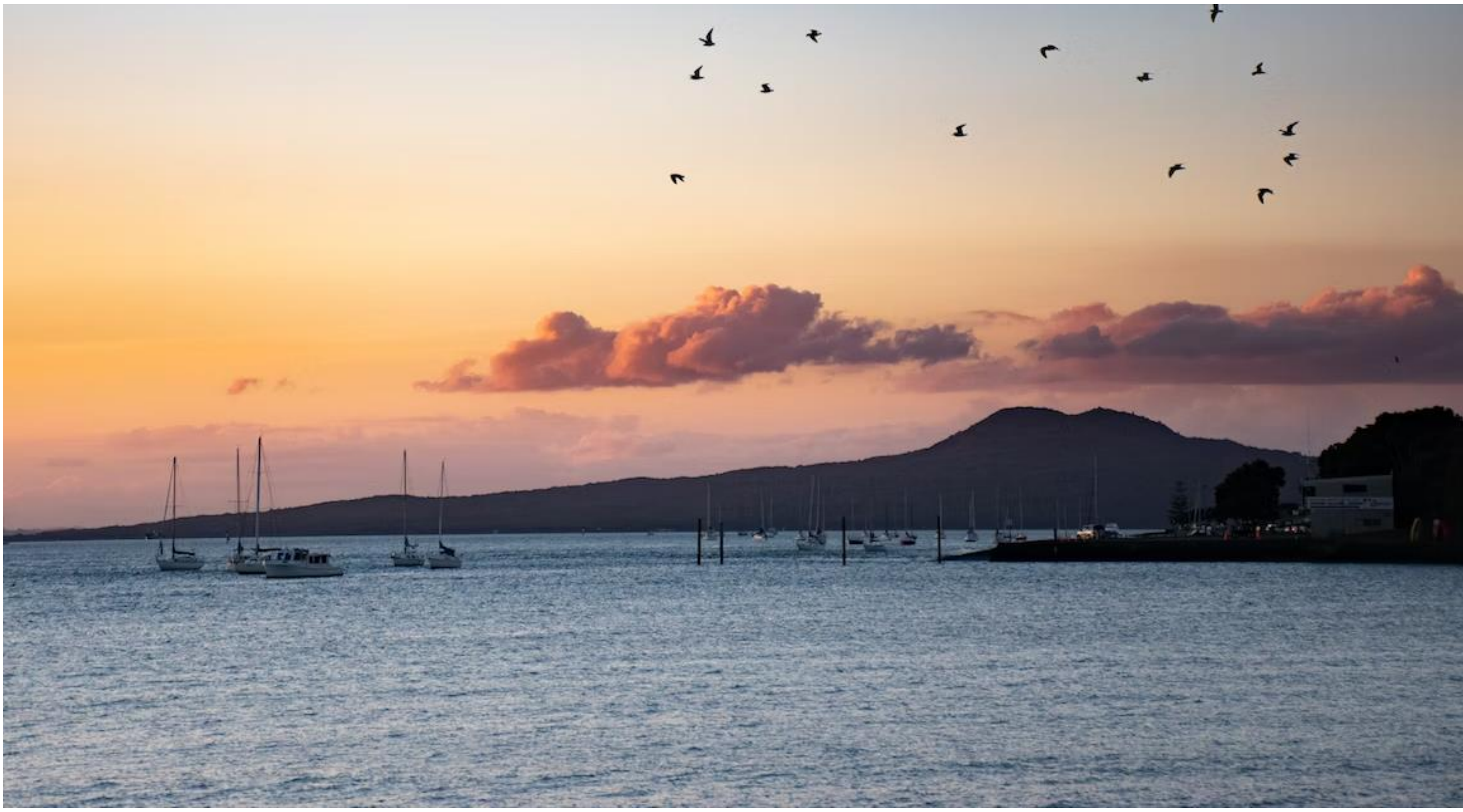

# Valuing the Hauraki Gulf

## An ecosystem services and natural capital approach

**NZIER report to The Hauraki Gulf Forum**

July 2023

## About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice.

We undertake and make freely available economic research aimed at promoting a better understanding of New Zealand's important economic challenges.

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We pride ourselves on our reputation for independence and delivering quality analysis in the right form and at the right time. We ensure quality through teamwork on individual projects, critical review at internal seminars, and peer review.

NZIER was established in 1958.

## Authorship

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# Key points

### Purpose of the report

The Hauraki Gulf Forum commissioned NZIER to provide a top-down assessment of the Gulf's value using a Total Economic Value framework (TEV) and an Ecosystem Services approach.

The objective of this research is to estimate the value of the Hauraki Gulf using an approach that is useful for a range of assessments about how to consume, manage, conserve and protect the natural environment. It is intended to counter the risk that marine ecosystems are perceived as being less valuable simply because their actual value has not been sufficiently quantified, and that environmental damage has been inadequately recorded. Resource use and management decisions can be distorted by incomplete monetary valuation with which to compare costs and benefits of potential activities, so environmental effects with long-term consequences can be under-valued in the decisions made.

This report adds to the knowledge base by building on prior work about the Hauraki Gulf's economic value and going beyond just updating those estimates by expanding the scope of what's being estimated to include non-market as well as market-based values and drawing out implications for decision making. It looks more closely at components of value derived from the Gulf as a set of functioning natural ecosystems and hence provides ways of attaching economic value to the observed decline in the state of its environment to better assess the economic worth of reversing that decline.

### Defining the scope of this report

The Hauraki Gulf can be defined as broadly synonymous with the Hauraki Gulf Marine Park, which covers more than 1.2 million hectares, extends beyond the east coasts of Great Barrier Island and Coromandel Peninsula and includes 50 islands, some of which are held in reserve status. It includes approximately 400,000 hectares of inner Gulf, west of Coromandel and Great Barrier Island and south of Little Barrier Island and Cape Rodney.

The Gulf encompasses the sea, numerous islands, and the coastal littoral zone, which is variously described as including the inter-tidal zone, foreshore, beaches and cliffs behind the shoreline, estuaries, inlets and bays. Land further inland from the coast is the source of run-off and other discharges into the sea, affecting the Gulf environment. As much of this land is privately owned and its natural ecosystems have been heavily modified, we do not include this in the Gulf's natural capital account but recognise its role as a source of pressures acting on the Gulf environment.

### What is natural capital, and how can it help?

Natural capital is a monetary expression of the value streams obtainable over time from healthy functioning ecosystems. This is a 'hidden value' which needs to be made explicit, using both the ecosystem services approach to identify and quantify value streams and the total economic value on approach to monetary valuation, covering both market and non-market values. Market values are based on the goods and services traded in the market. In contrast, non-market values reflect the value of the natural environment to society beyond transactions for goods and services.

The ecosystem services approach categorises the benefits people obtain from the natural environment into provisioning services, cultural services, regulating services and supporting services. Of these categories of services from the environment, only the provisioning services are currently counted as contributing to gross domestic product (GDP).

While natural capital valuation of terrestrial ecosystems aims to attach values to the mosaic of land uses and ecosystems and the interrelationships between them, this is more difficult for marine environments because of different ecosystems at sea-bed, surface and water column level, relatively limited information of what's happening to each level and the continuous perturbation and mixing of waters. In practice, this requires accounts to simplify causes and effects associated with marine ecosystems and work around available data gaps.

## A feasible way forward

Practical approaches to compiling natural capital accounts range from the academic, which aims to be comprehensive and value as many items as possible, and approaches of quasi-official agencies such as the World Bank, the United Nations and many countries' national statistical offices, which place a higher emphasis on consistency with existing national accounting and defensibility of values used. These quasi-official approaches tend to focus on valuing things which contribute to marketed values.

This report uses an ecosystems services framework drawing on local and international examples. A natural capital valuation can help management decision making by placing monetary value on the services at risk from encroachment on, or modification of, the Gulf's marine ecosystems. A credible non-zero value changes the weighting of environmental effects in decisions that impact the environment and signals how much it is worth taking measures to avoid, remedy or mitigate any adverse environmental effects. Preparation of natural capital valuation depends on biophysical information on the state of the Gulf, so such valuations add a purpose to the collection of comprehensive biophysical data. They give visibility to matters of value that are otherwise hidden and omitted from decision making.

## Devising and populating a long list of the Gulf's ecosystem services

A natural capital valuation informs decisions about the management of the natural environment and should be aligned with the State and Impact components in a Pressure-State-Impact framework for monitoring environmental impacts. It requires a shift in focus from previous accounts that have identified the contributions to GDP of various activities in marine areas like the Gulf. Such accounting systems say little about the state or value of natural capital because:

- The values they identify derive from the combination of many different types of input and capitals, from which it is difficult to discern that attributable to natural capital
- They are derived from production accounts and omit consideration of any value derived from the consumption of ecosystem services from the Gulf, such as non-market values of recreation and natural and cultural heritage protection provided by the Gulf.

A natural capital account to inform decisions about the management of the environment needs at least to include the following:

- A snapshot of the value obtained from the current configuration of ecosystems, i.e. the annual value obtained from the environment as it is now, with the contribution of the state of the environment clearly attributable and separate from that of other capitals
- An asset value based on the capitalisation of the economic surplus or 'rent' obtained from the natural environment, estimated from projecting forward the value of services into the future, taking account of any changes in expected volume or value, drawing expectations from past trend analysis and other foreseeable future pressures.

The ecosystem services approach provides a recognised framework for identifying sources of value attributable to the state of the natural environment, including both market values and non-market values.

### The ecosystem services associated with the Hauraki Gulf have an estimated total economic value of $5.14 billion per year (see Table 1)

The assessment of the ecosystem services shows that the value of GDP associated with the Hauraki Gulf is about half of the Gulf's non-market values not captured within GDP. The implication is that regulatory and business decisions that only consider values measured in GDP could be missing important environmental benefits and costs that have consequences for the sustainability of economic wellbeing, growth and development.

The extractable provisioning services captured in GDP (commercial fishing, aquaculture and sand mining) are substantially less than those not captured in GDP (recreational fishing). Cultural services of recreation and property value uplift account for most of the estimated ecosystem service value. The value of regulating and cultural services is much smaller but also incomplete due to the data limitations to quantify and value all these services.

The natural capital approach requires the estimation of three distinct types of value:

- Annual value from ecosystem services: this is a value of service outputs, the source of economic value added (or GDP) after deducting the value of inputs
- Economic rents attributable to nature, the residual value after deducting returns to all other capital (human capital, productive capital) from the output value
- Asset value, which is the capitalised value of future expected flows of economic rent from environmental sources: may be used to measure the sustainability of service flows.

### There is a lot of scope for further research in the assessment and valuation of the Hauraki Gulf

The inputs into the assessment of the value of the Hauraki Gulf often relied heavily on one-off studies or economic valuations from other parts of New Zealand.

More scientific and statistical research on the ecology and economy of the natural environment of the Hauraki would greatly improve the ability to assess the benefits and costs of regulatory and business decisions that impact the Hauraki Gulf environment.

The recommended priority areas for further research are:

- Non-market valuation studies specifically related to the ecosystem services of the Hauraki Gulf, which include Māori perspectives as well as the general population
- GIS mapping of ecosystem services from the Hauraki Gulf

- Measuring the frequency of recreational activities in the Hauraki Gulf, not just annual participation
- Evaluation of the role of the Hauraki Gulf in moderating Climate Change.

### Table 1 Central estimates of ecosystem services from the Hauraki Gulf

Per year in 2023 dollars

| Ecosystem service category | Central estimate ($m) | Included in GDP ($m) | Not included in GDP ($m) |
|---|---|---|---|
| **Provisioning services** | | | |
| Ports and shipping | $1,340.0 | $1,340.0 | |
| Cruise tourism | $292.0 | $292.0 | |
| Aquaculture | $83.3 | $83.3 | |
| Commercial fishing | $29.8 | $29.8 | |
| Recreational fishing | $187.8 | | $187.8 |
| Sand extraction | $5.0 | $5.0 | |
| ***Total provisioning services*** | **$1,937.9** | **$1,750.1** | **$187.8** |
| **Cultural services** | | | |
| Recreation | $2,493.0 | | $2,493.0 |
| Property value uplift | $526.1 | | $526.1 |
| ***Total cultural services*** | ***$3,019.1*** | | ***$3,019.1*** |
| **Regulating & support services** | | | |
| Water quality | $96.0 | | $96.0 |
| Biodiversity health | $89.8 | | $89.8 |
| Carbon sequestration | $2.5 | | $2.5 |
| ***Total regulating & support services*** | ***$188.3*** | | ***$188.3*** |
| **Total economic value of the Hauraki Gulf ecosystem** | ***$5,145.3*** | ***$1,750.1*** | ***$3,395.2*** |

Source: NZIER

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# 1 Objectives and scope

The Hauraki Gulf Forum commissioned NZIER to provide a top-down assessment of the Gulf's value using a Total Economic Value framework and an Ecosystem Services approach.

## Research objective

The objective of this research is to estimate the value of the Hauraki Gulf using an approach that is useful for a range of assessments about how to consume, manage, conserve and protect the natural environment.

It is intended to counter the risk that marine ecosystems are perceived as being less valuable simply because their actual value has not been sufficiently quantified and environmental damage has been inadequately recorded.

A natural capital value account for the Hauraki Gulf could act as a 'balance sheet' to complement the flow statistics of economic and environmental change.

## Scope of the research

The scope of the research includes the following research activities:

- Developing a framework to capture the Total Economic Value (TEV) of the Hauraki Gulf, which covers market and non-market activities
- Using existing research to estimate the value of the Hauraki Gulf
- Identify key priorities for further research.

The following research activities are out of scope:

- New empirical and primary research
- Policy recommendations and evaluations of existing policies.

## Funding statement

The Hauraki Gulf Forum (henceforth The Forum) funded the research. The research was completed independently of The Forum.

## Structure of the report

The report begins with assessing the frameworks and theories available to evaluate and categorise the TEV of the economic system linked to the Hauraki Gulf.

## 2 The Hauraki Gulf

The Hauraki Gulf is the area of sea on the northeast coast of the North Island bordering the eastern coastline of the Auckland and Waikato regions, from Mangawhai in the north to Waihi in the south, including the Firth of Thames and the entire Coromandel coastline. It is commonly described as covering 1.2 million hectares, an area broadly coincident with the Hauraki Gulf Marine Park and encompassing the coastal inlets and shorelines of Auckland and the Waikato coastline. It also encompasses more than 50 islands, some of which are managed as reserves by the Department of Conservation (such as Rangitoto and Tiritiri Matangi) and others of which are largely in private ownership (such as Waiheke and Rakino). Figure 1 below shows the extent of the Hauraki Gulf Marine Park.

Some documentation refers to an Inner Gulf area of 400,000 hectares, describing the area bounded by the western shore of Coromandel Peninsula, the southwest shore of Great Barrier Island and the southern shore of Little Barrier Island and Cape Rodney along the eastern shore of Auckland Region. This area is closest to the main population centres and receives the most intense interest as a setting for recreation and other cultural activities. But the outer Gulf beyond the Barrier Islands contains a larger area and also has pockets of high interest for recreational and cultural use.

The length of coastline in the Gulf adjoining the Waikato region is 830 kilometres (55 percent of all Waikato Coastline), encompassing both sides of the Coromandel Peninsula and the base of the Firth of Thames (Waikato Regional Council 2023). We have less specific data for the Gulf's shoreline for Auckland region: Auckland's total shoreline is stated to be 3,200 kilometres (Carpenter et al. 2017), and we expect the eastern Gulf-facing side, to account for at least half, including the Gulf islands, but have found no verifiable data on that. At the time of writing, our best estimate is around 2,400 kilometres of coastline in the Gulf.

Water depths range from shallow estuarine areas in the Firth of Thames, averaging around two metres, to the outer Gulf, where average depths increase to 85 metres (Hauraki Gulf Forum 2011).

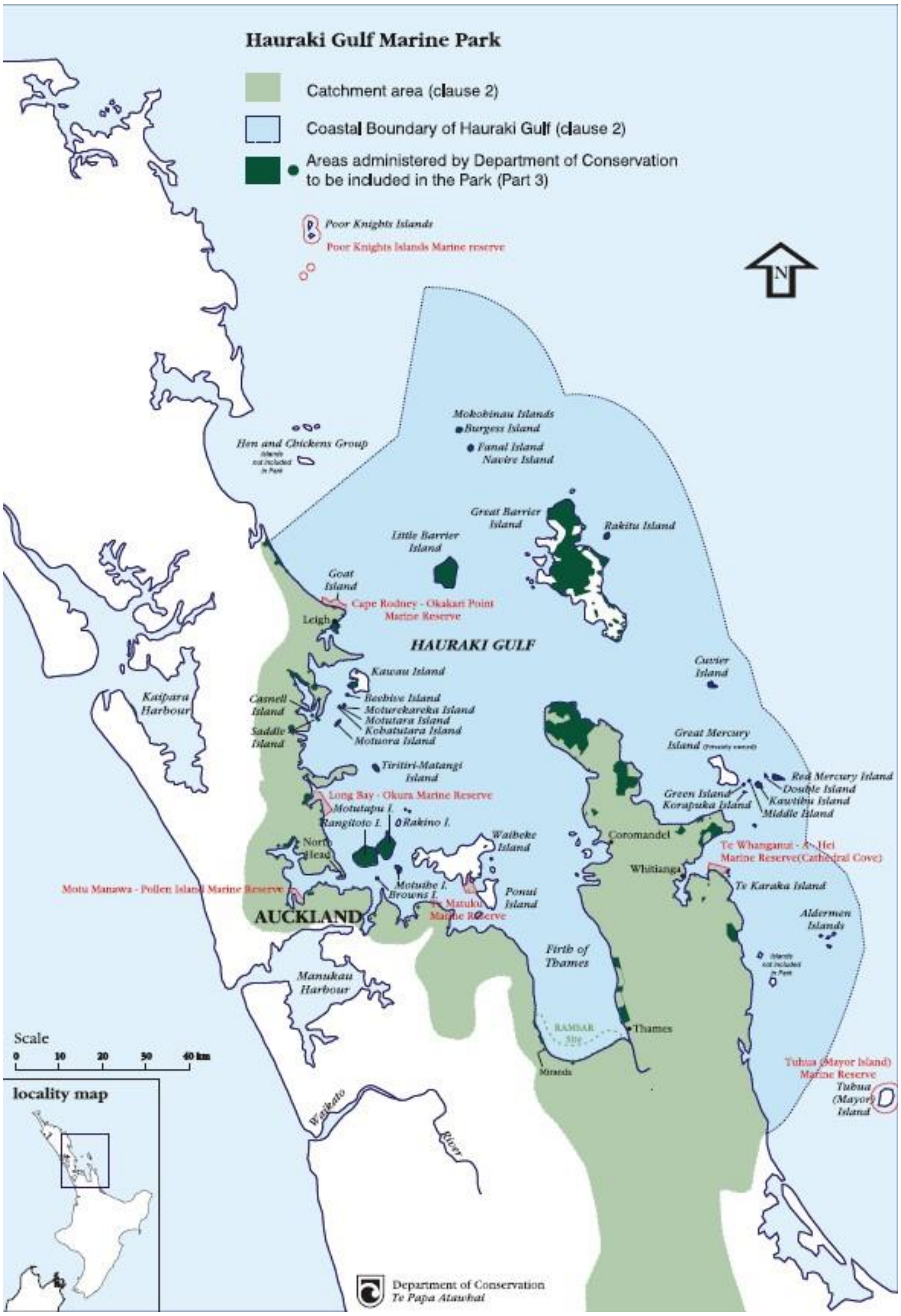
Figure 1 also shows shaded areas on the mainland representing the catchment areas of streams that drain into the Gulf. These catchments are the source of discharges into the Gulf, particularly in the Firth of Thames. However, they are primarily in private ownership and subject to regional regulations over land use and discharges into aquatic media.

The Hauraki Gulf Marine Park (2000) was established to protect the natural and historic features of the Gulf. The Act established objectives for the Gulf, its islands and catchments and provides for integrated management across land and sea, with links to the Resource Management Act, Conservation Act, Fisheries Act and other legislation. The Act established the Hauraki Gulf Forum to facilitate local and central government coordination and recognise tangata whenua's relationship to the Gulf. The Act requires the Forum to produce a State of the Environment Report for the Gulf every three years.

For this report, we define the Hauraki Gulf as coinciding with the Maritime Park area to use data collection that is already aligned with those boundaries. However, data about the Maritime Park and its uses are not evenly available for all parts of the Park, and attempts to quantify and value the benefits obtained from the Park are subject to that uneven data availability.

Benefits include those obtained from the open sea, coastal inlets and the land/sea interface of the littoral coastline. They include things obtained from the Gulf as a setting for recreation and cultural focus, a source of food and materials (e.g. fish and shellfish) and a sink to receive and assimilate material flowing from the shore. They also include the regulatory services provided by the Gulf that protect activities and values for people living in or visiting areas around the Gulf.

## Figure 1 Geographical extent of the Hauraki Gulf




Source: Department of Conservation

# 3 Methodology

## 3.1 How widely to define natural capital?

Natural capital can be defined widely to include any natural feature that provides value for people. Such wide definitions have resulted in previous attempts to value marine resources as the sum of industries that generate GDP and are associated with activities in the marine area, including ports and shipping, naval bases, commercial fishing and mining, recreation supply industries and educational and scientific endeavours. This was the basis of previous studies for the Auckland Gulf (Barbera 2012) and also at the national level with Marine Economy Accounts (Statistics New Zealand 2023).

