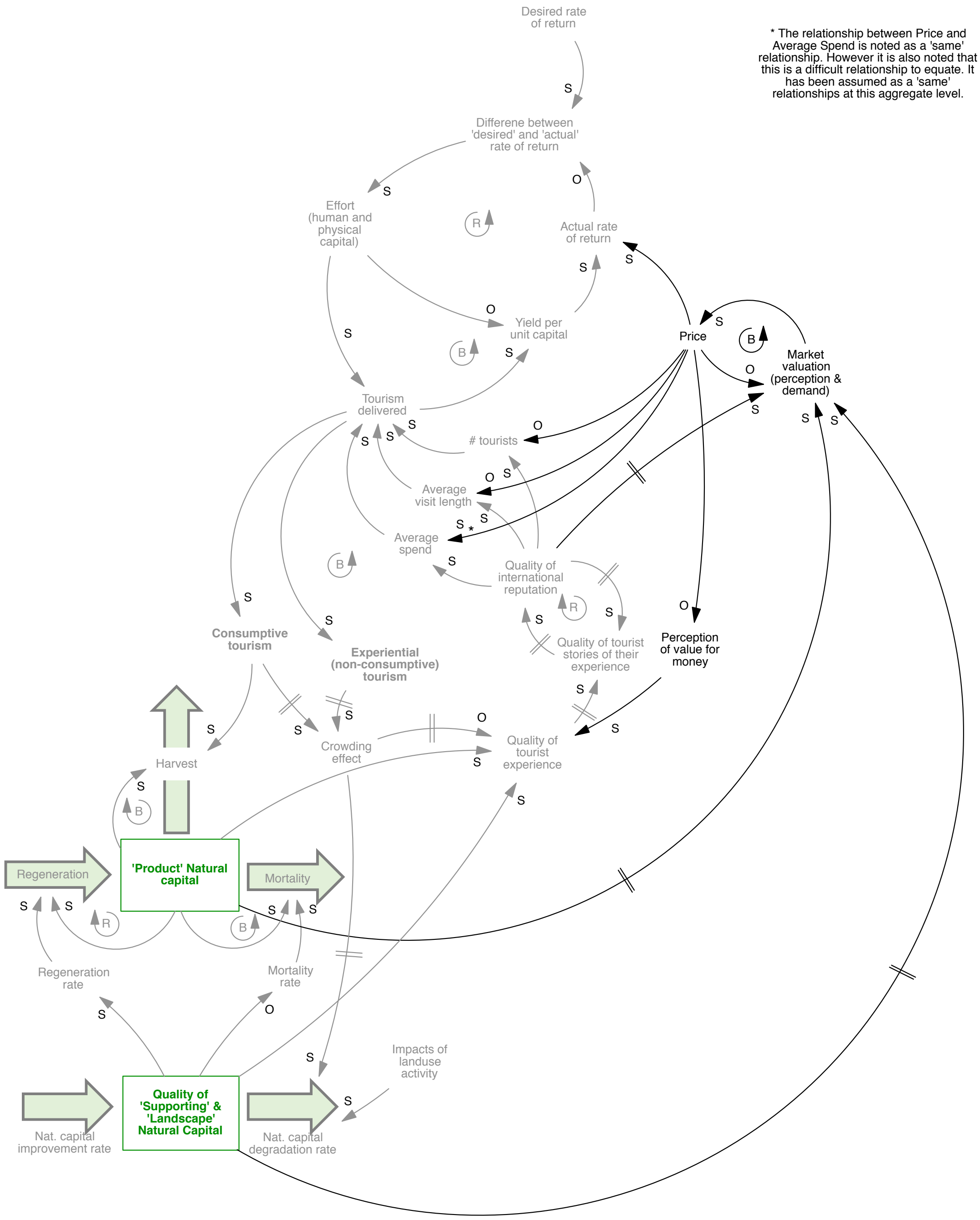
Investment could increase either or both *Human capital* and *Financial and physical capital*. The greater these capitals the greater the *Effort*. This influence will flow on into the balancing and reinforcing loops described earlier in Figure 34.

As in the other examples, an increase in *Financial and physical capital* in particular will drive an increase in *Desired tourism delivered,* as a way to increase the *Rate of return* in order to pay for the investment. However, an increase in *Desired tourism delivered* creates another goal/gap structure with *Tourism delivered* and the *Difference* between the two.

Again, this is another balancing loop that influences the tourism *Effort*. Any increase in *Desired tourism* leads to a greater *Difference* which drives greater *Effort*, which increases the *Tourism delivered* which reduces the *Difference* (all other things being equal).

In Eco-tourism, the relationships between the *Tourism experience*, *Market valuation*, *Price* and *Rate of return* is a little more complicated than the fisheries examples.

Figure 36. The relationship between Tourism experience, Reputation, Price and Rate of return



Primarily this is because *Price* is not just an input into the *Rate of return* as it has been represented in the fisheries systems. Here it also has an opposite impact (if *Price* goes up the others go down) on both the *# tourists*; the *Average visit length*; and the *Perception of value for money,* which has a direct impact on the *Quality of tourist experience*. These opposite impacts on both *# tourists, Average visit length* and *Quality of tourist experience* are fairly immediate. Over time, a decline in *Quality of tourist experience* would be expected to translate into a decline in the *Quality of tourist stories*, which in turn will turn lead to a decline in *Quality of international reputation*.

The relationship between *Price* and *Average spend* is complicated and is represented here as a same relationship (an asterisk (*) in the map) – i.e. if *Price* goes up then *Average spend* goes up, and vice versa. This is because the type of tourist that the *Price* attracts is assumed to change. Therefore, as prices increase (and tourist numbers and average stay decrease) the type of tourist attracted is willing to spend more money. This reflects a particular assumption about price elasticities of demand in tourism. This is a particular section of the system map that could be expanded or explored in more detail in potential future research.

Quality of international reputation is one of the three things outlined in the system map that impact *Market valuation (perception & demand)*. If reputation was to decline then it would be expected that, over time, this would also present as a decline in *Market valuation*. Valuation is also directly influenced by the quality of the two natural capital stocks – if either of these were to decline this would also present as a decline in *Market valuation*.

The delays in these influences are important as this highlights that they take time to present.

In one sense, such delays could be viewed as beneficial. For example if reputation or natural capital declined this may not *immediately* impact *Market valuation*, as word takes time to spread and *Market valuation* may not decline until a larger number of people share the same stories.

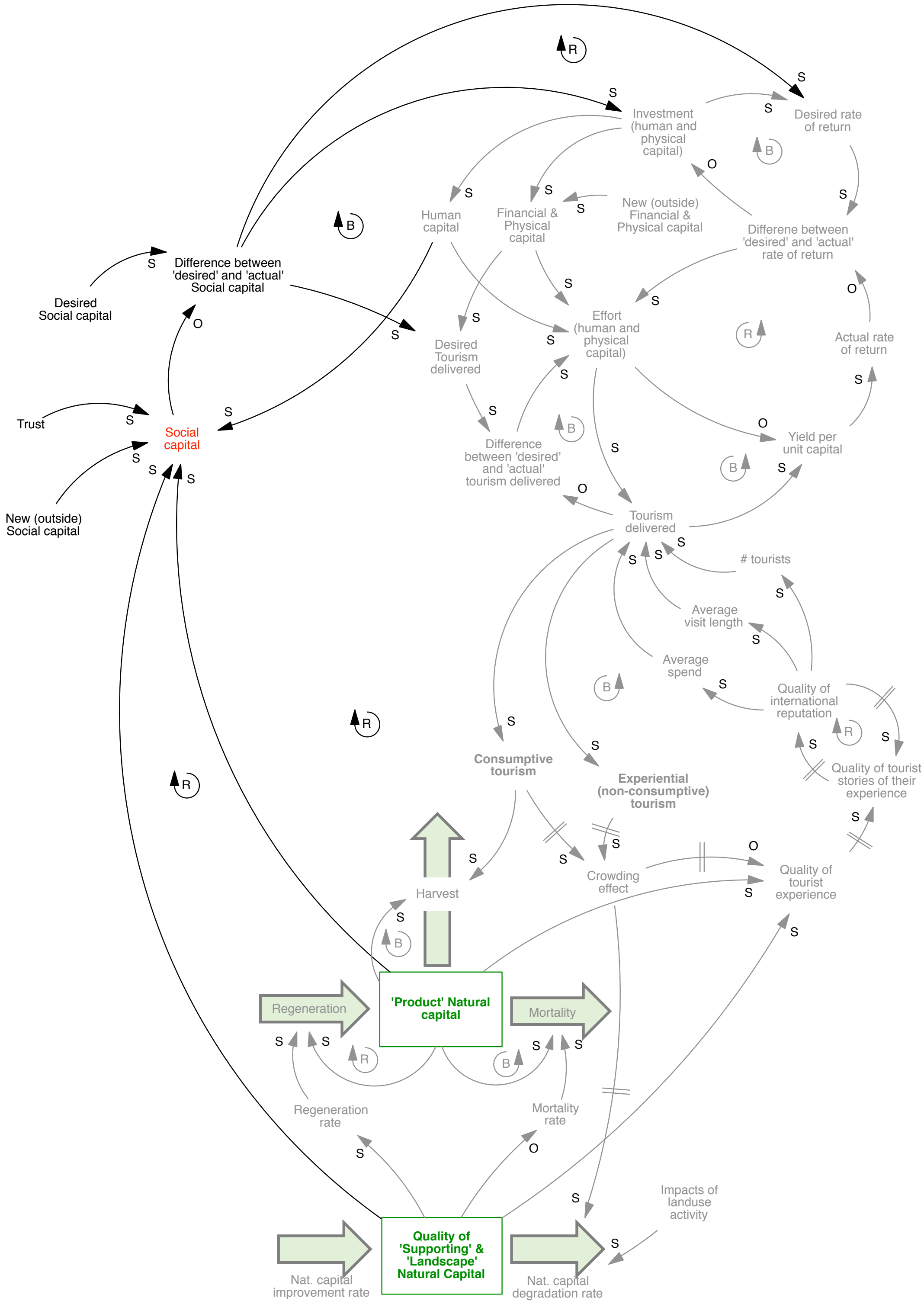
Yet a cautionary principle should be taken here, for the opposite is also true. If *Market valuation* was low and action was taken to increase natural capital and the *quality of the tourist experience*, this change in reputation would also take time to manifest and would require a larger number of people to share similar stories in order to improve *market valuation*. In fact, it may possibly even take longer as there may be a longer delay involved in a low reputation being reversed into an improved one, as opposed to the time required for a good reputation to be tainted or eroded.

The final loops added to this system map are those based around *Social capital*, the final of the capitals in the Living Standards Framework. How these are connected is outlined in Figure 37. The dynamics of these relationships remain the same as explained at the end of section 9.1.1 (see pages 10-11).

This does not suggest that there is some kind of utopian state for social capital – rather it simply infers that healthy social capital is likely to improve up to some relatively appropriate level. This appropriate level is unlikely to increase without limit.

Social capital is again represented here as a 'goal/gap' structure. Endogenously, those things that directly influence *Social capital* are *Human capital* and the two *Natural capitals*. New social capital may be introduced from 'outside', from the influences of social norms adopted from elsewhere, possibly as a result of immigration or maybe from interaction of this society with other societies (domestically or internationally). The 'goal' part of the 'goal/gap' structure is *Desired Social capital*, and the 'gap' is the *Difference between 'desired' and 'actual' Social capital*. If this difference is low then the actual level is near the desired level, so Social capital can be assumed to be near the appropriate or desired amount.

Figure 37. Social capital – Supported by natural and human capital and a major driver of business investment and return



If the level of Social capital is near a desired amount and society is in a satisfied state, then there is less need to increase the *Desired level of tourism*, the *Desired rate or return*, or the level of *Investment (human and physical capital)*.

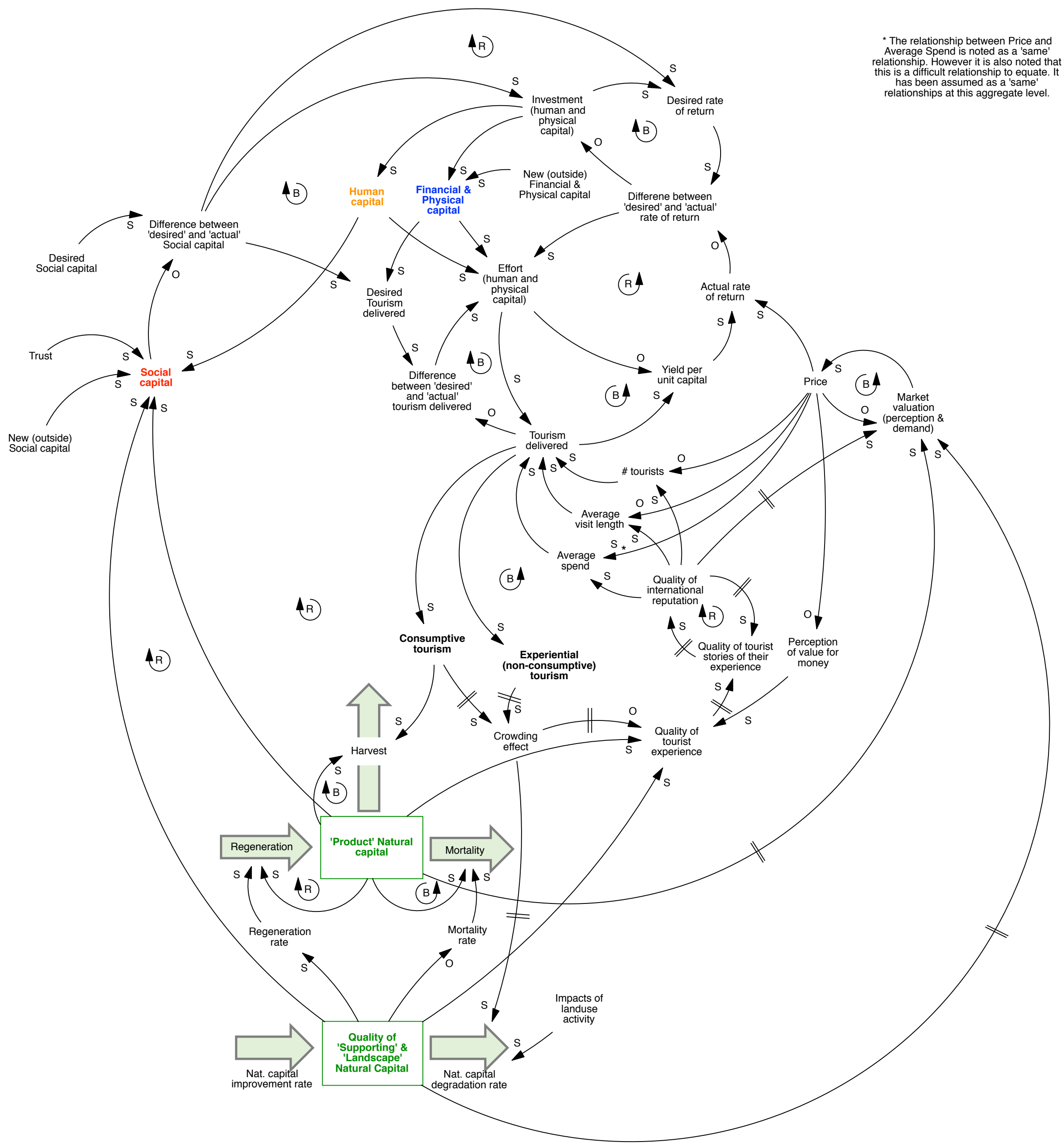
The impacts of this throughout the system are significant, as this relieves pressure to increase tourism and make a return (the upper half of the system map). While these influences only causally flow as far as the level of *Tourism delivered*, the extended interconnections mean that the contribution of average spend, visit length and number of tourists – and their impacts on the natural capitals – are likely to find some form of dynamic equilibrium, where these levels would remain relatively constant over time. This would continue to underpin the level of Social capital that has been achieved.

It is noted that while other pressures may find a form of dynamic equilibrium there is a balancing loop that operates between investment in *Human capital* and the level of *Social capital* realised. Any reduced investment in *Human capital* in turn reduces *Social capital*, in turn increasing the gap and encouraging a greater investment in *Human capital* again. If all other things were considered equal, this balancing loop may still prove to cause some slight fluctuation in the levels of the other activities in the wider system.

9.3.2 Eco-tourism – complete map

The above section described an eco-tourism system in parts. The complete map for an Eco-tourism activity is shown below, in Figure 38.

Figure 38. Eco-tourism – Natural capital focus



10 Potential risks

The previous section described the three system maps. This section outlines generic risks identified to these systems and, based on the system understandings developed, discusses the potential impact of these risks.