However, such studies do not say much about the natural capital of the marine area because:

- The gross domestic product (GDP) figure is the product of a wide range of inputs and other types of capital investment (plant and machinery, infrastructure etc.), and by the time a return on these capitals is accounted for, the residual value accruing to natural capital is likely to be a very small percentage of the headline figure
- The GDP figures are derived from accounts that measure production in the market economy and exclude the potential non-market contributions and consumption benefits obtained from the presence of the Gulf (e.g. from recreational activity, enjoying the view).

This report has been commissioned for the Hauraki Gulf Forum at a time when the Hauraki Gulf is reportedly coming under pressure from multiple human activities, and many of its natural ecosystems are depleted or diminished. The problem that a natural capital account can address is the failure to adequately account for non-market ecosystem impacts because they are not adequately measured or valued and hence are not given much weight in decisions guided by economic analyses.

Consequently, this report focuses on ecosystem services as the most critical elements of natural capital requiring measurement and valuation. Human impacts on the state of the Gulf are externalities, the costs of which are hidden and fall on people other than the perpetrators of impactful activity. The mainly biological aspects of ecosystem services are also the matters most likely to require management interventions to ensure their survival. So, putting explicit values on the ecosystem services can help decisions on options for management by providing insights that are not already available elsewhere.

## 3.2 The framework underpinning natural capital valuation

The value of natural capital is the combination of several factors that vary over time as markets and social preferences change. A generalised formula of the value of natural capital captures the various inputs and considerations. The formula provides a framework for the market and non-market factors that influence the value of natural capital.

$$V = \sum_{t=1}^{N} \frac{P_t \times F_t}{(1+r)^t}$$

Where:

V is the value of natural capital

P is the unit price of the flow of natural capital, which can include market and non-market values

F is the flow of natural resources

r is the social discount rate to convert the future flow into present value

N is the timeframe being considered

t is the year of interest.

This formula captures three types of risks to the value of natural capital:

- Changes in P could include market dynamics and a shift in society's valuation of the benefits of a resource
- Risks from the changes in flows of beneficial services from the natural environment
- Changes in the social discount rate that reflect social preferences over time.

Such an approach can be applied quantitatively to decision-making assessments such as cost-benefit analysis to incorporate considerations for the effects of decisions on the provision and consumption of natural capital. It provides a means to convert a physical change in environmental condition to a change in value to people, which may be compared with the cost of measures to mitigate that change. It could also be used to consider the sustainability of natural capital and its contribution in dollar value terms, reflecting other factors that influence prices. This would require consistent measurement over time.

## 3.3 Whose values count?

For any valuation of a natural resource, a question arises as to how widely to cast the valuation. For the Hauraki Gulf, all New Zealanders and even overseas visitors could value the sustaining of its environment, either as tourists or valuing its existence for its own sake.

A wide community of interest would increase any estimated value, but held values tend to decline with distance from a resource, and many benefits of the Gulf primarily accrue to local residents. We limit values to those accruing to local residents in or around the Gulf in the first instance, the area within which benefits are most experienced and management responses most feasible, with consideration of national or wider value where appropriate.

The Hauraki Gulf Survey (Horizon Research 2021) shows that people from the area enjoy a range of water-based activities in the Hauraki Gulf. This is equivalent to about 1.9 million active recreational users of the Hauraki Gulf based on the population of the surveyed districts in 2023 using population estimates (Statistics New Zealand 2022). The total population of the surrounding area was 2.6 million in 2023.

# 4 Framing the value of the Hauraki Gulf

## 4.1 Problem definition

The Hauraki Gulf is a natural resource bordering a large city and serves many purposes. It is simultaneously a:

- source of food, fibre and other materials that are extracted and used by people
- setting for cultural activities, recreation, education and scientific research
- space/location for navigation and related port and marine support activities
- sink for discharge of its terrestrial catchment area's rivers and their suspended sediment and contamination and for assimilation of wastes, including overspill from urban wastewater and stormwater systems.

Previous attempts to estimate the value of New Zealand's natural capital have been limited or partial in coverage. Statistics NZ provides a national analogue in its Marine Economy account, but it is primarily confined to the marine area as a source of commercially extractable materials or products or as space for shipping, port services and other marine-related activities (e.g. boat building). It misses values not expressed through markets (e.g. cultural, recreational) and the effects of activities that detract from the natural characteristics and value for other uses (Statistics New Zealand 2023).

Previous reports on the value of the Hauraki Gulf have similarly been confined by the availability of economic data. For instance, Barbera (2012) compiled data for commercial activities located on or connected to the Hauraki Gulf, such as the Port of Auckland, commercial fishing and aquaculture, recreational fishing, marine recreation supply industries and mining of sand. Excepting fishing and aquaculture, arguably, none of these sources of value is dependent on ecosystem services. However, all of them may disturb natural ecosystems to the detriment of the ecosystem services they provide.

Long-term sustainability of value and how it changes over time and with compositional shifts in activity are not discernible from these previous studies. Consequently, changes in the environment that impact on value for people may be missed or dominated by commercial values in economic assessments of the state of the Gulf and potential changes to it.

This report pushes beyond earlier attempts to guide how to provide:

- A more comprehensive account of natural capital, with market and non-market values
- Information of not just value at a snapshot in time but of how that value changes over time, and with marginal changes in the mix and composition of activities on the Gulf
- Recognition of the trade-offs that exist when choosing between activities on the Gulf
- Information to fill or overcome gaps in currently available data.

## 4.2 Organising frameworks relevant to natural capital

Economic valuation needs a framework to structure the assessment and valuation of natural resource assets and services linked to the Hauraki Gulf. The purpose of the framework is to provide a structured approach to combining potentially disparate information in an ordered fashion. The framework assists with categorising natural resources, which also helps identify the information gaps and manage the potential for double counting.

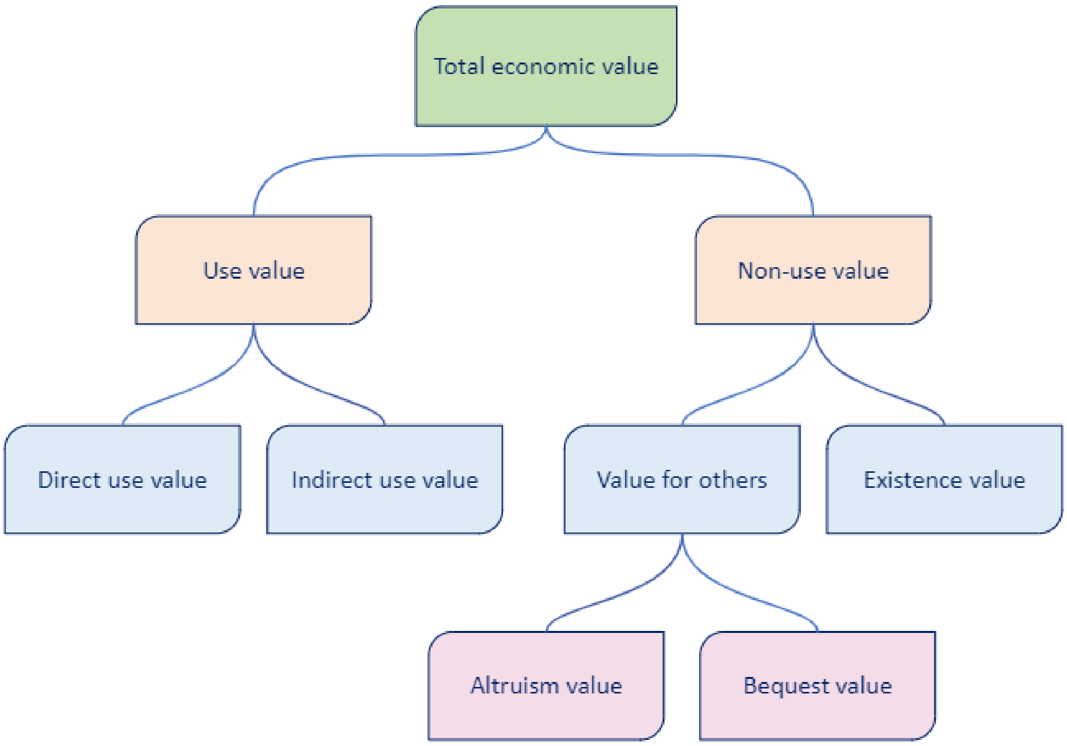
This section of the report explains two key frameworks, TEV and ecosystem services (ES). The use and relationships between the two frameworks provide the context for the approach taken in this report to value the Hauraki Gulf.

### 4.2.1 Total economic value

The concept of TEV was defined in the 1980s in the then-emerging field of environmental economics (David Pearce, Markandya, and Barbier 1989). The aim of the TEV approach was to give effect to the recognition that environmental resources have value beyond their current or potential tangible uses, and understanding this value was critical to the robust assessment of decisions that affect or consume environmental resources.

Figure 2 shows the conceptual structure of the TEV framework and the sub-category values that contribute to the valuation of overall TEV. It is divided into two main subcategories of use and non-use values.

**Figure 2 The total economic value framework**




Source: OECD (2006)

Use value measures the extent to which environmental resources are used or consumed in consumption or production (D. Pearce et al. 1991). For example, aquaculture production yields and nutrient recycling. The sub-components of use value include:

- Direct use value, also known as current use value or actual use or active use value. It reflects mostly tangible values of uses made of an environmental resource by people for final consumption or inputs into production, including such things as harvesting of food products, seaweed, fuel or mineral compounds, and non-consumptive uses such as recreational and cultural activities that use the environment in situ without extracting materials or organisms.
- Indirect use value (sometimes called production support value) is an additional category that refers to benefits derived outside the ecosystem that creates them, such as carbon sequestration benefits for the global community, water filtration benefits for people downstream, or the storm protection of mangroves that benefits coastal properties and infrastructure.

Non-use values include the benefits from the environment without any human consumption. The subcomponents of non-use value include:

- Option value, more accurately described as a value for future use, comprising option value, or the value of retaining something for future use and quasi-option value, or the value of waiting for better information before committing to resource use which may be irreversible; it can also be construed as the potential value of as yet unknown attributes or uses of a resource that could be beneficial in future.
- Value for others is an individual's willingness to pay for the benefit of other people, both those alive today (altruism value) and those alive in future (bequest value).
- Existence value is an individual's willingness to pay for the benefit of other things, principally other species that are considered to have a right to continued existence, but sometimes more abstract notions (like environmental integrity).

The TEV framework comes from the perspective of the natural environment as input to and source of human consumption and satisfaction. It can be applied to monitor sustainable development. Its weakness is the tendency to still see the economy and the environment as interconnected but separate. A detailed investigation of the TEV framework, including its strengths, weaknesses, uses and limitations for policy analysis, is provided by Bealing and Clough (2018).

### 4.2.2 The ecosystem services framework

The contribution of the natural environment can be defined using the ecosystem services framework, which links ecosystem conditions to natural functions and services of value to people. It focuses on four different kinds of ecosystem services that nature provides for humans:

- **Provisioning services** such as the supply of wild food, timber, sources of energy and water.
- **Regulating services** such as flood mitigation and erosion control and water quality.
- **Cultural services** such as providing settings for recreation and non-use or passive nature appreciation – simply knowing that species like Maui's dolphin exist or that sites with heritage associations will remain for future generations to enjoy.

- **Supporting services** such as basic processes like nutrient cycling or pollination on which all other services depend – but supporting services are rarely subject to separate estimation because of their interconnection with other services and the risk of double counting.

The ecosystem services framework describes how ecosystem functions produce things of value that can be extracted and mediated through other types of capital – built capital like plant and infrastructure, human capital (knowledge and skills) and social capital (organisation and institutions) to produce goods of benefit to people's wellbeing. Natural capital pertains to that part of the value that is derived from the natural environment, and the expected flow of future such services can be capitalised through discounting into an asset value of the current stock.

Quantification and valuation vary with the type of ecosystem services.

- Many provisioning services are already subject to market provision, so the value can be attributed to the supply and demand observed in the markets.
- Regulating services are not so often supplied through market processes, so while some may be readily quantified, others require bespoke estimation and may use non-market valuation techniques based on avoided costs or replacement costs of things that would be needed in the absence of ecosystem services.
- Cultural services of ecosystems are often not supplied through market processes, or they involve public goods for which it is not practicable to monitor who benefits or by how much. Hence, quantification requires field observation, and valuation requires bespoke exercises that may involve more abstract non-market valuation techniques, including revealed preference methods such as hedonic price analysis of the premium attached to the value of properties with high environmental surroundings or stated preference methods that ask a sample of people how much they would be willing to pay to retain or improve some aspect of the environment.

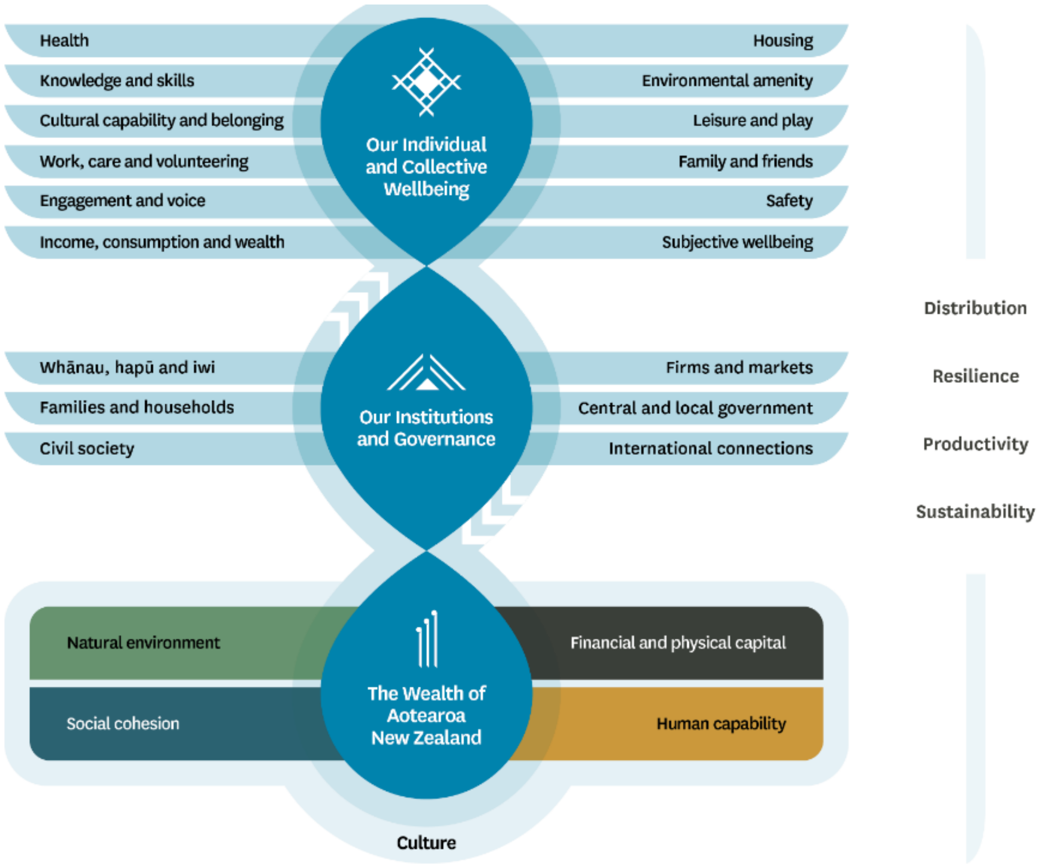
### 4.2.3 The Living Standards Framework

The Treasury's Living Standards Framework (LSF) aims to cover multiple attributes of life that contribute to New Zealanders' wellbeing. The LSF is intended as a flexible framework that supports thinking about policy impacts across the different aspects of wellbeing. The framework assists structured consideration to understand the drivers of wellbeing.

It supports Treasury analysts by providing a framework to understand the drivers of wellbeing and to consider the broader impacts of its policy advice in a systematic and evidenced way. The LSF includes three levels:

- individual and collective wellbeing
- institutions and governance
- the wealth of Aotearoa New Zealand (Figure 3).

## Figure 3 The Treasury's Living Standards Framework




Source: The Treasury (2022)

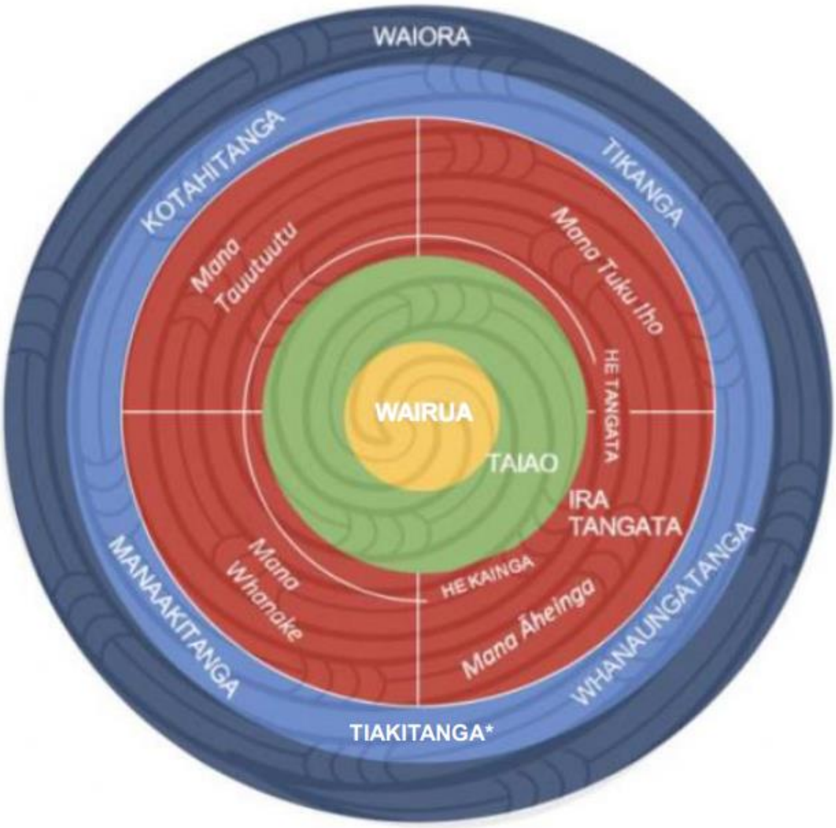
The Hauraki Gulf and its ecosystem services fit fundamentally into the foundation wealth of Aotearoa New Zealand. The LSF wealth level aims to capture aspects of wealth not fully captured in the system of national accounts, such as human capability and the natural environment.

The value of the Hauraki Gulf acts through two levels of the framework. At the individual and collective level, the Hauraki Gulf is a source of income, consumption and wellbeing through employment and enterprise. The Gulf is also a source of leisure, play and environmental amenity contributing to wellbeing. The Hauraki Gulf is a natural environmental asset, locally, regionally and nationally, contributing to New Zealanders' wealth.

### 4.2.4 He Ara Waiora, the LSF and the Hauraki Gulf

He Ara Waiora is a framework built from te ao Māori knowledge and perspective of wellbeing to define living standards. Waiora reflects a broad conception of human wellbeing for Maori, which is grounded in water (wai) as the source of life (ora). It aims to convey that all aspects of waiora are interrelated. He Ara Waiora addresses ends and means. The ends are the outcomes in domains that are important. The means are approaches and processes society must follow to achieve the ends.

**Figure 4 He Ara Waiora**




Source: The Treasury (2021)

The **ends** of waiora are the enhancement and sustaining of key aspects of living:

- Wairua (spirit) is at the centre to reflect that it is the foundation or source of wellbeing. Values, beliefs and practices related to wairua are essential to Māori conceptions of health and wellbeing.
- The wellbeing of Te Taiao (the natural world) is paramount and inextricable from human wellbeing. There are responsibilities and obligations to sustain and maintain the wellbeing of Te Taiao.
- Te Ira Tangata (the human domain) encapsulates human activities and relationships. People (tangata) and collectives (kainga) thrive when they:
  - Have a strong sense of identity and belonging (mana tuku iho)
  - Participate and connect within their communities, including fulfilling their rights and obligations (mana tautuutu)
  - Have the capability to decide on their aspirations and realise them in the context of their own unique circumstances (mana āheinga)
  - Have the power to grow sustainable, intergenerational prosperity (mana whanake).

The **means** are principles for how to approach the creation of waiora (wellbeing):

- Kotahitanga means working in an aligned, coordinated way across the system and in partnership with businesses, communities, iwi and whānau.
- Tikanga means that decisions have to be made in accordance with the right processes. This includes working in partnership with the Treaty partner.
- Whanaungatanga means fostering strong relationships and networks, both through kinship and shared interests.
- Manaakitanga means maintaining a focus on improved wellbeing and enhanced mana for all New Zealanders. It means supporting each other and demonstrating an ethic of care for our fellow New Zealanders. Distributional analysis is important to identify and address inequities.
- Tiakitanga means guardianship, stewardship (e.g. of the environment or other important processes and systems that support wellbeing).

# 5 Putting frameworks into practice

## 5.1 International efforts at including the natural environment in economic accounts

International efforts at including the natural environment in an economic accounting frame are split between academic approaches and more cautious approaches by official international agencies. Academic or experimental literature may lack rigorous adherence to accounting disciplines. Official approaches are more rigorous but also more limited in what they cover.

### 5.1.1 Academic attempts at ecosystem accounting

Attempts at extending economic accounts to include natural resources in measures such as green GDP and Net National Wellbeing can be found in state-sponsored measures in France, Norway and Japan in the 1980s. These include simple estimates of Net National Product (deducting stock depreciation from GDP), Green Domestic Product (similarly deducting some measure of environmental deterioration) and New Net Welfare measures. Although raising awareness of values missing in the economic accounting of GDP, these early initiatives had little effect on changing the scope of accounting in practice.

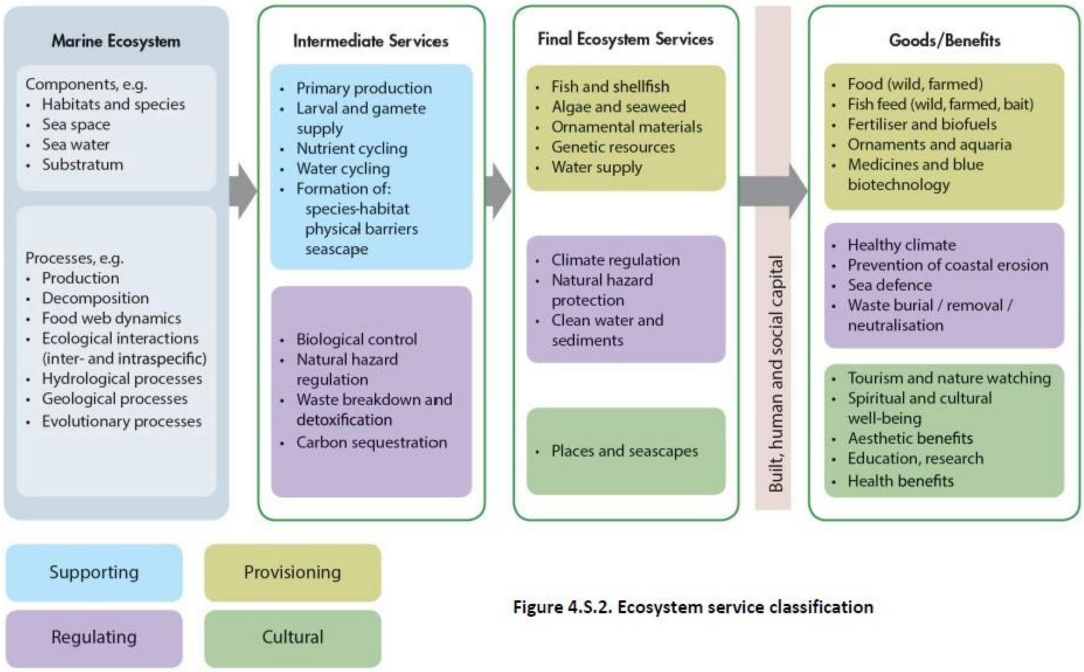
Accounting for ecosystem services first received prominence in Costanza et al.'s 1997 article, *The Value of the World's Ecosystem Services and Natural Capital,* published in *Nature* magazine (Costanza et al. 1997). This was a large-scale exercise, drawing on a range of market and non-market valuation techniques to assign value to particular services. It estimated the value of the world's ecosystem services to be collectively worth about three times the world's total GDP output in that year (Costanza et al. 1997). Many economists criticised it for mixing valuation concepts and not providing meaningful values for marginal changes in ecosystem services outputs. In a 2014 update of this study, Costanza et al. conceded that their estimate could not be used for marginal analysis but argued it was still useful as an illustrative tool in drawing attention to the unstated values associated with ecosystem services (Costanza et al. 2014).

In 2001, the United Nations initiated the Millennium Ecosystem Assessment (MEA), which was charged with assessing the consequences of ecosystem change on human wellbeing. It described ecosystems as "*a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit*", and it proposed in its 2005 report a four-fold division of the benefits of natural assets into provisioning, supporting, regulating and cultural services. This provides a framework for inferring the economic value of different functions and services (Millennium Ecosystem Assessment 2005).

A Common International Classification of Ecosystem Services (CICES) has been developed from the work on environmental accounting undertaken by the European Environment Agency. This builds on the basic four categories of ecosystem services to distinguish between biotic and abiotic components, divisions within these categories (e.g. between water and non-aqueous within abiotic services), and groups within these categories (e.g. surface water and groundwater, minerals and non-mineral non-aqueous services). Its extensive data requirements may make it more difficult to apply in practice.

Various countries have attempted to prepare natural capital accounts under the ecosystem services framework. One of the most ambitious has been the UK's National Ecosystem Assessment (2011), a highly resourced, interdisciplinary exercise that is more extensive than most (UK National Ecosystem Assessment 2011). That assessment combined information on the state of the environment, its direction and rate of change, and some detailed modelling of implications for value for such activities as recreation and tourism. It drew a distinction between intermediate and final ecosystem services, which are mediated through built, human and social capital into goods and benefits (Figure 5), and identified these for eight habitat types, including Coastal Margins and Marine. There is as yet no indication of whether the Assessment will be repeated in full, but there has been some follow-on work, including on the application of adaptive management to achieve more sustainable management of the coastal and marine environment (UKNEAFO 2014).

**Figure 5 Ecosystem services in coastal and marine areas**




Source: UKNEAFO (2014)

Costanza's 1997 approach has been replicated for New Zealand terrestrial ecosystems by (Patterson and Cole 2013) in a contribution to a Landcare Research book on ecosystem services in New Zealand (Dymond 2013). Patterson and Cole's estimate does not cover marine areas other than estuarine and waterfront habitats (e.g. mangroves). It provides a single estimate only, with little indication of how values might vary with changes in the state of ecosystems. In the same Landcare book, (MacDiarmid et al. 2013) estimate the ecosystem services' contribution to wellbeing from the marine environment is far greater than from fisheries and that scaling the New Zealand value by the global relativities of terrestrial and marine value in Costanza et al. (1997), New Zealand's marine area (including the exclusive economic zone) would provide US$357 billion worth of services each year.

Using Costanza et al.'s (2014) approach to valuing the ecosystem services from the marine environment would suggest the value would approach $1 trillion. Recent assessments of the marine environment suggest that the sustainability of the contribution of the natural marine environment to wellbeing is under pressure from human activities and pollution (Ministry for the Environment and Stats NZ 2019). The contribution of fisheries and mangroves to the wellbeing of New Zealanders has varied over the last three decades.

### 5.1.2 Official attempts at environmental accounting

International official agencies' efforts at environmental accounting fall principally into four categories:

- UN System of National Accounts (SNA): the basic economic production accounts from which are derived GDP, income measures (such as gross national disposable income) and other aggregate monetary measures – but largely excluding measures of environmental quality, other than measures of environmental expenditure (to halt decline or restore some quality level).

- UN System of Environmental Economic Accounts (SEEA): application of SNA accounting principles to construct consistent 'satellite accounts' of some environmental stocks, such as fish, forests, minerals and renewable generation capacity – still largely limited to monetary value flows related to those that appear in the main SNA accounts.
- World Bank measures of Genuine Savings, Total Wealth or Comprehensive Wealth which calculate the stock value of various aspects of natural capital, including metals and minerals, fossil fuel reserves, farmland, forests and fisheries, but also include values for the extent of protected areas and some ecosystem services from forest lands and mangroves – an attempt to show how future wealth sources are tracking over time, but still largely confined to market values.
- United Nations Inclusive Wealth, which defines aggregate wealth as the shadow value of stocks of all assets in an economy – including those categorised as built capital, human capital and natural capital such as forests, agricultural land, fisheries, oil, coal, gas and minerals – as a means of assessing the sustainability of income possibilities over time, but still confined mainly to items with market values, and excluding cross-category assets such as biodiversity and landscape, which contribute to resilience, stability and value for tourism.

The strength of these approaches lies in the consistency and rigour of their accounting frameworks, which require that certain factors remain in balance by narrowing the boundary of what's in and out of the accounting frame. The differences and merits of these systems are outlined in the table below.

### Table 2 Summary assessment of the merits of accounting systems

| System | Objective | Strength | Weakness |
|---|---|---|---|
| System of Environmental-Economic Accounting | Providing better national accounting linkages between the economy and the natural environment | Utilises information that is easier to gather and comparable with other national accounts | Relies solely on the market valuation of natural resources and excludes the non-market components of the social value |
| Comprehensive or total wealth measures | Understanding what is happening to the total stock of assets in the context of economic growth | Tracks trends in natural resources over time to show whether resources are being utilised at a sustainable rate | Assumes substitutability between produced, natural and human capital (weak sustainability), which may undermine the contribution from natural capital over time |
| Inclusive wealth | Measures the intergenerational sustainability of using produced, natural and human capitals | Seeks to capture the social value of natural resources and environmental services beyond those traded in the market | Demands much more information and a more complex assessment |

Source: NZIER

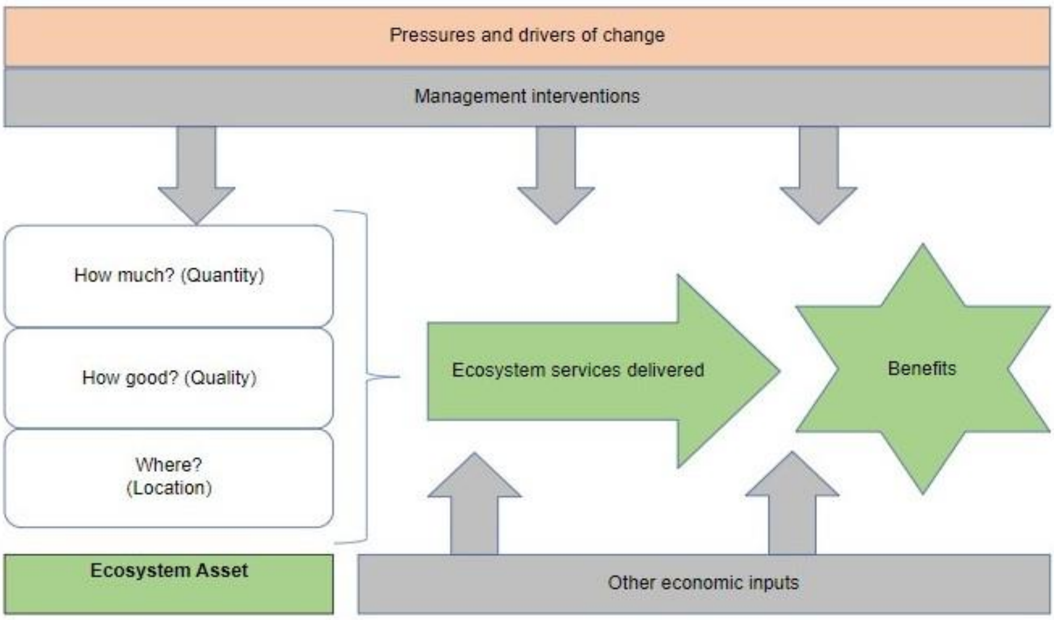
There is a risk of distorting relative values when attempting to extend accounting frameworks to take account of values not originally accounted for. This was well illustrated by Sport New Zealand's estimate of the economic value of sport and recreation in New Zealand: this started with a simple compilation from the production accounts of all activities related to sports and recreation (the value added of sports facilities, sports equipment suppliers, tourism activities linked to sporting events etc.), to which it then added the value of sports participants and volunteer supporters at an assumed opportunity cost of their time, with the result that the value of sport and recreation rose from around 5 percent of GDP to about 12 percent. Most of this opportunity cost value is not realised and is fundamentally distinct from all other values in the national accounting frame. To use that approach properly would require adjusting the boundaries of the accounting frame, comparing the value of sport and recreation not against GDP but against 'GDP-Plus', which covers the opportunity cost of volunteer time spent on supporting economic activity in all other sectors of the economy. GDP-Plus would be bigger than GDP, so sport's share of the total would be proportionately smaller than shown in the simple GDP comparison.

## 5.2 A practical framework for natural capital accounting

A practical guide to natural capital accounting for the Hauraki Gulf may be drawn from two overseas approaches.

The UK's Office of National Statistics provides some useful a schema for preparing natural capital accounts. Figure 6 shows the important measurement of quantity, quality and location of natural assets that generate ecosystem services of benefit to people and also how they are affected by other economic inputs (e.g. relative prices of different products) and by pressures for change and management interventions.

### Figure 6 Natural capital, ecosystem services and the pressure-state-impact framework




Source: Department for Environment, Food and Rural Affairs (2021)

This framework shows potential for linking natural capital accounts explicitly to information gathered in the Pressure-State-Impact framework that has informed Statistics NZ's collection of environmental data: it could enable the natural capital account to signal not only how the value is changing but what pressures and other influences are driving that change. This will be more informative of what corrective policies are needed than a natural capital account on its own.

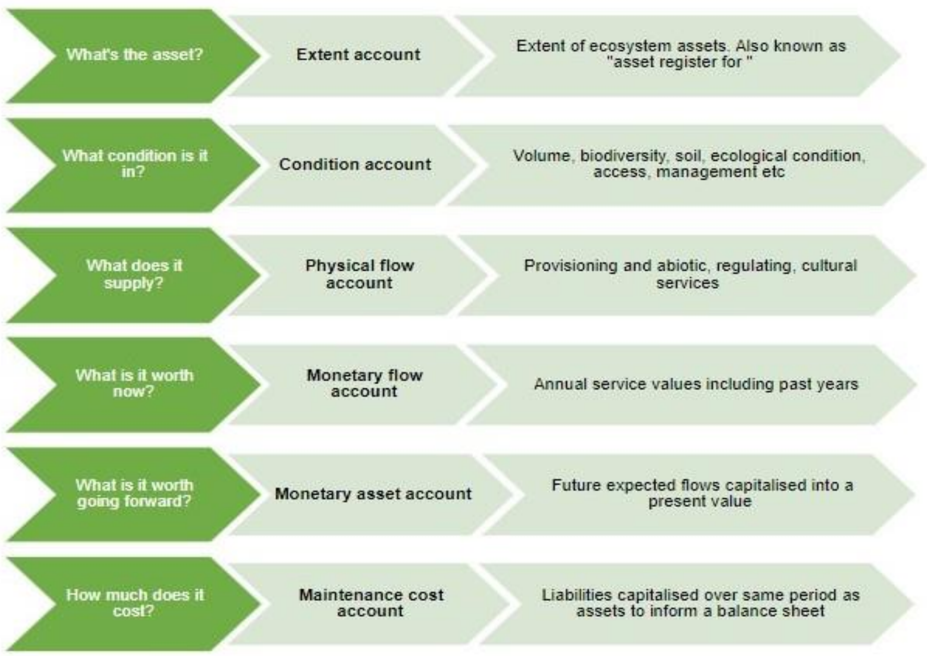
The Pressure-State-Impact framework continues to evolve as a tool that links environmental monitoring and inventions to support the natural environment. The framework could be linked to the valuation framework for the Hauraki Gulf to incorporate the value of ecosystems that might be at risk. For example, the State of the Gulf report signals that some ecosystem services are declining and becoming increasingly rare (or endangered). When reporting the value of specific ecosystem services, it is possible in many cases to combine three aspects to provide complementary benefits in the framework:

- trends in the physical stocks and flows in the measurable ecosystem service
- value of the ecosystem service over time
- an indication of the health or risk status.

The risk status indicator would work in tandem with the physical stocks and flow trends to signal natural capital at greater risk. This could support decision makers at many levels to make informed considerations about the use, management, conservation or protection of elements of the natural environment. The indicator risk could be colour-coded in summaries to assist users. Value at risk could be colour-coded to add clarity and communication benefits to summary material. The implication is that there is potential for integrating the State of the Gulf report and ecosystem service valuation, consistent with the aim of ecological economics.

Figure 7 shows the scope and architecture of accounts required to compile a headline natural capital account in which observed changes can be traced back to their source. This architecture has separate components recording the stock of natural assets, their extent and conditions; the flows of physical services derived from them, and the monetary value of those flows; and the monetary asset accounts of value looking forwards, and how much it costs to maintain.

## Figure 7 The scope of natural capital accounts




Source: Department for Environment, Food and Rural Affairs (2021)

Figure 6 and Figure 7 together describe a workable natural capital framework with a number of components for monitoring and adjustment by management.

The UK's Office of National Statistics produces marine accounts with a broader scope more oriented to natural capital than Statistics NZ's Marine Economy accounts (Office for National Statistics 2021). As shown in Table 3, the UK's marine accounts retain some natural capital that has little relevance to ecosystem services, such as the value of offshore fossil fuel production, but it excludes activities that simply take place in the marine area but whose value is primarily attributable to produced capital and does not vary with the condition of marine ecosystems (such as shipping and ports). The asset values refer to the long-term stream of services obtained from marine natural capital, assumed to last 100 years for renewable services and 25 years for non-renewable services (like fossil fuels).

The first row in Table 3 is an overall estimate that compares the asset values associated with each ecosystem asset estimate covered in the table. For the UK, the largest ecosystem service value is for marine recreation, followed in declining order of scale by carbon sequestration, wastewater assimilation, fish capture, aesthetics and renewables. Fossil fuels (mainly oil and gas) would be third on that list but is not an ecosystem service.

## Table 3 Measures in the marine accounts, natural capital, UK, 2021

| Category | Measures | Quantified estimate | $ value estimated? |
|---|---|---|---|
| Cultural | Asset value of marine services in a year: Recreation, carbon storage, fossil fuels, wastewater treatment, fish caught, aesthetics, renewables, minerals | Yes | Yes |
| | Total recreational visits to coastal margins (with trend over time) | Yes | Only gross spending unadjusted for cost |
| | Number and value of properties that gained value from sea view (amenity value) | Yes | Yes |
| Provisioning | Volume and value of wild fish capture | Yes | Yes |
| | Net profit and wages generated by fish caught in specified waters | Yes | Yes |
| | Profitability per tonne of sustainable fishing | Yes | Yes |
| | Annual value of offshore wind energy generation | Yes | Yes |
| | Annual value of offshore fossil fuel production (oil & gas) | Yes | No |
| Regulating | Areas of land and land use potentially affected by marine flooding | Yes | Yes |
| | Extent (ha) of blue carbon sequestering habitats (3 habitats only) | Yes | Yes |
| | Daily discharge of wastewater, measured on population equivalent basis | Yes | No |
| | Annual value of coastal and estuarine nutrient remediation services | Yes | Yes |
| Supporting | Water Quality: Percentage of surface water bodies classed as high or good | Yes | No |
| | Water Quality: Percentage of coastal bathing water sites of sufficient or higher quality for use | Yes | No |
| | Marine protection: Area of coastal waters under some form of protection designation | Yes | No |

Source: Office for National Statistics (2021)

Figure 8 shows what’s practically possible in an account prepared of ecosystem services in Irish coastal waters. Under the four Millennium Ecosystem Assessment categories, it identifies specific ecosystem services (linked to their CICES categorisation) with estimates of physical flows and monetary estimates attached to them (D. Norton, Hynes, and Boyd 2014). While this is a nationwide estimate, a similar account can be prepared for defined areas within a nation (like the Hauraki Gulf) as long as data and environmental indicators are sufficiently disaggregated to ascribe flows of sources to the local area.

### Figure 8 Value of Irish coastal and estuarine ecosystem services

| Ecosystem service | CICES classification | Estimate of the quantity of ES per annum | Estimate of the value of ES per annum (€) |
|---|---|---|---|
| *Provisioning ecosystem service* | | | |
| Offshore capture fisheries | Wild animals | 469,735 tonnes | 472,542,000 |
| Inshore capture fisheries | Wild animals | 14,421 tonnes | 42,113,000 |
| Aquaculture | Animals and aquaculture | 39,725 tonnes | 148,769,000 |
| Algae/seaweed harvesting | Wild plants and algae/plants and algae from aquaculture | 29,500 tonnes | 3,914,000 |
| Genetic materials | Genetic materials from biota | Not quantified | Not valued |
| Water for non-drinking purposes | Surface water for non-drinking purposes | 1,189,493,326 m³ of seawater used for cooling in power plants | Not valued |
| *Regulating and maintenance ecosystem services* | | | |
| Waste services | Mediation of waste, toxics and other nuisances | 9,350,642 kg organic waste<br>6,834,783 kg nitrogen<br>1,118,739 kg phosphorus | 316,767,000 |
| Coastal defence | Mediation of flows | 179 km of coastline protected by saltmarsh | 11,500,000 |
| Lifecycle and habitat services | Lifecycle maintenance, habitat and gene pool protection | 773,333 ha protected through SACs | Not valued |
| Pest and disease control | Pest and disease control | Not quantified | Not valued |
| Climate regulation | Atmospheric composition and climate regulation | 42,647,000 tonnes $CO_2$ absorbed | 818,700,000 |
| *Cultural services* | | | |
| Recreational services | Physical and experiential interactions | 96 million marine recreation trips per year | 1,683,590,000 |
| Scientific and educational services | Scientific and educational | Marine education and training fees | 11,500,000 |
| Marine heritage, culture and entertainment | Heritage, cultural and entertainment | Not quantified | Not valued |
| Aesthetic services | Aesthetic | Flow value of coastal location of housing | 68,000,000 |
| Spiritual and emblematic values | Spiritual and/or emblematic | Not quantified | Not valued |
| Non-use values | Existence and bequest values | Not quantified | Not valued |

Source: D. Norton, Hynes, and Boyd (2014)

## 5.3 Developing a long list of natural capital (of relevance to Hauraki Gulf)

There are various listings of marine natural capital from the literature surveyed. They have some things in common, but also differences reflecting local preoccupations and data availability.

Much international literature stresses the difficulty of determining ecosystem services in a marine environment due to the 3-dimensional nature of marine space (seabed, water column and surface) and limited data and knowledge about interconnections between different components of ecosystems. Ecological information needs to be simplified into formats that can be practically compiled and analysed to inform policy needs (M. Townsend, Thrush, and Carbines 2011; Michael Townsend et al. 2018).