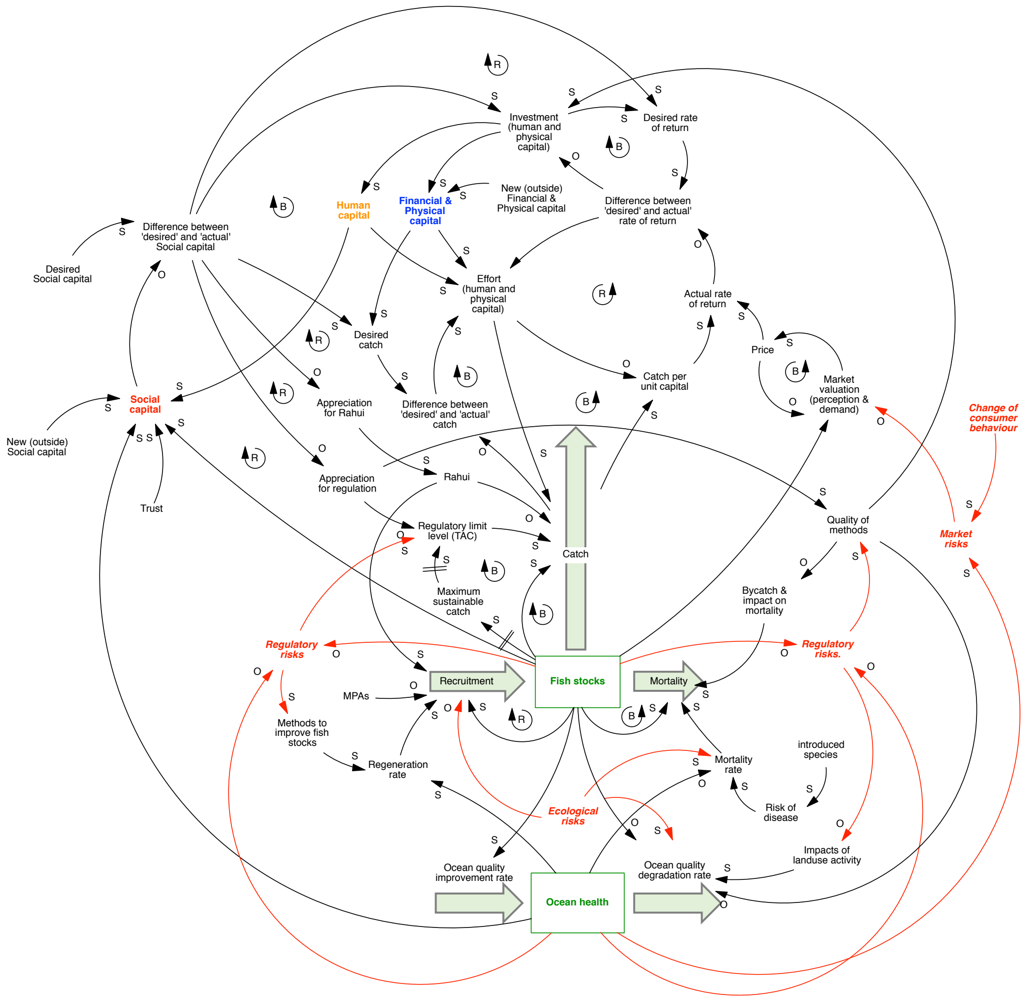
In these maps, risks and their associated influences have been drawn **in red**.

The nature of system maps provides pathways for influences to flow in many ways through a system. Those pathways that have been highlighted in the following maps are considered the likely *main* pathways that the described risks would likely follow. They may not represent the *only* pathways. The validity of these assumptions could be explored further in future research, possibly through validation with expert audiences or simulation modelling, or both.

10.1 Wild fishery – an overview of risks

This section outlines the three main risks that were identified in Assoc. Prof. Nick Lewis' research: Market risks; Regulatory risks; and Ecological risks (shown in red in Figure 39). Each of these are explored in more detail and with visuals on the system map, in the following sections.

Figure 39. Overview of wild fishery risks – Market; Regulatory and Ecological

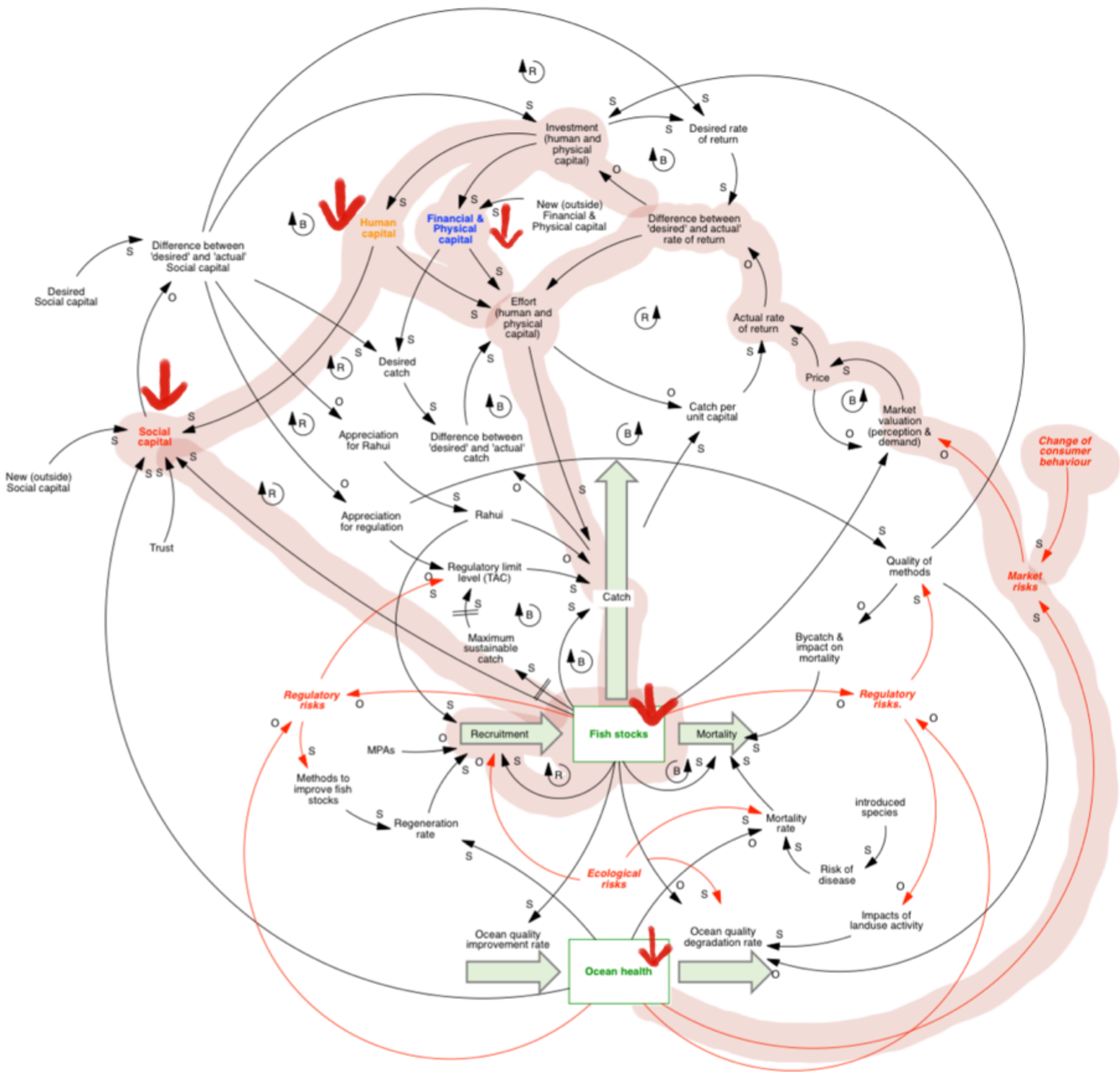


10.1.1 Wild fishery – Market risks

Market risks are risks that may impact on the *Market valuation*. This could occur in various forms, ranging from competition in overseas markets to changes in consumer tastes or expectations. These risks are predominantly exogenous to the Wild fishery itself.

One major risk that is endogenous to the Wild fishery is the impact that the perception of *Ocean Health* may have on consumer demand. Primarily this would be through a decline in *Ocean health*, which itself would likely be a result of human activity that degraded the quality of the ocean (see Figure 40). However, changing social values may also have an impact (for example, an increase in veganism and the associated desire to protect fish themselves), this is considered to be captured in the factor of *change in consumer behaviour*.

Figure 40. Wild fishery – Market risks



These impacts are traced through the map in the above figure.

A decline in ocean health could change the perception of the fishery in the market, or consumer changes may have an impact on market perception and valuation. In turn this would depress the *Rate of return*, increasing the *difference between desired and actual profit*, and reducing the likelihood of investment in *Physical capital* and *Human capital*, both of which are shown with downward arrows. A reduction in *Human capital* will flow on into a reduction in *Social capital*.

At the same time, it is likely that a reduced profit will drive a greater fishing effort to catch more to increase profits. This would put ongoing downward pressure on the *fish stocks* themselves, reducing their size and their ability to regenerate. A reduction in fish stocks would also flow on to a reduction in *Social capital*, as this would likely reduce the level of trust that society has in the commercial operations.

Overall a downward trend across all four capitals would be expected. This would be expected to result in a reduction in *Social licence to operate*.

Table 1. Wild fishery – impact of Market risks on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Market risks	-	↓	↓	↓	↓

10.1.2 Wild fishery – Regulatory risks

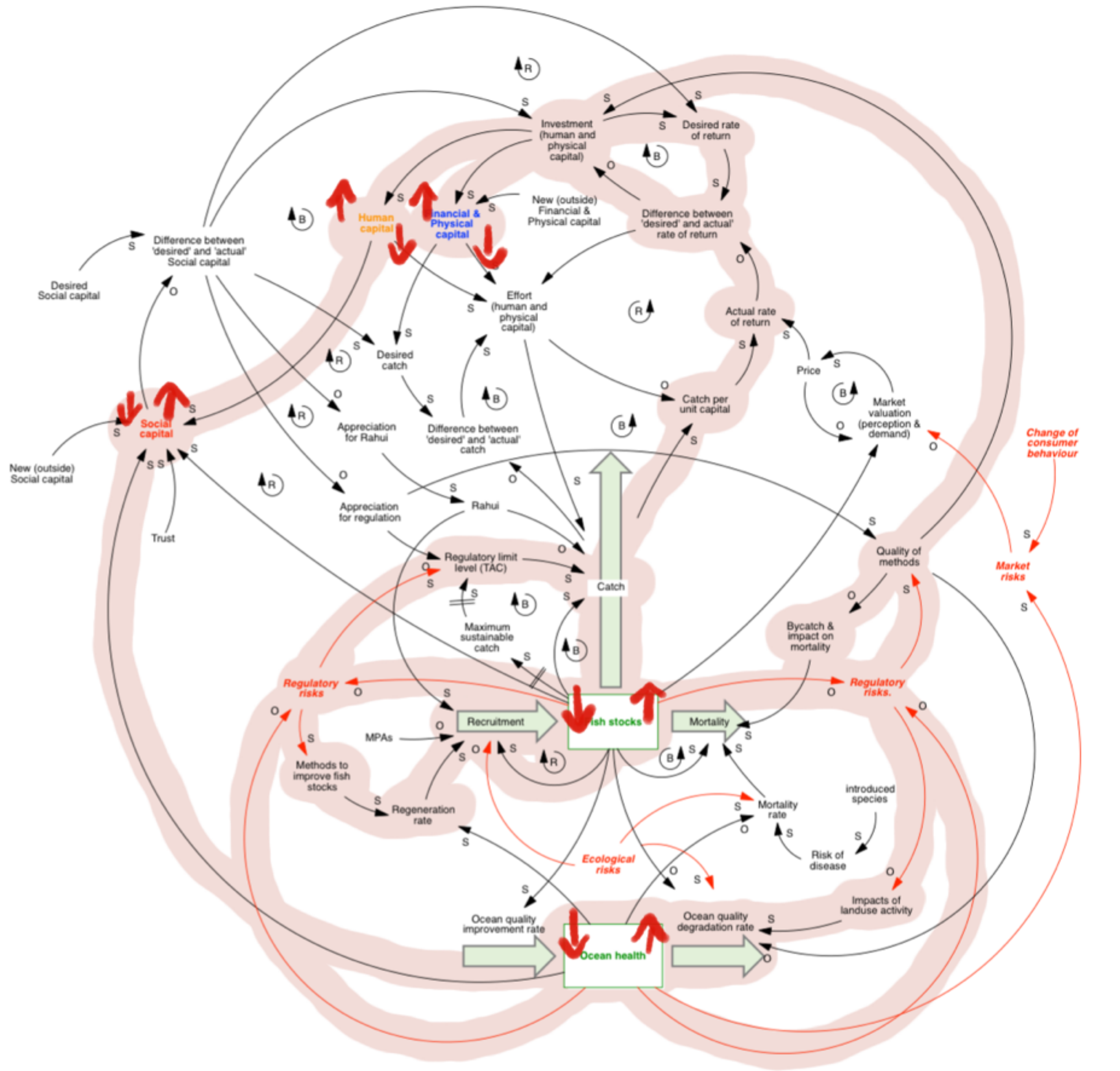
Regulatory risks exist endogenously within the New Zealand legislative context. Primarily these would be driven by the level of *Ocean health* and the *Fish stocks* themselves. If the loops driving *Catch* continued to dominate, resulting in a decline in *Fish stocks*, then it would be likely that this would result in revised legislation or means of *Regulatory limits* or *Methods to improve fish stocks*. It may also result in changes to fishing techniques, which may mandate additional investment in *Physical capital*.

At the same time the reduced catch and diminished fish stocks would reduce the voluntary investment in *Physical capital* and *Human capital*. This means that *Physical capital* would be influenced in both directions. The net change in *Physical capital* would depend on which loop or pathway was dominating. A reduction in *Human capital* would put downward pressure on *Social capital*.

The nature of a decline in *Ocean health* may drive different kinds of regulatory risks. For example, if a decline in Ocean health is the by-product of fishing activity itself, this could result in further regulation of the method of fishing, or some kind of regulatory impact on the effects landuse.

Yet if additional regulatory constraints were put in place to improve either fish stocks of ocean health (or both), then over the much longer term it would be expected is both would begin in improve. While in the much longer term, this would potentially improve the capitals of *Fish stocks* and *Ocean Health*, with flow on effects to *Social capital*.

Figure 41. Wild fishery – Regulatory risks



Overall a downward trend across all four capitals would be expected in the short term. Some increase in *Physical capital* may be experienced, but it would likely be mandated by regulatory requirements. This would have a negative impact on the *Social licence to operate*. In the longer term, however, *Fish stocks* and *Ocean health* would be expected to improve, which would have flow on effects of improved *Social capital*.

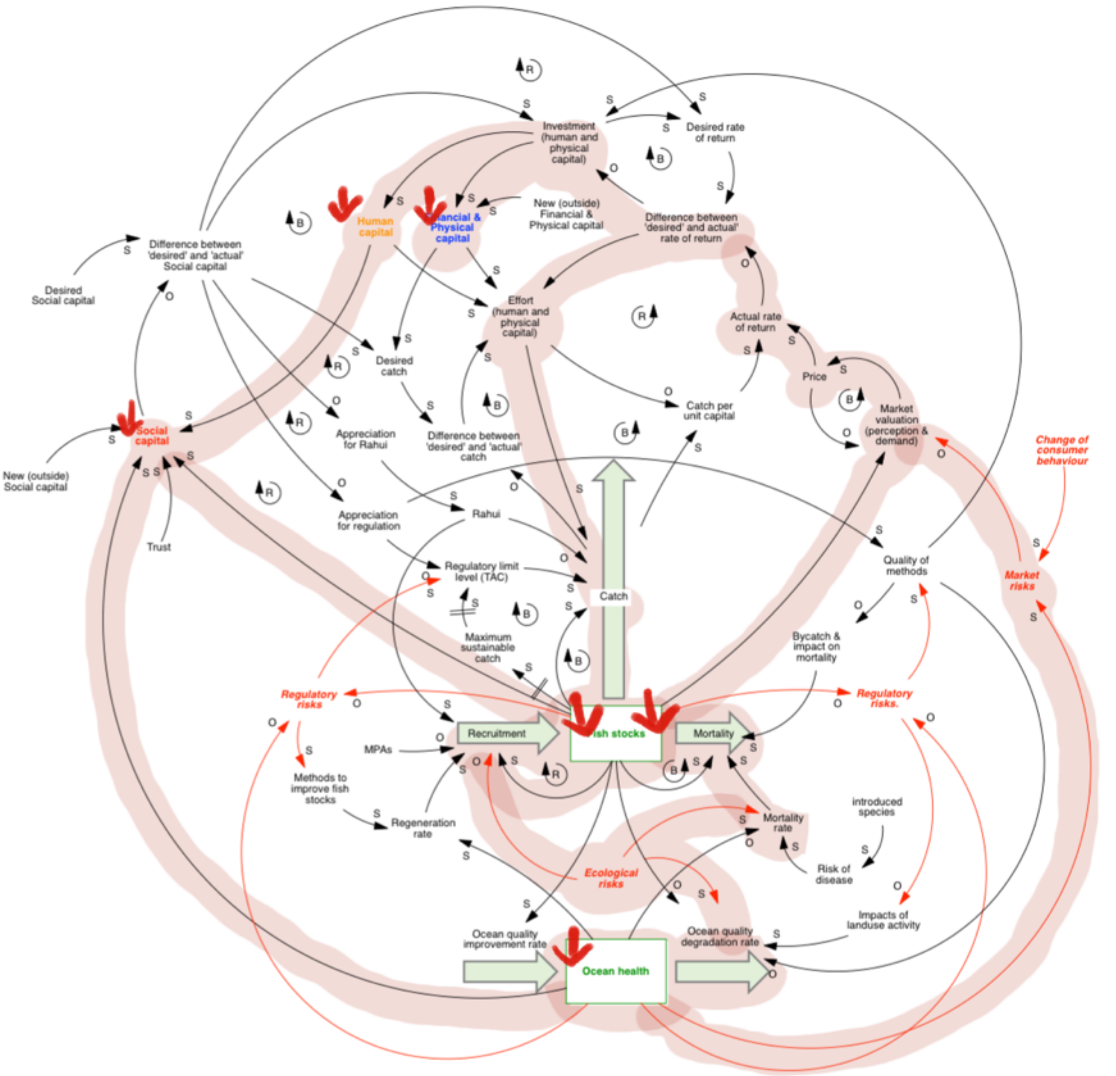
Table 2. Wild fishery – impact of Regulatory risks on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Regulatory risks	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓	↓ (short term) ↑ (long term)	↓ ↑ (both in short to med. term)

10.1.3 Wild fishery – Ecological risks

Ecological risks are the third type of risk and are generally exogenous to the system. Exogenous examples may include changes in oceanic conditions resulting in the reduced prevalence of a fish species in an area, or an entire migration of it from an area. Introduced species may also have an impact on local *Ocean health* or local *Fish stocks*.

Figure 42. Wild fishery – Ecological risks



If ecological risks were to be realised in a fishery, these would flow on to impact the *Market valuation* of the fishery, which would reduce the *Rate of return* and may result in greater fishing *Effort* to try to increase the *Catch* to increase the *Rate of return*. This is likely to reduce *Fish stocks* even further, which will flow on to reduced levels of *Social capital*.

Reduced *Rate of return* would limit further investment in *Physical capital* and *Human capital*. Reduced *Human capital* would flow on to reduced *Social capital*.

Overall a downward trend across all four capitals would be expected in the short and longer term. This would have a negative impact on the *Social licence to operate*.

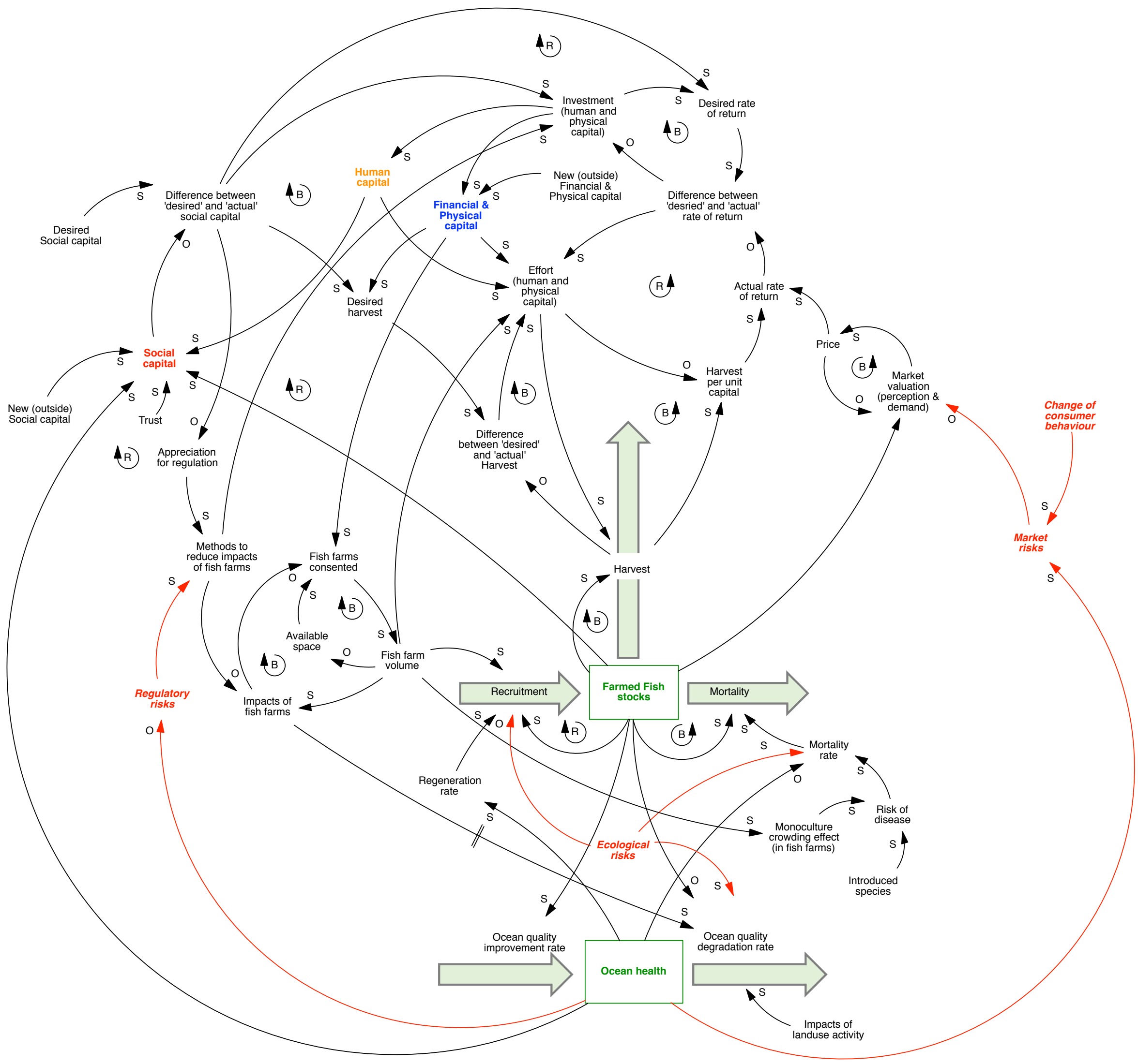
Table 3. Wild fishery – impact of Ecological risks on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Ecological risks	↓	↓	↓	↓	↓

10.2 Farmed fishery – an overview of risks

This section outlines the same three risks types identified in Assoc. Prof. Nick Lewis' earlier research: Market risks; Regulatory risks; and Ecological risks (see Figure 43).

Figure 43. Overview of farmed fishery risks – Market; Regulatory and Ecological

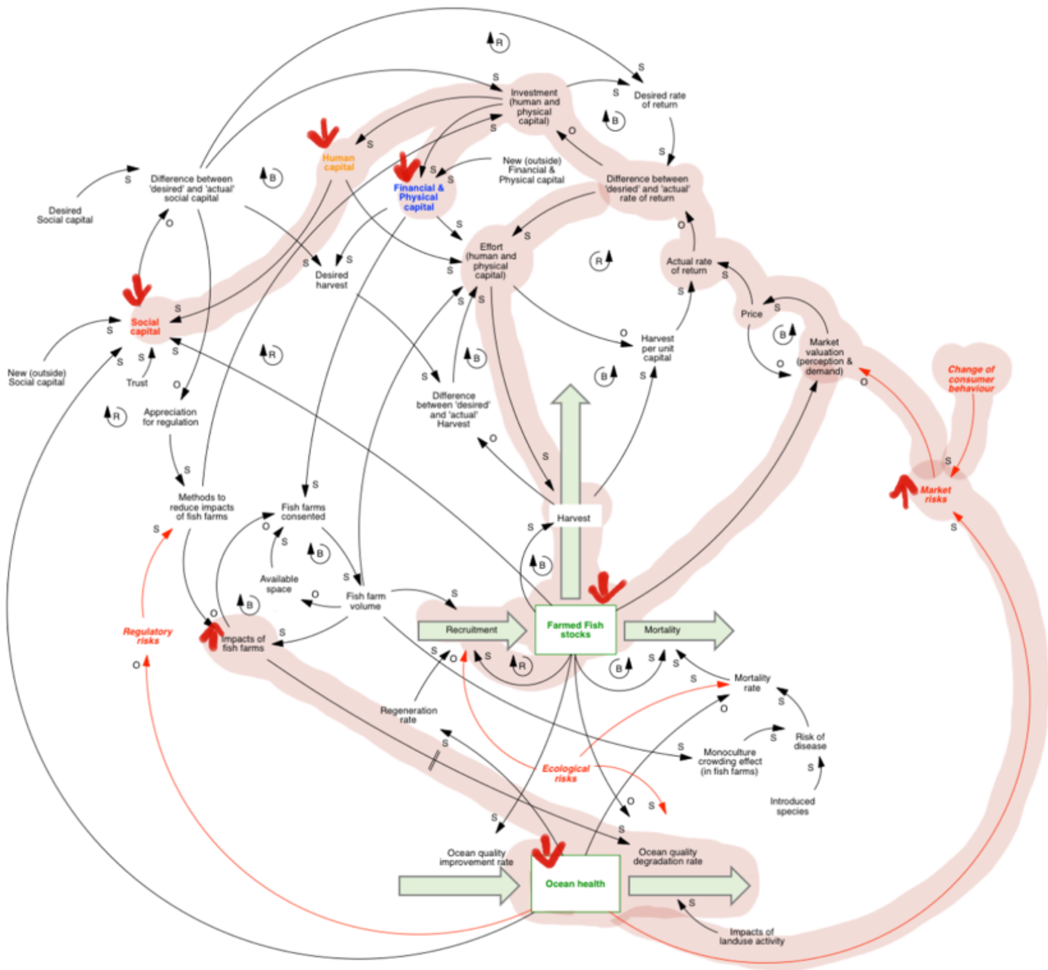


10.2.1 Farmed fishery – Market risks

Market risks are risks that may impact on the *Market valuation*. Again, this could be overseas competition or changes in consumer tastes and are predominantly exogenous. Yet the potential impact that a decline *Ocean Health* (from Fish farming) may have on consumer demand remains an important endogenous risk.

For example (see Figure 44), if ongoing *Impacts of fish farms* led to a decline in *Ocean health*, this would lead to Market risks and a decrease in Market valuation (through perception and possibly demand). This would put downward pressure on *Profit*, increasing the *Profit 'gap'*, in turn this might drive additional *Effort* to generate more *Harvest* which would likely reduce the *Fish stocks*, and may further reduce the *Market valuation* even more. This loss of positive perception in the market leading to a decline in Market valuation could result in a vicious cycle of pressures and activity. This vicious cycle would also put downward pressure on *Social capital*.

Figure 44. Farmed fishery – Market risks



Loss of *Market valuation* and an ongoing *Difference between desired and actual rate of return* would also lead to reduced investment in *Physical capital* and *Human Capital*. Reduced *Human capital* would also flow on to reduced *Social capital*.

Overall, the endogenous market risk of the Impacts of fish farms would be expected to have a negative effect across all of the capitals.

Table 4. Farmed fishery – impact of Market risks on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Market risks	↓	↓	↓	↓	↓

10.2.2 Farmed fishery – Regulatory risks

Given the fish farms already require consent, any *Regulatory risks* to the fisheries are likely to result from a decline in *Ocean health* (as a result of fish farming).

If there were significant *Impacts from fish farms* on *Ocean health*, this would be likely to impact the regeneration of *Farmed fish stocks*. This would then mean a flow on effect reduced *Harvest*, *Rate of return* and investment in *Physical* and *Human capital*. This would result in reduced *Social capital*, which would also be impacted by the reduced *Farmed fish stocks*.

If Ocean health was to decline, the Regulatory risk that would likely present is the likelihood that these impacts will lead to a great requirement for *Methods to reduce the impacts of fish farms*. This may lead to an increased investment in *Physical capital*, although this may be mandated by regulation, rather than driven by profit incentives. While this is likely to reduce the *Impacts of fish farms*, it is likely that there would be a significant delay in achieving this. Consequently, although reduced impacts may be the longer-term result, it is likely that there would be a significant delay before *Fish farm consents* increased, leading to more *Fish farm volume*.

If this was to happen, it could be expected to lead to an increase in *Farmed fish stocks*, which would flow on through *Profit* to a greater investment in *Physical* and *Human capital*, which would have a positive impact on *Social capital*.

Overall, it would be expected that the Impacts of fish farms may have detrimental impacts across all four capitals. Any Regulatory risk that mandated an investment in methods to reduce impact could result in an increase in *Physical capital* in the medium term, and an increase in all four capitals in the much longer term, as impacts reduce, and a greater number of fish farms may be consented.

It should be noted that the total volume of fish farms will also be constrained by the available space. As space is finite, the dominance of this loop will diminish over time as the available space is taken up. Therefore, once all possible space available for fish farms is in use, the main pathway for improvements to any of the capitals to be made is via reducing the impacts even further. This will reduce the detrimental impact on *Ocean health* and allow it to regenerate, which will enable the regeneration of fish to improve, thus increasing stocks, harvest and so on.