Mehvar et al. (2018) present a set of broad categories divided between direct and indirect use values and non-use values. These can be readily arranged in an ecosystem services framework, as in Table 4 (M. Townsend, Thrush, and Carbines 2011; Mehvar et al. 2018). Categories are fairly stylised and need some disaggregation to determine what data to collect and what to exclude, e.g. there are multiple categories of recreation that contribute to value drawn from the Gulf, both on the water and beside it. Table 4 also includes in its right-hand column examples of measures that can be used to quantify and value the services obtained, drawing on what was feasible for the Irish coastal services estimate (D. Norton, Hynes, and Boyd 2014).

### Table 4 A categorisation of TEV and ES value components from marine areas

| Direct Values | Indirect Values | Non-use values | Types of measure |
|---|---|---|---|
| **Cultural** | | | |
| Recreation/tourism setting | | Cultural heritage | *Annual recreation trips by activity, user origin* |
| Education/science source | | Bequests to the future | *Value of educational trips to the Gulf* |
| Aesthetic | | | *Property value rise from coastal location* |
| Spiritual/inspirational | | Existence value | |
| **Provisioning** | | | |
| Food, fibre, materials | *Process industry output* | | |
| Wild resources | Marine organisms | | *Wild fish caught* |
| | | | *Aquaculture output* |
| | | | *Algae/seaweed* |
| Abiotic material outputs | | | *Non-drinking water use* |
| | | | *Sand, gravel & rock* |
| Biota-based genetics | *Conversion industries* | | |
| Transport artery | *Ferries, ships, ports* | | *Vessels & payloads* |
| **Regulation** | | | |
| *Waste services* | | | *Assimilation of waste, nitrogen, phosphorus* |
| *Coastal defences* | | | *Coastline protected by healthy ecosystems* |
| Flood control | | | Reduced frequency & cost of damage |
| Storm protection | | | |
| *Lifecycle habitat services* | | | *Area in conservation designations* |
| *Climate change regulation* | | | *Tonnes GHG absorbed* |
| **Supporting** | | | |
| Nutrient cycling | | | *Biodiversity health* |

Source: Drawing on Mehvar et al. (2018)

This list can be refined according to the available data and evolve when new data sources become available. Non-market valuations are required to account for unpriced effects, such as the value of non-commercial recreation and the public preferences for valuing cultural and historic heritage. Value in having the option of retaining a depletable resource for future use may apply to other components in the table, such as stocks of fish and other physical resources, which may be subsumed within prices of goods traded in well-functioning markets and require a non-market valuation for things that are not.

In terms of the UK's natural capital framework outlined in Figure 7 above, the key data requirement is to assemble information on the number of natural resources and the services derived from it, with trend analysis to determine if those services are sustainable into the future, or whether they are declining. The natural capital asset value then becomes the capitalisation of future value streams from continuing physical production, considering whether it is declining, stable or expanding.

Ideally, such accounts would be described with some disaggregation so that it would be possible to identify productivity and prospects that vary with locality. Disaggregation can also distinguish between resources with different functional characteristics: for instance, fish harvest can distinguish between offshore fishing locations and inshore locations and commercial, customary and recreational fisheries. Given sufficiently disaggregated data, a natural capital account can be compiled as a mosaic of different functioning ecosystems, differentiated by location, function and quality, which will assist in identifying changes in the localised value of ecosystem services and where management changes may be required.

Figure 7 also shows that both the stock of natural capital and the ecosystem services that flow from it can be affected by external pressures acting on the environment, which may include such things as population growth (both residents and tourists), increases in intrusive behaviour (trampling, littering), and management responses aimed at controlling environmental impacts. It also shows that underlying economic conditions can have a similar effect on the flow of ecosystem services: increases in market prices may change incentives for how a resource gets used, and increases in people's incomes may increase demands for activities like boating on the Gulf, with associated environmental impacts of noise, disturbance, spills of engine fuels into the water, the spread of invasive pests, which in turn can affect the quality and value of ecosystem service in various ways.

The overseas frameworks for marine natural values do not need to provide for indigenous populations who may value the natural environment differently from the wider population. However, these frameworks can be disaggregated so that distinctive views of minority populations that have different value sets from those of the general population can be recorded separately and not be buried in the overall valuation.

For the Hauraki Gulf valuation, the extent of disaggregation depends on the data available and is still to be assessed. However, there is some data on the distribution of coastal features across seven sub-regions within the Auckland Council jurisdiction – Tāmaki, Hauraki Gulf Islands, Hibiscus Coast, Mahurangi Inlet, Wairoa Valley and Waitematā – to which can be added the waters under the jurisdiction of Thames Coromandel District in the Waikato Region. Geographical disaggregation of natural capital accounts would assist in determining where issues of declining natural capital arise, what value to attach to such declines and where, and help prioritise where remedial interventions could achieve the greatest value benefit.

## 5.4 Implications for scope

### 5.4.1 Shifting the focus

Previous attempts at preparing economic accounts of the value of the Hauraki Gulf have been built on adaptations of regional data consistent with the national economic accounts. For instance, Barbera (2012) focused on a range of wealth-generating activities associated with the Gulf, such as the Ports of Auckland, shipping, the cruise industry, tourism, marine recreational suppliers, aquaculture, commercial fishing and recreational fishing. While these industries may directly or indirectly affect the Gulf's ecosystem services and the state of its natural capital, they are not equally affected. Ports and shipping (and the use of the Gulf for naval facilities) derive value from their location beside the sea, which is used as a means of transport that does not vary in economic worth with changes in natural capital. By contrast, recreational and commercial fishing and aquaculture directly depend on the state of ecosystem services and the natural processes that sustain them. Tourism and marine recreational suppliers sit between these two groups as they serve demands derived from the health of the Gulf's ecosystems but not directly dependent on them.

Another drawback with Barbera's and other previous assessments of economic activities on the Gulf is that they are framed in terms of the economic impacts of activities as recorded in the national economic accounts and provide no guide to activities not identified as 'productive' in the national accounts. The 'non-productive' aspects of the Gulf include the psychological component of the value derived from the Gulf, the enjoyment derived from it and the benefits it confers. In economic assessment, these are items for which there is usually no direct market value, so non-market valuation techniques have been devised to identify the value as either an avoided cost (as in the case of storm damage alleviated by buffering ecosystems) or as a wider mix of use and non-use values which by their nature do not appear in production accounts.

This report adds to the knowledge base by building on prior work about the Gulf's economic value and going beyond just updating estimates by expanding the scope of what's being estimated to include non-market as well as market-based values and drawing out implications for decision making. It looks more closely at components of value derived from the Gulf as a set of functioning natural ecosystems, and hence provides ways of attaching economic value to the observed decline in the state of its environment to better assess the economic worth of halting that decline.

An ecosystem services-based natural capital account requires shifting focus away from previous accounts of GDP-related activity, which are not informative of the total economic value of the Gulf and its condition. This requires:

- Removing from consideration those activities like shipping and ports that do not depend on the condition of ecosystem services
- For those that remain, focus on the economic rent attributable to the natural ecosystem services of the Gulf, by taking observed values and deducting costs of all other resources used in obtaining that ecosystem service value
- For ecosystem services for which market prices do not exist, identify evidence of non-market values likely to apply, including avoided costs of regulatory services and willingness to pay values for cultural services

- Project expected future flows of ecosystem service values into the future and capitalise into a set of asset values.

### 5.4.2 Allowing for cultural diversity

Natural capital accounts aim to represent society's value in the ecosystem services obtained from the natural environment. A simple approach is to seek an average value for the population at large per unit of natural capital or service obtained, but this obscures variation in value held by different subsets of the population. This is particularly the case for non-market values for such matters as the state of the Gulf's water quality or the abundance of its wildlife stocks, including harvestable species that are not traded in markets.

For the Hauraki Gulf, this is most pertinent for local iwi and Māori, who may place different values on aspects of the natural environment than the rest of the population. In the case of decisions being made over components of the Gulf environment, such diversity is commonly addressed through consultation with local Māori with interest in the area in question. Considering the natural capital value of the entire Hauraki Gulf, this would require engagement with more than one iwi.

Primary research to generate values specific to Māori is beyond the resourcing of this study, but an indication of values can be found in the Sea Change report on the Hauraki Gulf Marine Spatial Plan (Auckland Council 2017). The April 2017 Sea Change report compares a Māori perspective of the Gulf with a Western world view which literally turns the latter on its head: the map depicts the Gulf oriented to the sun with the equator beyond the bottom border and the Hauraki Gulf catchments pointing towards Antarctica beyond the top, with a multitude of marae, pa sites and other ancestral sites spread around the coasts and islands. That report identifies key priorities for Hauraki Gulf management as:

- Replenishing the food basket: restoring fish stocks and fostering aquaculture
- Ridge to Reef, Mountains to Sea:
  - Restoring biodiversity (including clearing marine debris and ensuring biosecurity)
  - Improving water quality (dealing with sediment, nutrients, heavy metals and microbial pathogens)
  - Inspiring the Hauraki Gulf Marine Park community
  - Providing access to the Hauraki Gulf Marine Park
  - Designing coastal infrastructure implementing blue design principles.

These priorities aim at improving the Hauraki Gulf's setting – reducing contamination and disturbance from encroachment by infrastructure – to improve biodiversity and build up harvestable food sources. While there may not be Māori-specific values to attach to these matters, the significance of food gathering echoes that found in a willingness to pay study of freshwater resources that yielded separate results from Māori and other respondents by Miller, Tait, and Saunders (2015), and it is likely that the value to Māori of improving the environment for food gathering will be greater than or at least as high as that for the general population.

## 5.5 A feasible approach to accounting for natural assets and societal wellbeing

Natural capital accounts are means of measuring stocks of natural resource-based services in monetary terms. The management function of such measures is to illuminate the value obtained from natural ecosystem services, some of which may not be evident from market trades, and also to compare the level of value obtained from ecosystem services from the same place at different time periods, or from different places at a point in time.

The problem that natural capital accounting seeks to address is the absence of economic values for various functions of the natural environment, which means that the sustainability of these functions is undervalued in economic assessments that affect them. Natural capital accounting provides such values, which can be aggregated values of the total benefit provided by aspects of the current natural environment; or alternatively marginal values of incremental changes in the condition of the natural environment from its current state.

Economic accounting based on the United Nations System of National Accounts (SNA) production-oriented accounts used to estimate gross domestic product (GDP) enumerate the value of goods and services produced by a combination of production capital (plant and machinery), human capital (labour and skills), institutional capital (markets and regulations) and natural capital providing inputs such as fish, minerals and energy. But there are also missing values for natural capital as not all environmental resources are traded in markets, and not all are recognised. The value of a healthy mangrove forest in buffering a shoreline against incoming waves and protecting the value of property behind the shore would not be counted in the current production accounts.

From the perspective of societal wellbeing, however, avoidance of damage to property behind the shoreline would be considered a benefit as long as retaining the buffering mangroves does not incur excessive costs. Additional to their protection value, mangroves provide other beneficial functions, such as nurseries for fish species and habitats for seabirds, some of which support production values (e.g. fish stocks) and some of which support consumption values (e.g. preferences for healthy habitats). For a natural capital account to be consistent with the SNA requires shifting the boundary of accounts coverage, including some consumption-oriented values (such as secure enjoyment of coastal property) alongside the production-oriented values in the current SNA.

The United Nations System of Environmental and Economic Accounts (SEEA) are designed to be consistent with the main SNA, at least in its 'core accounts'. These are production-based, and their natural capital accounts are based on the economic concept of resource rent, the surplus value accruing from the use of an ecosystem service calculated after deducting all costs and 'normal' returns on the inputs and non-natural capital used in obtaining that service. Resource rent represents a return to the extractor of service and will be positive in the long term if the resource is scarce and access restricted, but if there is open access to the resource, its use can increase to the point where the rent is dissipated across many users and is reduced to zero. Even more use could lead to negative rent, which is clearly inefficient, as it means the cost of extraction exceeds the value derived from the resource.

Resource rent provides a basis for computing the asset value of a resource by estimating the stream of rents from future resource use discounted to a net present value (NPV). Statistics NZ applies SEEA to produce asset values for renewable energy, forestry and minerals from its SNA accounts for these sectors by deducting costs of production from the gross operating surplus of these activities after adjusting for any specific subsidies and taxes:

Gross Output
- operating costs
= gross operating surplus (SNA basis)
- specific subsidies on extraction
+ specific taxes on extraction
= gross operating surplus (for resource rent derivation)
- user cost of produced services (opportunity cost of investment in wider economy)
= resource rent

Statistics NZ uses an alternative method for fishing, basing rent on the value of Individual Transferrable Quota (ITQ) for commercial fishing and, since its introduction in 2001, Annual Catch Entitlement (ACE). This is because the traded value of ITQ represents an asset valuation, what someone is willing to pay to acquire the quota to use in future years. The number of quota trades has declined since the 1990s, and the ACE was introduced to create a short-term entitlement to catch fish derived from quota for a standardised period of a year (in place of the variable periods of previously used quota leasing arrangements). So, whereas the value of ITQ can be used as an asset value in its own right, the ACE needs to be treated as an annual resource rent, with asset value computed from the NPV of expected future streams of services obtained from the resource.

### 5.5.1 Adjustments to current valuations

However, the value of fish quota or ACE derived from it refers to opportunities for future catch over fishery management areas much larger than the Hauraki Gulf. Such values are unlikely to be responsive to changes in the size and condition of fish stocks within the Gulf and hence will not provide a good indicator of changes in the Gulf's natural capital. Accordingly, we use fish catch within the Gulf as the output value for the sector and calculate economic rent and asset value on catches within the Gulf.

Statistics NZ's environmental accounts refer to the SEEA's "core accounts" only, so the natural capital that it counts is confined to that currently being used for economic gain. In principle, the same rental and asset value approach can be applied to non-market values, although there may be issues of overlap and double-counting to be avoided and some special treatment of particular services.

For example, there is no quota or licensing for recreational fishing to provide a value of the asset of access to the natural fish resource. The value of fish caught could be taken as a proxy for the output value of the provisioning service of recreational fishing, but what would be the operating costs? Estimates of spending by recreational fishers are likely to exceed the value of fish caught, partly because fishing efficacy is highly variable across recreational fishers, with a minority of fishers catching large volumes of fish, while a majority of fishers and fishing outings result in modest catches. That is also partly because fishers value the fishing experience over and above the value of what they actually catch.

Many recreational fishers incur high costs per fish caught (especially if accounting for the opportunity cost of their time) and would be considered inefficient at extracting protein for the plate. But the fact that they continue to incur these excess costs of fishing by going out repeatedly indicates they obtain economic value in excess of the value of their catch from time on the water, connecting with nature, socialising with others etc. The difference between their total spending and the value of what they catch may be interpreted as their willingness to pay for the fishing experience, and the NPV of a stream of future experiences could be viewed as the Gulf's asset value, as a source of fishing experiences.

Ideally, in the long term, natural capital accounts for the Gulf could be prepared for discrete geographic areas within the Gulf, so changes in condition and value can be identified at a disaggregated level. That could include, for instance, values attached to individual bays or significance for Māori for food gathering having a higher value attached for that purpose than the value for the general population. Such disaggregated accounts would require a geographically referenced database and mapping of environmental conditions that go beyond the capability of this current exercise and possibly beyond the limits of current geographically referenced data on pollution, species abundance, human interactions etc. In this natural capital accounting exercise, we focus on two broad geographical areas:

- The littoral strip between land and sea, encompassing around 200 metres on each side of the mean high water mark – this being the area of highest interface between the natural environment and human activity and the area in which ecosystem services of natural habitats have the most impact on matters of value to people (e.g. protection against storm surge, watchable wildlife)
- Open water, comprising areas of the Gulf beyond 200 metres from the shore, which provide space for most activities such as fishing (commercial and non-commercial), marine farming, recreational boating and nutrient and carbon absorption by seaweed.

### 5.5.2 Duration of asset life

Calculating asset values requires making assumptions about the duration over which the services are received in future. In its Marine Natural Capital accounts, the UK's Office of National Statistics assumes renewable assets such as fish stocks and wind resources are expected to last 100 years; non-renewable assets such as fossil fuel sources and unregulated fisheries whose sustainability is uncertain are assumed to last for 25 years. Statistics NZ, in its Environmental Economic accounts' methods description, draws a distinction between resources that are managed sustainably and those that are not. If it is assumed that fish stocks are being managed sustainability through the Quota Management System (QMS) and other controls, the stock's lifetime is potentially infinite, and a constant sustainable rate can be maintained. In that case, the NPV formula reduces to the resource rent divided by the discount rate, i.e.

$$V_0 = p_t Q_t / r$$

Where $V_0$ is the value of the asset now

$p_t$ unit rent price of fish at time t

$Q_t$ quantity of fish caught during time t

r the discount rate

Sustainability may be a strong assumption, given complicating factors in forecasting future conditions, such as climate change, risks of biosecurity incursions and numerous other factors that may confound expectations of a smoothly predictable future. In most cases, it will be preferable to define an expected benefit stream over a period of years and estimate the asset values over that period.

### 5.5.3 Discount rate

In its environmental and economic accounts, Statistics NZ uses a discount rate of 9 percent, a fixed rate held constant each year. This is relatively high compared to a 2004 UN survey of economic and environmental accounting for fisheries, which found rates ranged from a low of 3.5 percent (Norway) to 10 percent (Namibia). The 9 percent rate was chosen for New Zealand because it was consistent with the return on similar assets in the New Zealand economy and because values of both ITQ and ACE trades over the period 2002-2009 implied a rate of 8–9 percent.

Further assumptions in estimating asset values include the volume of service received, the unit value of that service, and other material factors that might affect the value. Both volume and value may change over time, so asset value depends on whether calculations are based on fixed variables (which are easily computed) or variables adjusted to reflect expected changes.

A simple approach would be to estimate asset value, assuming that current service levels can be sustained into the future. This is grounded in the current situation and readily defensible but may be considered to understate value if the environmental resource is degraded and its restoration is being sought. An alternative would be to estimate asset values on the expectation of some improvement in the annual quantity available and/or the value attached to the quality of the resource. Another alternative would be to project a current trend which, if declining, would indicate deteriorating natural capital over time. These approaches would provide:

- asset value estimated assuming continuation of current levels of service
- asset value estimated assuming continuation of current trends in levels of service
- asset value estimated assuming achievement of aspirational improvement in levels of service.

## 5.6 How would natural capital accounts help the management of the Gulf?

The foregoing has identified a range of natural capital accounting approaches that could form the basis of a valuation of the Hauraki Gulf. We propose applying these approaches to the Hauraki Gulf to identify what natural capital can be valued, where are the data gaps and how they might be filled. A potential end product would be a suite of accounts that tell different things about the value of the Gulf, including:

1. A static valuation of the Hauraki Gulf at a point in time, similar in structure to the account of terrestrial ecosystems (Patterson and Cole 2013) which would show market-based values, non-market values in separate columns and a combined total, to give a non-zero value of the Gulf. This could also include some of the values that appear in Statistics NZ's Marine Economy, in a separate column, although we argue that most of these, other than fish and tourism values, are not values associated with the state of natural capital, but rather derived from location and artificial capital.
2. Natural Capital Flow Accounts, showing the monetary value of flows of ecosystem services from the Gulf at the present time.
3. Natural Capital Asset Accounts, which are derived by projecting expected future values over a period and capitalising the benefit stream as an NPV. Values obtained depend on the assumptions in the calculation, e.g.:

a Projection of continuation of current levels of value from natural capital would provide a steady state asset valuation

b Projection of continuation of recent trends in levels of value in different aspects of natural capital would provide a declining asset value over time

c The difference between these two provides a value for arresting the decline in natural capital, which may be useful in justifying intervention measures in cost-benefit analyses of policy measures

d Applying this approach to disaggregated natural capital accounts (e.g. by geographical sub-regions) could assist management decisions on how much to invest in intervention and which areas offer the greatest net benefits.

4 Beyond the accounting, repeating this process at intervals over time could enable statistical comparisons with some of the influences, such as pressures on the environment and economic growth, improving understanding of how these external influences impact the value of natural capital.

The feasibility of any of these accounts depends on data availability. We have found no set of natural capital accounts anywhere in the world that covers the items that could potentially be covered in the accounts. In the sections below, we focus on three indicators of natural capital value that are commonly encountered in estimates:

- The annual value of an ecosystem service at current quantities and values
- The economic rent attributable to natural capital after deducting from annual value returns to other inputs and forms of capital
- The asset value of a continued stream of annual values into a future period.

# 6 Values for inclusion

This section covers the estimated volume and values associated with the Hauraki Gulf. The categorisation of the findings aligns with the structure shown in Table 4. The section is divided into four sub-sections, one for each of the four ecosystem services: cultural, provisioning, regulation and support. In each of these sub-sections, these components of the overall value of the ecosystem service are explored:

- The definition of the services and associated natural capital
- The volume of the ecosystem service
- Existing data about the underlying trends in the ecosystem services and the associated natural capital
- Observations about the quality of the natural capital underpinning the ecosystem systems that emerged during the research. This is limited to existing complementary and statistical evidence. Quality assessments are complementary to the valuation of the ecosystem services gained from the natural capital.
- Evidence of the value of ecosystems based on the best available international and domestic research.
- Recommendation for the value of the ecosystem service.