Figure 45. Farmed fishery – Regulatory risks

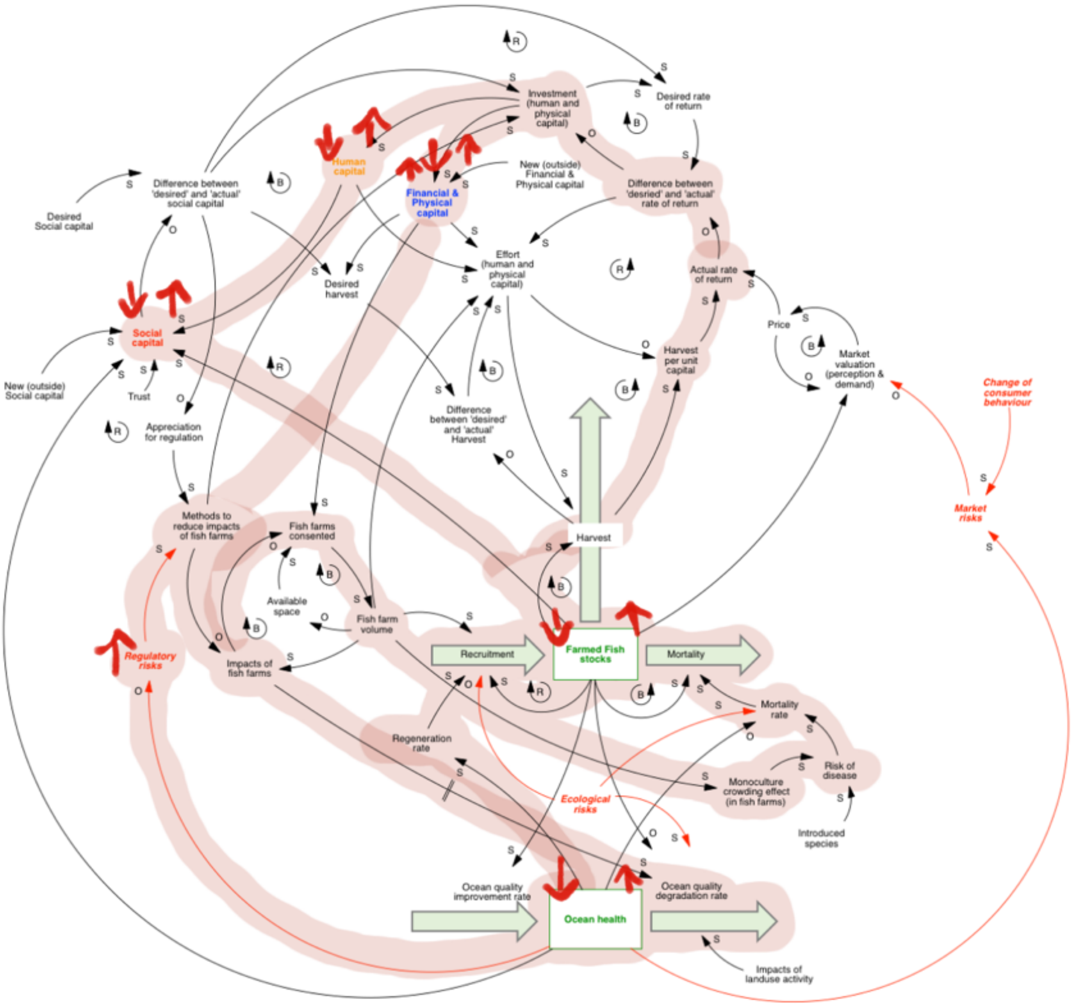


Table 5. **Farmed fishery – impact of Regulatory risks on the four capitals**

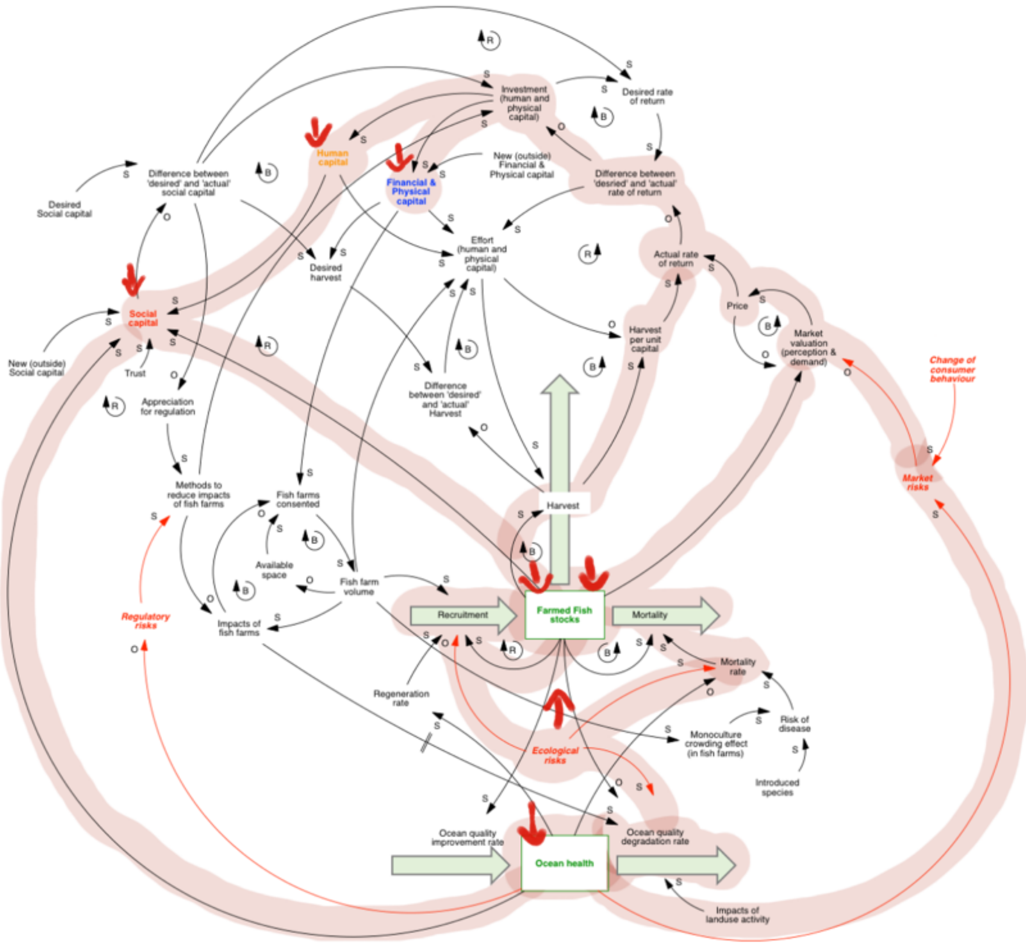
	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Regulatory risks	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓ ↑ (both in short to med. term) ↑ (long term)

10.2.3 Farmed fishery – Ecological risks

Ecological risks are again likely to be exogenous to the system. Examples may include changes in oceanic conditions resulting in declining *Ocean health* which, in turn, may increase the *Mortality rate* or decrease the *Regeneration rate*. Introduced species may also have an impact through the risk of disease and an impact on mortality.

If one of these risks were to eventuate, they would likely lead to a reduction in either *Farmed fish stocks*, *Ocean health*, or both. Not only would this reduce the potential *Harvest*, but it may also reduce the *Market valuation*, both of which would reduce the *Rate of return*. If the *Difference in desired and actual rate of return* was to remain high, then there would be little incentive to invest in *Physical* and *Human capital*. Reductions in both *Farmed fish stocks* and *Human capital* would detrimentally impact *Social capital*, as would a decline in *Ocean health*.

Figure 46. Farmed fishery – Ecological risks



Overall, any realisation of Ecological risks is likely to result in a reduction across all capitals.

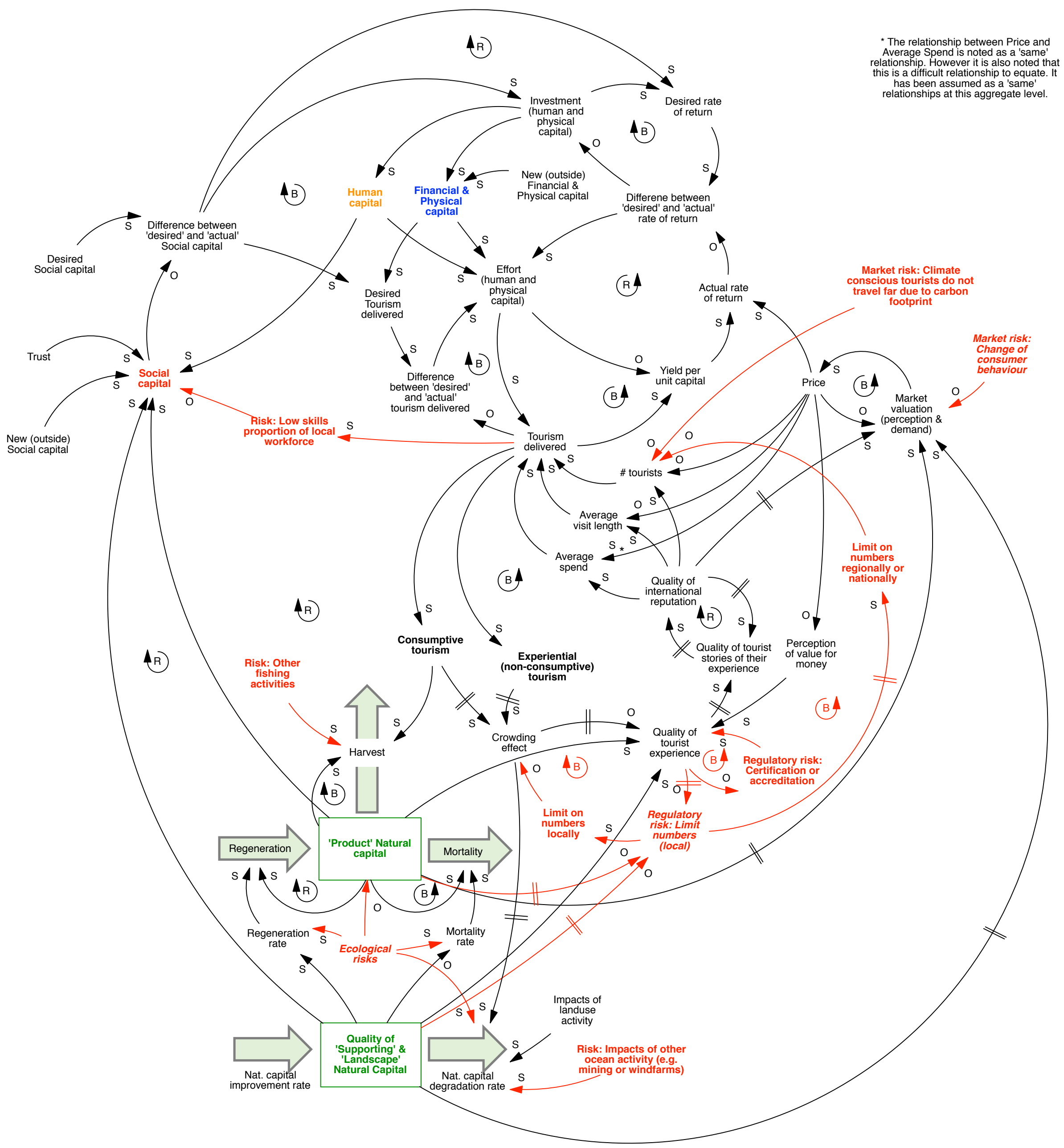
Table 6. Farmed fishery – impact of Ecological risks on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Ecological risks	↓	↓	↓	↓	↓

10.3 Eco-tourism – an overview of risks

Like the two fisheries examples, this section also outlines the same three risks types identified in Assoc. Prof. Nick Lewis' earlier research: Market risks; Regulatory risks; and Ecological risks. An additional type of risk is also included, that of the impacts of other types of activity in the ocean. This is included in eco-tourism because this is an industry that is more highly based on people's *perceptions* of the impacts of other activities in the ocean space. Therefore, the risk landscape of eco-tourism is slightly more complicated than the other fisheries examples.

Figure 47. Overview of Eco-tourism risks – Market; Regulatory; Ecological and Other Ocean activities

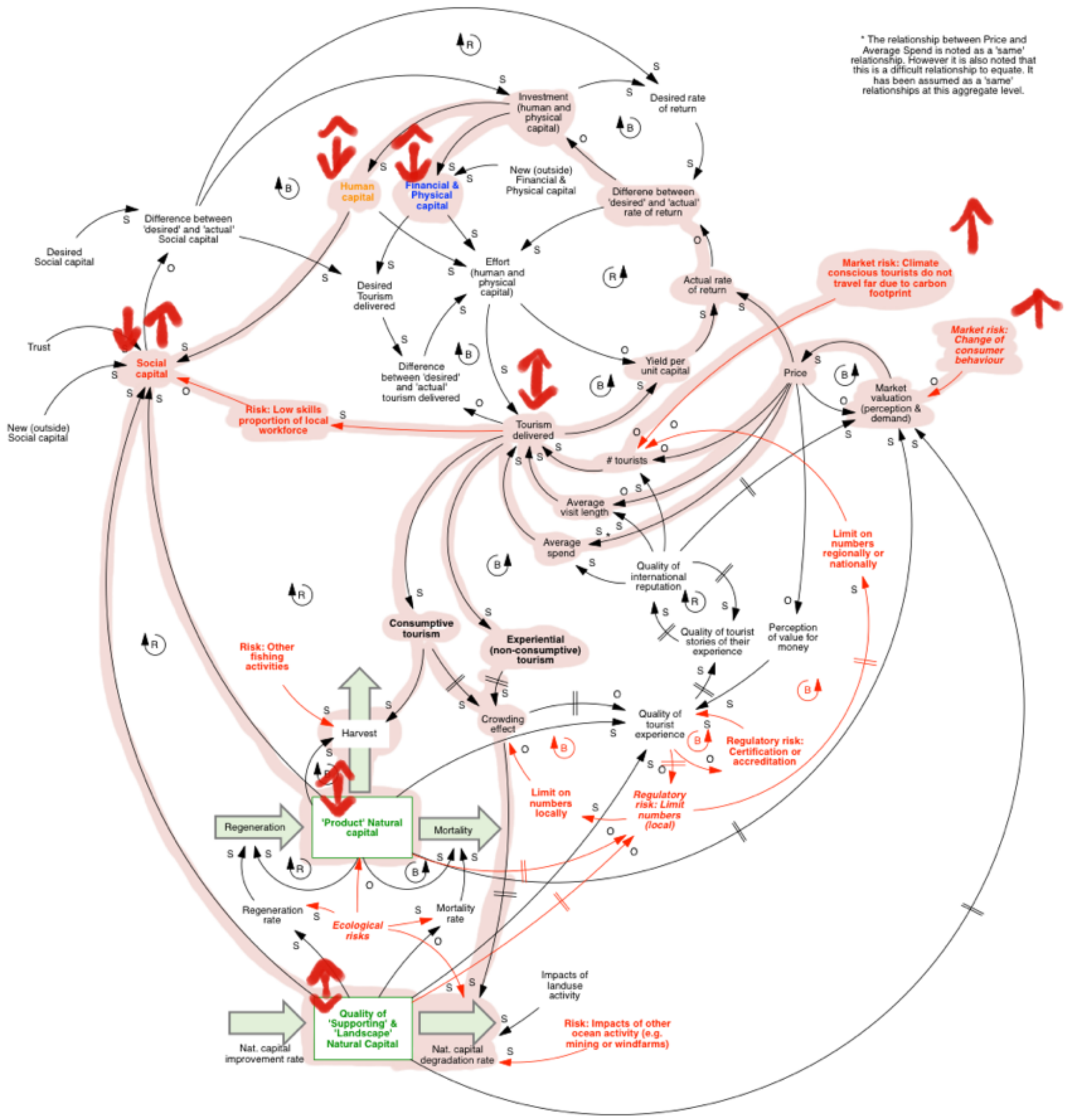


10.3.1 Eco-tourism – Market risks

Previous sections have outlined how a tourist's experience has an impact on Market valuation is already an endogenous influence within the system. The Market risks articulated here are those that may arise from either a change in market behaviour (that is, people may want a different experience than what New Zealand offers); or that climate conscious tourists no longer want to travel long distances due to the carbon footprint inherent in traveling to New Zealand, therefore directly reducing the number of tourists that visit.

These two risks have similar impacts but also present in slightly different pathways.

Figure 48. Eco-tourism – Market risks



The first of these – that there was a general change in consumer behaviour or what New Zealand had to offer fell out of favour – would primarily depress the *Market valuation* and *Price*. If a premium *Price* was no longer able to be charged, the *Actual rate of return* would drop, increasing the Difference between desired and actual (meaning goals were not being met), and decreasing any additional investment in *Physical* or *Human capital*. This would go on to decrease *Social capital*.

At the same time however, while a reduction in *Price* may mean less premium-price tourists, it may actually *increase* general tourist numbers overall, as well as the *Average length of stay*. However, given the complicated relationship between *Price* and *Average spend* (discussed earlier), this is also assumed to reduce. If the numbers of lower-price tourists increased significantly enough, then it may cancel out the reduction in *Actual rate of return* from the drop in *Price*, and therefore the investment in *Physical* and *Human capital*. This may mean that the type of tourism delivered became a model based on volume rather than quality, in order to maintain the same rate of return.

If this was to occur, then the additional risk highlighted as *Low skills as a proportion of local workforce* may also be realised more strongly. In reality, this is a likely risk for most types of tourism but is particularly prevalent for low-value and high-volume tourism. This would go on to decrease *Social capital*.

The dynamics described above articulate the impact of these risks on the upper part of the system map and primarily *Physical* and *Human capital*. Any change in the quantum of Tourism delivered will also have a significant impact on the lower part of the system map – primarily the *natural capitals*.

Any *decrease* in the amount of *Tourism delivered* is actually likely to increase both natural capitals. If there is less of both *Consumptive* and *Experiential tourism*, then there is less extractive (*Harvest*) pressure on the *Product natural capital*, and less potential degradation of the *Supporting or Landscape natural capital*. Over time, this would be expected to improve the stocks of both of these, which would then also mean an increase in *Social capital* in the longer term.

The converse is also true, if tourism *increased* (perhaps due to consumer behaviour desiring *more* of New Zealand), then a reduction in the *Natural Capitals*, as well as a reduction in *Social capital* could be expected. This is more likely to be realised if the dominant type of tourism is based on volume not value.