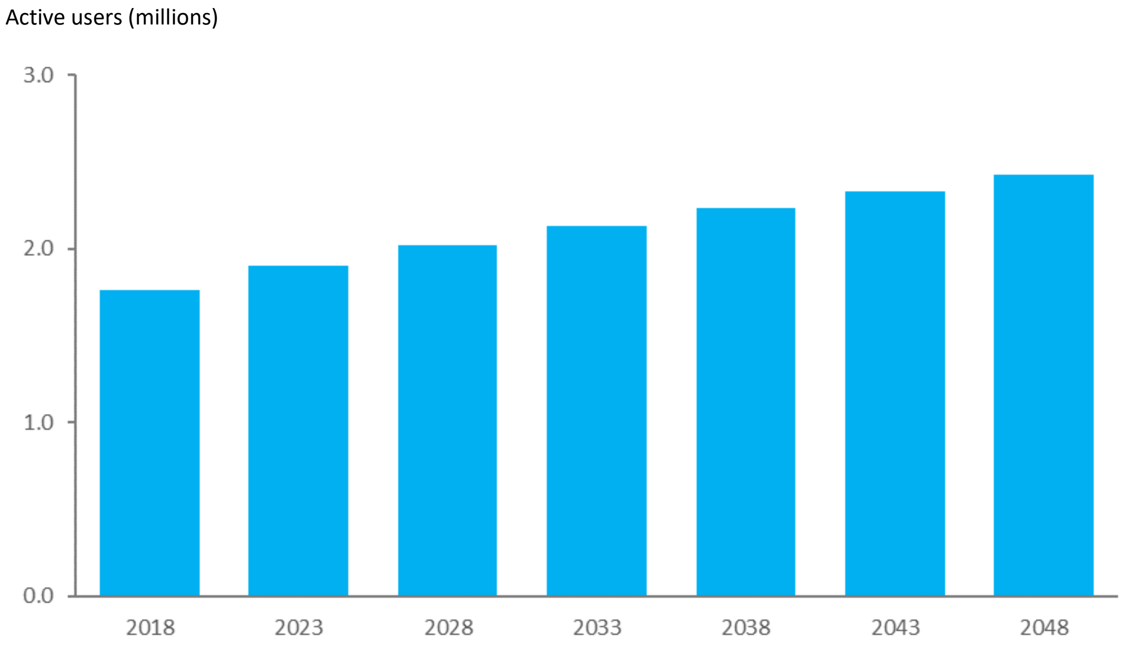
## 6.1 Cultural services gained from the Hauraki Gulf

In the ecosystem services approach, cultural services cover the benefits of access to the natural environmental amenity of the Hauraki Gulf for recreational activities and/or cultural connection to the environment in general and specifically.

### 6.1.1 Recreation benefits

The marine and coastal environment of the Hauraki Gulf is the source of a vast array of potential opportunities for recreational activities in the water and near it (Pakalniete et al. 2021). The Hauraki Gulf Survey (Horizon Research 2021) shows that people from the area enjoy a range of water-based activities in the Hauraki Gulf. In 2021, 74 percent of respondents from the surrounding districts engaged in activities in the Hauraki Gulf, and 69 percent had participated in coastal activities around the Gulf (such as coastal walks). This is equivalent to about 1.9 million active recreational users of the Hauraki Gulf based on the population of the surveyed districts in 2023 using population estimates (Statistics New Zealand 2022). Figure 9 shows the estimated numbers of active users of the Hauraki Gulf from 2018 to 2048 based on applying the Hauraki Gulf Survey results to the projected population. By 2048, the number of active users from the surrounding districts is estimated to be 2.4 million.

**Figure 9 Projected active users of the Hauraki Gulf 2018–2048**




Source: NZIER

The Hauraki Gulf Survey (Horizon Research 2021) provides insight into the percentage of the population from the surrounding area that actively uses the Hauraki Gulf for recreation. But it does not tell us how frequently people use the Gulf for recreation. The survey could be even more useful if future iterations asked people how often they participated in the Hauraki Gulf activities (e.g. how many days in the year they spent on the Gulf engaged in different recreational activities).

People benefit from using the Hauraki Gulf each time they participate in recreational activities in and around the water. Currently, there is a gap in the research because the non-use value of recreational activities has not been estimated directly. This gap is a challenge for this research project and an opportunity for future research to add value to knowledge and policy analysis.

To estimate the value of recreational benefits, two sources of information were used to bridge the gaps in the frequency of activities and the marginal value of each activity. Firstly, the frequency of activities was based on the frequency of swimming in the Auckland region report in the Active NZ survey (Sport New Zealand 2019). In 2019, 35 percent of respondents said they had been swimming in the previous seven days, although this does not distinguish between swimming in the sea and swimming in pools. If this is used as a proxy for the level of Hauraki Gulf use by active users, then the average active users will use the Hauraki Gulf 18.2 times per year. The timing of the survey helpfully avoids any effects of the pandemic on activity levels. Secondly, a recreational visit to water in New Zealand has been valued by Covec (2013) at $72 ($40–$156) in 2023 dollars.[1]

The value of recreational activity in and around the Hauraki Gulf is the combination of the number of activity participants, the frequency of use and the value of each experience. Table 5 shows the estimated value of recreation benefits in and around the Hauraki Gulf.

### Table 5 Estimated value of recreation benefits

2023 dollars

| Year | Active users | Lower value ($m) | Central value ($m) | Upper value ($m) |
|---|---|---|---|---|
| 2018 | 1,766,170 | $1,286 | $ 2,314 | $5,015 |
| 2023 | 1,902,470 | $1,385 | $ 2,493 | $5,401 |
| 2028 | 2,018,190 | $1,469 | $ 2,645 | $5,730 |
| 2033 | 2,129,300 | $1,550 | $ 2,790 | $6,046 |
| 2038 | 2,234,340 | $1,627 | $ 2,928 | $6,344 |
| 2043 | 2,334,460 | $1,699 | $ 3,059 | $6,628 |
| 2048 | 2,428,250 | $1,768 | $ 3,182 | $6,894 |

Source: NZIER

The average value of recreational benefits for active users is $1,310 ($728–$2,839) per person per year.

The estimated value for recreation in the Gulf has been estimated as an average of around $25 per week or around $1,310 per year; this may seem high, as it would imply over $2,600 per year for the average household in Auckland, or about $216 per month per household. This recreational estimate is quite high compared to some choice survey results suggesting much lower household monthly spending on other local amenities, of around $10 per month each for sports fields and leisure centres and $27 per month for neighbourhood parks (Nexus, Accent, and Rand Europe 2020).

Statistics NZ's household expenditure survey identified the average household weekly spending on recreation and culture to be $131 in Auckland in their last year of survey

[1] The 2012 values were adjusted using the Reserve Bank of New Zealand inflation calculator.

(2019). This equates to $6,812 per year or $567 per month per household. At the national level, all multi-person households recover a higher figure than the average weekly figure, which is dragged down by lower spending in single-person households. Against those statistics (which may have changed since 2019), the estimated value of recreation in the Gulf amounts to 38 percent of the total household monthly expenditure on recreation and culture.

### 6.1.2 Educational and science trips

There is evidence of educational and science-driven activity in and around the Hauraki Gulf. For example, 54 percent of visitors surveyed in 2022 reported they had learnt something about the environment during a paid excursion in the Hauraki Gulf. However, building a cohesive picture of the activity level and trends over time proved too difficult when writing this report. This means the value of this important activity in the Hauraki Gulf is not incorporated into the overall assessment of the ecosystem service.

The economic value of nature-based trips is commonly measured based on the visitor expenditure per trip. This expenditure supports the development of tourism business and associated economic activity such as travel, retail, accommodation, and eateries (Orams 2002). There is evidence from around the world that conserving megafauna and the ecosystem that supports them is much more valuable for local economies than catching and consuming iconic species (Hoyt and Hvenegaard 2002).

The economic contribution of marine research is more than the sum of the economic activity associated with research jobs and institutions. Preserving the state of the natural environment for its research potential has both an option value (the expected value of as yet unknown future uses) and an altruistic value in making a bequest of environmental quality to future generations. We have found no value estimates of either of these sorts of values that could be informative about the Hauraki Gulf.

### 6.1.3 The aesthetic benefits and the effect on property values

The natural capital of the Hauraki Gulf includes aesthetic benefits from the view of the Gulf. This ecosystem service is often measured by the effect of those views on consumer-driven property prices. A study of the effect of proximity to the coastline of property with a wide view of the Hauraki Gulf showed that property views are positively affected by how near they are to the coastline of the Gulf (Rohani 2012). The results of the study show that a property in Auckland located on the coast with wide views of the Hauraki Gulf is worth 47 percent, 92 percent and 144 percent more than if the property was 100 metres, 500 metres and 2 km from the coast, respectively.

Based on median house prices in Auckland in March 2023, the uplift in value for a coastal property with a view of the Hauraki Gulf could be worth $1.1 million ($600,000–$1.8 million). Assuming that 1 percent of houses in Auckland are located on the coast of the Hauraki Gulf, the aggregate uplift in the value of the property could be from $3.0 billion to $9.1 billion.

This value is a capitalised value over the life of the asset rather than the annual benefit to owner-occupiers, and it is not comparable to annual values in an ecosystem services approach. Making it comparable requires calculating the equivalent annual value from the uplift value in the property value from being located on the coastline. Table 6 shows the equivalent annual value uplift by being on the Hauraki Gulf Coastline based on the following assumptions:

- the median house price in Auckland in March 2023
- a required rate of return of 9 percent per annum
- an average ownership period of 7.4 years.[2]

The estimate of the equivalent annual value of the capital uplift from a property located on the Hauraki Gulf coastline ranges from $53,820 to $164,520, based on market values when writing this report.

### Table 6 Equivalent annual value uplift for a coastal location

2023 dollars

| Scenario | Capital value uplift from the coastline | Equivalent annual value |
|---|---|---|
| Low | $598,000 | $53,820 |
| Medium | $1,172,000 | $105,480 |
| High | $1,828,000 | $164,520 |

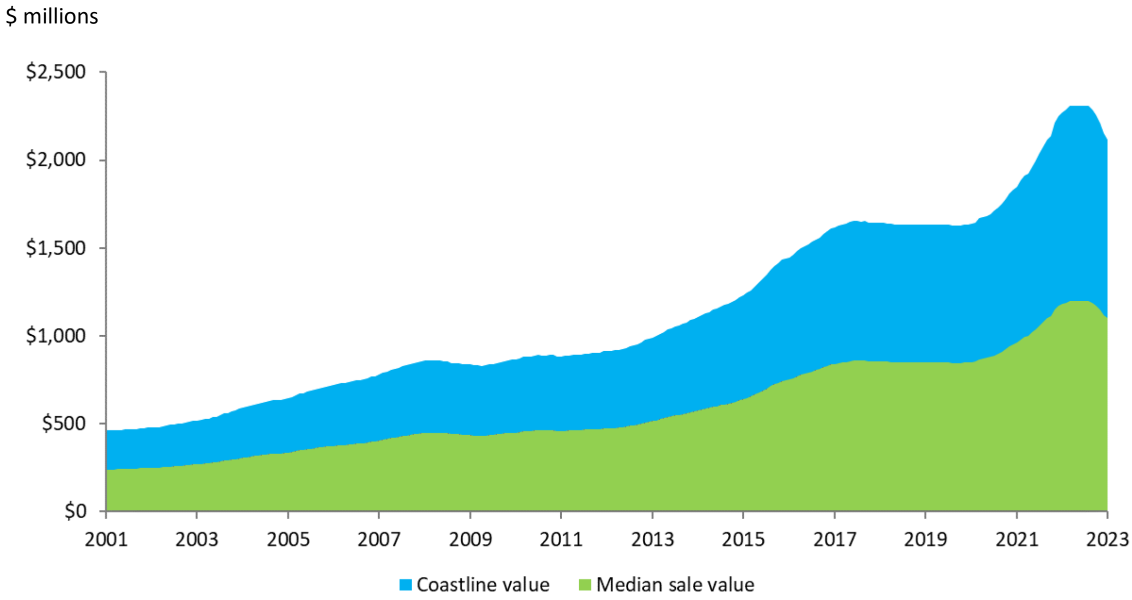
Source: NZIER

The equivalent annual value of the capital uplift from a property located on the Hauraki Gulf coastline is sensitive to these assumptions. The median house is a fundamental input into this estimate of the value of coastline property. Auckland house prices have increased over time. This increase in median value (shown in Figure 10 ) is more derived from location rather than a direct connection to the Gulf's ecosystem services or their variation in value. This means the value of the property uplift should be used with caution as it captures the market effects not associated with the natural capital. Figure 10 shows how the coastline premium is linked to the underlying median house value and is driven by market dynamics that are not directly linked to the natural capital of the Hauraki Gulf. This is a limitation of this method of estimating the value of natural capital on the value of property.

Another limitation is due to using a single study to estimate the capital value uplift. If the uplift effect was assessed periodically, such as every 5 or 10 years, it could provide greater insight into the benefits of the environmental amenity on property values. A periodic assessment would be even more useful if it were paired with changes in the quality of the environmental amenity, such as the assessment of the prevalence of wildlife or changes in the urban intensity on coastline vista.

2 https://www.corelogic.co.nz/news-research/news/archive/how-long-do-owners-hold-their-properties

**Figure 10 Median house sale price in Auckland 2001–2023**




Source: NZIER

The same study of property value variation with views to the sea also found that a property's land value declines by 17 percent on average with a doubling of its network distance to access a beach (Rohani 2012). That value change with restricted access to a beach is potentially more relevant to the natural capital value of the Gulf than the variation in property values with access to a view: the value conferred by a view is unlikely to change much with variation in water quality, but a locality that has poor water quality and stay out of the water notices fundamentally reduces access to swimmable water for nearby properties, reducing their value. Such value changes have direct relevance in managing the waters of the Gulf, as they indicate a value loss from poor water quality and a value gain from enhancing the water quality that can be compared against the cost of improvement measures. The valuations required for such purposes would be disaggregated and based on GIS data of properties, road and track networks and localised variations in water quality. Such localised valuations have not been prepared in this report.

### 6.1.4 Cultural and spiritual values and the Gulf

Since the 1970s, economists have been actively working to advance methods and theories to measure and conceptualise the values of goods and services provided by the natural environment that are not traded in markets or reflected in market prices (Manero et al. 2022). The value of the natural environment includes human relationships with the natural environment (Jackson and Palmer 2015). Perspectives on the relationship between the natural environment, economic activity and societal wellbeing vary with culture. Therefore, it is possible the assessments of the value of ecosystems can vary between cultures. In the context of New Zealand, an important consideration is how the conceptualisation and assessment of value might vary between Māori and Pakeha, the partners in the Treaty of Waitangi.

As noted above, the assessment of wellbeing among Māori includes consideration of place-based factors. Indigenous peoples worldwide have strong cultural and spiritual connections to specific places and environments. This topic deserves a literature review and investigation, which is beyond what is possible in the timing and resources available for this report. Highlights of the literature indicate the following:

- Survey results indicate that Māori express higher regard for the environment than Pakeha (Cowie et al. 2016).
- From a Te ao Māori worldview, the wellbeing of Te Taiao (the natural world) is paramount and inextricable from human wellbeing. This means people have responsibilities and obligations to sustain and maintain the wellbeing of Te Taiao (The Treasury 2021).
- The iwi of the Hauraki Gulf have an ancient connection to the area and the natural resources associated with it from the past to the present (Coast and Catch Environmental Consultants, Forthcoming).
- Sociocultural and environmental dimensions need to be integrated for a culturally appropriate approach to Māori wellbeing (Panelli and Tipa 2007).

This implies the assessment of wellbeing and wellbeing benefits from the natural environment among indigenous people might be different from those captured in non-market valuation with samples dominated by those with Western cultural roots.

A systematic review of non-market values of indigenous peoples' values (Manero et al. 2022) found that:

- There was a limited number of studies globally. Only 63 studies were reviewed
- Only one study for New Zealand was found (Miller, Tait, and Saunders 2015)
- The studies had mixed results as to whether indigenous people valued the environment differently from immigrant people
- Framing the assessment of value in ways that are consistent with indigenous paradigms is important in survey design.

The New Zealand-based consideration of indigenous values in non-market valuation found that Māori in Canterbury were willing to pay 40 percent more than Pakeha for water quality levels that supported food gathering from the freshwater environment (Miller, Tait, and Saunders 2015). This result suggests that consideration of Māori views and responses in estimates of natural capital may be quite important, especially when willingness to pay findings are used to determine resource use or conservation. But a single study is a limited evidence base for making generalisations. More studies of this type would be a valuable contribution to environmental management in New Zealand.

### 6.1.5 Future use value

Future use value is the value of preserving the natural environment at a quality and level to ensure it is there for use in the future. Future use value includes the value of the option to use the resource in the future, and the quasi-option value for it its future use. Quasi-value, or the value of waiting for better information before committing to resource use, may be irreversible – which can also be construed as the potential value of yet unknown attributes or uses of a resource that could be beneficial in the future (Bealing and Clough 2018).

Future use value is linked to the rarity of the resource and the availability of substitutes. This means that the future use value of the Hauraki Gulf depends on the availability of substitutes and consumer views on what defines a substitute. For example, the Manukau Harbour and the Kaipara Harbour are bodies of seawater close to the population centre, but they are smaller and not necessarily comparable on an ecosystem or aesthetic level.

Future use value is distinct from use value in the present and existence value associated will the conservation of the ecosystem (see Table 7).

An example of future use is the potential future value from recreational benefits. On the individual level, the average value of recreational benefits for active users is $1,310 ($728–$2,839) per year. This is a current use value that can be projected forward to provide a future use stream of value. But there can also be an option value in retaining environmental quality for the future among current users and those who do not currently use the resource. Option value is the willingness to pay now for the retention or enhancement of the Gulf's capacity for recreation in future, which is not just the projection of value that current users are expected to have in future. Another variant is quasi-option value, which is the value of deferring decisions on changing a resource pending the development of improved information with which to make the decision.

Option and quasi-option values are values about the future uses of the Gulf, distinct from and additional to the projection of current uses into the future. But we have found no estimates separating option or quasi-option values from other future uses, so their scale remains indeterminant at this time.

### Table 7 Where future use value fits in

| Non-market value | Source of value and changes in value |
|---|---|
| Use value (present) | Present recreational use benefits<br>Present aesthetic amenity benefits |
| Future use value | Future supply of present recreational use benefits<br>Future supply of present aesthetic amenity benefits |
| Existence value (perpetual) | Natural character<br>Water quality<br>Soil erosion<br>Endangered species population<br>Biodiversity |

Source: NZIER adapt from Sharp and Kerr (2005)

### 6.1.6 Existence value of the Hauraki Gulf

There are no specific studies on the existence value of the Hauraki Gulf and very few studies for elsewhere in New Zealand. This is a major gap in the current body of knowledge about the natural capital of the Hauraki Gulf. This gap means that estimating the potential value of the Hauraki Gulf requires using the benefit-transfer approach. This approach involves taking a value derived from one location and applying it to another. The approach is commonly used in policy analysis due to the frequent absence of unit values for the specific case under consideration. The benefit approach has limitations because it assumes that value estimates for the original site and population apply to the site and population of current interest. Such limitations make applying existence values from international sources more questionable than domestic values.

Very few non-market valuation studies in New Zealand consider the existence values of marine environments. In one study, Covec (2013) estimated the existence value of freshwater environments in Southland was $53 ($47–$56) per river per household annually. Extrapolating Covec's to the Hauraki would be unwise and require a cascade of heroic assumptions. Several other options were explored during the course of this research project; however, the credibility of the results was not robust enough for publication. Investment in primary research to establish the existence value of the Hauraki Gulf is the best way forward, given the scale and complexity of the Hauraki Gulf ecosystem.

## 6.2 Provisioning services of the Hauraki Gulf

The Hauraki Gulf ecosystem provides a wide range of provisioning services that benefit the surrounding communities. Provisioning services are defined as material products sourced from the environment, including fish, fibre, seafood and minerals (Cotas et al. 2023). Provisioning services are an example of use values in the TEV framework.

### 6.2.1 Port activities

Natural harbours provide important hubs of economic activity in the global and domestic supply chain. Port of Auckland is New Zealand's largest import destination and an important export hub. The Port exists due to the natural marine environment and the population that has developed in the hinterland. It is not, however, primarily a product of the Gulf's natural capital, as the value of port activity derives from the accumulation of lots of non-natural capital and other inputs and is not particularly affected by changes in such natural attributes as water quality and biodiversity,

Port of Auckland's economic contribution to New Zealand's GDP in 2019 was valued at $1.29 billion[3] (NZIER 2019). Estimating up-to-date values using sophisticated methodologies is beyond the scope of this report. A rough-order estimate of the Port's contribution to the economy can be derived from two simplifying assumptions:

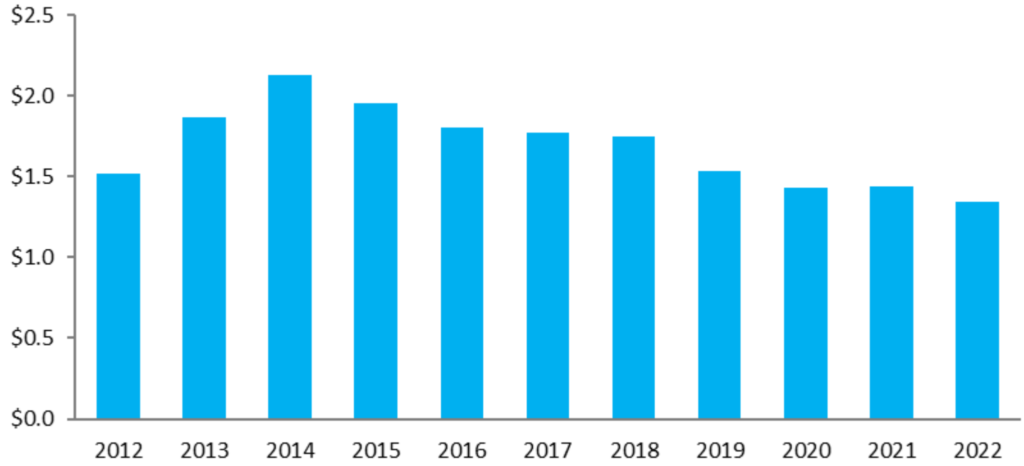
- the contribution of the economic activity of the Port is proportional to the volume of trade
- the value of the economic impact increases with inflation.