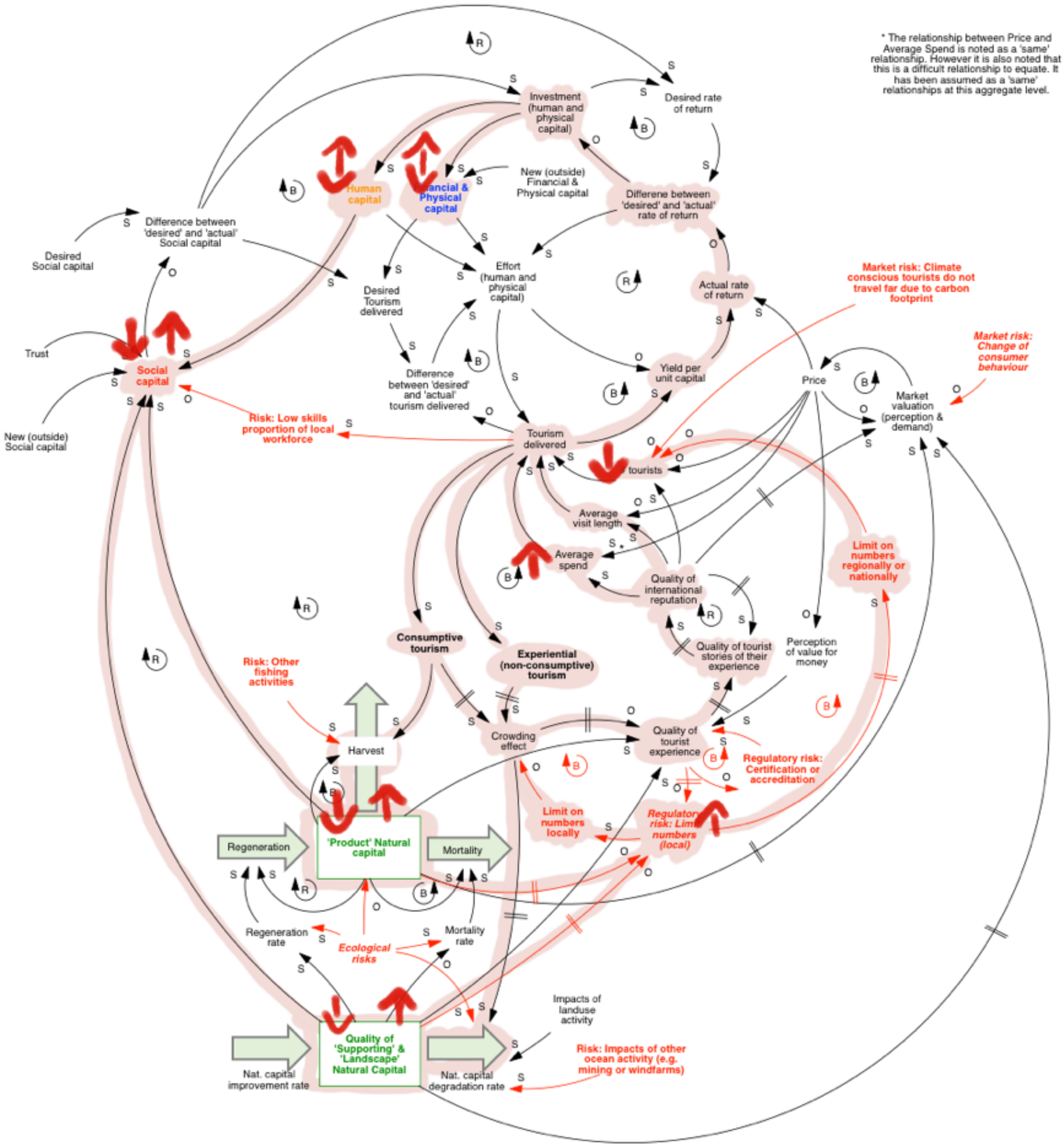
Table 7. Eco-tourism – impact of Market risks on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Change of consumer behaviour	↑ or ↓ (short term) ↑ or ↓ (long term)	↑ or ↓ (short term) ↑ or ↓ (long term)	↓ (short term) ↑ (long term)	↓ (short term) ↑ ↓ (both in long term)	↓ (short term) ↑ (long term)
Carbon footprint too high	↑	↑	↓	↓ (short term) ↑ (long term)	↓

10.3.2 Eco-tourism – Regulatory risk: capping visitor numbers

The regulatory risk of a cap on visitor numbers is the first of two regulatory risks explored (see Figure 49).

Figure 49. Eco-tourism – Regulatory risk: capping visitor numbers



This risk would likely to be realised if there is a significant decline in either or both of the *Product* or *Supporting/Landscape natural capitals*, which also has a flow on effect on *Social capital*. If this occurred, a likely response would be limiting the number of tourists that could be involved in any activity – either locally or at a larger regional or national scale.

If this occurred, it would reduce the total amount of *Consumptive* and *Experiential tourism*, decreasing the *Crowding effect* and thus making the experience more exclusive This would lead to a likely increase in the *Quality of tourist experiences* and potentially the *Average spend*.

Because the variables of *# tourists* and *Average spend* both contribute to the total *Tourism delivered*, the flow on effect from this point will depend on which dominates the most. If the increase in *Average spend* compensated for the reduced tourist numbers, then this would flow into increases in *Physical*, *Human* and *Social capital*. If not, these would likely reduce.

Yet the # tourists will be the dominating factor in the amount of both *Consumptive* and *Experiential tourism* delivered. This means that both *natural capitals* would increase over time, which would also lead to an increase in *Social capital* over time. Whether this led to a net increase in Social capital would depend on the dominance of the influence of the *natural capitals* over the *Human* and *Physical capitals*.

Table 8. Eco-tourism – impact of capping visitor numbers on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Capping visitor numbers	↑	↑	↓ ↑ (possibly both)	↓ ↑ (possibly both, likely increase longer term)	↓ ↑ (possibly both)

10.3.3 Eco-tourism – Regulatory risk: certification or accreditation

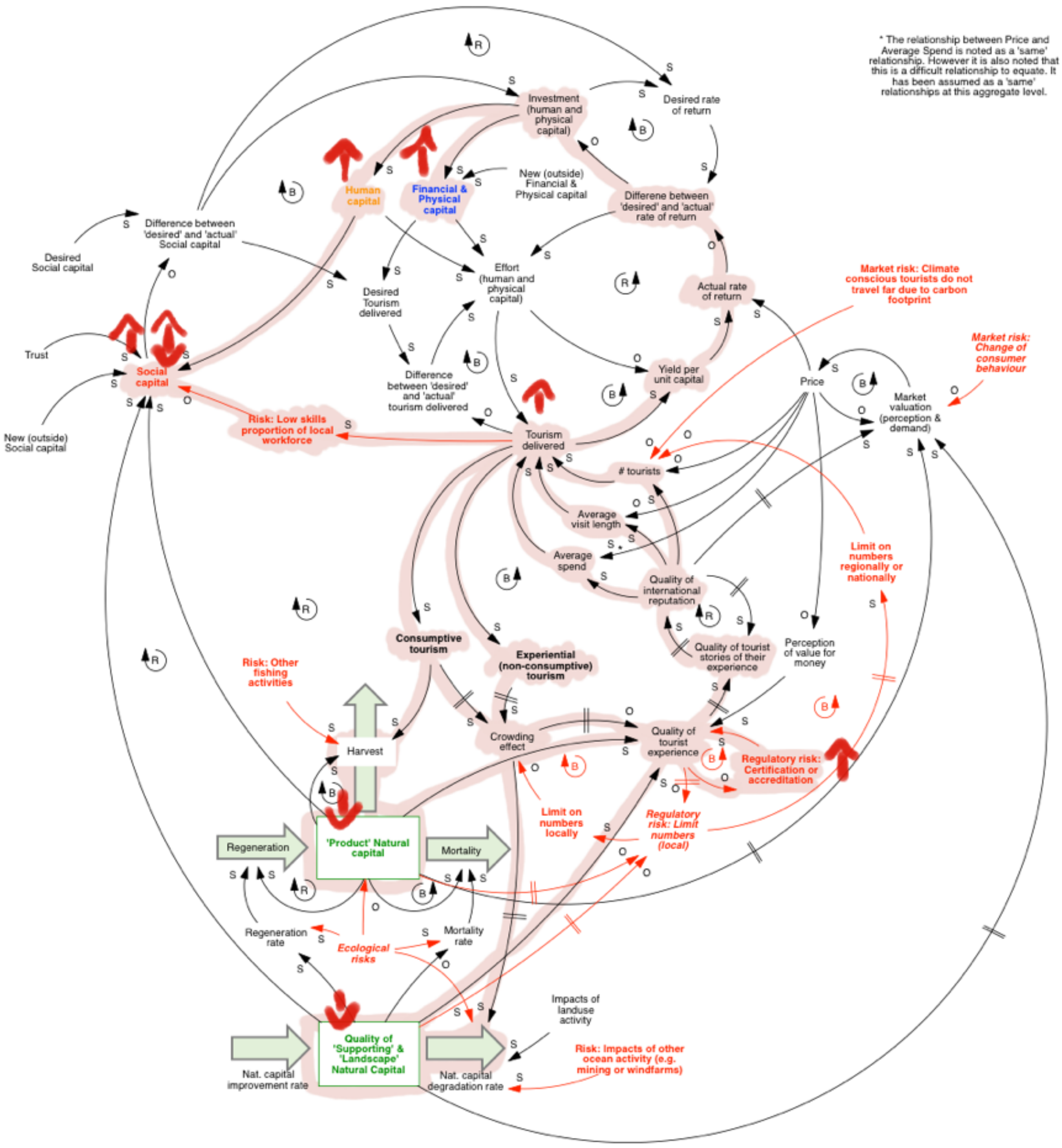
The regulatory risk of a requirement for certification or accreditation is the second of two regulatory risks explored (see Figure 50).

Certifying or accrediting tourism activities would be one way of regulating for a minimum level of service that consumers wants from eco-tourism providers. This could be provided by a range of organisations, from government agencies to the tourism industry itself. Primarily, it is expected that this risk would be realised in order to assure a certain level of *Quality of tourist experience* – thus it is human experience focused, rather than natural capital focused. Such experience quality may be under threat from a crowding effect, or a decline in either of the natural capitals drawn on by eco-tourism.

Unlike most of the other risks, this one exists in a balancing loop with the *Quality of tourist experience*. The greater the certification or accreditation the better the quality of tourist experience, while at the same time the better the experience, the less the need for certification or accreditation.

Once certification or accreditation is required, the quality of experience, stories told by tourists and New Zealand's international reputation would all be expected to improve. This would lead to more *Tourism delivered* which would flow through to increased investment in *Physical* and *Human capital*, which would also lead to improved *Social capital*. At the same time however, an increase in *Tourism delivered* would also be expected to increase the reliance on low-cost labour. This would have the counter effect on *Social capital*, meaning that this might reduce slightly given this low-skills focus.

Figure 50. Eco-tourism – Regulatory risk: Certification or accreditation



Without knowing what was required by certification or accreditation, there may not be any guarantee that it may lead to less impacts on natural capital. In fact, if it led to an increase in *Tourism delivered*, it might be expected that impacts on both forms of *natural capital* actually *increased*, counter-intuitively leading to their decline.

This also serves to highlight the need to ensure that any certification/accreditation ensures that impacts are minimised, not just the tourist experience enhanced. Otherwise there my be erroneous claims of some tourist activity to be "eco", when in actual fact, as noted above, they may counter-intuitively lead to further decline of natural capital. As this was difficult to ma here, without fully understanding what accreditation may be, this could be explored in future research for specific examples.

This may not be the case if certification or accreditation involved some form of limiting numbers. If this was the case, then the realisation of this risk would likely result in some combination of what is described here and what was described in the previous section (capping visitor numbers, see section 10.3.2).

Table 9. Eco-tourism – impact of certification or accreditation on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Certification or accreditation	↓	↓	↑	↑ (short term) ↓ ↑ possibly both long term)	↑

10.3.4 Eco-tourism – Ecological risks

This section discusses the potential impact of ecological risks (visualised in Figure 51).

Ecological risks are portrayed as impacting the system in three separate areas. They may degrade the *Supporting or Landscape natural capital*; they may impact the *Mortality rate* of *Product natural capital*, thus reducing it; or they may result in *Product natural capital* migrating or moving from their physical location[6].

All would lead to a reduced *Quality of tourist experience* and a reduced *Market valuation*, a lower *Price*, less *Tourism delivered* and a lower *Rate of return*. These would all result in less investment in *Physical* and *Human capital*, eroding the stock of *Social capital*.

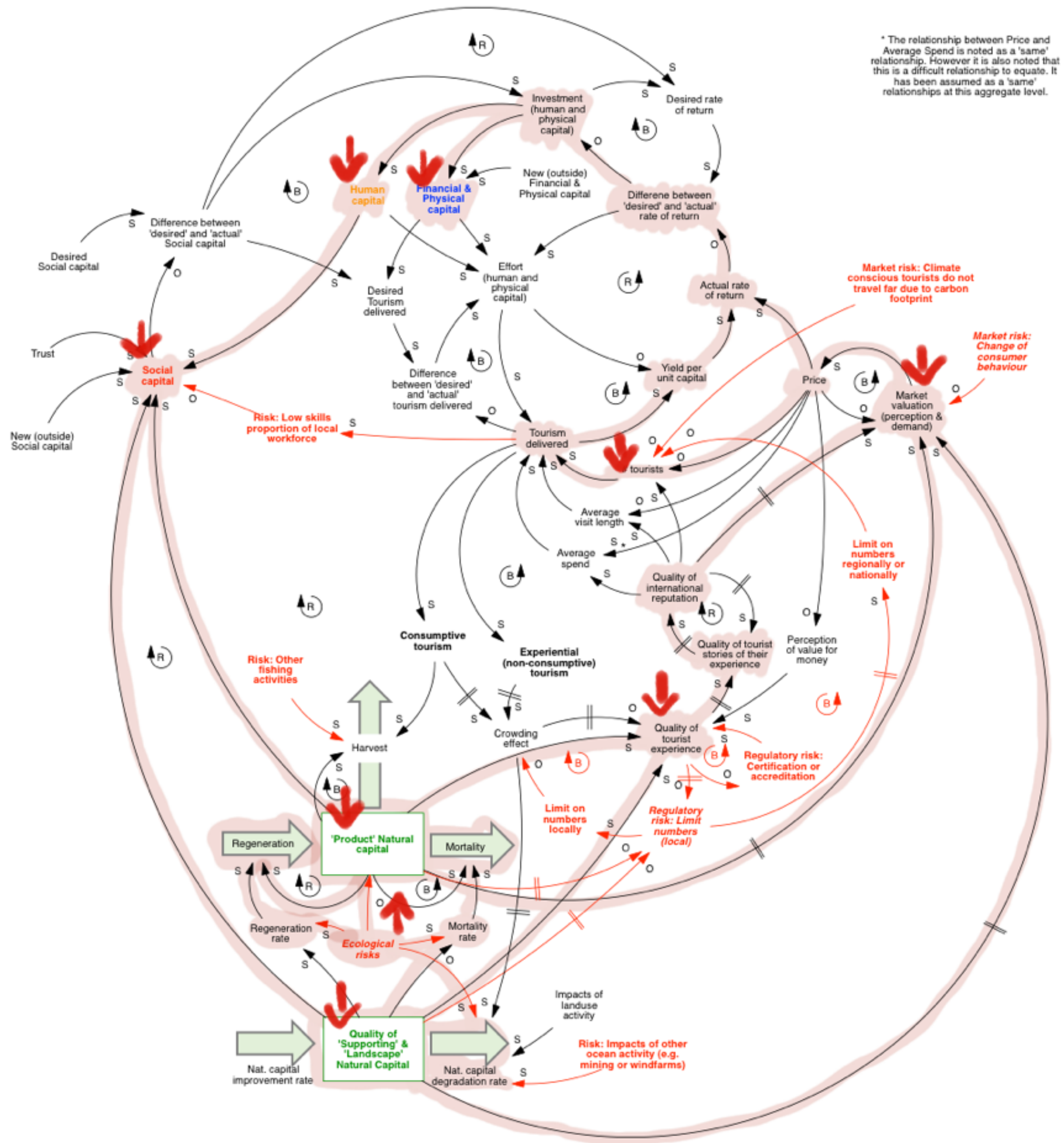
If any of these risks were to occur, the impacts would all be detrimental to the eco-tourism activity. The difference between them would be which ones presented faster than others. For example, the erosion of *Supporting natural capital* may occur more slowly than the migration of a species to a difference physical location.

[6] This last risk is represented by the unorthodox representation of an arrow directly influencing a 'box' variable (a stock). This is unusual as influences are usually connected to the inflows or outflows associated with stocks (see section 4.5), yet in this case the migration of a certain marine species may not reduce its total amount, just change its location.