Figure 11 shows the estimated value of the contribution of the Port's activities, which is underpinned by the natural harbour originating from the natural environment of the Hauraki Gulf. The value of the Port's activities in 2022 was estimated to be $1.34 billion. The simplifying assumption about the economic contribution of the freight volume is strong and might not hold if the composition of goods has changed a lot over time.

[3] Or $1.54 billion in 2023 prices.

**Figure 11 Port activity value of the Hauraki Gulf**

$ billions, 2023




Source: NZIER

### 6.2.2 Fish harvesting

Fish harvesting is an activity that depends on the ecosystem services of a healthy marine environment and its ability to support diverse populations of wild fish species. Harvesting activity is broadly divided between commercial fishing, which is subject to the QMS in which catching fish carries an obligation to obtain ACE derived from ITQ, which is held by and traded between a variety of fishing interests, and non-commercial fishing, both recreational and customary (for tangata whenua), which are not subject to the QMS or ACE requirements except to the extent that total harvest is intended to be managed within the Total Allowable Catch for each species, as inferred from assessments of the state of the stocks of each species within different Fishery Management Areas.

#### Commercial fish harvesting

The direct contribution to GDP from commercial fishing in the Hauraki Gulf was estimated to range from $5.0 million to $64.6 million for 2019/20, 20/21 and 21/22 (Martin Jenkins 2022). The variation in the value for the contribution to GDP reflects seasonality in harvesting commercial fish stocks managed under the QMS in the Gulf. Martin Jenkins (2022) also published estimates of the indirect economic contribution; however, they used multiplier analysis, which is not considered rigorous or credible for policy analysis. Therefore, those estimates have been excluded from this report.

Whether this level of economic activity reflects sustainable commercial harvesting is outside the scope of this report. The latest State of the Gulf Report indicates the current measures of sustainability show a mixed and unclear picture of the sustainability of fish stocks:

- Of the 20 top commercial species monitoring, only snapper and tarakihi were determined to be overfished and needing intervention to rebuild stocks.
- Milky flesh and slower growth rates are possible indications of depleted food sources for commercial species.

Overall, this points to warning signs that at least some parts of the provisioning services from the natural environment in the Hauraki Gulf are under pressure. Work is under way to assess what should be done to ensure sustainable management of fish harvesting.

### Non-commercial fish harvesting

The largest share of non-commercial fish harvesting is undertaken by recreational fishers, using a variety of techniques (mostly rod and line, but also handlines, nets, pots etc.) and a variety of platforms (from boats, piers/jetties, beaches, rocks etc.). National Panel Surveys of Marine Recreational Fishers are undertaken at five-year intervals, yielding some information about the Hauraki Gulf, but mostly report information at the national level (Wynne-Jones et al. 2019).

The most recent survey was undertaken in 2017–2018 and includes some national-level comparisons with the previous survey in 2011–2012. The total recreational marine harvest in 2017–18 is estimated to be about 11 million fish, of which 7 million were finfish and 3.9 million other marine species (shellfish, crustaceans, cephalopods etc). That total recorded harvest was lower than that recorded in 2011–2012 when the total harvest was estimated to comprise 8.7 million finfish and 8.3 million other species.

The national survey estimated that the total number of fishing trips in 2017–2018 was 1.96 million, 20.4 percent lower than for 2011–2012 (2.47 million). Fishing trips are most frequent in summer, but the amount of fishing varies with diverse factors, such as the coincidence of storms with holidays or long weekend periods: 2017–2018 experienced ex-Cyclone Fehi and ex-Cyclone Gita, which would have lowered the appeal of fishing. The changes to the seabed following the Kaikōura earthquake would also have contributed to the 40 percent reduction in non-finfish species caught in 2017–2018 compared to the earlier survey. The harvest was higher for 18 finfish species but lower for 42 species in 2017–2018 compared to the 2011–2012 survey.

While the recreational fishing survey indicates a national decline in fishing catches between the two surveys, which may be reflected in local catches, it does not pinpoint the trend within the Hauraki Gulf other than to state that in the Hauraki Gulf, the average recreational snapper catch has seen a lot of fluctuation, "*almost tripling in the last 30 years, but trending down since the last survey in 2012*" (Wynne-Jones et al. 2019). This is suggestive of a fishery that has seen rapid growth aligned with rises in regional population and expansion in, and lowering the price of, the range of tackle and boats that can be used for fishing. The recent downward trend suggests a fish stock under pressure, but this could be due to various other influences.

The 2017–18 survey estimated that 56 percent of New Zealand's recreational fishing activity occurred in FMA1, comprising Northland's east coast, Hauraki Gulf and Bay of Plenty. Legasea provides an estimate of the economic impact of recreational fishing in Northern New Zealand that covers a similar area, albeit including the west coast of Northland and Waikato as well (Southwick Associates, Moana Consultants, and Blue Water Marine Research 2016). That estimate for the year 2016 covers both direct and indirect economic impacts on spending, incomes and jobs supported by recreational fishing. Updating those values and apportioning a share to the Hauraki Gulf in proportion to some local measure of demographic or economic activity would be one way of generating a value for recreational fishing in the Gulf consistent with the system of economic accounts and similar to those prepared by Barbera (2012). But the apportionment would be rough and possibly overstated, as the wider Northern New Zealand covers smaller districts with a higher proportion of accommodation and hospitality industries supporting fishing by visitors than is likely in the Hauraki Gulf, where the majority of recreational activity is by local residents.

The latest statistics available about recreational fishing are from 2018.[4] The value of the recreational catch was based on survey results on the willingness to pay for snapper and Kahawai by Wheeler and Damania (2001). They estimated the marginal willingness to pay (MWTP) and average willingness to pay (AWTP) for recreational fishing catch for several species of fish in New Zealand. The MWTP is the marginal benefit of catching an additional fish, whereas the AWTP reflects the average benefit over the total catch. Snapper has a higher MWTP than kahawai due to snapper's greater desirability among fishers, whereas kahawai has a higher AWTP than the MWTP due to the greater quantity of the kahawai catch relative to snapper.

### Table 8 Estimated value of the recreational snapper catch in the Hauraki Gulf

2023 $

| Period | Snapper catch (t) | 2001 MWTP $/t | 2001 AWTP $/t | 2023 AWTP $/t | Total value of catch |
|---|---|---|---|---|---|
| 2004-05 | 1,745 | $5,790 | $31,160 | $53,595 | $93,523,624 |
| 2011-12 | 2,786 | $5,790 | $31,160 | $53,595 | $149,316,227 |
| 2017–18 | 2,461 | $5,790 | $31,160 | $53,595 | $131,897,787 |

Source: Wheeler and Damania (2001)

The estimated non-market value of recreational fishing for snapper in 2017/18 was $131.9 million (Table 8). This estimate was based on catch statistics, and the AWTP adjusted to 2023 dollars. Similarly, the estimated non-market value of recreational fishing for kahawai in 2017/18 was $55.9 million (Table 9). The combined value of recreational fishing in the Hauraki Gulf for snapper and kahawai in 2017-18 was an estimated $187.7 million, slightly down from the $197.3 million in 2011-12.

### Table 9 Estimated value of the recreational kahawai catch in the Hauraki Gulf

2023 $

| Period | Kahawai catch (t) | 2001 MWTP $/t | 2001 AWTP $/t | 2023 AWTP $/t | Total value of catch |
|---|---|---|---|---|---|
| 2004-05 | 134 | $2,800 | $48,490 | $83,403 | $11,175,975 |
| 2011-12 | 575 | $2,800 | $48,490 | $83,403 | $47,956,610 |
| 2017–18 | 670 | $2,800 | $48,490 | $83,403 | $55,879,876 |

Source: Wheeler and Damania (2001)

4 The catch estimates were provided to NZIER by Ministry for Primary Industries.

## Table 10 Estimated value of the combined recreational catch of kahawai and snapper in the Hauraki Gulf

2023 $

| Year | Catch weight (t) | 2023 AWTP $/t | Total value of catch |
|---|---|---|---|
| 2004-05 | 1,879 | $55,721 | $104,699,599 |
| 2011-12 | 3,361 | $58,695 | $197,272,837 |
| 2017–18 | 3,131 | $59,974 | $187,777,663 |

Source: Wheeler and Damania (2001)

### 6.2.3 Aquaculture

Aquaculture is the cultivation of aquatic plants and animals for commercial or public benefits. Aquaculture in the Hauraki Gulf comprises mainly mussel and Pacific oyster farming, with much smaller volumes of seaweed cultivation and collection (from biofouling of shellfish farms). Aquaculture output was valued at contributing around $83.3 million per to GDP. The economic contribution of aquaculture appears to be increasing over time, with room to expand into consented areas.[5]

#### Provisioning and regulatory services of seaweed and seaweed farming

Seaweed provides a range of ecosystem services to the ecosystem (Theuerkauf et al. 2022), including structural habitat and food sources for other species to thrive. The ecosystem services and ecological benefits are associated with natural or farmed seaweed. Seaweed is often promoted as a fast-growing biological agent with a range of provisioning and regulatory ecosystem services, whether grown in seaweed farming or the restoration of depleted seaweed beds. These services include carbon sequestration options, shoreline protection,[6] and feedstock for a range of industries producing fertiliser, pharmaceutical and food products.

Some studies have investigated the ecosystem services of seaweed and the benefits for humans (Cotas et al. 2023; Vásquez et al. 2014). Table 11 shows the conceptual categorisation of the ecosystem services and the examples of benefits for humans. This categorisation shows the potential natural capital that could potentially be assessed for the Hauraki Gulf. However, estimating the value of all these benefits would be a complex and definitive contribution to ecological economics and policy development.

The literature is divided over the permanence of carbon storage under seaweed farms, as carbon matter sinking to the seabed and being absorbed into the substrate is a long process and is liable to release carbon with disturbance of seabed material. This causes uncertainty similar to questions about the permanence of carbon build-up in fertilised soil, as carbon absorbed into growing crops, exposed by earth movements like ploughing, can be released again.

5 The State of the Gulf draft report (2023) identifies nearly 1700 hectares in current use for marine farming, around 3,500 hectares consented but not yet in use (including 2,556 hectares in Wilson Bay in the Firth of Thames), and around 500 hectares seeking consent or in process.

6 Seaweed patches absorb some wave energy, but marine farms are less substantial than established buffers like mangrove forests.

## Table 11 Ecosystem services provided by seaweeds

| Ecosystem service category | Ecosystem services provided by seaweeds | Benefits for humans |
|---|---|---|
| Regulating and supporting services | Climate regulation | Ameliorate the global climatic change |
| | Erosion regulation | Coastal and shore protection and improvement of water quality |
| | Water purification and waste treatment—both in nature as well as in treatment plants | Enhancement of water quality by reducing nutrients and pollutants |
| | Genetic resources | Conveyance of varieties that help aquaculture |
| | Environmental monitoring | Indication of water quality, pollution and community integrity |
| | Production of atmospheric oxygen | Seaweeds capture the CO2 (dissolved in water) to produce carbon-based molecules and atmospheric O2 |
| Provisioning services | Fibre | Conveyance of a number of types of products |
| | Food Biochemicals, natural medicines, and pharmaceuticals | Delivery of sea crops and wild plant products Conveyance of important compounds for human welfare |
| Cultural services | Educational value | Benefits human development and critical thinking |
| | Aesthetic values | Aids human introspective development |
| | Recreation and ecotourism | Economic and other benefits for society and for local populations |
| | Cultural heritage values | Aids human introspective development |
| | Inspiration | Aids human introspective development |
| | Local knowledge system | Benefits social welfare |
| | Spiritual and religious services | Nonphysical benefits |

Source: Cotas et al. (2023)

Scientific papers on seaweed farming offer widely divergent conclusions on the effect of seaweed on carbon capture and storage. Enthusiasts such as Duarte et al. (2017) see wide opportunities for non-market benefits from seaweed farming, including:

- Potential $CO_2$ mitigation of about 15 $tCO_2$ per hectare per year[7]
- Improving soil quality by substituting for synthetic fertiliser
- Lowering methane emissions when seaweed is included in cattle feed (most interest in this is for red seaweeds, not the Eklonia brown kelp species common in the Hauraki Gulf)

7 This is an order of magnitude greater than the figure cited for kelp forests in Claes (2022), which seems too large to be explained by differences in species and suggest other differences in measurement approach and reliability.

- Damping wave energy and protecting shorelines as an aid to climate change adaptation
- Supplying oxygen to waters and elevating pH, reducing effects of ocean acidification.

Conversely, there are more sceptical papers, such as Troell et al. (2022), which suggest the benefits have been overstated by assuming seaweeds can be used simultaneously for human consumption, animal feed and other applications:

- The potential for carbon sink or storage has been exaggerated, as the growth cycle for seaweed is relatively short and harvest and regrowth only enter the fast carbon circulation cycle, not the long-term cycle for enduring storage.
- The physical mechanism by which seaweed fragments fall to the seabed and are absorbed into the substrate for long-term storage is poorly understood and unlikely to provide significant carbon removal effects.
- The main carbon emission implication is from seaweed-based products displacing products like animal feed and fertiliser that contain higher embedded carbon, particularly carbon from fossil resources that have been out of circulation for millions of years.

A study by Visch et al. (2020) of the environmental impact of another species of kelp (*Saccharina latissima*) concludes it is at least benign and probably positive for fostering the benthic community beneath its kelp farm. Another study by Hasselström et al. (2020) finds that seaweed farming of S. latissimi has the potential to become a profitable industry on Sweden's west coast, including the value of externalities such as:

- A significant share of annual anthropogenic nitrogen and phosphorous inflows to the coastal basin (8 percent of N and 60 percent of P) could be sequestered by large-scale seaweed farming, but the positive value of sequestration would be potentially offset by negative values from interference with recreation.
- Payment schemes for nutrient uptake based on socio-economic values are likely to be only a minor share of returns from seaweed and unlikely to be a tipping point for the industry.
- Seaweed cultivation is not a cost-effective measure for removing nutrients, so the future of seaweed cultivation depends on developing the industry to meet the market potential of biomass, with bio-remediation opportunities as a bonus.

A study by Vijn et al. (2020) shows there is a benefit in feeding supplements of red seaweeds as part of cattle feed for reducing methane emissions of ruminants, but notes a range of unknowables at this time and the likelihood of less effect for seaweeds other than red varieties.

All of this discussion points to the need for more research into the contribution of seaweed through ecosystem services. That much-needed research is, in the first instance, in the natural sciences, then in the economics of the ecosystem services of seaweed.

### 6.2.4 Sand extraction

Sand can be mined from riverbeds and beaches as ready-ground fine material or quarried from hard rock beds and ground down to size. It is a product of natural processes of aggradation, transportation and deposition of fine aggregates in water. Sand supply is abiotic and is not an ecosystem service that depends on the functioning of biological communities, although its extraction can affect the health and functioning of ecosystems. Extraction can encroach on shore-land ecological communities and also disrupt the replenishment of sand on the beach, leading to coastal erosion and inundation.

Sand extraction occurs at Pakiri Beach, a few kilometres south of the Mangawhai River mouth and just within the Hauraki Gulf Marine Park boundary. A single operator has extracted it since the 1940s and is currently seeking renewal of consents to continue extracting around 76,000 cubic metres per year from a 'near shore' area and up to 150,000 cubic metres per year from a 'far shore' location.[8] The sand is used as a filler and binding agent for concrete, which is widely used in residential, commercial and infrastructure construction.

News reports of recently contested consent applications suggest a larger volume take is being sought, totalling 9 million cubic metres over a 35-year consenting period, through three separate consents: the 'inshore' (between the 5 metres to 10 metres seabed contours off Pakiri Beach), the 'mid shore' (15–25m contours), and the 'far shore' (25–40 metres contours). In 2022 resource consents were sought to renew operations on all three shores: two were declined, and the third was given limited approval. These decisions are subject to appeal, and operations can continue pending the outcome of that appeal.

Objections have been raised to the continuing extraction of sand because of the potential damage to beach and dune habitats which includes nesting sites for fairy terns. Commissioners considering the appeal also heard from local mana whenua of the cumulative impacts on their cultural landscape and seascape.

As a high bulk and low-value material, sand is expensive to transport, so there is a cost advantage in having extraction close to centres of high demand, such as Auckland city; otherwise, it must be obtained from further away at a higher transport cost. Sand is not a high share of costs in much building activity, so much of the industry can absorb such cost increases.

We cannot know the outcome of the consenting appeals but can estimate a value for sand extraction at the current time. This can be included in an asset value as if the current levels of extraction continue, pending revision in future with changes in the court outcomes.

Sand extraction from Pakiri Beach is a high-volume, low-value abiotic product that we have valued as contributing around $5 million per year to GDP. Demand for sand is likely to grow with the rising population, but this operation is facing a decline of consents for continued operation, which, if upheld, will necessitate finding alternative sources of sand within proximity to Auckland's urban area.

## 6.3 Regulating services of the Hauraki Gulf

The Hauraki Gulf ecosystem provides a wide range of regulating services that benefit the surrounding communities. Regulating services are defined as benefits derived from the natural management of ecological processes, such as the regulation of climate, flood control and some natural pest control (Cotas et al. 2023). In this section, we examine the Gulf's contributions to:

[8] The extraction company's website indicates the far shore consent is for 2 million cubic metres over 20 years (mean 100,000/year), with a maximum extraction of 150,000 cubic metres per year. https://thenittygritty.co.nz/resource-consents/

- Climate change regulation, divided between:
  - Blue carbon approaches to averting emissions through carbon sequestration
  - Shoreline protection from coastal inundation and erosion
- Water quality and wastewater assimilation
- Non-use values of water quality effects and biodiversity.

### 6.3.1 Blue carbon options

The organisms in the Hauraki Gulf absorb carbon in their bodies as they grow and release it when they die, as well as in the daily process of respiration. A healthy ecosystem of abundant seaweed, seagrass and mangroves will therefore store some carbon and withhold it from the atmosphere, while an adversely impacted ecosystem with enhanced organism mortality will have lower stored capacity and contribute less to carbon emission reduction efforts.

In principle, therefore, the stock of biomass in the Gulf could be used to base an estimate of the carbon sequestered by its ecosystems, and changes in that stock sequestered could be the basis for management interventions to sustain the volume and value of carbon sequestered. In that case, halting or reversing the spread of 'kina barrens' by restoring areas of marine plants like kelp could have economic value for carbon removals from the atmosphere, as well as other value such as providing habitats in which juvenile fish, shellfish and crustaceans can flourish, or creating a buffer to reduce damaging impacts of incoming waves.

The amount of carbon stored would need to be known and verifiable as additional to a baseline, such as 1990 levels, to realise such value through measures such as the Emissions Trading Scheme. This would require the capability to survey the entire Gulf, estimate the extent and quality of marine plants and stored carbon, and register changes in observed stocks. In practice, the data available on the extent of seaweed may be insufficient to enable even a simple estimation of stored carbon to be made.

While calculating total values is challenging at this time, there may still be an opportunity to manage marginal changes in seaweed distribution and volume by incentivising blue carbon. Claes et al. (2022) summarise global options for nature-based, blue-carbon solutions for addressing climate change. It divides these into three categories:

- **Established nature-based solutions** that meet minimum standards of scientific understanding and implementation potential, in which proven carbon stocks and sinks can be protected from degradation or restored in areas already degraded, such as salt marshes, mangrove forests and seagrass beds
- **Emerging nature-based solutions** which have potential stocks or sinks but with uncertainty around their contribution, including kelp forests, controls on bottom trawling of seabed sediments, and seaweed farms
- **Nascent nature-based solutions**, which have potential indirect impacts, including predators to maintain ecological balance and support vegetated coastal carbon stocks (against excessive grazing); mesopelagic fauna, which support deep-sea sequestration by transporting biomass from surface layers to seabed sediments; and whales, which support deep-sea sequestration by enhancing phytoplankton carbon absorption.

Claes et al. note that "*science has yet to quantify to what extent underwater carbon capture through seaweed farming reduces atmospheric CO2*." In comparison with more familiar terrestrial carbon credits such as forest sinks, blue-carbon offset opportunities appear to be high-risk, subscale and expensive, and they need to be made attractive to investors through well-designed pilots that demonstrate the real sequestration potential to establish a track record that will support financing.

Claes et al. cite a carbon sequestration rate of 1.4t$CO_2$ per hectare per year for kelp forests, but they do not disclose the rate for seaweed farming other than that it comes from another report prepared by the World Resources Institute (Hoegh-Guldberg et al. 2019), which in turn draws on Duarte et al. (2017). Claes et al. suggest the main mechanism for carbon sequestration from marine farms is not from the production of harvested seaweed "*but from organic material sloughed off from the growing seaweed, which sinks to the seabed and gets buried in sediments"*. The up-scaled seaweed farms they envisage are floating structures positioned over deep water – more than 1000 metres deep – to remove the organic material from rapid recycling through animal grazing and emissions that may occur in shallower waters where sunlight penetrates the seabed.

Gallagher, Shelamoff, and Layton (2022) note that global seaweed carbon sequestration estimates are usually made as a fraction of the net primary production of biomass exported to the deep ocean but that they do not account for $CO_2$ emissions from the consumption of seaweed by organisms that proliferate in the expanded seaweed habitat. The expansion of seaweed ecosystems could therefore cause net emissions of carbon to the atmosphere, releasing more carbon through grazing and expulsion by animals than the amount sequestered in the seabed. This claim is based on a compiled dataset which shows that, on average, seaweed ecosystems are net emitters.

However, this claim has been refuted by Filbee-Dexter et al. (2023), who argue that it is based on a severely limited and biased data compilation that conflates different seaweed ecosystems, many of which play a minor role in global seaweed carbon cycling. That data compilation repurposes studies that are not designed to measure carbon sequestration in coastal ecosystems. Filbee-Dexter et al. explore how to incorporate community respiration into seaweed carbon sequestration estimates and account for replacing seaweed with other ecosystems to assess the net losses or gains on net $CO_2$ emissions, including long-term carbon storage beyond the ecosystem.

Those disagreements are largely a consequence of attempting global estimates of carbon mitigation potential, which will inevitably involve assumptions and generalisations and loss of detailed differences between ecosystem types. But it remains relevant to consider the effect of all organisms when changing from one ecosystem to another.

The literature stresses the distinction between compliance markets for carbon credits (such as the New Zealand Emissions Trading Scheme or the EU Emission Trading System (EU ETS)) and the voluntary markets that have arisen to provide value for emission reduction credits. Compliance markets require a high level of accounting and verification, and they tend to attract interest from major industries that are required to account for their emissions. Voluntary markets attract a wider range of organisations, including private companies and NGOs, that want to demonstrate they are taking steps to offset their greenhouse gas emissions even if they are not legally required. While credits for the compliance market of the EU ETS are currently traded above US$40/tCO2-e, those of the voluntary markets trade at much lower values, around US$15/tCO2-e, reflecting the lower demand for voluntary credits and their lower quality verification. The market for compliance credits was US$851 billion in 2021, compared to around US$1 billion trading in voluntary credits that year (Claes et al. 2022).

This discussion and that in section 6.2.3 above on aquaculture indicate there is significant uncertainty around carbon sequestration in marine plants and the verification of the additionality of such sequestration, which affects its value and the incentives to invest in it. While it is likely that restoration or extension of seaweed beds should have positive impacts in sequestering carbon, a sound basis for quantifying and valuing such impact is not available at this time, although may be developed in future.

We have provided an estimated value of protection carbon sequestered by mangroves and sea grasses over a relatively small proportion of the Hauraki Gulf coast where this vegetation is known to exist. These estimates are 4,578 hectares of mangroves, 460 hectares of saltmarsh and 773 hectares of seagrasses which together occupy a combined area of about 60% of the former known extent of these habitats (EnviroStrat 2022). Carbon storage potential is estimated as 6.32 $tCO_2$-e/ha for mangroves, 4.4 $tCO_2$-e for seagrass and 7.97 $tCO_2$-e for saltmarsh. Multiplying these storage rates by current areas and a carbon price of $70/$tCO_2$-e (as in the NZETS at the start of 2023) gives a combined value of about $2.5 million per year for carbon storage. This is a one-off stock value, not one that accumulates year after year. Based on this calculation, the carbon storage value of these combined habitats is $433 per hectare, and that average value could be used as an indicator of the value obtained from expanding the areas of these habitats (or value lost from their decline).

### 6.3.2 Shoreline protection from inundation and erosion

Climate change is an outcome of a warming atmosphere, which contains more energy and carries more moisture over greater distances than was common in previous experience. A result is the increased likelihood of storm events and storm surges in coastal areas that result in the battering of property and infrastructure, increased erosion and sediment transport and higher risk near the coast of inundation by water or burial under accreted material. In the longer term, there will be a slow onset of similar effects from sea level rise.

Healthy ecosystems can help to moderate such adverse effects as storm damage, coastal flooding and erosion. The value of these effects varies with the local characteristics of the coast, but international studies have shown that coastal wetlands can function as self-maintaining ‘horizontal levees’ for protection against storm surges and that their restoration and preservation can be a cost-effective option for reducing storm damage. A US study of the value of coastal wetlands for hurricane protection found that a loss of 1 hectare of coastal wetland corresponded to an average increase in storm damage of US$33,000 (Costanza et al. 2008).

Costanza’s value for wetlands converted to New Zealand dollars would be $43,650 per hectare, which adjusted by New Zealand’s GDP deflator, would equate to NZ$59,300 in 2022. Costanza et al. also compare this with a value Barbier (2007) estimated for mangroves of US$5850 per hectare which, converted on the same basis, would equate to NZ$11,000 per hectare in 2022.

In New Zealand, the risk of coastal inundation under climate change has been modelled at NIWA (Paulik et al. 2019). This reports on modelling of the land area, population, buildings and lengths of transport, energy and three-waters infrastructure at risk from coastal flooding under current conditions and how those results would change with specific increases in sea level rise in future. A replacement value is provided for buildings (although no values are available for wider disruption of activities by flooding events). All results are presented on a regional basis.

For Auckland, the results suggest a 0.3m rise in sea level would affect 2,719 buildings causing damage with a replacement value of $1.2 billion. A doubling of inundation depth would affect 3,831 buildings causing damage of $1.85 billion. These figures are for all of Auckland and therefore cover both the east and west coasts, but the greatest value of buildings and infrastructure affected will be on the east coast bordering the Hauraki Gulf.

The damage from inundation by sea level rise is not the same as that from intermittent flooding by storm surges. Intermittent flooding may prompt a response of building defences, whereas long-term inundation forces relocation. There will clearly be some locations where storm surges driven off the Hauraki Gulf will result in significant damage, the probability of which in any one year will increase over time with climate change.

As the volume and value of storm damage vary with location, an accurate valuation requires geographically referenced data on buildings at risk, exposure to risk at different locations and the likelihood of the risk being converted into damage at each point. We do not have the capacity to map risk of potential damage in that way in this report. But for illustrative purposes, if Barbier's protection value of mangroves were applied to the 4,578 hectares of the mangroves identified in the Gulf, they would be equivalent to an asset value worth around $50.3 million.

### 6.3.3 Water quality and wastewater assimilation

Land uses that generate runoff of sediment and contaminants that end up in the Gulf can be described as receiving an ecosystem service of waste assimilation. While this is a common way of describing waste assimilation in the environment, it ignores the effects on other services, and it is problematic in implying the environment is just a waste disposal option rather than a multifunctional system that provides many functions and services.

Accumulating waste can reach levels so high that it exceeds an ecosystem's ability to handle it and fundamentally changes its composition and function. Such a situation is not sustainable. It is more accurate to describe the ecosystem as being transformed or destroyed rather than providing a service that can be sustained in the future alongside all other services it provides.

One of the ways to place an economic value on ecosystem services such as wastewater assimilation is to consider the value of the next best alternative way of achieving the same outcome. Cities can discharge their wastewater to natural water bodies, which is almost 'free' to the city authorities (except for collection and piping infrastructure), but it comes at a cost to the quality of the natural environment. Such an approach treats the natural environment as a waste disposal option but needs to be considered against the costs of lost environmental services from so doing.

Over time municipal authorities have introduced treatment processes to lower the level of contamination in their discharges to natural waters, the cost of which can be equated to a public willingness to pay value to protect the natural environment from contamination. The Central Interceptor project aims to reduce the volume of wastewater that overflows the wastewater reticulation system and discharges into the sea via stormwater drains or natural waterways. It is claimed that it will reduce 90 percent of current contaminated discharges. Given such information is the annual volume of contamination, capital and ongoing operating and maintenance costs of infrastructure such as the Central Interceptor, the additional annual cost of operating the wastewater system with the Central Interceptor in place, divided by the volume of contamination avoided, will indicate the cost per tonne of contamination averted each year.

It is hard to locate verifiable figures on the amount of wastewater-contaminated discharges currently experienced each year (i.e. the volume entering the Gulf that would be attributed to the contaminated stormwater) and also the likely additional operation and maintenance cost of the wastewater system with the central interceptor included. If such details were known and calculations made, it would highlight the cost of reducing discharges. It might also raise objections from some people that environmental protection is valued too highly, i.e. there is a risk that valuing the Gulf as equivalent to an alternative artificial wastewater investment may cause some to question the current investment in a cleaner harbour.

The value of water quality in the Gulf is not just its value as an alternative to a wastewater treatment plant. Restricting the amount of treatment has a cost in deteriorating recreational opportunities, beach closures and warnings against consuming fish from the Gulf. And for Māori, any degree of contamination of the Gulf with human wastes may be seen as a detraction from the mauri of the Gulf and a diminishment of the mana of the iwi associated with it.

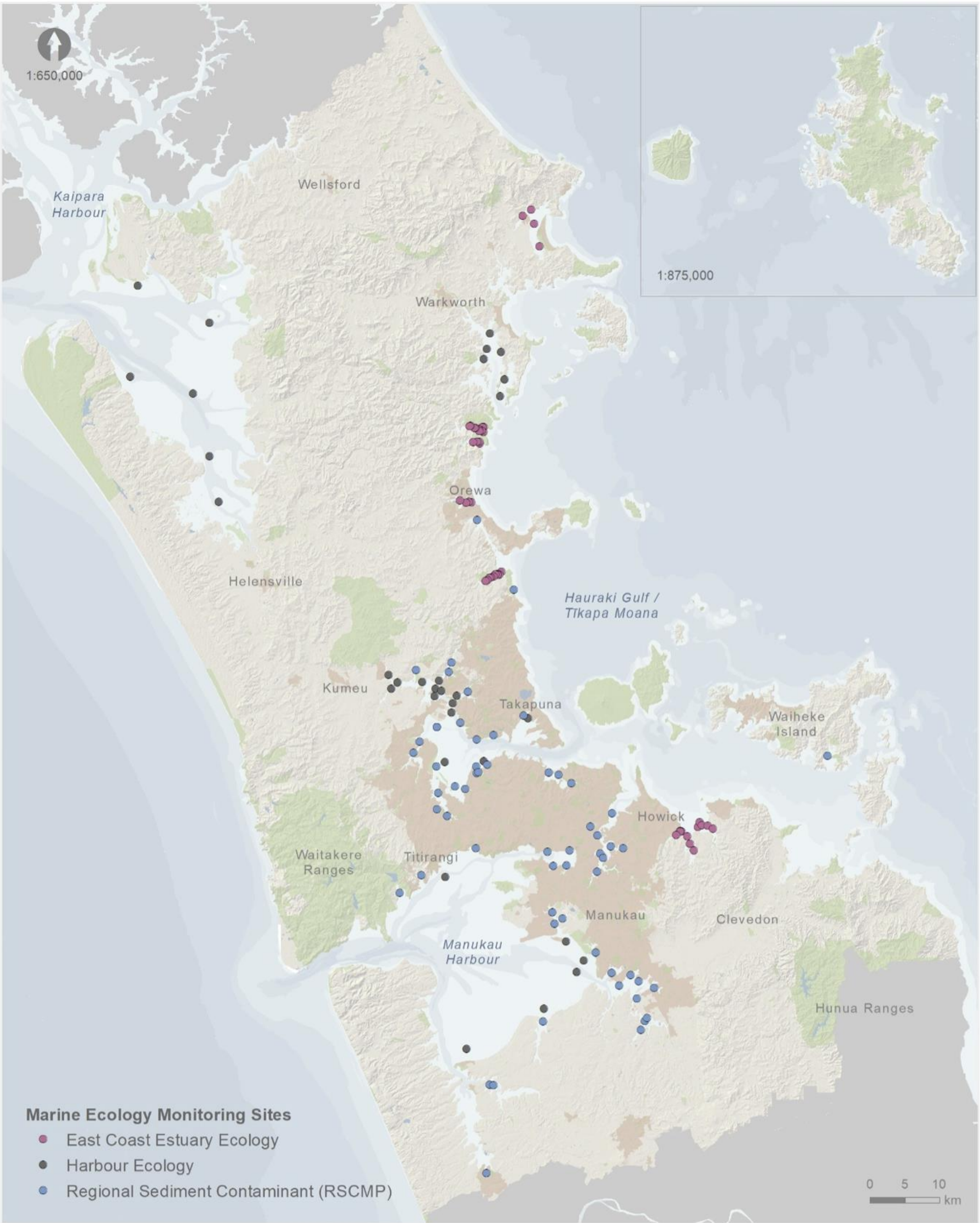
Besides, treating the Gulf as just an alternative to a wastewater plant does not sit well with the multi-dimensionality of the ecosystem services approach to natural capital, in which the integrity of functioning natural ecosystems is central. Even with the numbers to calculate the value based on treatment plant equivalence, strong caveats would be needed on the estimates regarding the ability to reliably value all the other effects on the Gulf that the choice of treatment plant vs Gulf discharges throws up.

### 6.3.4 Non-use water quality values

Water in the Gulf also provides regulating services for the natural environment beyond its recreational and aesthetic amenity value. High levels of sediment content and metal contamination in the water entering the Gulf can damage its coastal and marine ecosystems, which diminishes its environmental value.

Auckland Council has been conducting long-term monitoring of the coastal and marine environment around the region as a part of its broader State of the Environment monitoring and reporting. Marine ecology trends to 2019 (Drylie 2021) indicate that ecological health in terms of sedimentation and metal contamination is predominantly fair across the Council's monitoring sites within the Gulf's catchment. Sites in Upper and Outer Waitematā Harbour have higher levels of both sedimentation and metal contamination (marginal to fair), while these are lower in places in more rural areas (e.g. Okura, Ōrewa, Pūhoi, Turangi, Waiwera) – except Mahurangi. Over time, Waitematā and Mahurangi also have a larger number of sites experiencing degradation in terms of sedimentation and metal contamination.

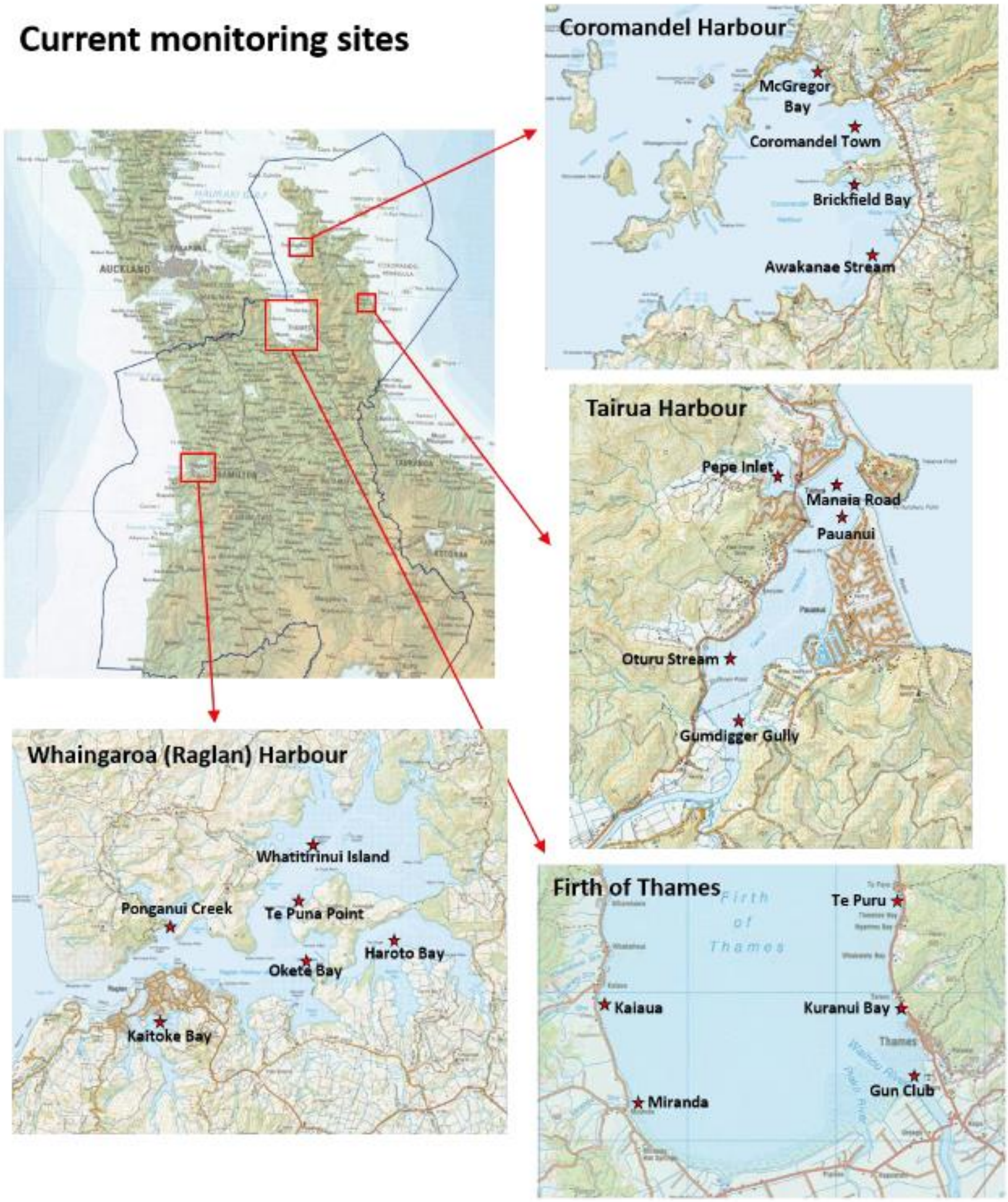
## Figure 12 Auckland Council's marine ecology monitoring sites




Source: Drylie (2021)

Using similar measures, trends to 2018 in sedimentation and metal contamination for Waikato Region's sites in the Firth of Thames and Tairua Harbour estuaries range from fair to good (Jones 2021). Sites in the southern Firth of Thames have been more prone to sediments. This reflects the fact that the Firth of Thames, especially southern, is a receiving environment for runoff and sediments. Green and Zeldis (2015) suggest that about 40 percent of the estimated 430,000 tonnes per year of sediment deposited in the southern Firth comes from the catchment of the Waihou and Piako Rivers in the Waikato Region, which drain the Hauraki Plains. There is also a scattering of sites across Tairua, Coromandel and Thames which are associated with historic mining activity, with high levels of key metal contaminants (Hauraki Gulf Forum 2020).

### Figure 13 Current sites of Waikato's Regional Estuary Monitoring Programme




Source: Jones (2021)

A report by MRCagney (2019) documents existing studies for valuing water quality. One of the examples they have included is an existing study by Batstone and Sinner (2010) on Aucklanders' wiliness to pay for having better coastal and marine environments. This study recognises the values people place vary by component, location, and status of the coastal and marine environment. Willingness to pay is the lowest for improvements in upper-harbour environments which currently have low quality. For water quality improvements, their estimated willingness to pay per Auckland household ranged from $40.98 to $274.96 in 2010 dollars (see Table 12 below).[9]

### Table 12 Aucklanders' willingness to pay for water quality improvements

2010 dollars

| | Willingness to pay per household per year |
|---|---|
| Outer water quality – from low to medium | $189.45 |
| Outer water quality – from medium to high | $274.96 |
| Middle water quality – from low to medium | $47.18 |
| Middle water quality – from medium to high | $86.90 |
| Upper water quality – from low to medium | $40.98 |
| Upper water quality – from medium to high | $99.16 |

Source: Batstone and Sinner (2010)

Using the indicator trends in sedimentation and metal contamination by site reported by Auckland Council (Drylie 2021) and Waikato Regional Council (Jones 2021), we calculated a weighted average of willingness to pay for water quality improvements in the Gulf of $99.21 (in 2010 dollars) per household per year. This will decrease if water quality worsens.

In the Hauraki Gulf Survey (Horizon Research 2021), 82 percent of the respondents rated the Hauraki Gulf's environmental health on a spectrum of very poor to excellent. Given the timing of this survey,[10] this is equivalent to about an estimated resident population of 2.04 million across the 12 surveyed local authorities in 2021 and over 784,000 households based on an assumed average household size of 2.6 people.[11] Applying the Hauraki Gulf Survey results to Statistics NZ's projections, we estimated the number of households from the surrounding local authorities who will likely place some value on the Hauraki Gulf's environmental health, as shown in Figure 14 below.