Table 10. Eco-tourism – impact of ecological risks on the four capitals

	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
	Capitals				
Ecological risks	↓	↓	↓	↓	↓

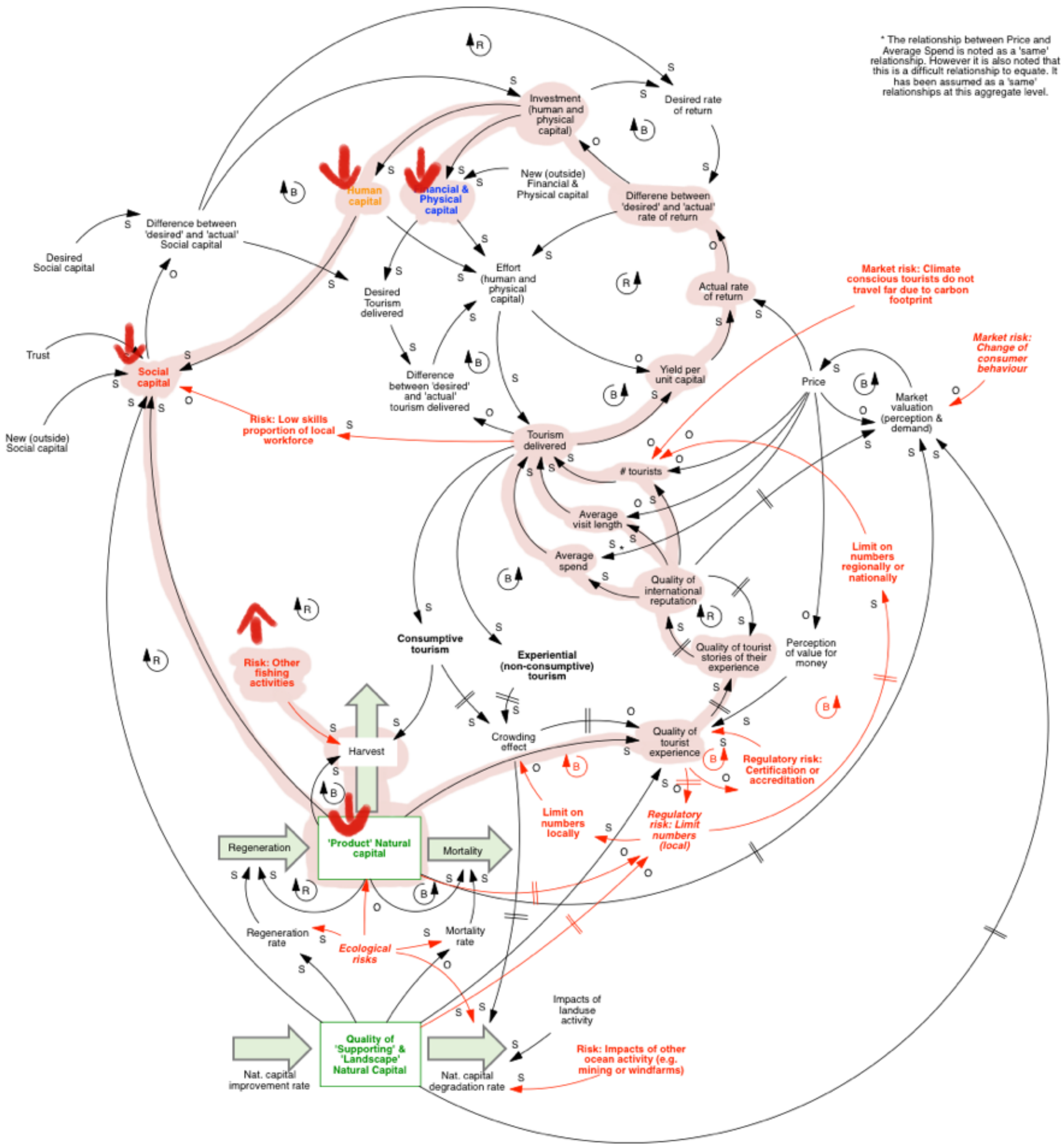
Figure 51. Eco-tourism – Ecological risks



10.3.5 Eco-tourism – Other activity risk: Other fishers

This section describes the first of two risks from other activities in the marine space – The impact from other fishers (see Figure 52).

Figure 52. Eco-tourism – Other activity risk: Other fishers



The impact of the risk from other fishers has a very direct and specific impact within the system that has been mapped – it would be additional *Harvest* pressure on the *Product natural capital*, where this was a marine product (for example fish or shellfish). The very nature of this consumptive use would mean that there was less *Product natural capital* for tourists.

If this resulted in downward pressure on the *Product natural capital* then the *Quality of the tourist experience* would be expected to decline, as would the *reputation*, the total *Tourism delivered*, the investment in *Physical* and *Human capital* and eventually the resulting *Social capital*.

The volume of this competing activity would dictate how significant this risk was and how quickly it would present as an impact on the eco-tourism industry.

Table 11. Eco-tourism – impact of other fishers on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Other fishers	-	↓	↓	↓	↓

10.3.6 Eco-tourism – Other activity risk: Other marine activity

The second of the two risks from other activities is the impact from other marine activity (see Figure 53).

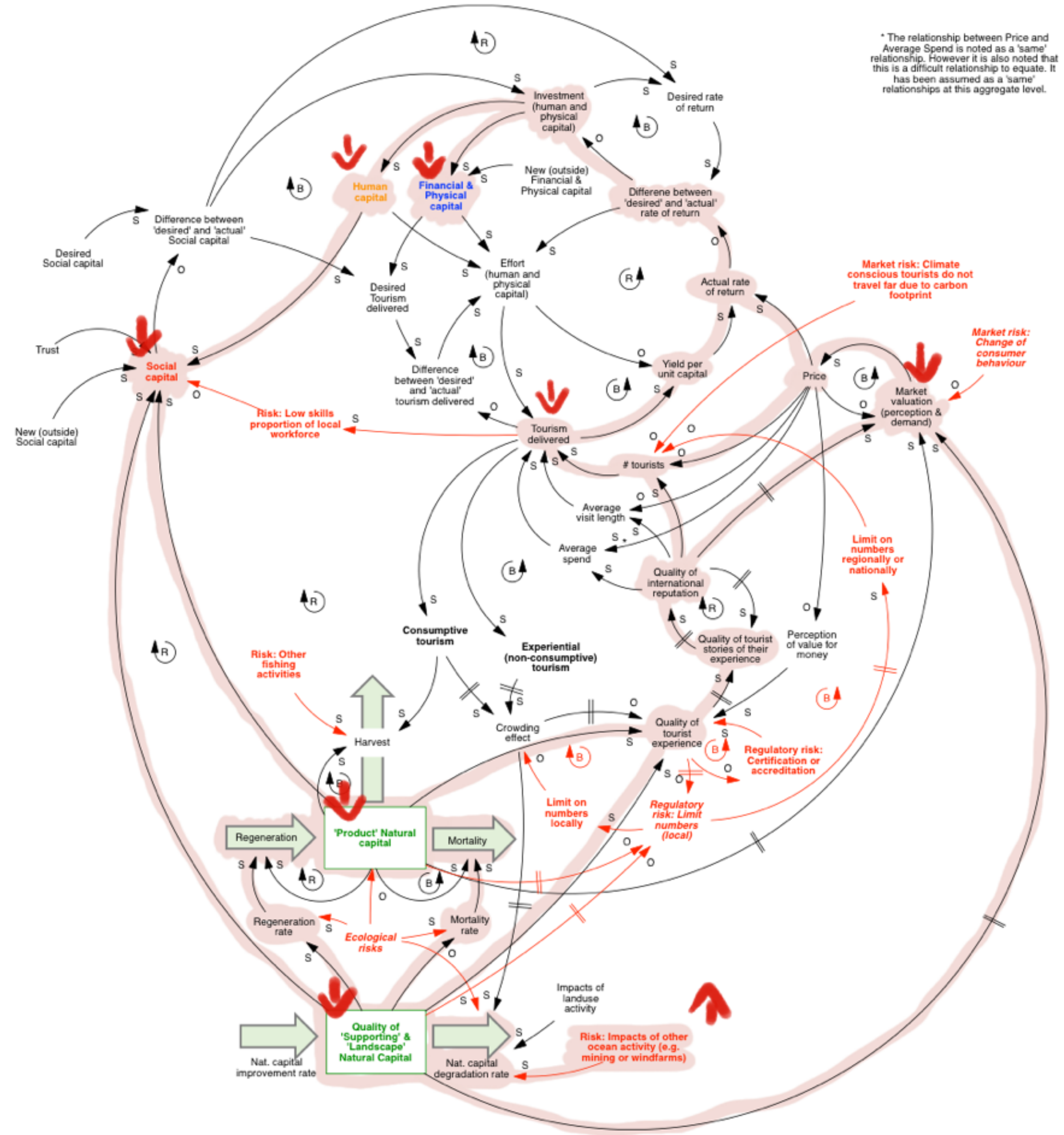
Examples of this type of activity might be activity that extracts things from the ocean floor (such as mining of drilling), or that may interfere with habitats in some way (such as offshore wind farms). The impacts of these would be different to other fishers as these would directly impact the *Supporting natural capital* (by degrading it), rather than the *Product natural capital*. This would though, result in consequential impacts on *Product natural capital*, through both increased *Mortality* and reduced *Regeneration*.

A reduction in both of these capitals would lead to a reduction in the *Quality of tourist experience*, *International reputation*, *Market valuation*, *Price*, the *Rate of return* and eventually *Tourism delivered*. This would further present in lower *Investment*, reduced *Physical* and *Human capital*, and eventually less *Social capital*. The reduced levels of the two *natural capitals* would also contribute to a reduction in *Social capital*.

Table 12. Eco-tourism – impact of other marine activity on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Other marine activity	↓	↓	↓	↓	↓

Figure 53. Eco-tourism – Other activity risk: Other marine activity



10.4 Summary of risks

This section summarises (in table form) the risks described in the preceding sections.

Table 13. Summary if risks across fisheries and their impact on the four capitals

	Capitals				
	Natural (Ocean health)	Natural (Fish stocks)	Human	Social	Financial & Physical
Wild fishery					
Market risks	-	↓	↓	↓	↓
Regulatory risks	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓	↓ (short term) ↑ (long term)	↓↑ (both in short to med. term)
Ecological risks	↓	↓	↓	↓	↓
Farmed fishery					
Market risks	↓	↓	↓	↓	↓
Regulatory risks	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓ (short term) ↑ (long term)	↓↑ (both in short to med. term) ↑ (long term)
Ecological risks	↓	↓	↓	↓	↓
Eco-tourism					
Market risk: Change of consumer behaviour	↑ or ↓ (short term) ↑ or ↓ (long term)	↑ or ↓ (short term) ↑ or ↓ (long term)	↓ (short term) ↑ (long term)	↓ (short term) ↑↓ (both in long term)	↓ (short term) ↑ (long term)
Market risk: Carbon footprint too high	↑	↑	↓	↓ (short term) ↑ (long term)	↓
Regulatory risk: Capping visitor numbers	↑	↑	↓↑ (possibly both)	↓↑ (possibly both, likely increase longer term)	↓↑ (possibly both)
Regulatory risk: Certification or accreditation	↓	↓	↑	↑ (short term) ↓↑ possibly both long term)	↑
Ecological risks	↓	↓	↓	↓	↓
Other fishers	-	↓	↓	↓	↓
Other marine activity	↓	↓	↓	↓	↓

11 A consideration of Justices required to achieve sustainable transitions

Previous sections have described three ‘marine-economy’ activities in system maps, which provide an analytical tool to explore the extent to which these activities might be considered ‘Blue-economy’ activities.

This section describes important elements that any interventions in those systems may require (in part or in total) in order to achieve *Just transformations to Sustainability* (Bennett et. al, 2019).

In this work, Bennett et. al (2019) argue that for transformations to be successful they need to not just achieve *ecological* transformations, but also just *social* transformations. Otherwise the ecological benefits are at risk of not being fully achieved, or not being achieved at all, due to a stalling of activity due to low social capital. This combination of ecological and social justice is presented here and described (later in this section) as *Environmental justice*.

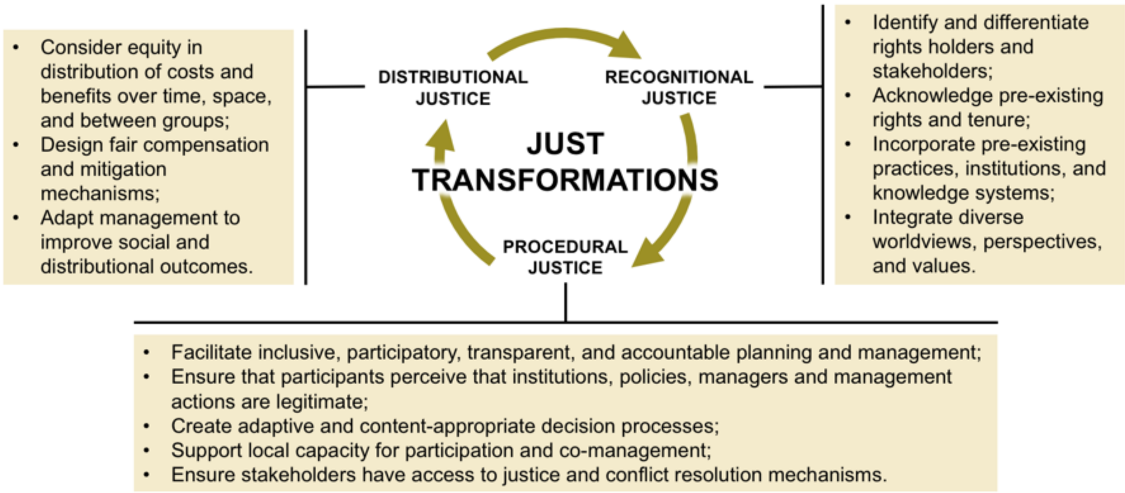
11.1 Overview of types of justice required to achieve just transformations

Bennett et. al propose that three types of justice need to be taken into account for sustainability transitions to be successful: recognitional, procedural and distributional justice. Their definitions for these justices are reproduced below:

- *“<u>Recognitional justice</u> refers to the acknowledgement of and respect for pre-existing arrangements as well as the distinct rights, worldviews, knowledge, needs, livelihoods, histories governance arrangements as well as the distinct rights, worldviews, knowledge, needs, and cultures of different groups in decisions;*
- *<u>Procedural justice</u> refers to the level of participation and inclusiveness of decision making and the quality of governance processes; and,*
- *<u>Distributional justice</u> can be defined as fairness in the distribution of benefits and harms of decisions and actions to different groups across space and time.”* (Bennett et. al, 2019, pp.4-5)

Actions to help achieve these justices are described in the following image (Figure 54).

Figure 54. Key considerations and guidance for just transformation management

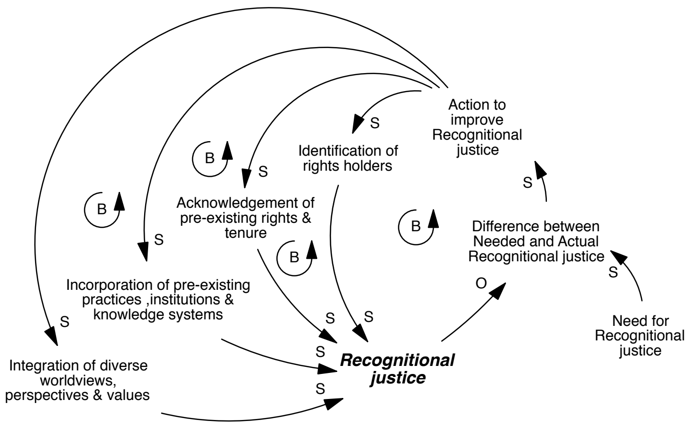


Adapted from Bennett et al. (2019)

11.2 Recognitional, procedural and distributional justice

Recognitional justice is considered the basis of the other types of justice. Without it, it would not be possible for some groups to have either procedural or distributional justice (Bennett et. al, 2019).

Figure 55. The balancing loop of actions that help to achieve Recognitional justice



The actions that could help to establish Recognitional justice are shown here in a balancing loop with a *Need for recognitional justice* and *Recognitional justice* itself (Figure 1). If the actual level of *Recognitional justice* is not as high as that needed, then the difference (deficit) will drive *Actions to improve Recognitional justice*, which prompts any of the individual actions, which improves *Recognitional justice*.

The two other justices also exist in balancing loops with the actions that help to achieve them. These are shown in a similar formation to the above in the following two diagrams (Figure 56 & Figure 57).