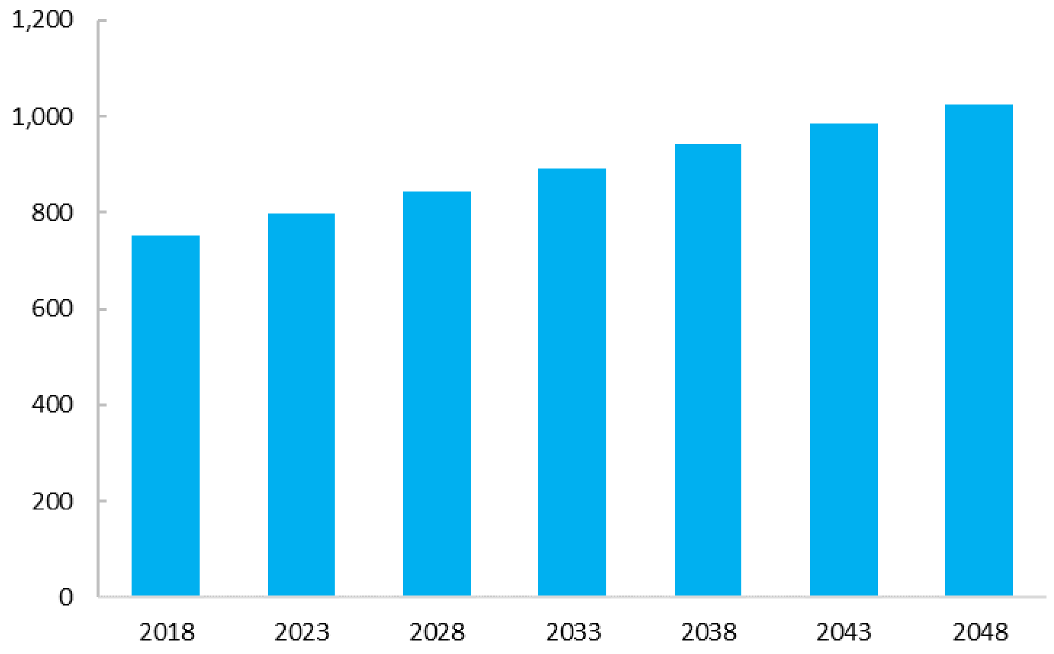
9 We take the results in Table 12 at face value. However, we note that they imply that households are willing to pay more to improve water quality from medium to high quality than from low to medium quality, which is contrary to the principle of diminishing marginal utility, which would predict higher willingness to pay to move from low to medium quality, and lower willingness to pay to move from medium to high quality.

10 The Hauraki Gulf Survey was undertaken between 27 September and 17 October 2021.

11 Based on Statistics NZ's projections of average household size of the 12 surveyed local authorities.

## Figure 14 Projected households rating environmental health of the Hauraki Gulf

Number of households (000s)




Source: Statistics NZ (2021; 2022), NZIER

The non-use value of Hauraki Gulf's water quality is the product of the estimated household number rating Hauraki Gulf's environmental health and the average willingness to pay for water quality improvements. The total household willingness to pay based on Statistics NZ's population estimates for 2021 is estimated as $96 million per year (in 2020 dollars), with an average willingness to pay of $122.39 per household (in 2020 dollars).

Our estimated values for improved water quality are summarised in Table 13.

## Table 13 Estimated values of improved water quality in Hauraki Gulf, 2018–2048

2020 dollars

| Year | Number of households | Willingness to pay per year ($m) |
|---|---|---|
| 2018 | 753,472 | $ 92.22 |
| 2023 | 798,158 | $ 97.69 |
| 2028 | 842,735 | $103.15 |
| 2033 | 892,397 | $109.22 |
| 2038 | 943,071 | $115.43 |
| 2043 | 985,870 | $120.66 |
| 2048 | 1,023,098 | $125.22 |

Source: NZIER

## 6.4 Supporting services of the Hauraki Gulf

The natural environment of the Hauraki Gulf supports the development and continuation of all other ecosystem services in the Gulf. These services constitute the foundation for all others, and their benefits to people are indirect or occur over time. However, valuing supporting services is difficult, given they tend to inter-relate with provisioning and regulating services.

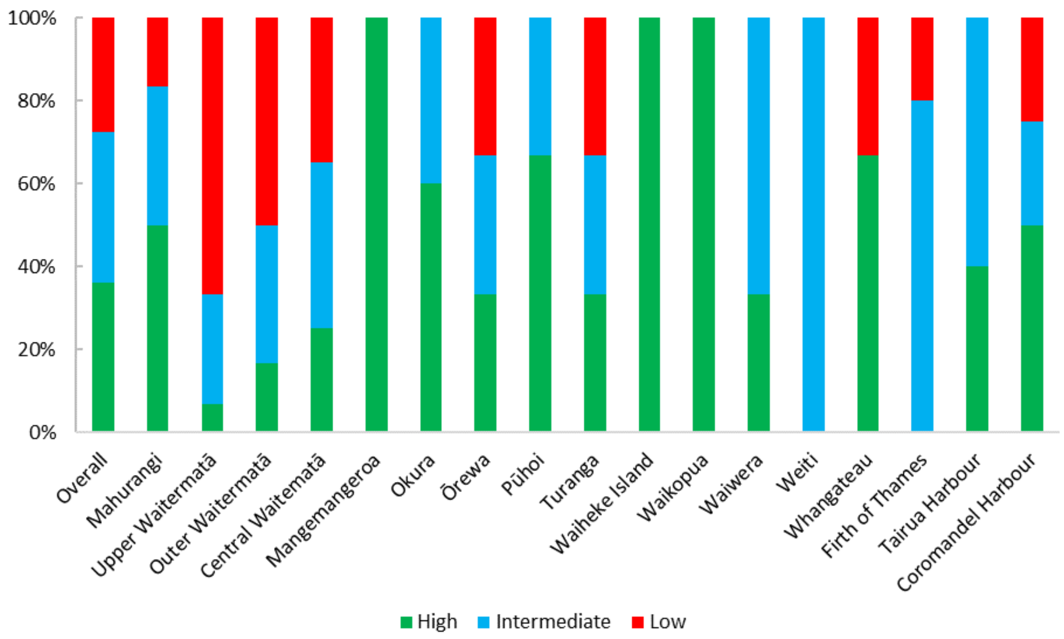
### 6.4.1 Nutrient cycling – non-use values on benthic biodiversity health

Benthic biodiversity is essential for the functioning of coastal and marine ecosystems (Belley and Snelgrove 2016). Inhabitants of sediments cycle nutrients between the sediment and water, stabilise and rework sediments and are an important food source for birds, fish and crabs (Waikato Regional Council 2022).

Auckland Council and Waikato Regional Council have been monitoring the biodiversity of species in macrofaunal communities as a part of their coastal and marine ecology monitoring programme for the State of the Environment reporting. To assess the overall ecological health for the monitored sites, the Traits-based-Index (TBI) has been used as an indicator of health in terms of biodiversity (Drylie 2021; Jones 2021; Waikato Regional Council 2022). TBI measures the richness of species in the macrofaunal communities exhibiting traits respective to body size, structure, shape and features, mobility, and feeding behaviour. It ranges between zero and one, with one being the most healthy and zero being the least healthy.

#### Figure 15 Biodiversity health status (TBI) by site

Percentage (%) of monitored sites




Source: Drylie (2021), Jones (2021), Waikato Regional Council (2022), NZIER

Trends in TBI indicate 36 percent of monitored sites in the Hauraki Gulf's catchment have a high level of ecological health with respect to benthic biodiversity, while the remaining sites either have immediate (36 percent) or poor (28 percent biodiversity health (see Figure 15). Macrofaunal communities in sites located in Okura, Pūhoi, Waikopua and Waiwera estuaries are generally healthier and richer, whereas sites in Upper and Outer Waitematā Harbour, inner areas of Central Waitematā and southern Firth of Thames predominantly have poorer biodiversity health. Although biodiversity health status has not changed over the last decade for most sites, there has been some noticeable degradation in several sites in the southern Firth of Thames and Tairua Harbour in the Waikato Region.

We used the willingness to pay values from Batstone and Sinner (2010) to calculate the non-use value of the Hauraki Gulf's nutrient cycling services. Their Auckland-based study suggests that households are willing to pay between $63.6 to $181.45 per year (in 2010 dollars) for ecological health improvements in coastal and marine environments. As shown in Table 14, values are lower for improvements in upper-harbour environments with a low quality of ecological health.

### Table 14 Aucklanders' willingness to pay for ecological health improvements

2010 dollars

| | Willingness to pay per household per year |
|---|---|
| Outer ecological health – from low to medium | $135.64 |
| Outer ecological health – from medium to high | $181.45 |
| Middle ecological health – from low to medium | $84.83 |
| Middle ecological health – from medium to high | $110.45 |
| Upper ecological health – from low to medium | $63.60 |
| Upper ecological health – from medium to high | $83.00 |

Source: Batstone and Sinner (2010)

Based on the reported trends in TBI from Auckland Council and Waikato Regional Council's monitoring programmes, the weighted average of willingness to pay for ecological health improvements in the Gulf was calculated as $92.78 per household per year (in 2010 dollars) – or $114.45 in 2020 dollars.

We assume households who would give some rating on the environmental health of the Gulf in the Hauraki Gulf Survey (Horizon Research 2021) will also likely be willing to pay for improvements to the Gulf's ecological health in terms of biodiversity. Combining our estimates of those households, the current non-use value of the Gulf's nutrient services as measured by households' willingness to pay for improvements to ecological health is estimated at $90 million per year (in 2020 dollars).

Our estimated values for the 30 years from 2018 to 2048 are shown below.

## Table 15 Estimated values of improved ecological health in Hauraki Gulf

2020 dollars

| Year | Number of households | Willingness to pay per year ($m) |
|---|---|---|
| 2018 | 753,472 | $86.24 |
| 2023 | 798,158 | $91.35 |
| 2028 | 842,735 | $96.45 |
| 2033 | 892,397 | $102.14 |
| 2038 | 943,071 | $107.94 |
| 2043 | 985,870 | $112.84 |
| 2048 | 1,023,098 | $117.10 |

Source: NZIER

## 6.5 Summing up

Table 16 summarises the results outlined above. The valuation of ecosystem services has many gaps. However, even with those gaps, some ecosystem services have substantial value. These are values from (mostly) non-extractive consumption of the Gulf's environmental ambience, which are high compared to some of the extractive productive values. Ports and shipping are still huge value generators by virtue of their location next to a city and deepwater channels, but there is substantial value in the ecosystems of the Gulf.

## Table 16 Estimated value of the Hauraki Gulf ecosystem

| Summary estimates (2023 dollars) | GDP$m/yr | Non-GDP $m/yr | Combined $m/yr |
|---|---|---|---|
| ***Provisioning services*** | ***$1,750.1*** | **$187.8** | |
| Ports and shipping | $1,340.0 | | |
| Cruise tourism | $292.0 | | |
| Aquaculture | $83.3 | | |
| Commercial fishing | $29.8 | | |
| Recreational fishing | | | $187.8 |
| Sand extraction | $5.0 | | |
| ***Cultural services*** | | ***$3,019*** | |
| Recreation | | $2,493 | |
| Property value uplift | | $526.1 | |
| ***Regulating & support services*** | | ***$188.3*** | |
| Water quality | | $96.0 | |
| Biodiversity health | | $89.8 | |
| Carbon sequestration | | $2.5 | |
| **Total economic value o** | ***$1,750.1*** | ***$3,395.2*** | **$5,145.3** |

Source: NZIER

Table 17 summarises estimates of the economic rent attributable to the natural capital of the Gulf and the asset values implied by the continuation of these rents into the future. The table excludes Ports and Shipping, Cruise Tourism and Ferries, as the value of these services is not closely dependent on the quality of the natural capital. It includes the three provisioning services of aquaculture, commercial fishing and sand extraction, two cultural services (recreation and existence values) and three regulatory and supporting services (water quality, biodiversity health and shoreline protection).

For provisioning services, the annual rent is calculated from each sector's value added less all costs of obtaining that value added, including employee costs, fixed capital consumption and a 'normal' rate of return from investments in the sector. The natural capital asset value is obtained by projecting the annual rent over 25 years and discounting at 9 percent.[12] For the cultural and regulatory services, the consumer-based values are used as the economic rent, projected over 100 years and discounted at 9 percent to estimate asset values.

### Table 17 Estimated value of economic rent and asset value of natural capital

2023 dollars; asset values calculated with a 9% discount rate

| Summary estimates | GDP$m/yr | Annual rent $myr | Asset value $m |
|---|---|---|---|
| **Provisioning services** | | | |
| Aquaculture | $83.3 | $8.8 | $93.8 |
| Commercial fishing | $29.8 | $9.6 | $102.3 |
| Recreational fishing | | $187.8 | $2,010.5 |
| Sand extraction | $5.0 | $3.8 | $40.8 |
| **Total provisioning services** | **$91.4** | **$208.9** | **$2,247.4** |
| **Cultural services** | | | |
| Recreation | | $2,493.0 | $30,187.5 |
| Property value uplift | | $526.1 | $5,632.7 |
| **Total cultural services** | | **$3,019.1** | **$35,820.2** |
| **Regulatory & support services** | | | |
| Water quality | | $96.0 | $1,162.8 |
| Biodiversity health | | $89.8 | $1,087.4 |
| Carbon sequestration | | $2.5 | $30.5 |
| **Total Regulatory & support services** | | **$188.3** | **$2,280.7** |
| **Total value of economic rent and asset value of natural capital** | | **$3,417.4** | **$40,348.4** |

Source: NZIER

For the extractive provisioning services, the annual rents and asset values are modest; they are higher for aquaculture, which is the only one of these sectors likely to grow in the

12 We use the UK's Office of National Statistics recommended asset life of 25 years for extractive matters and 100 years for non-extractive ones; and a discount rate of 9% as used in Statistics NZ's Environmental Economic Accounts.

foreseeable future. The combined value of all these provisioning services is far exceeded by the combined value of regulatory services, even before accounting for other regulatory services which have not been quantified in this report.

The cultural services estimates are many times larger again than those for regulatory services. This is partly due to methods used for cultural service estimates that rely on stated preference non-market valuations, which can appear high because they may not be as tightly bound by income constraints as other methods and because they may reflect expressions of option value and existence value that are not captured by other methods.

Nevertheless, these estimates are not necessarily exaggerated. The annual rent for recreation looks like a large number, but it is derived from visits to the Gulf by a large resident population: the figure is equivalent to everyone in that population spending an average of around $25 per week on visits to the Gulf for recreation throughout the year.

The natural capital asset values in Table 17 are calculated using a discount rate of 9 percent, a rate used by Statistics NZ in its SEEA accounts. This may appear rather high; Table 18 presents the results of using the same data with three discount rates (9 percent, 6 percent and 3 percent) and with the annual rental value for each service shown for comparison purposes.

### Table 18 Estimated natural capital asset value under varying discount rates

2023 dollars

| | Annual rent | 9% | 6% | 3% |
|---|---|---|---|---|
| | *$m/yr* | *$m* | *$m* | *$m* |
| Aquaculture | $8.8 | $93.8 | $118.7 | $157.1 |
| Commercial fishing | $9.6 | $102.3 | $129.5 | $171.4 |
| Recreational fishing | $187.8 | $2,010.5 | $2,544.5 | $3,367.9 |
| Sand extraction | $3.8 | $40.8 | $51.6 | $68.3 |
| **Provisioning service total** | **$209.9** | **$2,247.4** | **$2,844.3** | **$3,764.7** |
| Recreation setting | $2,493.0 | $30,187.5 | $43,913.2 | $81,139.4 |
| Property value uplift | $526.1 | $5,632.7 | $7,128.8 | $9,435.9 |
| **Cultural service total** | **$3,019.1** | **$35,820.3** | **$51,042.0** | **$90,575.2** |
| Waste assimilation | $96.0 | $1,162.8 | $1,691.6 | $3,125.5 |
| Biodiversity & habitat | $89.8 | $1,087.4 | $1,581.8 | $2,922.8 |
| Mangrove (tCO2/yr) | $2.0 | $24.5 | $35.7 | $65.9 |
| Saltmarsh (tCO2/yr) | $0.3 | $3.1 | $4.5 | $8.4 |
| Seagrass (t/CO2/yr) | $0.2 | $2.9 | $4.2 | $7.7 |
| **Regulatory service total** | **$188.4** | **$2,280.8** | **$3,317.8** | **$6,130.3** |
| **Combined services total** | **$3,417.4** | **40,348.4** | **57,204.1** | **100,470.3** |

Source: NZIER

The Table shows that the asset value increases as the interest rate is lowered, other things held constant. At a 3 percent discount rate, the total value of combined ecosystem services is over $100 billion from what is an incomplete assemblage of natural capital values. Most of that value is derived from ecosystem services other than provisioning services, driven by high values for individual items such as recreation and property value uplift and also because of the assumption that the non-provisioning services are managed sustainably to yield their current real values over the next 100 years. In contrast, the provisioning services all depend on the extraction of stocks that have recently been depleted, so their annual rent is only projected to continue for 25 years.

## 6.6 Interpretation matters

These results raise two particular questions: what is the appropriate discount rate to be applied in these calculations, and are the assumptions of longevity of resource availability reasonable and reliable?

Choice of discount rate is a much-debated issue in economics which is beyond the scope of this current report to resolve. The purpose of a discount rate is to adjust values of things according to when they occur in the present and future timeframe. The discount rate usually ensures future values for receiving a given benefit are lower than current values for the same benefit because humans often display a preference for the current over the future, if for no other reason than that, they may not survive long enough to enjoy a future benefit. But when considering values obtained from a natural environmental resource which successive generations will share, discounting's tendency to favour the present over the future has inter-generational implications.

The practical choice over discount rates is between basing it on the social opportunity cost of capital (SOC) available or on the Social Time Preference Rate (STPR), which is usually expected to be lower. The SOC rate can be derived from market interest rates, adjusted for such matters as rate fluctuation over time, inflation, risks around outcomes, to feed precise calculations of the present value of future benefits received. The STPR is not so readily observable but can be inferred from empirical observations.

The New Zealand Treasury publishes tables of risk-free discount rates that fluctuate around 5 percent for the next two decades before settling around 4.3 percent from 2062. Compared to that, 9 percent appears high for natural capital accounting. The UK's Natural Capital Accounts Methodology Guide (Office for National Statistics 2022) recommends a social discount rate set out in the HM Treasury Green Book (H. M. Treasury 2018), which draws on an extensive review of literature: a 3.5 percent discount rate for flows projected out to 30 years, declining to 3.0 percent thereafter and 2.5 percent after 75 years. This report does not recommend a rate but presents comparative results using different rates across the range used in practice for illustrative purposes.

Regarding the reliability of assumptions about resource longevity, the asset value calculation projects the current level of ecosystem services over either 100 years or 25 years, depending on whether the service is sustainable. The projection forward of current rental values represents the value of the natural capital asset in its current state. If a natural capital stock is depleted or degraded, as with commercial fishing species, this method presents a rather dismal view of the natural capital value. A stock restored to a more sustainable level available for harvest would have a higher rent and asset value.

The asset value calculation method can vary the expected volume of services received in future years in line with recent trends. The trends we have seen from State of the Gulf reports and other sources are not sufficiently established, robust or comparable enough for modelling at this time, but this could be addressed in further research. For instance, if there was a project to re-establish or restore kelp forests over a wide area of the Gulf, the increase in kelp area over time and its associated values for blue carbon and biodiversity could be used to shift the trend and estimate the value of benefits derived. The method used here can estimate a more aspirational value of potentially restored Gulf and also estimate value for a growing population with new demands on the stock. This report does not do that, as the aspirational parameters have not been defined, but estimating the values of alternative futures is one of the functions this method could serve.

There is a risk with economic valuation of losing sight of the thing which it is intended to illuminate. Relying on monetary valuations can be a double-edged sword, for as a natural resource becomes scarcer, its value increase, creating an illusion of prosperity over a state of decline. This is not so much a problem for products of provisioning services destined for export markets, as international markets set the border price that does not move with local scarcity variations, except for products in which New Zealand has a sufficiently large share of world supply to be a price maker rather than price taker on international markets. The risk is more for ecosystem services that are largely consumed locally, with limited options for trade and limited substitutes available in the locality.

While monetised natural capital values serve a useful role in illustrating the existence values where they are not otherwise apparent, they depend on, and need to be viewed beside, compatible accounts of the biophysical status of local ecosystems that show fundamental changes unobscured by the valuation process.

# 7 Conclusion

This report has prepared a valuation of the natural capital of the Hauraki Gulf. It is building on previous attempts to enumerate the value of the Gulf but goes beyond them to place values on a range of economic services obtained from the environment, many of which provide value to the community without passing through the market process.

The natural capital account builds on biophysical indicators of the state of the environment, quantifies services of value to people obtained from the current state of the Gulf, and attempts to place monetary values on them. It draws on information pertaining to the Hauraki Gulf and adjoining settlements in Auckland and Coromandel/Waikato and minimises resorting to transferring values from other parts of the world.

The monetised accounts presented here are products of their time and can be improved as new information becomes available in future. There remain some gaps that need filling and some refinements to the valuation method that could lead to a more robust interpretation. But even with those limitations, they shine some light on aspects of the natural environment that provide economic value to the communities that share them, even though they are not fully recognised in market transactions.

## Looking ahead

The estimates presented here cover only a fraction of the value sources identified in overseas studies. Further work on this subject could follow several different strands:

- Seeking new information with which to fill in the gaps in the theoretical schema for Table 4 for a more complete picture of the value of natural capital stocks
- Seeking new information focusing on obtaining more items, the marginal value of incremental changes in the ecosystem services obtained from the Gulf, which will be more informative than total values or average values when assessing the economic value gained from specific restoration or enhancement measures
- Over the longer term developing the accounting framework based on more disaggregated data based on a Geographical Information System, which would enable:
    - More detailed inputs into the natural capital account, for instance, by identifying the value of properties at risk from storm surge, pluvial flooding and rockfall and better estimates of the protection provided by mangroves and wetlands
    - More detailed information on the distribution of problems allowing better identification of values at risk and targeting of response interventions.

GIS mapping is beyond the scope of this current natural capital accounting study, but it would extend the usefulness of natural capital estimates. For instance, with GIS mapping, it would be able to pinpoint particular areas or bays with a recurring problem with water quality. If that problem leads to restrictive activity around certain bays or beaches, GIS mapping would enable the identification of the properties within walking distance whose recreation opportunities are diminished, and it would be possible to estimate a loss of value to those properties from the estimates by Rohani's (2012) of changes in property value with distance from access to the sea. Such a GIS-based model would allow a finer-grained assessment of values at stake and where remediation action would be most net beneficial.

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