Figure 56. The balancing loop of actions that help to achieve Procedural justice

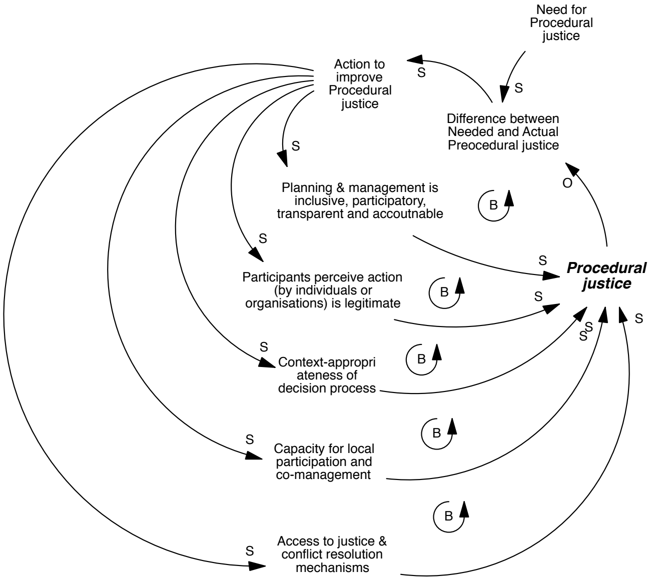
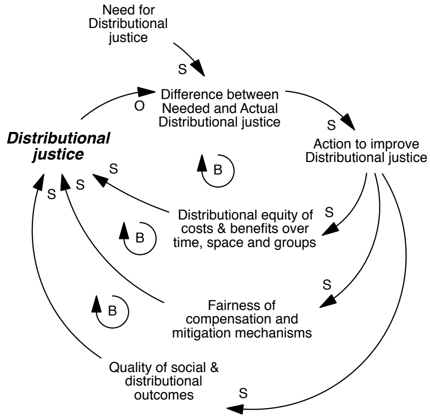


Figure 57. The balancing loop of actions that help to achieve Distributional justice

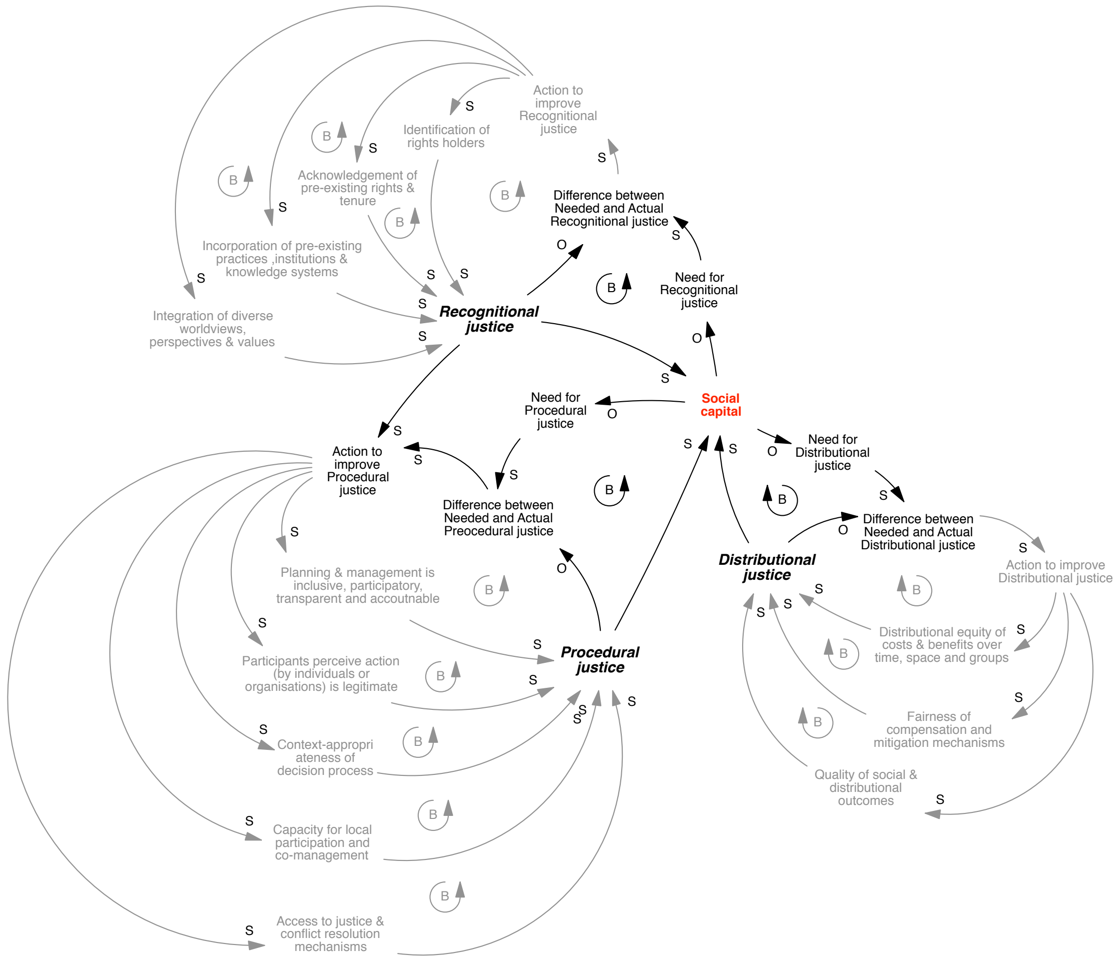


11.3 Linking the justices, the Living Standards Framework, and Environmental Justice

As discussed in the introduction to this section, the core element of transformational justice is the ability to deliver socially just transitions. Therefore, *Social capital* has been used as the key *Living Standards Framework* capital that links all these justices. How this operates is shown in Figure 58.

This shows that a higher level of *Social capital* is the result of all forms of justice, while also being the key driver of the need for any of the three justices. In effect, if the justices are present in society then *Social capital* is high, and there is minimal need for further justices. However, if they are not present, *Social capital* is low, which will drive a greater need for these justices until such need is met.

Figure 58. Linking Social capital with Recognitional, Procedural and Distributional justice.



The link to the other *Living Standards Framework* capitals is through *Social capital*. The structure of this section of the justice map reflects part of the common structure shared across the various Blue Economy system maps. That is, that *Social capital* is a key driver of the other capitals.

These connections were usually represented in the upper half of the earlier system diagrams, describing the influence that *Social capital* has on the *Desired rate of return* and *Investment*. As described in previous sections, *Human capital* operates in a balancing loop with *Social capital* – if *Social* is high *Human* will decline and thus reduce *Social*. While *Financial & Physical capital* tends to operate in a reinforcing loop with *Natural capital* and *Social capital*. That is, if *Social capital* is high, then the need for investment to make up any shortfall in Social capital is reduced, therefore *Financial & Physical capital* plateaus, in turn this reduces the pressures on *Natural capital*, which increases, and thus further increases *Social capital*.

Figure 59. Social capital – the link between the justices and the other capitals

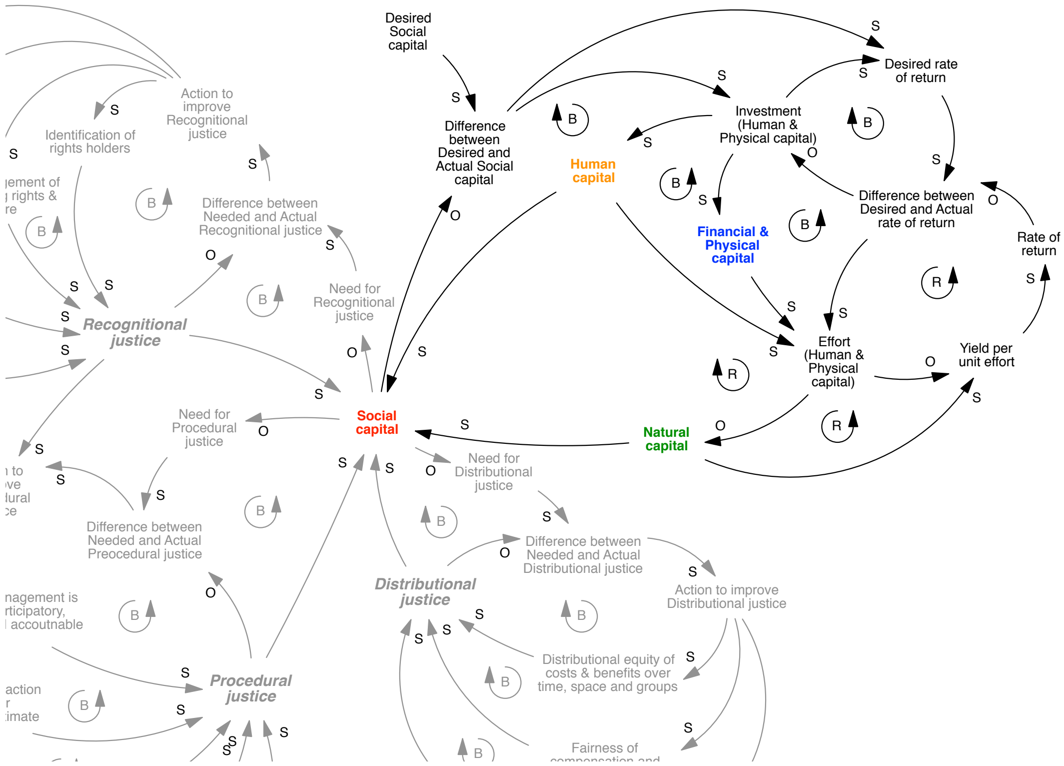
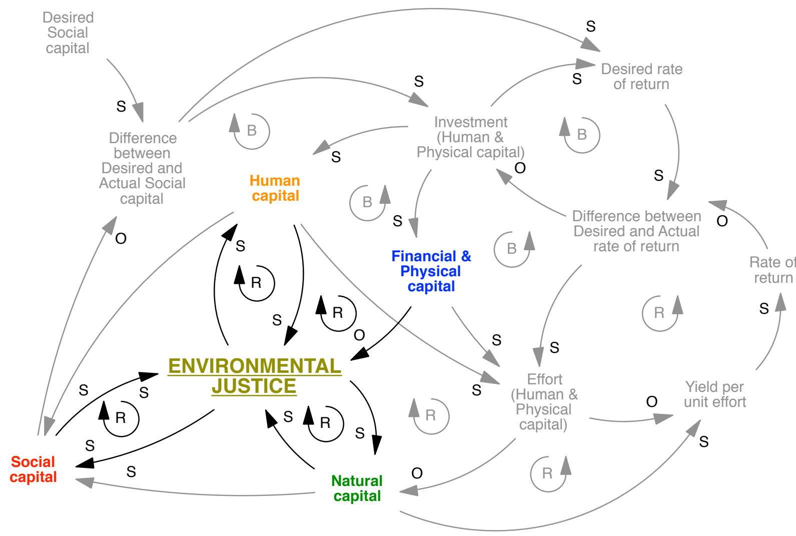


Figure 60. Environmental justice – a combination of all four capitals



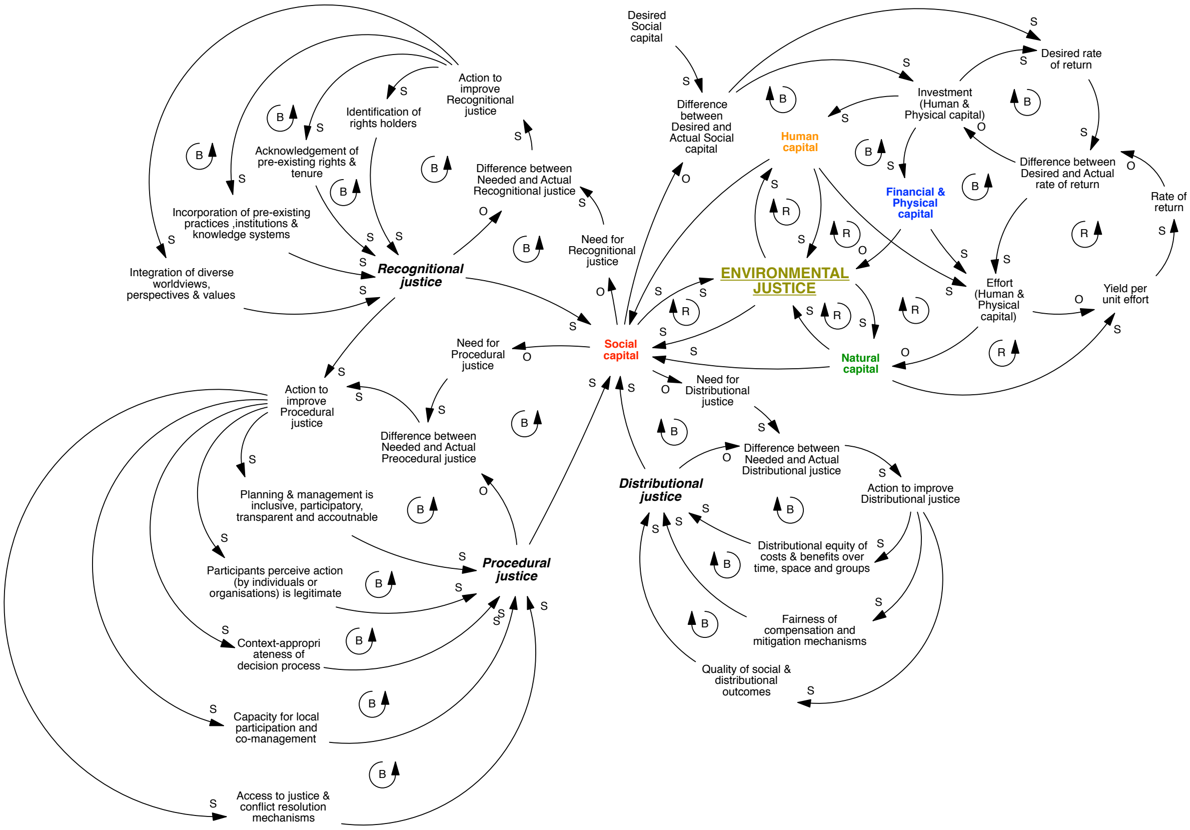
Finally, the concept of Environmental justice is proposed here as a unitless concept that reflects a healthy social and ecological balance in the environment.

It is partly an ecological construct, and partly a social construct.

Research by Assoc. Prof. Nick Lewis in the build-up to this report suggests that both of these components are required to be in a healthy state for there to be any Environmental justice.

The complete map of transformation justices, the Living Standards Framework capitals, and Environmental justice, is shown below in Figure 61.

Figure 61. The complete system map for the transformational justices and the four Living Standards Framework capitals



12 Exploring interventions – a demonstration

Previous sections of this report have outlined the system maps developed for three marine-economy activities, as well as outlined the concept of transformational justices required to achieve Environmental justice. This section discussed what may be expected from some potential interventions in the systems previously outlined, based on the system understanding gained from the earlier maps.

Potential interventions described here are not quantified and should only be considered conceptual. They are intended as tools to enable discussion about the types of interventions that best help to achieve desired outcomes.

This is done by describing a potential intervention and its consequential impacts on key variables. The system maps described earlier should be viewed in conjunction with the interventions described here. Discussion focuses on the main system maps described earlier but if pursued, interventions should also be considered from the perspective of how well they achieve or support transitional justice.

An assumed temporal change in key variables is demonstrated in conceptual graph format. It should be noted that this is entirely subjective. None of these graphs are quantified and no simulation modelling has been undertaken to develop them. Converting such graphs into quantified and parameterised simulation models could be the focus of future research.

The range of conceptual interventions is outlined below. These are not intended as a comprehensive list. Rather, they are intended as a sample of different types of interventions which provide an example of the types of insights that can be gained by this type of systems mapping. Any one of these interventions, or other not included here, could be explored in more detail as the subject of future research.

Wild fishery:

- Fishing companies make a voluntary commitment to greener performance by limiting their catch and improving their fishing methods (for example, with larger net sizes increasing the minimum size of the catch.

Farmed fishery:

- A fish farm receives a new capital investment from a green investment fund. This increases the total fish farm volume but locates the new farms further offshore. It also alters the feed being provided to the fish, so that there is less environmental impact.

Eco-tourism:

- A collection of local tourism operators gain permission from the local authority to set a cap on the numbers of tourists. This limits the number of passengers on their marine mammal watching tours and fishing charters in any one day or week. They seek to preserve the unique character of their location and establish a high-value market for their experience.

12.1 Example wild fishery intervention: limiting catch and improving methods

Fishing companies make a voluntary commitment to greener performance by limiting their catch and improving their fishing methods (for example, with larger net sizes increasing the minimum size of the catch.

The key variables graphed here are:

Desired catch	Wild fish stocks
Quality of fishing methods	Ocean health
Desired rate of return	Financial & Physical capital
	Human capital
	Social capital

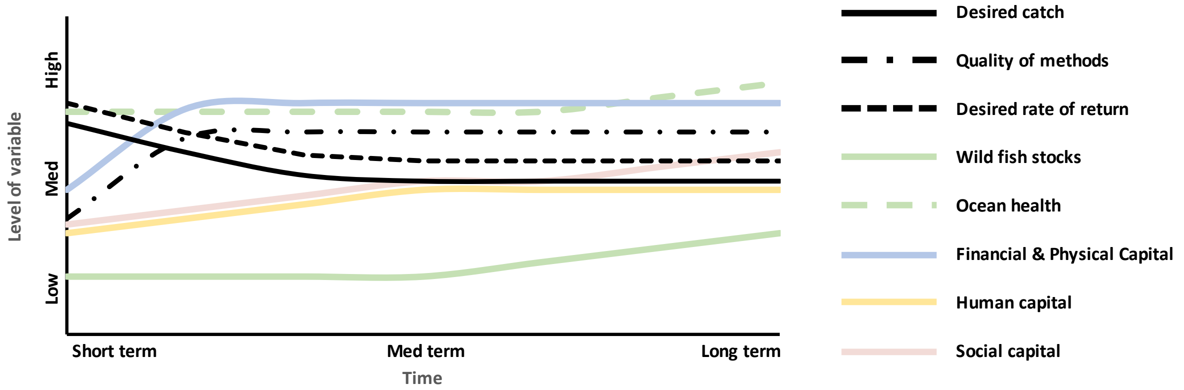
A reduction in *Desired catch* and the *Desired rate of return*, and an increase in the quality of fishing methods, are all shown as black lines on the below graph. The Living Standards Frameworks are shown in lighter colours that correspond to the colours used in the system maps. Short term is considered a couple of years, Medium term a decade, and Long term is several decades.

This intervention would likely result in a significant increase in investment in *Physical capital* in the short term due to the investment in improved methods. There would likely be a corresponding increase in *Human capital* through the medium term as this technology was established in the industry and the skills to use them normalised amongst workers in the industry. *Social capital* would rise with *Human capital* in the short to medium term.

The *Fish stocks* would be expected to increase beyond the medium term, assuming the reduction in Desired catch was sufficient to enable regeneration. Assuming that the *Ocean health* was not significantly reduced to begin with, this would remain fairly constant but improve in the longer term, with regenerating *Fish stocks*.

After growing with *Human capital* to begin, *Social capital* will be further increased by improvements in *Fish stocks* and *Ocean health* in the longer term.

Figure 62. A conceptual wild fishery intervention: Reducing desired catch & desired rate of return and improving fishing methods



12.2 Example farmed fishery intervention: Offshore location and improved feed

A fish farm receives a new capital investment from a green investment fund. This increases the total fish farm volume but locates the new farms further offshore. It also alters the feed being provided to the fish, so that there is less environmental impact.

The key variables graphed here are:

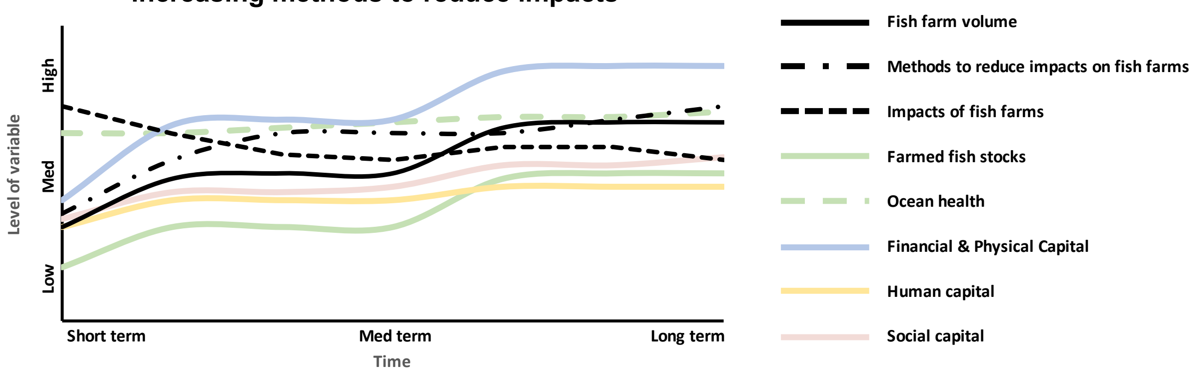
Fish farm volume	Wild fish stocks
Methods to reduce impacts of fish farms	Ocean health
Impacts of fish farms	Financial & Physical capital
	Human capital
	Social capital

A fish farm is established offshore, increasing the overall *Fish farm volume*. At the same time there is a greater investment in *Methods to reduce impacts of fish farms*. For novelty, in this conceptual example, there are two material expansions of the *Fish farm volume* – one in the short term and one in the medium term.

Unlike wild fisheries, the *Farmed fish stocks* are expected to mirror the *Fish farm volume*. Similarly, the amount of *Physical capital* will also increase to reflect the increase in *Fish farm volume*. *Human capital* also increases but it is expected that the marginal increase in this will not match that of *Physical capital*, possibly due to efficiencies or economies of scale with human labour and skills. *Social capital* grows with *Human capital* in the short to medium term.

Significant improvements in methods to reduce the impacts of fish farms are made in the short term, yet the realisation of most easily achievable improvements mean that this remains fairly constant afterwards. A small further level of improvement has been allowed in the longer term, to account for possible technological improvements in the future. *Impacts of fish farms* reduce significantly in the short term as a result, and a little further in the long term, assuming the technological advancements described above. There is a small rise in Impacts when Fish farm volume is increased the second time. *Ocean health* may improve slightly due to the reduced impacts, but only marginally given that overall volume is increasing. Ongoing increases in *Ocean health* and *Farmed fish stocks* will increase *Social capital* in the longer term.

Figure 63. A conceptual farmed fishery intervention: Increasing offshore fish farms and increasing methods to reduce impacts



12.3 Example eco-tourism intervention: capping tourist numbers

A collection of local tourism operators gain permission from the local authority to set a cap on the numbers of tourists. This limits the number of passengers on their marine mammal watching tours and fishing charters in any one day or week. They seek to preserve the unique character of their location and establish a high-value market for their experience.

The key variables graphed here are:

- Tourist numbers
- Crowding effect
- Quality of tourist experience
- Actual rate of return
- Wild fish stocks
- Ocean health
- Financial & Physical capital
- Human capital
- Social capital

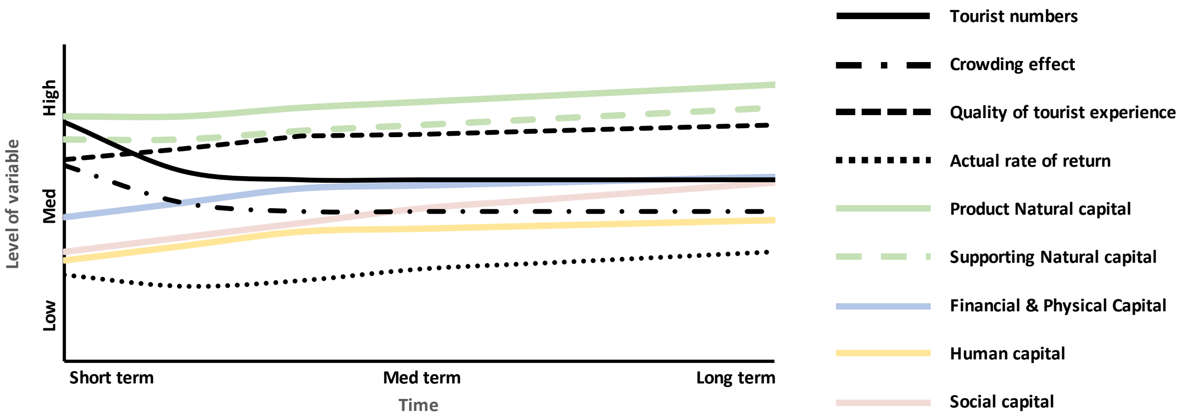
The behaviours on the graph in this example experience far less fluctuation than the previous examples. This is because limiting numbers has the impact of creating a reasonable amount of dynamic equilibrium in the system.

There is some movement in the short term as: the *tourist numbers* drop to the new cap; the *Crowding effect* reduces; and the *Quality of the tourist experience* increases. There is some short-term decrease in the *Actual rate of return*, but as the *experience* improves the *Market valuation* and *Price* increase to compensate. A longer-term rise in the *Actual rate of return* can be expected, based on this and an increase in the other capitals, particularly the natural capitals.

Both *Human* and *Physical capitals* will likely plateau or only increase slightly, as these are more dependent on *Tourist numbers*. Yet reduced tourist numbers can be expected to marginally improve both Supporting and Product capital. The extent to which this occurs will depend on how much Tourism numbers reduce compared to before the cap. In this theoretical example, the numbers only reduce slightly, therefore any improvement is only slight.

As per the other examples, *Social capital* rises in the short to medium term with *Human capital* and the *natural capitals*, and in the medium to longer term primarily with the improved *natural capitals*.

Figure 64. A conceptual Eco-tourism intervention: capping tourist numbers



13 Summary

This report has described three system maps for marine-economy activities in New Zealand - wild fisheries, farmed fisheries and eco-tourism. They were developed to synthesise some of the research findings from the Blue Economy theme within Phase one of the 'Sustainable Seas' National Science Challenge.

System maps are a useful tool from the discipline of System Dynamics. They seek to make explicit and synthesise the important inter-connections and feedback loops that produce the patterns of behaviours observed within systems over time.

There were many similarities across all three system maps. All were natural capital dependent being based on some kind of natural capital marine-stock that could be consumed (like fish) and the underlying health of the ocean that supported them (another natural capital stock). The broad drivers of extraction or exploitation are the same across all three systems, and these tended to be linked strongly to the other three of the four capitals (in addition to natural capital) that make up the Living Standards Framework – Financial & physical, Human and Social capital.

Yet important subtle differences between systems were evident. The regulatory mechanisms by which the two fisheries manage their stocks were quite different – one being driven by the health of the fish stock itself (wild fisheries), the other being driven primarily by the impact the operation may have as a by-product (fish farms). Eco-tourism also differed further, in that it had both consumptive and non-consumptive activities. Both of these are much more strongly and directly linked to the perception of these products in the marketplace, primarily because of the direct personal connection between visitors lived experiences and New Zealand's international reputation.

All three systems are exposed to the same broad risk types – Market, regulatory (also representing social risk), and ecological risks. When the risk types were summarised and described, it was found that both Market and Ecological risks were likely to have dominantly negative impacts across the four capitals. Unsurprisingly, and appropriately given the function of regulation to stabilise systems, regulatory risks have the greater likelihood of being able to have a positive impact on these capitals in the longer term, even if regulatory interventions can generate negative impacts in the short term.

Eco-tourism is also exposed to greater risk from the area of other activities that are occurring in the marine space. This is primarily because of the greater dependence on the perception of people who are actively experiencing the marine environment.

The system maps also provide a basis for visualising potential sites for management interventions and opportunities for transitioning to a blue economy. In this sense, they represent potential high-order environmental management tools.

The report demonstrates how these tools can be used in five ways.

First, the impact of the three activities on the combined health of the four capitals can be interpreted as a proxy for their contribution to what Sustainable Seas defines as the New Zealand blue economy. This is particularly helpful in considering potential interventions by allowing for their countervailing effects to be traced at a systems level. The report demonstrates the value of the systems maps as management tools by tracing and analysing a small set of example interventions.

Second, and as a direct consequence, the maps offer a systems level guide to cascading effects in multi-use environments. Eco-tourism is the most obvious example among the case activities where the three activities, four capitals, and action and perception are brought into tension. The cross-sector systems-level impact analysis developed for eco-tourism illustrates the potential of the approach to do this multi-use analytical work, and suggests that the same approach could be adapted to other uses (including developing an all-sector model).

Third, the maps allow for building a four-capitals and four well-beings approach to environmental management in the marine space. While high-order and systems-level, this contribution is novel and represents an important first step in bringing the new regulatory realm of well-being accounting to marine economy, and its potential to dovetail with blue economy approaches to value(s) creation.

Fourth, the maps allow for consideration of social licence. By linking risks to the impacts of changes on the four capitals, discretely or collectively, the maps provide a systems-level basis for considering, and potentially measuring, the extent and bounds of social licence within a blue economy.

Finally, the report works through in finer detail the implications of changes/interventions in the system for social and environmental justice. In this way, it provides a basis for considering what is required for transitional justice and evaluating efforts to achieve just transitions. The mapping exercise makes explicit relations between economic activities, environmental variables, social and economic change and three social justices pivotal to environmental management and economic development in the Aotearoa-New Zealand context – recognitional, procedural and distributional. In doing so, it also develops a working conceptualisation of environmental justice at a practical level. Each of these four justices is connected to the capitals of the Living Standards Framework. In this way, the report makes a major contribution to conceptual understandings of just transitions consistent with EBM and a blue economy, and to developing new ways to use them in applied settings.

14 Areas of potential future research

The benefit of systems approach is that is synthesises inter-connections, influences and tensions within a system. As a result, the system maps in this report are necessarily at an aggregated level. If it was felt that these aggregated maps highlighted some areas of the system where further attention should be focused, the maps could be expanded in these areas. Examples of areas like this include:

- Any of the system maps could be explored in more detail from the perspective of a specific industry or company.
- Disaggregating the Natural Capital stocks into a series of more specific measures that allow more specific feedbacks.
- The impacts of landuse on ocean health is only notionally represented on these maps, yet it is important impact on the critical underlying natural capital of ocean health. Therefore, the inter-connections with landuse could be expanded. One way this could be achieved is through using system maps to summarise the interconnections and dynamics researched in other National Science Challenges, such as the 'Our Land and Water' Challenge.
- In the eco-tourism map, the relationship between *Price* and *Average spend* is complicated (see section 9.3.1, pages 25-26). This could be mapped out in more detail as a separate map, if there was benefit in understanding these dynamics in more detail.
- Further explore how the Living Standards Framework may be incorporated into these maps. For example, this may mean the disaggregation of Physical & Financial capital. Or one of the other three capitals (Financial & Physical; Human; or Social) could be represented in these maps using the stock and flow notation as used here for natural capital. Alternatively, they might also be made the focus of their own map, to be read in conjunction with those focused on Natural Capital shown here. It is important to note here that this is not intended to develop separate or disparate maps. Rather, the intention is to explore how various maps might allow a focus on certain elements considered important within the ecosystem while still remaining accessible and not becoming overly complex – any maps developed are still intended to be read in conjunction with the other maps.
- Each system map in this report has been represented individually, yet they are intended for comparative discussion. Simple links between the maps could be developed and used in EBM to identify cross-sector impacts in a multi-use environment.
- The risks outlined in the Potential Risks (section 10) are based on the research undertaken by Assoc. Prof. Nick Lewis in Phase 1. These have not been presented back to interviewees or research subjects in the system map form, so this could be done to validate the systemic representation of these risks.

How these maps interconnect or influence other maps that may be developed in the Blue Economy could also be explored, or they could be refined for specific industries. Important dependencies or impacts across industries may then be able to be identified.

The nature of economic systems and the current growth dependent structure of economies is a major current theme in the economic literature (for example Raworth (2017) and Jackson (2017) and at odds with the concepts of low-to-no impact economic activities as defined within a ‘Blue’ economy. These tensions could be explored further in future expanded system maps. For example, mapping important conceptual concepts proposed in those literatures could be explored, such as:

- Explicitly seeking to map variables that capture the dynamics of decoupled (or decoupling) economic growth from resource use (as described in *Doughnut economics* (Raworth, 2017)). It is the opinion of the authors that many of the fundamental components of this are likely already included in these system maps, yet further refinement may make them more explicit.

Only a selection of possible interventions in the different systems were explored in graphical form, based on the narrative insights outlined in the system maps (see section 12). A variety of further interventions could be explored in this same qualitative manner. This could be coupled with validity testing of the system maps with stakeholders, and the resulting graphs even compared across stakeholders if this was not possible to happen all at one time.

Further exploration of these narratively developed temporal graphs are considered a core way to extend this research and validate these maps with a wider range of stakeholders. This should be prioritised in possible future research.

Finally, these maps are only qualitative. Some attempts could be made to turn these maps (or parts of them) in accessible small-scale simulation models, as championed by Donella Meadows in *Thinking in systems – A primer* (Meadows, 2008), and described at the beginning of this report. This would include the ability to use a dashboard interface or flight simulation approach in conjunction with the model, which would allow key leverage variables to be explored through role play or gamification.

It is stressed that this is not comprehensive modelling, but small-scale modelling for *understanding* rather than *forecasting*. However, given the importance of these industries to New Zealand and future human and economic prosperity, this could be impactful research. It would be most impactful if that was small scale modelling that was carried out in a participatory manner, thus increasing the likelihood of understanding and agreement amongst participants.

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